

# An Updated Avifauna of Moku‘ae‘ae Rock Islet, Kaua‘i<sup>1</sup>

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**Abstract:** Moku‘ae‘ae Rock Islet is located off the north shore of Kaua‘i and is protected as a Hawai‘i State Seabird Sanctuary. In the late 1970s it was also the site of a cross-fostering project for the endangered Newell’s Shearwater, *Puffinus newelli*. Few avifauna surveys have been undertaken on the islet, and none since 2007. In 2013 and 2015, we conducted burrow searches across the entire islet to obtain breeding population estimates for each species and to evaluate whether the Newell’s Shearwater had become established as a breeding species after the cross-fostering project. Auditory surveys were also conducted for 2 hr after sunset and 1.5 hr before sunrise, which are the peak calling periods for the Newell’s Shearwater on Kaua‘i. A total of seven seabird species was recorded on the islet, of which three, Bulwer’s Petrel, *Bulweria bulwerii*; Wedge-tailed Shearwater, *Ardenna pacifica*; and Red-tailed Tropicbird, *Phaethon rubricauda*, were confirmed breeding. This is the first time Bulwer’s Petrel has been confirmed breeding on Moku‘ae‘ae. Searches for Newell’s Shearwater did not produce evidence that this species breeds on the islet, suggesting that the cross-fostering project was not successful. Although the islet is small, it represents an important refuge for seabird species. However, high levels of depredation were recorded on Bulwer’s Petrel; we conclude that these were all killed by the introduced Barn Owl, *Tyto alba*, based on disposition of the bodies and the injuries they had sustained. Management recommendations for the islet include creation of a management plan, annual breeding bird surveys, annual rat monitoring, and Barn Owl control.

OFFSHORE ISLETS are important refugia for seabirds within the Hawaiian Island chain (Swenson 2008), due to their relative isolation and lack of human habitation. As such they represent areas where seabird management can be focused effectively. This is particularly true for eradication projects aimed at introduced mammalian predators [such as cats (*Felis catus*) and rats (*Rattus rattus* and

*R. exulans*)]: small islet size and isolation means that these species can be effectively eradicated and the islets subsequently kept predator free. There are at least 54 offshore islets within the main Hawaiian Islands, with only one, Moku‘ae‘ae Rock Islet, found off Kaua‘i.

Moku‘ae‘ae Rock Islet is a small (1.3 ha) islet located at 22° 14' 5" N latitude, 159° 24' 11" W longitude. The islet sits 117 m off the northern coast of Kaua‘i (Figure 1) and directly off Kilauea Point National Wildlife Refuge (KPNWR). It is protected as a Hawai‘i State Seabird Sanctuary, with access prohibited above the high-water mark without a permit. Apart from the two visits outlined in this article, the islet is rarely (if ever) visited by any other parties. It is also considered a priority islet by the Offshore Islet Restoration Committee (Swenson 2008), a multiagency group focused on restoring native bird and plant communities on islets across the main Hawaiian Island chain. At its highest point, it is 31.7 m above sea level and consists of a gently

