The Distribution and Abundance of the Band-rumped Storm-Petrel (*Oceanodroma castro*): A Preliminary Survey on Kaua'i, Hawai'i 2002

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Between April and October of 2002, the authors visited several locations on Kaua'i in order to gather data on the distribution and abundance of the Band-rumped Storm-Petrel (*Oceanodroma castro*). This paper describes the areas where Band-rumped Storm-Petrels were located and gives a census account for the number of calls heard at those sites. Several locations appear to be nesting populations including Waimea Canyon (east of Waimea Canyon lookout); four sub-populations along the Na Pali Coast (i.e., Kalalau, Pohakuao, Nu'ololo Aina, Nu'ololo Kai); one site in the Koke'e region of Awa'awapuhi called Awa'awapuhi vista, at the eastern rim of Nu'ololo and Awa'awapuhi Valleys (accessed from the Awa'awapuhi Trail, Koke'e State Park); and Lehua Islet. Three other sites were monitored and appear to be general fly-by sites where the petrels are in transit to near-by nests, including upper Waimea Canyon; Honopu (Koke'e); and Kalalau Rim (Koke'e). Five of these sites represent previously unpublished locations. Currently, the authors estimate 171—221 nesting pairs on Kaua`i. This research was funded by the U.S. Fish and Wildlife Service [USFWS Order No. 12200-2-M046] and the Kilauea Point Natural History Association (KPNHA), in addition to extensive volunteer time.

Band-rumped or Harcourt's Storm-Petrel (*Oceanodroma castro*) is the smallest and rarest seabird that nests in the Hawaiian archipelago, where its breeding distribution is poorly documented. They weigh around an ounce and a half, and are known to fly with ease through raging seas and storm winds (Harrison, 1990). Band-rumped Storm-Petrels are long-lived and probably do not breed until at least the third year of their 15—20 year life (Ainley 1984). Their range includes both the Pacific and Atlantic oceans where they are known to breed on islands of Hawai'i, Galapagos, Japan, and small eastern Atlantic islands off the coasts of Spain and Africa (Slotterback 2002).

Previously, the Hawaiian population has been considered a subspecies, *O. c. cryptoleucura* Ridgway 1882); however, according to more recent systematics, "the geographic differences should be recognized but not split into subspecies" (Austin 1952). Slotterback states that "the last detailed look at Band-rumped Storm-Petrels was during the 1960's and was based on morphological characters alone. Molecular techniques would aid our understanding of subspecies limits."

The genus *Oceanodroma* is Greek for 'ocean runner', in reference to the pattering of feet on the ocean surface while feeding (Harrison 1990; Slotterback 2002). The name petrel refers to Saint Peter (Pedro in Spanish) who walked on water (Ainley 1984). The Hawaiians called the seabirds 'ake'ake, lupe'akeke, oweowe, or oeoe (Pukui and Elbert 1986) with the last two names mimicking their calls, which are often compared to the sound made by rubbing a finger on wet glass.

On June 15, 2000, during a botanical survey, Wood and Boynton heard bird calls they didn't recognize during the evening hours, while camping at approximately 2800 ft. elevation in the back of Kalalau Valley. The calls, which appeared to come from two or three fixed locations, were described as "oo-wee" or "oo-whip." At the time, they did not know that the Hawaiian names (oweowe and oeoe) were so similar to the calls they heard. No attempt was made to locate the source of the calls, but they were very likely from adult birds at the nest.

Slotterback (2002), referring to Allan's (1962) paper on the Madeiran race of the Band-rumped Storm-Petrel, states that the "chick delivers a high but mellow tueep-tueep-tueep during feeding, long-drawn and slowly delivered without pause." This is also similar to the calls heard in Kalalau; however, since hatching probably does not occur until August, it is very unlikely that these calls were from juvenile 'ake'ake in their nests.

