FIRST CONFIRMED BAND-RUMPED STORM PETREL *OCEANODROMA CASTRO* COLONY IN THE HAWAIIAN ISLANDS

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ABSTRACT

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The Band-rumped Storm Petrel *Oceanodroma castro* is an endangered subtropical pelagic seabird found along the Atlantic and Pacific oceans. We used a combination of acoustic monitoring, night vision surveys, dog searches, and remote camera surveillance to search for occupied nests in support of the US Army's natural resource management requirements in Hawai'i. We discovered a breeding colony at 2 113 m elevation on the northern slope of Mauna Loa within the US Army's Pōhakuloa Training Area (PTA) on Hawai'i Island. Camera surveillance confirmed active breeding nests. Because this is the first confirmed location of a colony in Hawai'i, it deserves further investigation.

Key words: Band-rumped Storm Petrel, *Oceanodroma castro*, crevice-nesting, colony discovery, Hawai'i, range expansion

INTRODUCTION

The at-sea distribution of the Band-rumped Storm Petrel *Oceanodroma castro* (BRSP) spans subtropical waters of the Atlantic and Pacific oceans north and south of the equator (Harris 1969, Slotterback 2002), with confirmed breeding at several remote islands. BRSP breeding populations are confirmed in Japan (Austen 1952), Galápagos Islands (Snow & Snow 1966, Harris 1969), Cape Verde, Ascension Island (Allan 1962), the Azores (Teixeira & Moore 1983, Monteiro *et al*. 1996), and Madeira (Nunes 2000). Small populations of BRSP likely breed on the main Hawaiian Islands, based on several indications. Documented nocturnal calling on land, coastal sightings, and the discovery of a juvenile bird on the eastern slope of Mauna Loa suggest BRSP breeding activity on Hawai'i Island (Banko *et al*. 1991). Nocturnal calling has also been recorded at Haleakalā Crater on Maui (Wood *et al*. 2002). Fledglings confused by lights have been collected in the fall by the Save Our Shearwaters project on Kaua'i, and birds with brood patches were captured on Lehua Islet; for both islands, there is evidence for birds calling during the breeding season (Wood *et al*. 2002, Raine *et al*. 2017). Finally, the remains of a chick discovered on Lehua Islet is also a strong indicator of breeding (Vanderwerf *et al*. 2007). However, due to the cryptic nature of BRSP nests, no active breeding site locations had been confirmed prior to this study (Richardson 1957, Slotterback 2002, VanderWerf *et al*. 2007, Duffy 2010).

BRSPs are highly pelagic and feed by pattering the water surface, scooping up minute food items with their beaks. Individuals only return to the colony during the breeding season, where they are nocturnal and nest in cryptic crevices on remote terrain to avoid predation (Bolton 2007).

In Hawai'i, BRSPs have long been assumed to nest in burrows or natural cavities in lava fields at high elevation from May through November (Raine *et al*. 2017). BRSP bones were found in middens throughout the main Hawaiian Islands (Olsen & James 1982, Harrison 1990), which indicates that, historically, their colonies were more widely distributed; this species may have nested at coastal sites before habitat loss and the arrival of introduced predators (Slotterback 2002).

We first conducted acoustic monitoring from 2010 to 2012 to survey for Hawaiian Petrels *Pterodroma sandwichensis* at the Pōhakuloa Training Area (PTA) on Hawai'i Island. Although we determined that Hawaiian Petrels only fly over the installation occasionally, acoustic data revealed BRSP calls indicative of a colony. To further investigate, a team of US Army Garrison Pōhakuloa staff, supported by the Center for Environmental Management of Military Lands, employed four methods between 2015 to 2018 to determine if a BRSP colony exists at PTA: 1) acoustic monitoring, 2) night vision surveys, 3) dog searches, and 4) remote camera surveillance.

METHODS

Study area

This study took place within the boundaries of PTA (19°38′N, -155°32′E), approximately 40 km south of Waimea and 58 km west of Hilo, Hawai'i, in the vicinity of Pu'u Koli—a cinder cone caldera containing a collapsed lava tube crevasse extending toward the north (Figs. 1, 2). The terrain, at 2 100-2 200 m elevation, consists of *'a'ā* lava (characterized by a rough, jagged surface) and pāhoehoe lava (ropy or billowy with a smooth surface), ranging in age from < 750 to 5 000–11 000 years old.