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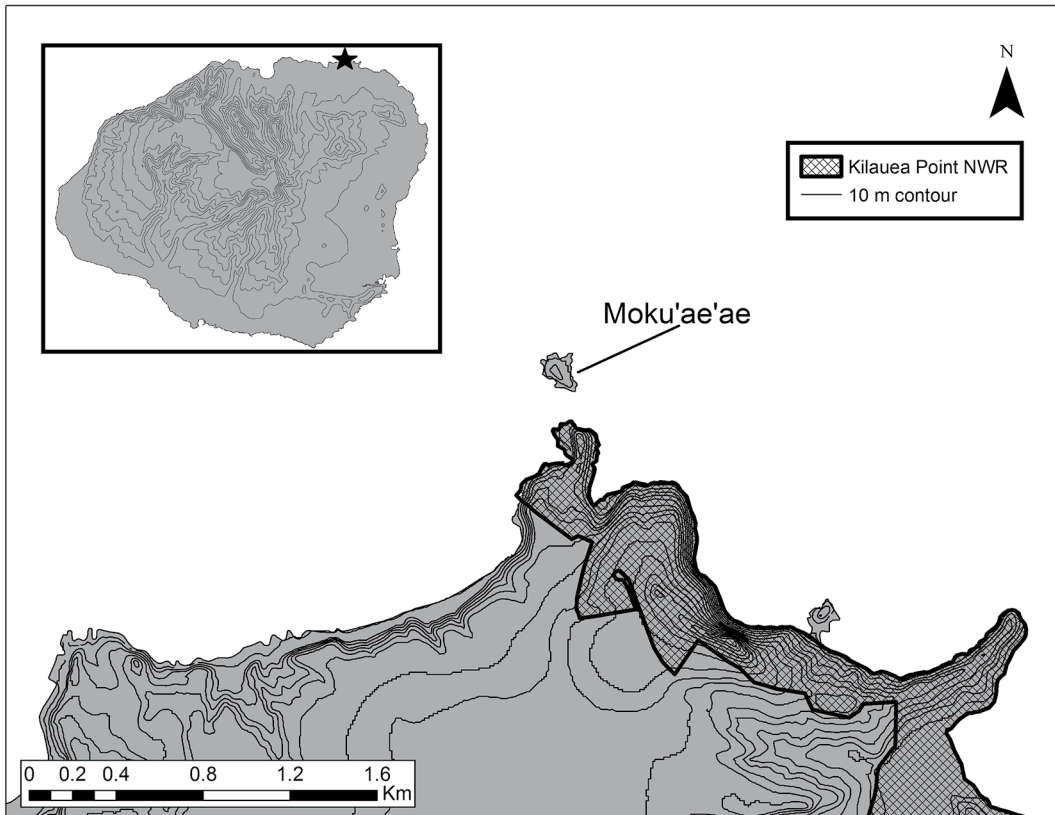


FIGURE 1. Map of Moku'ae'ae Rock Islet and its location off the north coast of Kaua'i, Hawai'i.

sloping plateau surrounded on all sides by cliffs and rock scree leading down to tide pools and the sea. The majority of vegetation on the islet is native, dominated by *Sesuvium portulacastrum*, *Chenopodium oahuense*, *Boerhavia coccinea*, and *Portulaca lutea* (Eijzena and Preston 2008).

In 1979, 25 Newell's Shearwater (*Puffinus newelli*) eggs were removed from burrows in montane colonies and placed in Wedge-tailed Shearwater (*Ardenna pacifica*) burrows on the islet, where they were fostered to fledging (Byrd et al. 1984). Of these, 13 fledged [44% were depredated by Common Mynas (*Acridotheres tristis*)], and it was hoped that they would return to colonize Moku'ae'ae in the future. A small number of surveys have been conducted on Moku'ae'ae since the cross-fostering project ended, with the most recent

being in September 2007 (Eijzena and Preston 2008).

We undertook surveys in 2013 and 2015 with two main purposes. One was to provide an updated inventory of all seabird species currently breeding on the islet, including estimated breeding population sizes. The second was to assess whether Newell's Shearwaters were breeding on the islet, thus evaluating the success of the cross-fostering project. This was considered particularly important, because of the large-scale decline experienced by the Newell's Shearwater on Kaua'i in recent years (Day et al. 2003).

#### MATERIALS AND METHODS

Moku'ae'ae was visited by a team of four ornithologists on 11–12 June 2013 and again on

22–23 September 2015. Due to its small size, it was possible to search the entire islet for burrows, with the exception of a few sheer cliff areas. The locations of all burrows were recorded using a GPS (Garmin Rino 650) and in 2015 were also recorded digitally on an iPad Mini. On both occasions the island was searched systematically starting with the perimeter and then moving to the upper plateau, which was quartered along cardinal directions and searched extensively as well. In total, 50 artificial burrows are located on the islet (mainly on the upper plateau); they were installed in the late 1970s for the Newell’s Shearwater cross-fostering project (Byrd et al. 1984). All of these were also inspected during both surveys and their contents recorded. Minimum breeding population sizes for all species on the islet were then determined using the total number of active burrows recorded on the islet, where “active” was defined as burrows where the presence of an adult, chick, or egg was confirmed. In the case of deep burrows where the chamber could not be viewed, an active burrow was defined as having scent, guano, and fresh footprints at the burrow mouth.

