SEABIRD ISLANDS No. 24/1

Bowen Island, Jervis Bay, Australian Capital Territory

Location: 35°07'07"S, 150°46'09"E; 700 m east of Murrays Beach, Booderee National Park, Jervis Bay, Australian Capital Territory (ACT).

Status: Bowen Island is jointly managed by Parks Australia and the Wreck Bay Aboriginal Community Council as part of Booderee National Park, gazetted in 1992 as Jervis Bay National Park. The name changed following title to the land and water covered by the park being conferred on the Wreck Bay Aboriginal Community Council in 1995[1]. The island and adjacent waters are designated a Special Purpose Zone to provide protection for seabird, fish and marine invertebrate habitat and breeding areas, as well as to cultural sites including middens[1]. Landing on the island is strictly controlled.

Other Names: None known

Description: Bowen Island is a tear-drop shaped landmass, aligned north-south 700 m wide and 1450 m long. The island's southern tip is 300 m east of the southern headland of Jervis Bay. Steep cliffs of up to 30 m surround the eastern portions of the island, which gently slopes to the western shoreline. The 52 ha of the island, like the adjacent mainland, is derived from Quaternary sediments—sand dunes and swamp deposits overlaying the Permian (Jervis Bay) sandstone[2]. A single fault runs through the island from the south-east to north-west, where it changes direction at 'North Beach'[3]. A track is maintained from the main Border Beach (also known as 'Penguin' Beach) and loops through the island's centre. Three groups of buildings are extant (see Fig.): 1. two recent constructions, for accommodation of Parks Australia staff and visitors, and a machinery shed upslope from Border Beach; 2. the ruins of World War II barracks and services and; 3. reinforced concrete emplacements for radar, a fixed gun and observation posts[4] at the island's highest point. Tourist accommodation, noted by Lane[5] in 1975, has been demolished and only the foundations and some chimney stacks remain. Other infrastructure includes 4. The island's jetty, which has suffered catastrophic Ship Worm *Teredo navalis* damage with only concrete footings, a rock groin and some timber on the area of Border Beach remaining and; 5. a redundant concrete reservoir tank, with drainage into the ocean, situated halfway along the western shore.

The western coastal slope of the island is dominated by Spiny-headed Mat-rush *Lomandra longifolia*, progressively increasing in abundance to the south. A dune swale directly behind the main beach is dominated by vegetation regularly inundated by fresh water and includes the invasive Inkweed *Phytolacca octandra*. North from here, invasive Kikuyu Grass *Cenchrus clandestinus* dominates the ground cover and surrounds current buildings and previous sites of accommodation. The island supports coastal heathland vegetation, dominated by Coast Banksia *Banksia integrifolia* and Scribbly Gum *Eucalyptus haemastoma* with