Kaua'i appears to be the predominant nesting site for the Hawaiian population of *O. castro*, although the species has also been documented on Maui and Hawai'i. The Maui accounts include an estimate of 3-4 birds heard in Haleakala Crater in 1970 (Johnston 1992a) and 1983 (Pyle 1984), and 3-5 individuals estimated during a pre-listing survey in 1992 (Johnston 1992a). The overall Maui population appears to be quite small.

The Hawai'i accounts include a dead juvenile collected in 1949 at Kilauea Military Camp; "most of a bird" including the wing of a specimen collected on Mauna Loa in 1968; and a downed bird collected alive in 1988 at Kulani Correctional Facility (Banko *et al.* 1991). During a Band-rumped Storm-Petrel Pre-listing survey conducted on Mauna Loa, USFWS biologist Scott Johnston reported that "eight of the 10 teams heard birds calling at night, with some teams hearing probably a dozen individuals" (Johnston 1992b). The vast size of Mauna Loa, and availability of suitable habitat, provides the potential for

existence of a sizeable population of *O. castro,* including the southwest rift zone, which will be within the new boundaries of the National Park.

On Kaua'i, evidence of 'ake'ake has been historically noted from Hanapepe Valley (Sincock pers. comm. and field notes, 1979), Nu'ololo Aina and Waimea Canyon (Harrison *et al.* 1990). Telfer documented Band-rumped Storm-Petrels, mostly juvenile birds collected during Kauai's *Save-Our-Shearwater Program*, between the years 1980 and 2002 (T. Telfer pers. comm.). George Munro made two collections (1893-94) which are curated at the Bishop Museum, one from Makaweli and the other from Waimea (Bishop Museum Data Base; C. H. Kishinami pers. comm.). Harrison (1990) states that the Makaweli bird was from "Makaweli Beach," a downed bird that might have come from Waimea or Olokele Canyon, or perhaps even from Hanapepe Valley.

In September of 2001, the presence of a colony was reported along the cliffs of an isolated hanging valley (*i.e.,* Pohakuao) on the Na Pali Coast of Kaua'i (K. R. Wood *et al.* 2001). A parabolic disc amplifier was used to record the 'ake'ake calls as they returned to their nesting sites along Pohakuao's remote sea-cliffs after dusk. In addition, the ecology of the cliff habitat was described. In 2002, several additional trips were made into Pohakuao to further document this colony at different times during the breeding season.

Band-rumped Storm-Petrels are the only seabird in the Hawaiian Islands for which the nest and eggs have never been found in recent times. On Mauna Loa, W. E. and P. C. Banko "found two feathers from *O. castro* during 25-28 August 1973 in front of an apparent nest burrow entrance, about 1.6 km from a *O. castro* wing specimen. These feathers were lost after they were sent to the U.S. National Museum, and their identity could not be confirmed." (W. E. Banko *et al.* 1991). No confirmation was made that this was a nest burrow.

"Fossil" remains of Band-rumped Storm-Petrels have been found on O'ahu and Moloka'i (Olson and James 1982), and their bones are abundant in some ancient Hawaiian middens (A. C. Ziegler pers. comm.). Slotterback refers to a study by Moniz (1997) that found "bird bones excavated from 2 coastal habitation sites, one on O'ahu I. and one on Hawai'i I., made up of 89% and 65% seabird species, respectively (n=446, 227 bones)" (Slotterback 2002). He also notes that bones were found at sea level

middens on Kaua'i, as well as "middle elevation middens (>1,800 m elevation) on Hawai'i I" (Slotterback 2002, Athens *et al.* 1991). Apparently the Hawaiian populations once nested in coastal sites throughout Hawaii and loss of habitat has been an important factor in the decline of this species.

Predation by rats, cats, mongooses, owls, and dogs may also have played a role in the decline of the Hawaiian race of Band-rumped Storm-Petrels. On New Zealand's off-shore islands, whenever Polynesian rats (*Rattus exulans*) occur, storm-petrels are rare or absent, even when the birds are common on neighboring islands (Jones & Byrd 1979). On Japan's Izu Islands, huge numbers of *Oceanodroma tristrami*, a species that weighs more than twice that of *O. castro*, were exterminated by introduced black rats and cats (Hasegawa 1984). The authors have observed owls flying along basalt cliff faces where the Band-rumped Storm-Petrels nest in Pohakuao. These observations included consistent traffic of the Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*) during the day and the screeching of barn owls in the evening. The topic of owl predation on Hawaiian seabirds was covered in an article in the `Elepaio (Byrd and Telfer 1980).