In 2013 and 2015, auditory surveys were also carried out for 2 hr after sunset and for 1.5 hr starting 2 hr before sunrise using night-vision equipment [night-vision goggles (US Night Vision PVS-7 Gen 3)]. These were undertaken specifically to further assess the presence of Newell’s Shearwater and were undertaken at four locations on the islet in 2013 and five locations in 2015. Locations were chosen to maximize the auditory survey coverage across the islet. Surveys were split into 30-min sessions, with 5 min allotted for the collection of weather data, 25 min for auditory surveying, and 5–10 min for concurrent night vision. Surveyors were instructed to record all Newell’s Shearwater calls (classified as a single unbroken note or series of notes) heard during the survey period as well as any visual observations made during each survey period (either by eye or through night-vision equipment). For any observation of the species, we recorded time of observation, species, direction from observer, distance from observer, and the behavior of the bird (with

particular attention paid to circling behavior and ground calling). This information was recorded on standardized data sheets in the field and digitized after surveys were completed. A sea watch using a spotting scope (Swarovski 20–60X Zoom) and binoculars (Swarovski EL 8.5 × 42) was also conducted at dusk in both years, facing out to sea from the southernmost survey point.

## RESULTS

A total of 10 bird species was recorded over the course of the two surveys, consisting of seven seabird species (of which three, Bulwer’s Petrel, Wedge-tailed Shearwater, and Red-tailed Tropicbird, were confirmed breeding), one native waterfowl species, one migratory species, and one introduced species. Individual species accounts are presented here. A summary of population estimates for breeding seabirds on Moku‘ae‘ae Rock Islet in 2013 and 2015 is presented in Table 1, along with results reported during the last survey in 2007 for comparison.

### *Breeding Seabirds*

#### Bulwer’s Petrel, *Bulweria bulwerii*

In May 2013 a total of 16 Bulwer’s Petrel burrows was located, predominantly in boulder fields around the perimeter of the island

TABLE 1  
Estimate of Breeding Pairs of Seabird Species on Moku‘ae‘ae Islet in 2007 (Eijzena and Preston 2008), 2013, and 2015

Species	Year		
	2007	2013	2015
Bulwer’s Petrel	None found	16–19 pairs	4 pairs
Wedge-tailed Shearwater	91 nests	119–695 pairs	644 pairs
Red-tailed Tropicbird	2 nests	22 pairs	4 pairs

*Note:* The number of pairs counted should be considered a minimum only, because (1) a small portion of the islet was not searched due to inaccessibility and therefore burrows could have existed in those unsearched areas, and (2) Bulwer’s Petrel in particular is very hard to find, and so some burrows of this species could have been missed.