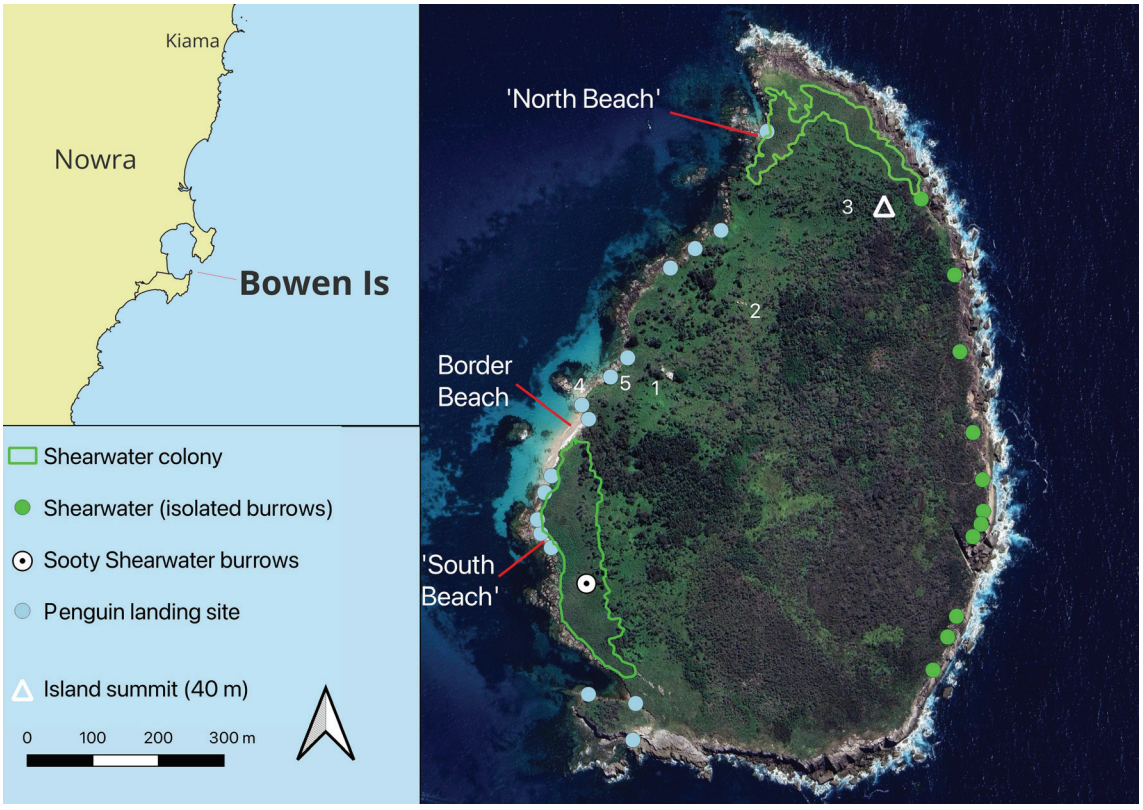

Figure 1. *Bowen Island, Australian Capital Territory, New South Wales coast with extant structures numbered (refer to text).*

dense stands of Tea-tree *Leptospermum squarrosum* on deeper draining soils. Towards the south, shallow soils support stands of Knotted Club-rush *Ficinia nodosa*, dominating waterlogged soils, which include a perched (12 m above sea level) saltwater flat of Beaded Glasswort *Sarcocornia quinqueflora,* fed by wave over-wash from 15 m cliffs to the south-east. The vegetation on Bowen Island is more fully described in other surveys[6,7] and has been listed on iNaturalist. Additional species present on the island but not included in these sources were:

Ceratopetalum gummiferum, Crinum pedunculatum, Dendrobium linguiforme, Dianella caerulea, Dichondra repens, Dipodium punctatum, Eucalyptus sieberi, Ficus rubiginosa, Gleichenia sp.*, Glochidion ferdinandi, Guioa semiglauca, Notelaea longifolia, Parsonsia straminea, Pittosporum revolutum, Stephania japonica.*

Landing: By small vessels onto a sandy western beach in most conditions. Only with permission from management.

Ornithological History: Lane[5] summarised some of the scant ornithological history to 1975 and surveyed the main south-west shearwater colony in April 1975. Australian Bird and Bat Banding Scheme (ABBBS) records indicate that Lane continued to visit around the same April date in 1976, 1979 and 1980 for the banding of shearwater fledglings. In June and November 1982, Lintermans[8] was the first to estimate the number of Little Penguin *Eudyptula minor* burrows on the island and the percentage of occupied penguin burrows. He surveyed one of the shearwater sub-colonies[9]. Fortescue[10] studied Little Penguins between 1988 and 1990, which included monitoring of 500 nests during the breeding season and count of beach landings. Fortescue continued these monthly visits during the Little Penguins breeding season until 1996 (ABBBS)[11]. In this same period, members of the Taronga Zoo Penguin Project banded penguins overnight between two to five months of each year (1990-1992 ABBBS data) as part of broader studies of the species[12, 13]. Fullagar *et al*. [14] reported on penguin transect survey counts in 1998. Carroll[15] visited several times between 2013 and 2015 to GPS track Little Penguins and collect faecal material, used by Lundbäck *et al*.[16] to investigate the dissemination of antimicrobial resistance from humans to wild birds. NC and LO'N reviewed seabird colony areas during a day visit in February 2010. Little Penguins were marked and recaptured for eight nights in October and November 2012, six nights between October and December 2013 and two nights in October 2014 by Vardeh[17]. Recently, the authors and others carried out several overnight visits: 22-23 August 2023, searches were made for active landing sites for Little Penguins; 18-22 September 2023, landing numbers were counted with eight participants along with diurnal surveys of penguin breeding burrows and nocturnal surveys for additional seabirds; 3-5 January 2024, diurnal transects and nocturnal surveys of other burrowing seabirds were made.