Other factors that might possibly have contributed to the decline of Hawaii's Band-rumped Storm-Petrels include pollution (mercury, oil spills, and ingested plastic); collisions with buildings, towers, and power lines, especially where there are bright lights that attract or confuse the birds; and fisheries interactions (Slotterback 2002). Harrison (1990) states that "on the Galapagos and Ascension, overcrowding is a major cause of mortality among Harcourt's chicks," but with the small population and huge availability of nesting sites in their Hawaiian habitat, this is unlikely to be significant here.

During 2002, several new Band-rumped Storm-Petrel locations were documented on Kaua'i within the valleys of Nu'ololo Kai, Honopu, Awa'awapuhi, Kalalau, and Lehua Islet (see maps). The authors estimate that four of those sites may represent nesting sub-populations (*i.e.*, Nu'ololo Kai; Awa'awapuhi vista, Kalalau, and Lehua). Recordings of Band-rumped Storm-Petrels and Newell's shearwaters were made by E. VanderWerf during this research in 2002. D. Kuhn has also made extensive digital recordings of these species, mostly from various sites around the rim of Waimea Canyon.

Currently, the Hawaiian population is listed as endangered by the State of Hawaii (Hawaii DLNR 1982), and is a candidate for listing by the Federal Government under the Endangered Species Act

(USFWS 2002). Our current estimate for the number of breeding pairs on Kauai is 171—221 pairs (see Table 1). This number is likely to increase as additional sites with suitable habitat along the Na Pali Coast are explored. An article by Harrison *et al.* (1990) entitled *The Status of Oceanodroma Castro in Hawaii* states that "the long term prognosis for any storm-petrel population is problematical, and all colonies require protection and possibly management. A more accurate assessment concerning the status of this species will help determine what conservation measures may be needed to protect the remnants of the Hawaiian population."

Abundance on Kaua`i. Estimated counts of Band-rumped Storm-Petrel individuals in Pohakuao and Nu'ololo Aina during this 2002 research were made by co-author Eric VanderWerf (USFWS), who has extensive experience in the field of ornithology. The remaining sites were censused for number of calls heard, and some preliminary estimates were made for the number of individuals.

The range of nesting pairs stated for the Awa'awapuhi and Waimea Canyon sites were general estimates. We have more confidence in our estimates at the remaining sites as they were based on pin-pointing distinctive arriving calls, but not including calls that were repeated around general nesting locations. Further research will be needed to better evaluate the number of nesting birds in each region. As one of the priorities for future research, Slotterback (2002) states that "we need to develop more reliable census methods for calibrating so we know how many birds are at a colony."

The Awa'awapuhi Vista site appears to be an excellent location for further research because of its remote yet easy access and its potentially high numbers of nesting storm-petrels. The Nu'ololo Kai site also had a very high number of calls and could be one of the most significant nesting sites, but further research is needed to document whether actual nesting is occurring or if the area is just a fly-by site. It would be advantageous to survey the birds from the cliff-top of Nu'ololo Kai, which is accessible from neighboring Nu'ololo Aina Valley.

Counts at Honopu and Kalalau were conducted late in the breeding season; these sites need to be surveyed earlier in the breeding season to determine if larger populations are present. In addition, a one time survey was conducted from the end of the dirt road above Miloli'i Valley late in the breeding season and no birds were heard, yet this site and neighboring Makaha Valley should also be re-censused

earlier in the breeding season, since they provide suitable cliff habitat and are adjacent to the other Na Pali colonies. USFWS biologist Scott Johnston, in an unpublished report on the Kaua'i pre-listing survey of Band-rumped Storm-Petrels, notes that Miloli'i Valley had "recent records of storm-petrels," and also saw "two possible nest sites" on a cliff face near the mouth of Makaha Valley (Johnston 1992c).