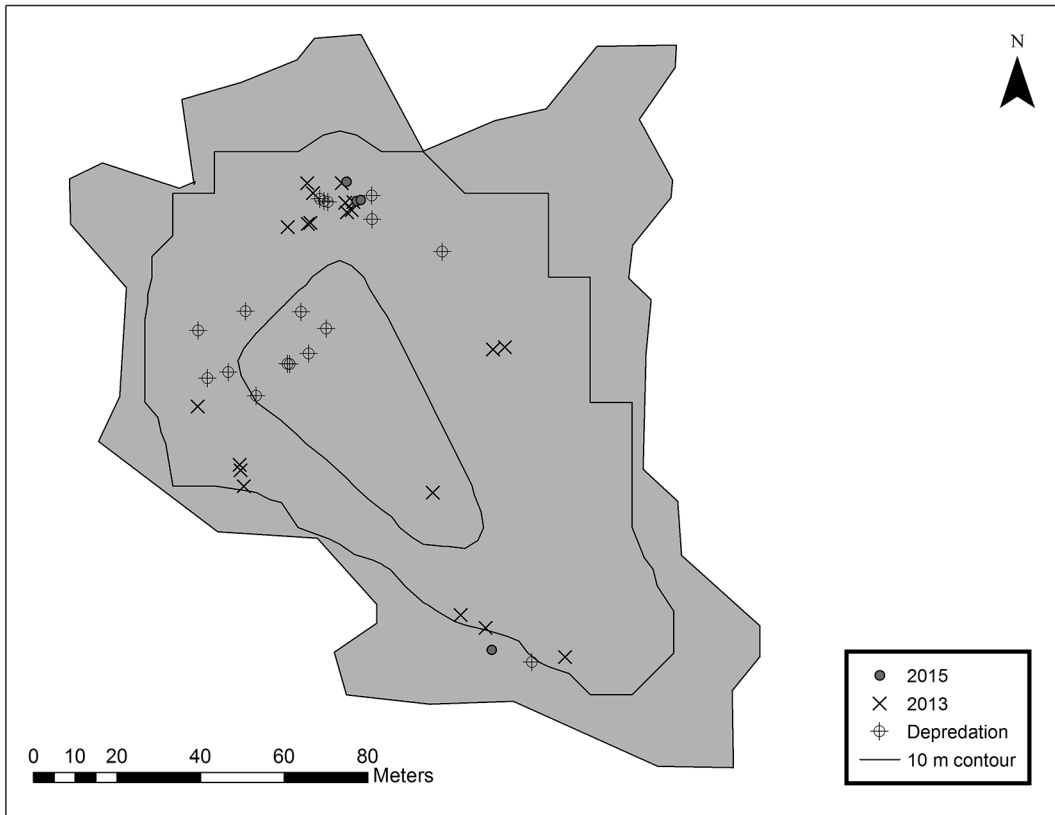


FIGURE 2. Map of Bulwer's Petrel burrow distribution on Moku'ae'ae Rock Islet recorded during 2013 and 2015 surveys, including birds depredated by Barn Owl.

(Figure 2) and in many cases near the intertidal zone. This is thought to be the start of the incubation period for this species in the Hawaiian Islands (Vanderwerf et al. 2007). Of these, five were confirmed with eggs, two with a dead egg (probably from a previous season) and three with pairs of birds present. The remaining six were identified by ground calling individuals heard at night. The burrows of these birds were located but they were too deep and convoluted to evaluate their contents. At three other locations a bird was heard ground calling at night from a general area within piles of rock boulders and each of these most likely represents another nest location. With these data we calculated a minimum breeding population of between 16 and 19 pairs. Previous surveys conducted on the

island recorded large numbers of dead Bulwer's Petrels [3 in July 1979 and 11 in September 1979 (Byrd and Zeillemaker 1981), 26 in 1984 (Moriarty et al. 1986), 24 in 2005 (USFWS unpubl. data), and 20 in 2007 (Eijzena and Preston 2008)] but never live breeding birds, so this represents the first confirmation that the species is actively breeding on the island. No dead adults were recorded during the 2013 visit.

In September 2015 [towards the end of the chick-rearing period for this species (VanderWerf et al. 2007)] only four burrows were located. Of these only one was still active (consisting of a ground-calling adult), and the other three were not active: one contained a freshly dead chick (cause of death unknown), and the remaining two consisted of dead

adults. The two adults were considered to have been killed by a Barn Owl, based on the disposition and injuries to the bodies, including stripped keels and neck, which are consistent with Barn Owl predation. Because burrows were mostly within boulder piles and only marked by GPS, it was difficult to confirm if these were any of the same burrows discovered in 2013, although it is highly likely that they were because they were in the same area where burrows were identified in the previous survey. Within the main breeding area first located in 2013, a total of 21 dead adults was found in 2015; all were recorded as being depredated by Barn Owl, based on the field signs described earlier (Figure 2).