Breeding Seabirds and Status

Ardenna pacifica Wedge-tailed Shearwater — Nests on the western and north-eastern coastal slopes in dense colonies. Smaller, discreet collections of burrows were identified at 12 locations above the eastern and southern cliffs (Fig. 1). The birds also burrowed within the wooded areas of the island's north and western interior at very low densities. Burrows on coastal slopes were interspersed with those of the Short-tailed Shearwater *A. tenuirostris* and Little Penguin. Targeted shearwater occupancy surveys occurred when Little Penguin breeding was substantially completed for the season. The size of shearwater populations were estimated by counting burrows within a series of 10 transects, 50 m long x 4 m wide, set approximately 50 m apart and perpendicular to the coastline in open habitat. Transect distance was measured from when the first shearwater burrow was encountered traversing inland from the shoreline to avoid rock platforms and foredune swales where waterlogged soils supported almost impenetrable vegetation. Shearwater burrows within each transect were counted and searched using a length of flexible hose pipe (equating to approximately 2 m in length, including operators' arm). Active burrows were identified by the occupant's interaction with the searching hand or hosepipe, or by vocalisation from within (which allowed species identification). Burrows of less than 30 cm in depth were considered not capable of supporting a nesting chamber. All birds able to be extracted from shorter burrows were found to be incubating an egg and it was assumed that birds in all other active burrows were similarly incubating eggs. Burrows that were too long to allow occupancy to be determined were classified as "indeterminable" and assumed to have the same occupancy rate and species ratio as determined from the other burrows. Due to the relatively low population of Little Penguins here compared to the substantial number of shearwaters, most unoccupied burrows were considered to be of shearwaters unless evidence of previous occupation by Little Penguins was observed.

The ratio of different shearwater species was determined from vocalising, or visible identification of birds. In addition, a nocturnal listening survey involved walking five random transects of various lengths through the colony. Vocalisations of species present were noted, until 20 calls from individuals had been heard.

During the January 2024 visit, the perimeter of all shearwater breeding colonies, within open vegetation habitat (identified by the presence of burrows) was mapped using a hand-held GPS, giving an area of 2.8 ha. Transects resulted in 2,000 m^2 area surveyed, equating to 7% of the combined open vegetation areas. Of the 441 burrows within the transects, 69 were indeterminable, with 175 occupied (plus 4 Little Penguins) and 197 empty, giving an occupancy rate of 47%. Burrow density within the transects was 0.22 per m^2. On the basis of the ratio of known vocalisations from transect burrows (68% WTSH, n = 19) and the nocturnal vocalisation transects (average 72% WTSH, n = 5), we assume that approximately 70 percent of birds breeding in shearwater burrows on the island were Wedge-tailed Shearwaters.