Acoustic monitoring

We deployed six Song Meter™ 2+ devices (SM, Wildlife Acoustics, Inc., Concord, MA) from 30 April to 05 October 2015 to record audio 60–300 min after sunset (Fig. 2). Recordings were made at a 22 050 Hz sample rate, in stereo WAV format. Conservation Metrics, Inc. (Santa Cruz, CA) analyzed acoustic data collected from 2015 SM deployment for BRSP calls with proprietary software that uses a speech recognition classification tool called Deep Neural Networks (Deng *et al*. 2013).

Night vision surveys

Two observers conducted night vision surveys beginning 120 min after sunset for a duration of 120 min July–September 2015 and again during June–August 2016. We scheduled surveys during new moon phases to avoid highly moonlit nights, when suppressed seabird activity was expected (Monteiro *et al*. 1999, Mougeot & Bretagnolle 2000). We used night vision binoculars (PVS7-3 Alpha, Armasight, South San Francisco, CA) in conjunction with near-infrared lights (Raymax 300, Raytec Systems, Inc., Ottawa, ON) to illuminate the sky and terrain. Because night vision goggles require some ambient light to function, the near-infrared lights ensured ample visibility despite a lack of moon and starlight. With this combination of equipment, observers could clearly see birds in flight up to a distance of 150 m. Observers collected data on species, flight direction, flight behavior (straight, erratic, circling, grounded), and calling behavior (silent, calling, ground calling). The main objective of night vision surveys was to document any BRSPs on or near the ground to guide subsequent nest searches. Additionally, circling birds can indicate colony activity (Harris 1969, Warham 1996); this behavior was used to guide further dog searches.

Dog searches

A search-trained springer spaniel outfitted with a Global Positioning System (GPS) device assisted in the search for BRSP nests. An observer, the handler, and the dog conducted five search sessions throughout September 2015, seven search sessions between July and September 2016, 10 search sessions between July and September 2017, and one search session in August 2018. We conducted morning searches for 3–5 h each session. We used data collected during night surveys to prioritize search areas. The Astro Garmin GPS device (Garmin Ltd., Olathe, Kansas) consists of two components that communicate via radio signals: a hand-held GPS device (Garmin Astro 320) and a dog collar GPS device (Astro T-5). Observers recorded GPS points and took photos when a Storm Petrel carcass or potential nest site was found. A location was deemed a potential nest when the detector dog pointed to indicate possible seabird presence.

Remote camera surveillance

We deployed Reconyx™ trail cameras (HC600 Hyperfire, Reconyx, Inc, Holmen, WI) or a Sharx Security camera (SCN3904, Sharx Security, Inc.) at selected potential nest sites identified by the detector dog. We placed Reconyx™ cameras on the ground and out of the way of the burrow opening. Sharx cameras were positioned on the ground and included a solar controller, 12 V battery, and two 50 V solar panels.

RESULTS

Our results show that a BRSP colony is present on the northern slope of Mauna Loa (Figs. 1, 2). Song meters detected the first BRSP call on 27 May 2015 and the last call on 03 October 2015. The nightly calling rates detected at eight locations during the monitoring period varied widely across nights as well as locations (Fig. 2, Table 1). Nightly peak calling across all sites occurred 150–210 min after sunset (Fig. 3).

We documented 447 BRSP visual sightings during 84 h of night vision surveys between 06 July and 11 September 2015. Observers noted circling flight patterns (Fig. 4), indicating that the birds may be flying over a colony and preparing to alight (Harris 1969, Warham 1996). Observers witnessed three instances of a Storm Petrel alighting.

The detector dog searched for a total of 90 h over an area of 3.4 km^2 during July–October each year between 2015 and 2018 (Fig. 1). The dog identified 18 potential nest sites, four of which we confirmed to be active using camera surveillance. Additionally, we recorded and collected eight BRSP carcasses.

On 09 September 2015 at 21h04, observers using night vision binoculars witnessed a BRSP touch ground at location N01 (Fig. 1).