#### Wedge-tailed Shearwater, *Ardenna pacifica*

In May 2013 a total of 119 active Wedge-tailed Shearwater burrows (where adults were physically present inside the burrow) was counted on the island, of which four were confirmed with eggs. A further 576 “probable” burrows were counted. “Probable” burrows were those with signs of shearwater activity, defined as the presence of nest material or extensive guano at the burrow entrance, although no birds were recorded inside them when the burrow chamber was examined. This represents a minimum breeding population of either 119 or 695 breeding pairs [695 breeding pairs assumes that each burrow counted (active and probable) represented a breeding pair on Moku‘ae‘ae]. That trip was early in the Wedge-tailed Shearwater breeding season (within the Hawaiian Islands) when birds have returned to court but have not commenced egg laying (Byrd and Zeillemaker 1981, Whittow 1997, VanderWerf et al. 2007), so it is likely that the majority of “probable” nests would have been active in a few weeks’ time. Indeed, during night surveys large numbers of Wedge-tailed Shearwaters were recorded coming into land on the island, and many of the burrows labeled as “probable” during the day were noted to have birds present at night. An estimated 1,500 to 2,000 individuals were present on Moku‘ae‘ae Islet on the night of 11 May 2013. The large number of birds present, compared with burrows

discovered, may also be due to prospecting individuals and nonbreeders.

In September 2015, a total of 644 active Wedge-tailed Shearwater burrows were counted, representing a minimum breeding population for the island (Figure 3). Of these 64.3% (414 burrows) had chicks, 7.6% (49 burrows) had eggs, 0.6% (four burrows) had adults only, and 27.5% (177 burrows) had signs of activity (guano, digging, footprints) but were too deep to see the contents of the burrow chamber. It is interesting that during banding operations carried out during the night on the islet there was a single recapture: a bird banded as an adult on Moku‘ae‘ae 10 yr previously on 12 August 2005. Seven dead adults were found, predominantly on the upper plateau; all were recorded as being depredated by Barn Owl, again based on the field signs described earlier.

#### Red-tailed Tropicbird, *Phaethon rubricauda*

In May 2013, a total of 22 Red-tailed Tropicbird nests was recorded on the island, the majority around the perimeter and cliff walls (Figure 4). This is the middle of the breeding season for this species in the Hawaiian Islands, with birds either incubating or with chicks (VanderWerf et al. 2007). Of these, 9.1% (two nests) had dead eggs/chicks, 13.6% (three nests) were confirmed with eggs, and 22.7% (five nests) had chicks. The remainder had adults only, or adults sitting in such a way that it was not possible to verify whether or not there were eggs or chicks present.

In September 2015, which is towards the end of the known Red-tailed Tropicbird breeding season in Hawai‘i (Byrd and Zeillemaker 1981, VanderWerf et al. 2007), only four active nests were located, all containing large, fully feathered chicks close to fledging. All were burrows previously located in 2013.

#### *Nonbreeding Seabirds*

##### Newell’s Shearwater, *Puffinus newelli*

No Newell’s Shearwaters were recorded during either trip, either on the islet or passing by. On Kaua‘i the breeding season for this species starts in April (with the courtship phase), and birds fledge from late September