Based on the mean burrow density in all transects, we estimate the total number (± standard error) of combined shearwater burrows in the non-wooded areas of the island to be 6160 ± 515. Using assumed occupancy rates (47%) and species ratios (70% WTSH) we estimate the total breeding population of Wedge-tailed Shearwaters for Bowen Island of 2026 ± 60 breeding pairs. Approximately 100 pairs were estimated breeding here in the 1970s[5]. The addition of the dense breeding locations on the northeast parts of the island, not surveyed previously, significantly increased the total. With the scattered smaller cliff colonies (Fig. 1) and additional shearwaters breeding in low densities in wooded areas the current estimate is probably conservative. The most easterly sub-colony (700 m sq.) had 157 burrows along a single 50 x 4 m transect, which is

similar to Lintermans' 150 burrows based on two 100 m^2 plots and assumed boundary measurements drawn from airphotos[9]. Similarly, Lintermans' percentage of combined shearwater burrow occupation at this site from a small sample (5 out of 13 burrows)[9] was similar to our sample here (58 out of 157). The current burrow density and burrow usage by combined shearwater species here and island-wide is likely to have changed little in the last 40 years, indicating population stability.

Ardenna grisea Sooty Shearwater — This species appears to nest in higher areas of the main shearwater colony on the island's western slopes. During the current survey its presence was only identified by nocturnal vocalisation of overflying birds and two ground calls heard during listening counts for species ratio estimates in January 2024. None were identified from vocalising birds within the diurnal transect searches. From this it is assumed only a few burrows are active here. Previously, 10 pairs had been estimated[5] and the approximate location of a burrow with chick in 1975 (and banding activities 1975-80 see Banding below) was in the same area where ground calls were identified during this current survey (Fig. 1).

Ardenna tenuirostris Short-tailed Shearwater — Nests in mixed colonies with Wedge-tailed Shearwaters and Little Penguins on the coastal slopes. Based on transect surveys and vocalisation ratios (as per method described previously for Wedge-tailed Shearwaters), 30 percent of shearwater burrows were attributed to Short-tailed Shearwaters. The population appears to have significantly increased since the 1970s estimate of 200 pairs[5], with the current estimate of 869 ± 86 breeding pairs. This increase is likely due to the better coverage of breeding areas by the 2024 survey.

Eudyptula minor Little Penguin — Nests on the coastal slopes of the north-east and western sides of the island in soil scrapes under thick shrubs, grass or soil-covered burrows. Burrows are generally located close to the shoreline inland from landing sites but can extend up to 150m inland, as found by Fullagar *et al*.[14]. Following initial landing site checks in August 2023, approximately 16 landing locations were identified based on penguin tracks on sandy beaches or accumulation of guano deposits along the rocky foreshore. In September 2023, we attempted to count all penguins that came ashore. Counts began at dusk and continued until no further penguins arrived during two consecutive 15-min periods (until approximately 20:30). Counts were conducted on two nights at each of the 16 identified landing sites including 'Penguin' Beach, 'North Beach', 'South Beach' used in previous surveys[10, 14] (Fig. 1). An average of 280 penguins landed per night. During the day, we examined 34 occupied nests (those containing at least one adult, egg or chick) to estimate the proportion of breeding adults ashore and the stage of breeding over the colony. Eleven active nests contained a single incubating adult (32%), 16 had an adult brooding a chick or chicks (47%) and one contained well developed chicks (3%). Six further nests contained an adult not yet breeding (18%). These last nests were considered to have visitation rates similar to those of nests with brooding adults. From the ratio of nests with one adult incubating, one adult brooding chicks (including unattended eggs or a waiting adult) and unattended chicks, combined with known breeding behaviour (three-day incubation shifts meaning 1/3 of incubating adults returning every night, nightly change-overs of brooding adults[18,] and one of the pair of parents generally returning nightly to feed offspring[19]), we estimate that each landing bird 'represented' 1.31 active nests. The nesting population was calculated to be approximately 366 ± 2 pairs. A recent publication refers to a figure of 7,000 pairs[20] and describes Bowen as containing 'The large breeding colony.. as.. one of the most significant in Australia, with exceptionally high breeding success and intact breeding habitat'. The last credible estimate[14] based on beach counts and island-wide transect surveys gives a more conservative estimate of 2450 pairs in 1998. Fullagar *et al*.[14] cast considerable doubt on previous high estimates due to inconsistencies in reported results and proposed they must have, at a minimum, been collected during 'a favourable period for the colony'. The earlier research by Fortescue[10] did provide a baseline from landing counts in which declines can be detected. In the 1988–90 studies, the average counts (no measure of variability given) at the prime landing site (Border Beach) were 310 birds per night[10]. In 1998, Fullagar *et al*.[14] had a one-off count at the same location of 181 birds. Between 2012 and 2014[17] counts here confirmed decline, with between 100 and 150 individuals arriving after sunset (between October and December annually). This suggests a halving of the population since the 1988–90 counts. The September 2023 surveys averaged 31 birds per night (SD 11.3) at Border Beach and indicate fewer than 10% of birds are now landing here than were in the early 1990s.

