

Once an abundant nesting seabird throughout Bermuda, this petrel was thought extinct for three centuries before 18 pairs were rediscovered breeding on tiny suboptimal islets in Castle Harbour between 1951 and 1961, since when intensive management (including the elimination of nest-site competition) has wrought a slow but steady increase to over 40 breeding pairs in the 1990s.

DISTRIBUTION The Cahow (see Remarks 1) or Bermuda Petrel is endemic to the island of Bermuda, Atlantic Ocean, where at the time of the early settlers' arrival in the sixteenth century it was widespread throughout the main island and its adjacent satellites, although it is now confined to four of the smallest islets (1 ha in total area) in Castle Harbour, east Bermuda (Bent 1922, Beebe 1935, Murphy and Mowbray 1951, Wingate 1985). Virtually nothing is known of its range at sea, but it probably wanders to the offshore waters of the southern Atlantic states (Clapp *et al.* 1982), with a possible sight record off the coast of North Carolina at 35°18'N 74°45'W on 18 April 1983 (Lee 1984). The only tangible evidence of the species away from its breeding grounds is that of fossil bones of at least one individual on Crooked Island, Bahamas (see Olson and Hilgartner 1982).

POPULATION At the time of Bermuda's discovery by European explorers in the early sixteenth century, the island had no indigenous human inhabitants or other mammals and there were large nesting colonies of seabirds, notably the endemic petrel (Wingate 1985). Evidence from first travellers, early settlers (see, e.g., Verrill 1902, Bent 1922, Beebe 1935, Bradlee *et al.* 1931) and fossil bones shows that the species must have been extremely abundant throughout the island (Shufeldt 1916, Wingate 1960, 1978), but excessive human exploitation for food and introduced mammal predators (see Threats) quickly relegated it to a few offshore islands, notably Cooper's, so that as early as 1621 it was believed extinct (Verrill 1902, Nichols and Mowbray 1916, Shufeldt 1916, Bent 1922, Murphy and Mowbray 1951, Wingate 1960, 1985), a view that persisted for three centuries until its haltingly slow rediscovery from 1906 to 1951 (Beebe 1935, Murphy and Mowbray 1951; see Remarks 2). By 1951 when the first breeding sites were discovered the species was in fact very close to extinction, with only 18 pairs remaining (Wingate 1978). It was estimated that since nest-site competition with White-tailed Tropicbirds *Phaethon lepturus* started, the decline of the Cahow must have been in the order of 50% every 30 years, and thus in 1906, when the first specimen was collected on Castle Island (a site where cahows no longer breed), the population may have numbered around 70 nesting pairs (Wingate 1978). As a result of continuous management efforts (see Measures Taken), the species's total population in Castle Harbour has steadily increased since 1962 from 18 pairs (eight young fledged) to 43 established pairs (23 young fledged) and five establishing pairs in 1992 (45 being the maximum in 1989, as of 1992 with 28 young fledged) (D. B. Wingate *in litt.* 1991, 1992). The total population is estimated at approximately 150 birds (D. B. Wingate *in litt.* 1992). Following management of Nonsuch Island (see Measures Taken), which could easily accommodate a population in excess of 1,000 pairs (many more with the use of artificial burrows), eventual recolonization by the species is expected (Wingate 1985).

ECOLOGY Cahows are believed to range widely on the open ocean, returning to land only to breed, where they are strictly nocturnal in habits (Wingate 1973). Their food consists primarily of cephalopods (small squid) and lesser amounts of shrimp and probably small fish (Wingate 1972). The stomach of a bird collected in June 1935 contained 17 beaks of cephalopods and several crystalline lenses of the same organism (Murphy and Mowbray 1951). The breeding season runs from late October to mid-June (Wingate 1973). Eggs are laid in January, hatch in late February and early March, and young birds fledge in late May and early June (Murphy and Mowbray 1951, Wingate 1978). The Cahows originally burrowed their nests into the soft soils of Bermuda, but predation by introduced mammals exterminated them everywhere except on the smallest offshore islets where soil cover was too sparse to permit burrowing, the birds being obliged to occupy natural erosion crevices in the cliffs and cliff talus instead (a breeding habitat already heavily used by the tropicbirds) (Wingate 1978; see Threats). Like other species of the genus, Cahow adults often cease tending their chicks long before they are able to fly, since the fat accumulated by the fledglings can provide enough energy to reach fledging condition: 15 days from abandonment to the chick's departure was not unusual; however, chicks that grow fast are tended up to fledging, while those that grow slowly are more likely to be abandoned (Wingate 1972; see Warham 1990).