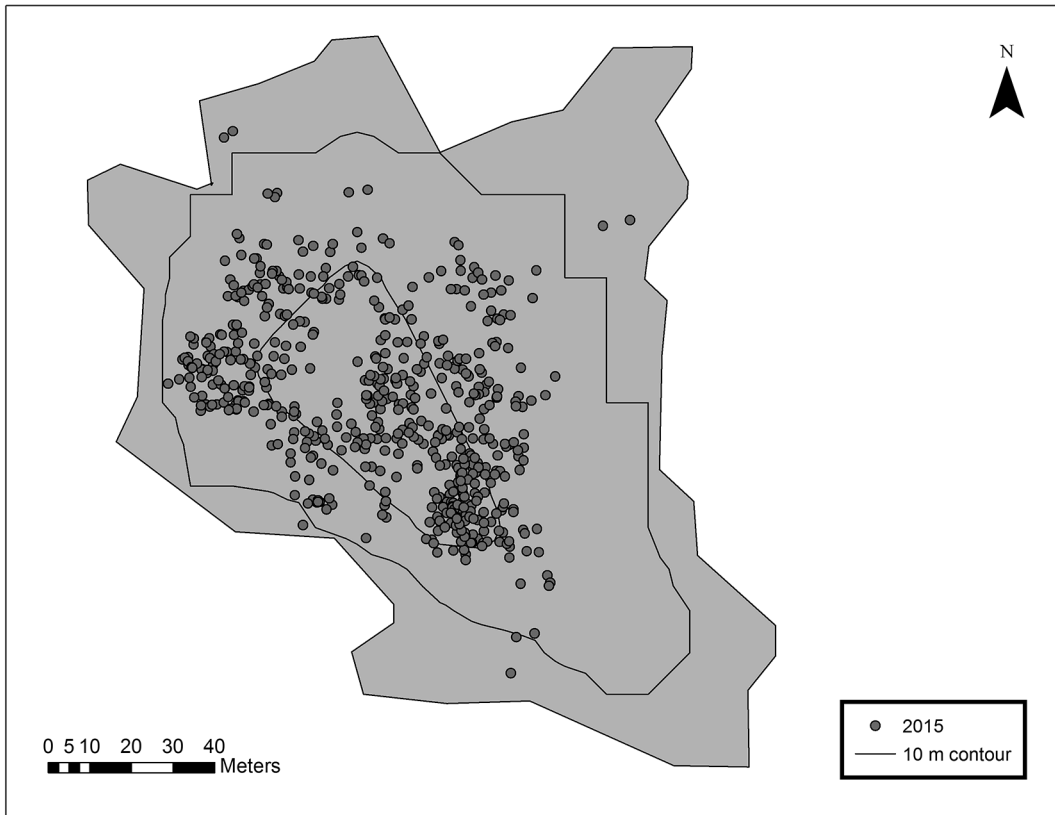


FIGURE 3. Map of Wedge-tailed Shearwater burrow distribution on Moku'ae'ae Islet during most recent survey in 2015.

to early November (Ainley et al. 1997, Pyle and Pyle 2009). The peak vocal period for this species is May to mid-September [Kaua'i Endangered Seabird Recovery Project (KESRP), unpubl. data], so both of the trips to Moku'ae'ae Islet should have recorded vocalizations of this species if it was present. On both trips, the contents of all of the artificial burrows on the upper plateau were inspected to see if there was any sign that this species was present. No Newell's Shearwater was recorded within the artificial burrows, although a large proportion of the burrows on each occasion were found to be occupied by Wedge-tailed Shearwaters.

#### Great Frigatebird, *Fregata minor*

During both trips, up to 40 Great Frigatebirds were recorded roosting on the islet and

using it as a base from which to harass passing Red-footed Boobies and Wedge-tailed Shearwaters. Although the majority roosted at night, several were noted (with night vision) as still being airborne above the islet well beyond midnight.

#### Brown Booby, *Sula leucogaster*

Two individuals were recorded passing by the islet on the night of 11 May 2013. One dead Brown Booby, cause of death unknown, was found on the islet in 2015.

#### Red-footed Booby, *Sula sula*

Large numbers of this species were recorded passing by the islet on their way to the breeding colony at KPNWR on both trips. A small number of individuals used the islet at dusk to roost, although invariably they moved on