Factors affecting status

Rabbits *Oryctolagus cuniculus* were introduced about 1954[6] and eradicated in 1981[21] from the island. Black Rats *Rattus rattus* were present prior to 1928 and eradicated by the 1990s[22]. While this should have allowed the native vegetation to recover, it likely exacerbated the spread of weed species such as Morning Glory (estimated at 430 m^2.) and Kikuyu Grass (north-west infestation 0.2 ha but also 390 m^2 of penguin arrival/departure shoreline has varying infestations inland). Control of Kikuyu was targeted from 1987, several decades after deliberate establishment, and by 1993 it was considered to be no longer impacting seabird habitat[23], although this was not determined by formal surveys. However, since then the Kikuyu has expanded and it now impacts the colonies of the different seabird species in various ways. In areas where the grass is thick and deep at the shoreline, Little Penguins have reduced access to inland nesting areas. Untreated, the grass will largely exclude penguins from once productive nesting areas and entrap them on a regular basis, as has been recorded on Barunguba-Montague Island[24]. The presence of active shearwater burrows within grass infested colony areas indicates they can withstand its encroachment, although some death by entanglement is likely. The Morning Glory infestation within the main shearwater breeding area has likely reduced new burrowing activity but at the time of this survey, the burrow density was only marginally different from areas without the weed.

The significant difference in recent breeding numbers of shearwaters from those recorded in 1975[5] and later[9] relates to the incomplete former surveys. Lane[5] covered only the south-western portion of shearwaters and Lintermans[9] followed up in 1982 with only a small portion of the north-east colonies. There is also a change in dominant shearwater species on the island. In 1975, the ratio of burrows with Wedge-tailed Shearwaters (33%) compared to those with Short-tailed Shearwaters (66%)[5] was similar to that recorded on average (from preceding five seasons) on Montague Island[25] (WTSW 25%; STSW 75%) in the same period. The ratio on Bowen Island in 2024 is now almost the opposite, with 70% Wedge-tailed Shearwaters and higher than now on Barunguba/

Montague Island (WTSW 56%)[25]. The change in the dominant shearwater species may be related to warming waters in the Tasman Sea[26], which has caused southward movement of fish species more likely to be previously encountered in tropical waters[27]. This has enabled the Wedge-tailed Shearwater to exploit this southern movement[28] and take up breeding on the southern NSW islands in greater numbers.

The decline in Little Penguins numbers is clear. Based on counts at Border Beach, even accepting this current count was seasonally earlier than other previous counts, and that counts were of 'maximum arriving numbers', we suggest a 90% decline compared with the late 1980s. While habitat degradation outlined above may have contributed, oceanic impacts are likely a major factor in the decline. Potential threats to the population include the increase in regional populations of Fur Seals *Arctocephalus* sp.[29] and climate-related ocean changes leading to changing prey availability[30]. Without significant further research on survival of breeding penguins and intensive tracking studies, the relative impacts of these potential factors remain speculative.

The most significant threats to the native vegetation on Bowen Island are competition from introduced weeds, fire, occasional drought periods and climate change[31]. The control and eventual removal of invasive Kikuyu Grass and Morning Glory, both of which have increased their spread in recent years (NC, LO'N pers obs.), needs to remain a priority for island management. The exclusion of fire within seabird colonies is necessary to avoid catastrophic impacts, as seen elsewhere[32].