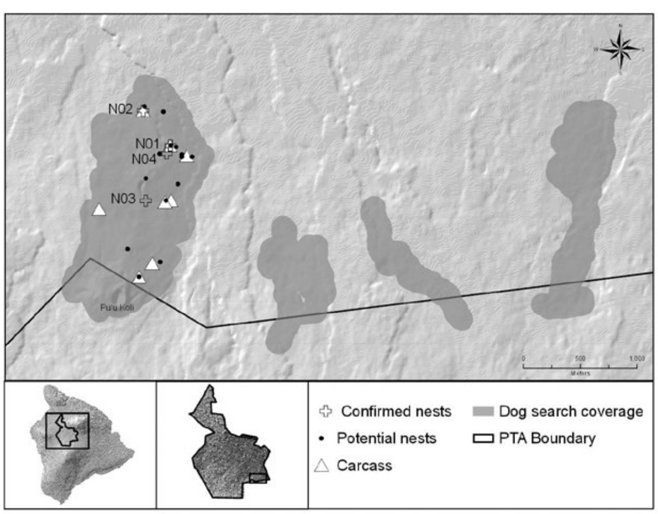

Fig. 1. Song meter locations in 2015, and confirmed nests, potential nests, and carcasses found by detector dog from 2015 to 2018.

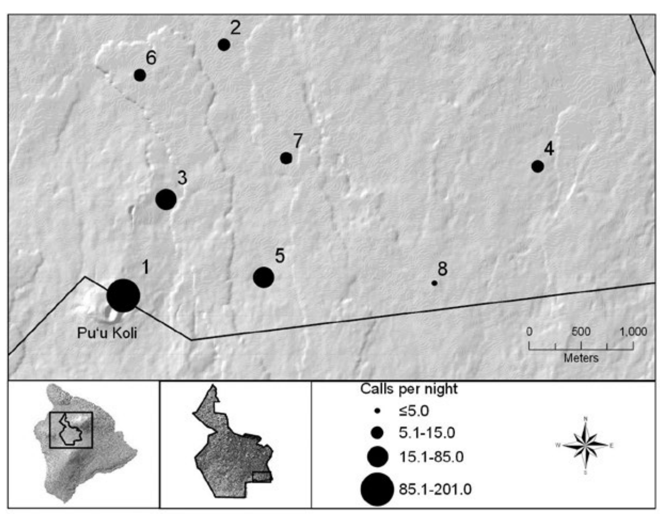

Fig. 2. Band-rumped Storm Petrel nightly call rates at song meter locations, May–October 2015.

Observers investigated the landing site and discovered a BRSP carcass within 1 m of a pāhoehoe pit opening at 2 113 m elevation. The pāhoehoe opening faces the east and shows evidence of human modification as described by Hu *et al*. (2001). The pāhoehoe pit could not be fully explored due to the small opening and winding interior. It is not confirmed, but the carcass was likely the breeding partner of the bird observed landing. On 10 September 2015 at 18h00 (96 min after sunset), observers heard ground calling at this location. A search on 15 September 2015 by the dog also indicated that the pāhoehoe pit was actively occupied. A Reconyx^{TM} camera captured photos of a BRSP in the pit entrance between 19–21 September 2015. While no activity was recorded at this location in 2016, we confirmed active breeding activity again in 2017. A Sharx Security camera deployed on 03 May 2017 captured video of an adult entering the nest on 01 June 2017. We observed adults making 19 visits to the nest from 01 June to 24 October 2017. On 27 October 2017 at 02h23, a nearly fully-feathered chick emerged from the nest. The chick emerged each night at various times to explore the surrounding area and exercise its wings until it fledged on 31 October 2017.

The dog detected a second potential burrow (N02), which was then confirmed as active by video (Fig. 1). This site resembled a linear lava tube, with openings that may have resulted from human prospecting or from natural causes (Monahan *et al*. 2013, Hu *et al*. 2001). The camera captured video of a BRSP visit to the nest location on 02 August 2017. A week later, we observed a cat at the opening. The cat and BRSP adults continued to make visits to the nest through September. Cat traps were deployed, but the cat extracted a BRSP from the nest and consumed it on 16 September 2017. This cat was subsequently captured in a live trap on 19 September 2017. For N01 and N02, cameras did not operate for 11 d in July, 6 d in August, and 8 d in October due to power failures.

The dog detected activity at N03 in 2017, but the camera did not capture activity. We placed a camera at N03 again in 2018 and confirmed the nest active on 07 August 2018. On 10 August 2018, the dog detected a potential burrow (N04), which was then confirmed as active by video that night. The site also showed evidence of human modification, similar to N01.