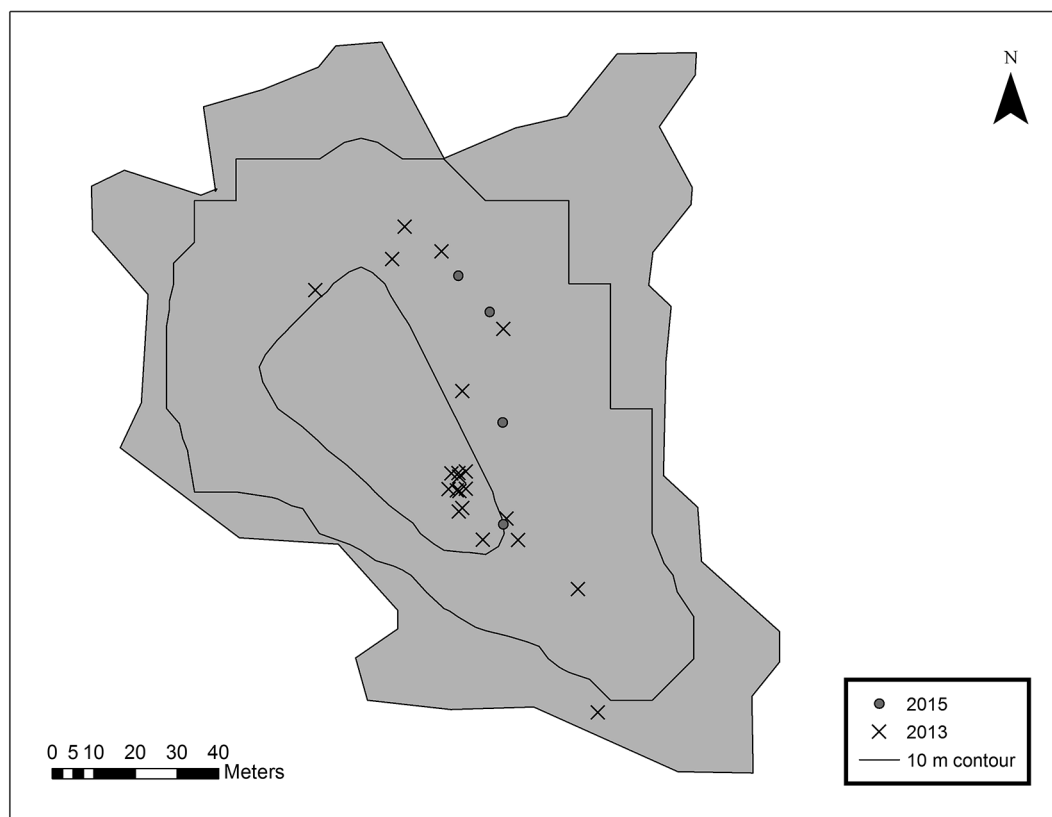


FIGURE 4. Map of Red-tailed Tropicbird nest distribution on Moku'ae'ae Rock Islet recorded during 2013 and 2015 surveys.

to KPNWR after dark. Two dead individuals (from unknown causes) were discovered on the islet in 2013.

#### Laysan Albatross, *Phoebastria immutabilis*

At least four individuals were recorded in the late afternoon on 11 May 2013 passing low over the islet, likely on their way to KPNWR. There was no sign of breeding behavior for this species. This species has been recorded as unsuccessfully attempting to nest on the islet in the past (Byrd and Telfer 1977) but not in recent years.

#### Other Bird Species Accounts

##### Nene, *Branta sandvicensis*

Two unbanded individuals roosted on the islet overnight during the 2013 visit, and the

presence of Nene droppings at various locations around the islet suggest that this is a regular occurrence. Four individuals landed on the islet during the 2015 trip and roosted overnight.

##### Ruddy Turnstone, *Arenaria interpres*

A flock of five individuals was recorded on the northern coastline in the afternoon of 11 June 2013. The birds left before dark.

##### Barn Owl, *Tyto alba*

In 2013, no Barn Owls were recorded during the trip, although five dead Wedge-tailed Shearwaters were found with injuries typical of Barn Owl depredation (stripped keel and neck). In 2015, an adult Barn Owl was flushed from the north side of the island, carrying an unidentified prey item in its talons. Large

numbers of dead Bulwer's Petrel and Wedge-tailed Shearwater were also recorded, all showing signs of Barn Owl depredation. A Barn Owl pellet was also collected from the upper plateau, with Bulwer's Petrel feathers and bones inside. This species is also known to depredate seabirds on adjacent KPNWR, as well as on Lehua Islet (KESRP, unpubl. data).

#### DISCUSSION

Despite its small size, Moku'ae'ae Rock Islet represents an important refuge for breeding seabird species off the north shore of Kaua'i. Currently, the island holds a large population of Wedge-tailed Shearwater, as well as smaller numbers of Red-tailed Tropicbird. Furthermore, it holds the only known breeding population of Bulwer's Petrel on Kaua'i, with the nearest known breeding colony of this species outside of Moku'ae'ae being 75 km away on Lehua Islet (VanderWerf et al. 2007). This also makes Moku'ae'ae one of the few areas where this species has been confirmed breeding in the main Hawaiian Islands, where it has also been recorded breeding on a small number of offshore islets (Pyle and Pyle 2009).