Swamp Harriers *Circus approximans* and White-bellied Sea-Eagles *Haliaeetus leucogaster* were observed flying over the island. These raptors could take adult or fledgling seabirds not adequately under cover or on the surface in-shore. While Powerful Owl *Ninox strenua* has been recorded here[22], with the close proximity of Booderee National Park, Sooty Owl *Tyto tenebricosa* and Masked Owl *T. novaehollandiae* (from e-bird lists) could also occasionally hunt over the island, taking seabirds from the surface at night..

Other seabirds recorded

Despite nocturnal/diurnal searches and spotlighting in a range of favourable habitats for both storm-petrels and other petrels, including extended periods of dedicated listening in both the September and January visits, no other species of breeding seabirds were detected. Other seabirds and shorebirds observed on the island or surrounding rocks included Silver Gulls *Chroicocephalus novaehollandiae*, Greater Crested Terns *Thalasseus bergii*, Sooty Oystercatcher *Haematopus fuliginosus*, Pied Cormorant *Phalacrocorax varius*, Little Pied Cormorant *Microcarbo melanoleucos*, Australian Pelican *Pelecanus conspicillatus* and White-faced Heron *Egretta novaehollandiae*. An additional species, Great Cormorant *Phalacrocorax carbo,* has been lodged on iNaturalist before the survey period.

Other vertebrates recorded

Since the eradication of Rabbits and Black Rats, the island has been free of feral animals. Delicate Skink *Lampropholis guichenoti,* Eastern Water Skink *Eulamprus heatwolei* and Red-bellied Black Snake *Pseudechis porphyriacus* were occasionally seen along slashed tracks and rocky shorelines. Additionally, Jacky Dragon *Amphibolurus muricatus* and Australian Striped Skink *Ctenotus taeniolatus* have been sighted here in herpetological surveys in 1994[33]. The Common Eastern Froglet, *Crinia signifera* inhabited the creek line vegetation behind the eastern end of Border Beach and the Green and Golden Bell Frog *Litoria aurea* was previously identified here[33] and although no breeding was detected it, was considered likely[7]. The skeletal remains of an Australian Fur Seal *Arctocephalus pusillus* were found high on a rock shelf north of 'North Beach', indicated that landing occurs on the rocky shores. Previously, Chocolate Wattled Bat *Chalinolobus morio* and Gould's Long-eared Bat *Nyctophilus gouldii* were trapped here in March 2004[22] and are likely common on the adjacent mainland. Additionally, 20 terrestrial bird species were noted during the current survey and a further two have been lodged on iNaturalist before and after the survey period.

Banding

Data for all banding records commencing 2 September 1958.

Ardenna pacifica – 75 nestlings banded on Bowen Island, with one recovery, 23 years and eight months after initial banding, 76 kms north in the Tasman Sea east of Wollongong, NSW.

Ardenna grise – Five nestlings banded on Bowen Island from 1975 to 1980 with no recoveries.

Ardenna tenuirostris – 185 nestlings banded on Bowen Island from 1975 to 1980 with no recoveries.

Eudyptula minor – 1240 adults and 592 nestlings banded on Bowen Island, with 864 recoveries on the island from 1987 to 1996. Of the recoveries on Bowen Island, 290 were aged three years or older. Nine NSW recoveries as far north as MacMasters Beach, 191 km away. Other locations have included known breeding locations on Five Islands, Port Kembla, and Lion Island, Pittwater. Eleven NSW coastal recoveries have occurred south of the island. In Victoria, there have been ten recoveries of Bowen Island penguins – two adult females on Rabbit Island, off Wilsons Promontory, 566 kms south, six recoveries on Phillip Island (four adults and two fledglings recorded as adults), and two adult females at Port Campbell. The furthest recovery distance (1,176 km) was of a juvenile female found two months after fledging on Troubridge Island, South Australia.

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