Although the Lehua population appears to be very small (estimated two breeding pairs) this may be one of the more accessible breeding populations, and hence deserves further evaluation.

Table 1. Estimated Number of Band-rumped Storm-Petrel (ake'ake) pairs estimated on Kaua'i during 2002 survey.

Site	# of evening counts	Estimated # of pairs
Pohakuao	6	46
Nu'ololo Aina	2	20
Nu'ololo Kai	1	?
Kalalau	1	2
Awa'awapuhi vista	2	70-100
Honopu	1	1
Waimea	16	30-50
Lehua	1	2
Total	**29**	**171-221***

*Estimate does not include potential nesting pairs in Nu'ololo Kai

Distribution.

Pohakuao. During research in 2001 and 2002, approximately 46 Band-rumped Storm-Petrels were estimated to be nesting on the *Kaua'i diverse mesic cliffs* of Pohakuao between 1200—1500 ft elevation (UTM 434777—2453322). The Na Pali coast valley of Pohakuao, Kaua'i, lies just to the northeast of Kalalau and to the southwest of Hanakoa. This region lies within the jurisdiction of the Department of Land and Natural Resources (DLNR), Division of State Parks. The lower forested slopes of Pohakuao rise from sea level to about 1000 ft elevation where towering black basalt cliffs climb up to several of Pohakuao's hanging valleys and continue ascending up the cliffs and adjacent slopes that are enclosed between the steep ridges of Kaaalahina and Manono. The length of Pohakuao extends for a distance of 1750 meters from sea level up to the corner of Hanakoa and Kalalau rim and ends where Alealau summit reaches an elevation of 3875 ft. The upper hanging valley of Pohakuao (1400—2000 ft. elev.) is

a relictual site for two rare plant communities, *Kaua'i diverse mesic cliff* and *Kaua'i diverse mesic forest* (Wood *et al.* 2001).

The Pohakuao cliffs where storm-petrels nest are dominated by the shrub *Chamaesyce celastroides* var. *hanapepensis* (akoko), and two native grasses, *Eragrostis variabilis* (kawelu) and *Panicum lineale* (panic grass). Other common shrub components in their order of abundance include *Nototrichium sandwicense* (kulu'i), *Artemisia australis* (hinahina), *Sida fallax* ('ilima), *Lipochaeta connata* var. *acris* (nehe), *Bidens sandvicensis* subsp. *sandvicensis* (ko'oko'olau), *Lythrum maritimum* (pükämole), *Boehmeria grandis* ('akolea), *Hedyotis acuminata* (au), *Wilkesia gymnoxiphium* (iliau), *Vaccinium dentatum* ('ohelo), *Wikstroemia oahuensis* ('akia), and *Styphelia tameiameiae (*pukiawe). Other less common shrubs include *Phyllanthus distichus* (pä-makani-mähü), *Lobelia niihauensis* ('oha), *Schiedea apokremnos* (ma 'oli'oli), *Lepidium serra* ('anaunau), *Hedyotis flynnii* (manono paliku), *Chamaesyce eleanoriae* ('akoko), and *Wilkesia hobdyi* (iliau).

Common herbs included *Plectranthus parviflorus* ('ala'ala-wai-nui), *Dianella sandwicensis* ('uki 'uki), *Peperomia tetraphylla, P. blanda var. floribunda, & P. cookiana* ('ala'ala wai nui), *Pilea peploides,* and *Peucedanum sandwicense* (makou). Sedges included *Carex meyenii* and *Cyperus phleoides.* Vines included *Alyxia oliviformis* (maile), and *Cocculus trilobus* (huehue). Occasional ferns (and fern allies) were also a component of these cliff regions and included *Psilotum nudum* (moa) *Doodia kunthiana* ('okupukupu lau'i'i), *Lepisorus thunbergianus, Selaginella arbuscula* (lepelepe a moa) *Nephrolepis exaltata* subsp. *hawaiiensis* (pämoho) *Doryopteris decipiens* (kumuniu), and *Microlepia strigosa* (palapalai).