TABLE 1
Band-rumped Storm petrel calls recorded per night in 2015

Location	Survey nights	Calls per night	SD	Median	Range
1	123	200.46	249.67	127	0–1358
2	131	13.53	26.40	4	0–195
3	131	84.90	92.57	61	0–552
4	115	10.07	13.93	5	0–65
5	112	82.35	116.93	25	0–740
6	28	10.15	8.63	8	0–34
7	26	7.85	10.30	4	0–40
8	50	3.66	8.73	0	0–39

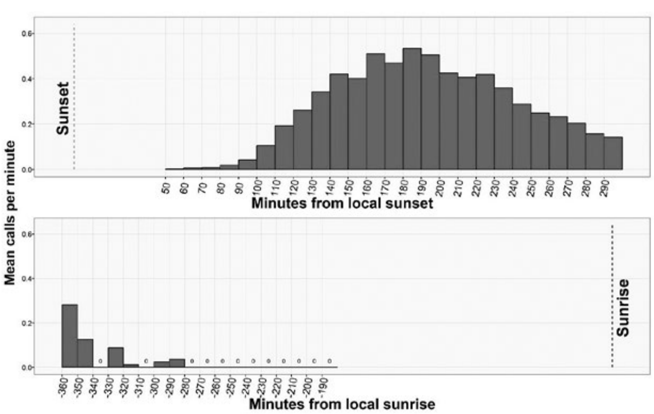

Fig. 3. Band-rumped Storm Petrel average calls per minute over all sites as a function of time, from sunset and sunrise. Graph provided by Conservation Metrics, Inc.

DISCUSSION

We found four active nest locations at PTA. At one location, we confirmed three seasons of BRSP activity. All nests were located in pāhoehoe lava aged 5 000 to 11 000 years old. The peak calling period of 150–210 min after sunset begins 80 min after peak calling by BRSPs monitored on Kaua'i (Raine *et al*. 2017). This difference is likely due to the extra distance individuals travel to reach PTA; BRSP populations on Kaua'i nest at lower elevations (highest elevation on Kaua'i is 1 570 m). There is no evidence of a winter breeding colony at PTA, which is also consistent with data collected on Kaua'i. Calls detected during the summer were highest at location 1 on Pu'u Koli, a cinder cone caldera clearly visible as a possible navigational cue. The ground calling heard—by adults emitting calls to attract partners to their nest, and by chicks emitting calls from the nest to communicate to a parent—indicated sites of BRSP ground presence (Mougeot & Bretagnolle 2000, Bolton 2007, Slotterback 2002) and BRSP nesting.

Locating colony sites and documenting the life history parameters of BRSPs, including phenology, is important for informing conservation efforts for the species, which is still poorly understood in Hawai'i. Based on the 31 October 2017 fledging date of the observed nest, we assume that the pair may have laid its egg on 11 June, a date that agrees with studies of BRSP phenology in Ascension, Galápagos, and Kaua'i (Allan 1962, Harris 1969, Raine *et al*. 2017). The chick fledged 153 d after the first arrival of an adult.

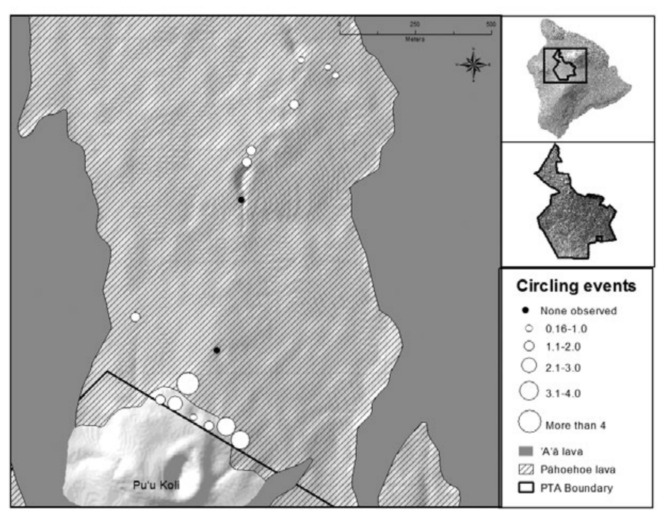

Fig. 4. Band-rumped Storm Petrel circling flights observed per nighttime survey hour at the Pōhakuloa Training Area (PTA), Hawai'i.

The presence of a BRSP colony at PTA is an exciting discovery. This finding provides an opportunity for researchers to monitor active nests and to learn more about the phenology and behavior of BRSPs in Hawai‘i. Further studies will investigate the full geographic extent of the colony, and the behavioral traits of the species, which will help guide management of BRSPs.

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