THREATS The Cahow has suffered the typical fate of oceanic island birds in being exposed to a multiplicity of threats, many interlinked, and all assuming an exaggerated significance in inverse relation to population size.

Early impact of man: habitat loss, exploitation, predation Pigs were introduced late in the sixteenth century by early voyagers and, by the time of the first human settlements in 1612, they had already decimated the seabirds on the main island; other man-introduced animals (e.g. rats, domestic cats and dogs) appeared with the early settlements and the impact of these new predators, combined with extensive burning, deforestation and human capture of birds and eggs for food, greatly reduced the seabird population, bringing the Cahows to the verge of extinction (Verrill 1902, Bent 1922, Murphy and Mowbray 1951, Wingate 1960).

Nest-site competition Even the smallest Castle Harbour islets were marginal breeding habitat because they were accessible to rats and were so eroded that they lacked sufficient soil to enable the birds to excavate nesting burrows; as a consequence, the Cahows were forced to nest in the few deep natural holes and crevices in the cliffs (optimum breeding habitat of the White-tailed Tropicbird) with the resultant nest-site competition invariably favouring the tropicbirds and leading to the deaths of more than 60% of Cahow chicks at the time the population was first rediscovered (Wingate 1978, 1985).

Pesticide contamination Detection of high levels of pesticides such as DDT and other chlorinated hydrocarbon compounds in unhatched Cahow eggs and dead chicks (one egg contained more than 11 ppm) was presumably a cause for the observed decline in reproductive success during the first decades after the species's rediscovery (Wurster and Wingate 1968), but the use of DDT rapidly declined in North America in the late 1960s and in the early 1970s reproductive success of the Cahows climbed back towards its earlier 60% fledging rate (Zimmerman 1975, King 1978-1979, D. B. Wingate *in litt.* 1992).

Airbase and military development and disturbance In 1941, after an agreement between the U.S.A. and the U.K., an airbase was established on the former breeding site of Cooper's Island, which was connected to the larger St David's Island through dredging and filling (Murphy and Mowbray 1951). By 1950 this airbase had grown considerably, airlines were using it to bring thousands of visitors in a prosperous post-war tourist boom, and the island population was increasing rapidly (Wingate 1960; see Measures Proposed). Furthermore, bright lights on a nearby NASA installation were believed to have contributed to the abandonment of one islet (D. B. Wingate *in litt.* 1992); but in 1987 the U.S. Naval Air Station installed an array of extremely bright security lights near Cooper's Island within half a mile of the breeding islets; appeals to rectify the problem resulted in all of the offending lights being turned off by early November 1990 and a surge of pre-breeding activity immediately followed (D. B. Wingate *in litt.* 1991).

Natural disasters In January–March 1987 a vagrant Snowy Owl *Nyctea scandiaca* targeted the species, resulting in the loss of at least five pre-breeding birds from two of the four breeding islets (D. B. Wingate *in litt.* 1991; also Amos 1991). In 1989, Hurricane Hugo may have been implicated in an unusually high (doubled) mortality rate in the population; this and the above events are believed to have resulted in drastically lower breeding success and a small reduction in the number of established breeding pairs in 1990 (D. B. Wingate *in litt.* 1991).

Global warming A longer-term concern, given the small size of the breeding islets, is the threat of sea-level rise and increased storm activity owing to anticipated global warming; after 25 years with no significant flooding problems, there have been four major burrow flooding events in recent years, two of them occurring during the 1991 breeding season and causing failure for at least two pairs (D. B. Wingate *in litt.* 1991).