Tree species were distributed randomly around small ledges and terraces where soil pockets could accumulate and included *Dodonaea viscosa* ('a'ali'i), *Psydrax odoratum* (alahe'e), *Metrosideros polymorpha* var. *glaberrima* ('ohi'a), *Hibiscus kokio* subsp. *saintjohnianus* (koki'o 'ula 'ula), *Diospyros spp.* (lama), *Acacia koaia* (koai'e), *Antidesma platyphyllum* var. *hillebrandii* (hame), *Bobea elatior* ('ahakea), and *Melicope pallida* ('alani) (Wood and LeGrande 2001; Wood *et al.* 2001). .

Band-rumped Storm-Petrel call counts from Pohakuao (2002).

	17 Jun	22 Jul	23 Jul	14 Aug	25 Oct	26 Oct

	Pohakuao S falls	Pohakuao N falls	Pohakuao S falls	Pohakuao S falls	Pohakuao N falls	Pohakuao N falls
7:50 pm	**0**	**0**	**0**	**70**	**0**	**0**
8:00 pm	**10**	**0**	**71**	**125**	**0**	**0**
8:10 pm	**83**	**0**	**140**	**153**	**0**	**0**
8:20 pm	**96**	**8**	**54**	**84**	**0**	**0**
8:30 pm	**62**	**14**	**68**	**24**	**0**	**0**
8:40 pm	**20**	**0**	**81**	**38**	**2**	**0**
8:50 pm	**21**	**21**	**87**	**49**	**0**	**0**
9:00 pm	**68**	**32**	**159**	**0**	**0**	**0**
9:10 pm	**41**	**13**	**28**	**0**	**0**	**0**
9:20 pm	**0**	**3**	**0**	**0**	**0**	**0**
9:30 pm	**0**	**0**	**0**	**0**	**0**	**0**
9:40 pm	**0**	**0**	**0**	**0**	**0**	**0**
9:50 pm	**0**	**0**	**3**	**0**	**0**	**0**
10:00 pm	**0**	**0**	**0**	**0**	**0**	**0**
1:25 am	**5**					

In Pohakuao, during the period of 25-27 October 2002, the lead author used climbing ropes and rappeled along three vertical transects where Band-rumped Storm-Petrels were estimated to be nesting. These sites were approached from the north falls area where the author could secure a line on an ‘ohia tree and drop below the ridge above the Pohakuao south falls nesting site (towards the primary nesting area that was observed from the Pohakuao south falls camp site). Perhaps because of the later period of the year, no birds or nests were located. However, even if adults and fledglings had left the colony, we expected to find evidence of nesting in the form of guano and feathers in the rock crevices.

One small cave had sea-bird bones which appeared to be too small to be shearwaters and fit the size range of a small petrel. Those bones will be identified at Bishop Museum by one of the authors (EV), who believes that they may represent a Band-rumped Storm-Petrel. The cave was approximately 1 m deep x 1 m tall x 1.5 m wide and had a western aspect. The interior substrate was littered with very little dried vegetation and was predominantly composed of a fine powdery soil that was cool to the touch. The strong aroma of bird guano was present. Although the cave did not have evidence of a live bird, if these are Band-rumped Storm-Petrel bones, this would be the first documentation of an actual nesting burrow in historic times. Ironically, rat bones were also found in this small cave, evidence of a primary threat to ‘ake’ake populations. Also, two live rats were observed walking about on tiny rock ledges along the vertical cliffs during the rappel.