Despite being the focus of a cross-fostering project for Newell's Shearwater in the 1970s (Byrd et al. 1984), there was no evidence that this species currently breeds on the islet, indicating that the project failed on Moku'ae'ae. The species does however breed on adjacent KPNWR, where the same cross-fostering project moved 65 eggs between 1978 and 1980 (Byrd et al. 1984), and which now has a current breeding population of between eight and 14 pairs (KESRP, unpubl. data). There is thus always the possibility that this species could colonize Moku'ae'ae in the future, particularly if the site was actively managed for this species.

Its location offshore affords Moku'ae'ae Islet a level of protection from invasive terrestrial predators, such as rats (e.g., *Rattus rattus* and *Rattus exulans*) and feral cats, *Felis catus*. No sign of any of these species was recorded during the two surveys, although all three species are known to exist in large num-

bers on Kaua'i itself. These species are known introduced predators of seabirds throughout the main Hawaiian Islands (Harrison 1990, Seto and Conant 1996, Ainley et al. 2001, Hodges and Nagata 2001). Bulwer's Petrel in particular, being a small-bodied seabird, is highly vulnerable to rat predation (Pyle and Pyle 2009), which is presumably why the species has managed to breed on apparently rat-free Moku'ae'ae.

Despite this, seabirds on the islet are still vulnerable to avian predation, particularly from the Barn Owl, which was deliberately introduced to Kaua'i in 1959 to control rats (Au and Swedberg 1966). High levels of Barn Owl depredation on Bulwer's Petrel in particular, as well as Wedge-tailed Shearwater, were recorded on the islet in 2015, highlighting the impact of this introduced owl to native seabirds. Depredation of large numbers of Bulwer's Petrel by Barn Owls was also recorded on previous surveys on the islet (Byrd and Zeillemaker 1981, Moriarty et al. 1986, Eijzenga and Preston 2008; USFWS, unpubl. data). Considering the levels of depredation on Bulwer's Petrel, this is probably the main limiting factor for this species on Moku'ae'ae currently. Likewise, the prevalence of egg depredation by Common Myna noted in the past is of concern. Although no evidence of this was found during the two current surveys, egg predation by that species was recorded on Wedge-tailed Shearwater in 1984 (Eijzenga and Preston 2008) and on cross-fostered Newell's Shearwater eggs in 1979 (Byrd et al. 1984). The Common Myna is a very common invasive bird on Kaua'i, and so it is likely that they visit Moku'ae'ae with regularity, making them a potential threat.

The results of these surveys have highlighted the importance of Moku'ae'ae Islet to the three identified breeding seabirds, particularly because it is one of only a handful of known breeding sites for Bulwer's Petrel in the main Hawaiian Islands. Furthermore, its proximity to a coastal Newell's Shearwater breeding colony and its past association with this species suggest that it could be colonized in the future by this endangered seabird.



### Recommendations

Introduced predators are a major threat to seabirds on the Hawaiian Islands, and Moku'ae'ae Islet is no exception. No rat sign was recorded during surveys on the island, but its rat-free status should be confirmed using appropriate methodologies (such as tracking tunnels), and if this is confirmed, keeping the islet rat-free should be considered a priority. The size and topography of the islet would make rat control (either through poison-bait stations or automatic rat traps) relatively straightforward. Barn Owl depredation currently appears to be the biggest threat to seabirds on the islet, particularly the Bulwer's Petrel. Undertaking active control of this predator (either on the islet itself or from the adjacent shoreline) should therefore be considered to be a high priority for the islet. And a long-term management plan should be considered for Moku'ae'ae Rock Islet to help direct management of the existing seabird colonies. It is recommended that key management actions include annual monitoring of breeding populations of seabirds, annual monitoring and control of avian predators (in particular Barn Owl), annual monitoring for rat invasion, control of invasive plants such as *Lantana camara*, and refurbishing the artificial nest burrows (many of which are currently exposed due to erosion, with the result that the eggs of nesting Wedge-tailed Shearwaters roll out of many of them). These actions would greatly improve breeding habitat and conditions for breeding seabirds on the islet and safeguard these populations into the future.

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