MEASURES TAKEN The Cahow has been the subject of an intensive conservation and research programme since the rediscovery of its breeding grounds in 1951 (see, e.g., Wingate 1972, 1985, Zimmerman 1975). This resulted in the establishment of the 10 ha Castle Harbour Islands National Park, consisting of nine small islands (Wingate 1985). Nonsuch Island (6 ha, the largest of the Castle Harbour islands) was selected in 1962 for restoration as a living museum, and after 1966 received full government recognition and support as a project of the Conservation Division; restoration has involved the elimination and/or exclusion of exotic species, reforestation with indigenous flora and the artificial creation of additional habitats, the island's small size and isolation making it possible to eliminate or exclude most exotic species including rats (Wingate 1985). In 1954 artificial entrances for the Cahow nesting crevices

were devised in order to avoid competition from White-tailed Tropicbirds, and since 1961 this system has completely prevented mortality from tropicbirds, effectively trebling the Cahow's reproductive success (Wingate 1978, 1985). Another manipulative technique has been the construction of artificial burrows on the level tops of the Cahow breeding islets in an effort to re-establish the original separation in breeding niches between the soil-burrowing petrel and the cliff-nesting tropicbird (Wingate 1985). The Cahow population has responded with a gradual but accelerating increase (see Population). Ultimately, this increasing population is expected to spill over onto the larger neighbouring soil-covered islands such as Nonsuch, where soil-burrowing will once again become possible (Wingate 1985). The problem of burrow flooding (see Threats) has been overcome by the construction (in autumn 1991) of a protective sea-wall in order to shelter low-lying nest-sites on the most vulnerable islet; this action proved to be effective when Hurricane Grace sent waves over that islet in late October 1991 which would probably otherwise have killed at least two nesting pairs (D. B. Wingate *in litt.* 1992). Consideration is now being given to accelerating long-term plans to attract Cahows to breed on Nonsuch Island, using techniques developed by Podolsky and Kress (1992) for Dark-rumped Petrels *Pterodroma phaeopygia* on the Galápagos (D. B. Wingate *in litt.* 1992).

The steady nurturing of the Cahow back from the brink of extinction has been the personal mission of D. B. Wingate for over 30 years; there are few cases in bird conservation where one figure has been so closely associated with and dedicated to a particular species, and the world is forever in his debt for his singular and continuing achievements.

MEASURES PROPOSED A proposal to restore Cooper's Island (where, according to the early histories, the bird widely nested: see, e.g., Bent 1922, Beebe 1935, Wingate 1960) as a wilderness area for the preservation of all Bermuda's endangered species of flora and fauna, much as is being done on Nonsuch Island today, represents a very important but very long-term investment in Cahow conservation: it would involve the dismantling of present installations and the re-opening of the natural channel (which formerly kept ground predators from spreading from St David's Island), and would thus also benefit Nonsuch Island in terms of reduced disturbance and risk of predator invasion (D. B. Wingate *in litt.* 1991). Unfortunately, there is little likelihood of this proposal being realized before the end of the 99-year lease agreement signed in 1941 unless circumstances change radically (D. B. Wingate *in litt.* 1992).

REMARKS (1) This is an onomatopoeic name (*cahow*, *cahowe* or *cowhaw*) given by early settlers of the island (Jobling 1991). (2) The species's rediscovery is generally regarded as having occurred in 1951 (with the discovery of breeding pairs), but the first bird taken alive in modern times was collected on Castle Island on 22 February 1906, although it was erroneously attributed to "*Aestrelata gularis*" or Peale's Petrel *Pterodroma inexpectata* (see Bradlee 1906, Hellmayr and Conover 1948), and not until 1916 was it named as "*Aestrelata cahow*" (Nichols and Mowbray 1916). In June 1935 a dead bird found at St David's Island lighthouse became the second known specimen of this mystery species (Beebe 1935). In June 1941 a third specimen was found dead, having flown into a telephone cable on St George's Island, and in March 1945 a dead adult apparently killed in a fight with a tropicbird was washed up on Cooper's Island (D. B. Wingate *in litt.* 1992). A summary of nineteenth century references to the species is provided by Bent (1922), from which it is clear that great confusion existed with other Procellariidae, notably Audubon's Shearwater *Puffinus lherminieri* (see also Murphy and Mowbray 1951, Wingate 1964c).