Nu'ololo 'Aina. During research in 2002, approximately 20 Band-rumped Storm-Petrels were estimated to be nesting on the *Kaua'i diverse mesic cliffs* of Nu'ololo Aina between 800—1200 ft elevation (UTM ca 428035—2450235). Nu'ololo 'Aina is a valley along the northwest Na Pali coast of Kaua'i that is renowned for its ancient Hawaiian agricultural terraces, in addition to being a relictual site for several rare and endangered Hawaiian vascular plant species. Several versions of the valley name have been used by authors and cartographers through history and include Nu'alolo, Nu'ulolo, and Nu'ololo. The authors wish to refer to this region as Nu'ololo, as that has been shown in our readings to be its most ancient name (Handy & Handy 1972).

The valley begins 80 ft. (24 m.) above a boulder beach and extends 1.35 miles (2.170 kilometers) to the back of the valley while gradually rising to an elevation of 800 ft. (240 m.). The valley is dissected by a perennial stream that runs its entire length. The area of semi-flat lands that spreads below the valley walls encompasses around 500,000 sq. meters and is enclosed by 1500 ft. vertical basalt cliffs, towering over the valley. Nu'ololo 'Aina generally averages around 650 ft. (200 m.) in width. The valley at its narrowest point is 115 ft. (35 m.) wide, occurring around 1150 ft. (350 m.) up valley. At its broadest it is 1800 ft. (550 m.) wide, at around 4600 ft. (1400 m.) up valley (Wood & LeGrande 2001).

Approximately 980 ft. (300 m.) to the southwest of Nu'ololo 'Aina's river mouth lies a coastal flat known as Nu'ololo Kai. It is around 2950 ft. (900 m.) long with an area of ca. 100,000 sq. meters and is surrounded by a fringing reef to the northwest and cliffs rising as high as 2000 ft. to the southeast. Nu'ololo Kai was evidently a preferred site for village life by the Hawaiians because of the broad reef for fishing, and a partial opening in the reef for access by outrigger canoes, and it was from the deep, fertile valley of Nu'ololo 'Aina that the Hawaiians did their farming (St. John 1975). Hawaiians living in Nu'ololo had terraced all the land available for growing irrigated taro (Handy and Handy 1972).

Bennet (1931) described the trail that lead from Nu'ololo Kai to the Nu'ololo 'Aina as an ancient path well worn by the Hawaiians who traveled between both sites. 'It starts around the base of a bluff on the east side of the flats (Nu'ololo Kai) and runs for 30 ft. or more on a narrow ledge, sharply overhung by the cliff about 20 ft. above the ocean. At the end of this ledge a rope ladder leads to a ledge 25 ft. above it. The bulge in the cliff makes the ladder hang out over the sea. The ladder is fastened into four rings

cut through the solid rock for that purpose. A protruding stone near the top of the ladder is grooved, probably for the purpose of lowering bundles to the ledge below. From the top of the ladder a series of notched steps and finger grips have been cut that lead to a narrow trail that runs up to the top or the cliff. The notches and finger grips have been worn smooth by ancient usage.

Before human habitation, Nu'ololo 'Aina was probably covered in a lowland dry forest dominated by lama (*Diospyros* spp.), loulu (*Pritchardia* sp.), and alahe'e (*Psydrax odorata*), along with a diverse assemblage of dryland and mesic forest species of plants and animals. With human arrival, and as a result of agricultural clearing and introduced goats, only relictual patches of lama and alahe'e remain today, yet there are sections where diverse dry cliff species still proliferate. This is mainly the result of having cliff habitat that extends around 1/3 of a mile up to the Koke'e forests above, and the general inaccessibility of vertical cliff regions by fire and mammals (Wood & LeGrande 2001).

Plant Communities. Above the boulder beach that lies at the mouth of Nu'ololo 'Aina and on the bluffs that steeply drop down to the sea can be seen a shrubland dominated by the native naupaka kahakai (*Scaevola sericea*). Maiapilo (*Capparis sandwichiana*) occurs within this coastal plant community and is currently listed as vulnerable by the USFWS. Maiapilo can be found along the Na Pali coast between Polihale and Hanakoa (Wood & LeGrande 2001).

The terraced slopes that encompass the lower end of Nu'ololo 'Aina between the naupaka kahakai zone and ranging up to 400 ft elevation is dominated by a relictual native naio (*Myoporum sandwicensis*) shrubland. In this region and throughout the whole valley, goats range in abundance and secondary non-native species such as *Lantana camara, Ageratina conyzoides, Kalanchoe pinnata, Erigeron karvinskianus,* and *Setaria gracilis* displace and threaten the native flora (Wood & LeGrande 2001).

Around 1.25 kilometers up valley is a relic alahe'e (*Psydrax odorata*) forest. Several hundred trees can be seen covering the north facing slopes above the main stream (ca. 500-700 ft. elev.). This is the region where the Federally Endangered *Canavalia napaliensis* can be found with an estimated 25 individual vines, many of which are growing up into the alahe'e branches. Goats and non-native plant species such as *Aleurites moluccana* and *Lantana camara* threaten this region (Wood & LeGrande 2001).

The most outstanding plant community within Nu'ololo 'Aina is the relictual mixed dry to mesic cliff community that still occurs on the towering basalt valley walls and is predominantly restricted to north facing cliffs. This is the habitat where the storm-petrels were nesting. The following list represents our attempt to define the main component species of this cliff community in their order of greater to lesser density: *Eragrostis variabilis, Lipochaeta connata var acris, Bidens sandwicensis, Artemisia australis, Nototrichium sandwicense, Sida fallax, Pilea peploides, Plectranthus parviflorus, Chamaesyce celastroides, Myoporum sandwicensis, Doryopteris decipiens, Lythrum maritimum, Nephrolepis hirsutula, Metrosideros polymorpha, Wilkesia gymnoxiphium, Diospyros sp., Dodonaea viscosa, Hibiscus kokio* subsp. *saintjohnianus, Peperomia blanda, Wikstroemia oahuensis, Pleomele aurea, Carex wahuensis, Cyperus phleoides, Lobelia niihauensis, Carex meyenii, Psydrax odorata, Psilotum nudum, Panicum lineale, Peucedanum sandwicensis, Neraudia melastomifolia, Munroidendron racemosum.* The cliff zones are threatened by goats, fire, landslides, and invasive species such as *Lantana camara, Erigeron karvinskianus, Psidium guajava, Ageratina conyzoides, Setaria parviflora, Melia azedarach, Kalanchoë pinnata, Abutilon grandifolium, and Vulpia bromoides* (Wood & LeGrande 2001).

Band-rumped Storm-Petrel call counts from Nu'ololo Aina (August 2002).

	15 Aug Nu'ololo Aina	16 Aug Nu'ololo Aina
7:40 pm	**0**	**0**
7:50 pm	**15**	**7**
8:00 pm	**0**	**9**
8:10 pm	**4**	**21**
8:20 pm	**6**	**23**
8:30 pm	**9**	**22**
8:40 pm	**7**	**17**
8:50 pm	**3**	**3**
9:00 pm	**0**	**1**
9:10 pm	**2**	**0**
9:20 pm	**0**	**0**
9:30 pm	**0**	**0**
9:40 pm	**0**	**0**
9:50 pm	**0**	**0**
10:00 pm	**0**	**0**

Nu'ololo Kai (Site at sea level)

While at Nu'ololo Kai on the evening of 29 August, calls of Band-rumped Storm-Petrels were heard by L. Arnold around 8:00 pm while walking along the trail back from the beach. A rough count at this point revealed 117 calls in a 5 minute period. Later in the evening, calls were counted for a 30 minute period, in 10 minute intervals at different locations along the trail between the beach and the base of the cliff, in an attempt to discern where the most activity might be.

At this time we are uncertain as to whether the petrels were flying over to the near-by nesting site of Nu'ololo Aina, or were nesting in the Nu'ololo Kai cliffs and recommend this area be more carefully monitored for seabird nesting activity.

The Nu'ololo Kai dry coastal cliffs are composed of native plant species such as *Lipochaeta connata var acris, Artemisia australis, Nototrichium sandwicense, Myoporum sandwicensis, Bidens sandwicensis, Panicum torridum, Capparis sandwicensis* and *Hedyotis st.-johnii.* Weedy species include *Pluchea carolinensis. Lantana camara, Erigeron karvinskianus,* and *Ageratina conyzoides.*

Band-rumped Storm-Petrel call counts at Nu'ololo Kai (29 August 2002).

	29 Aug Nu'ololo Kai
8:45-8:55	**186**
9:00-9:10	**131**
9:10-9:20	**158**

Kalalau, Awa'awapuhi, & Honopu. During 2002, Band-rumped Storm-Petrels were heard by L. Arnold around the *Kaua'i diverse mesic cliff's* of Kalalau, Awa'awapuhi, & Honopu between 2500-3500 ft elevation. Good listening conditions prevailed for the evenings at Awa'awapuhi vista. Gusty wind conditions made the data recorded above Honopu and Kalalau very questionable in reflecting the number of birds that may be nesting along the walls of these valleys. Casual observations were made at these sites to learn more about Band-rumped Storm-Petrels and in the hopes of observing them in the evening time, with the observer returning to Koke'e State Park by flashlight and moonlight. It would be advantageous to re-survey these locations with overnight camping earlier in the breeding season.

The Kalalau birds were heard along the rim to the northwest of Kalalau Lookout, at approximately 3800 ft. elevation. The Honopu birds were heard from the old Honopu Trail, where it first opens up to a view of Honopu Valley.

The site which we denote as "Awa'awapuhi vista" is at the end of the Awa'awapuhi Trail that begins in Koke'e State Park. The vista, at approximately 2400 ft. elevation, overlooks the heads of both Nu'ololo Aina and Awa'awapuhi Valleys. Most of the birds were calling from the Nu'ololo side of the dividing ridge, although some of the calls were coming from Awa'awapuhi. Both sides provide excellent habitat, with steep basalt cliffs descending 1600—1800 ft. to the valley floors.

Primary native components of the Kalalau, Awa'awapuhi, and Honopu mesic cliffs include the following taxa in their order of abundance (Kaua'i Endemics indicated by *): Dominant shrubs are *Chamaesyce celastroides* var. *hanapepensis* (akoko *), *Artemisia australis* (hinahina), *Bidens sandwicensis* (ko'oko'olau *), *Nototrichium divaricatum* (kulu'i *), *Sida fallax* (ilima), *Dodonaea viscosa* (‘a'ali'i), *Wilkesia gymnoxiphium* (iliau *), and *Wikstroemia oahuensis* (‘akia). Shrubs of less common abundance include: *Dubautia microcephala* (na'ena'e *), *Lobelia niihauensis* (‘oha), *Wilkesia hobdyi* (iliau *), *Lepidium serra* (‘anaunau *), and *Hibiscus kokio* subsp. *saintjohnianus* (koki'o ‘ula ‘ula *). Occasional small terraces, randomly perched along the vertical gradient, where dominated by trees such as: *Acacia koa & A. koaia* (koa), *Canthium odoratum* (alahe'e), *Diospyros spp.* (lama), *Metrosideros polymorpha* (‘ohi'a), *Pipturus albidus* (mamaki), *Pipturus kauaiensis* (mamaki *), and *Psychotria mariniana* (kopiko). Less common components of arborescent taxa include: *Melicope pallida* (‘alani *), *Nestegis sandwicensis* (olopua), *Pleomele aurea* (halapepe *), *Rauvolfia sandwicensis* (hao), and *Santalum freycinetianum* var. p*yrularium* (iliahi *). Small herbaceous sub-shrubs also had an even and undisturbed distribution. A few of these include: *Dianella sandwicensis* (‘uki ‘uki), *Lipochaeta connata* var. *acris* (nehe *), *Lysimachia glutinosa* (kolokolo kuahiwi *), *Peucedanum sandwicense* (makou), and *Schiedea apokremnos* (ma ‘oli'oli *). Dominant grasses and sedges on these cliffs include[in order of abundance]: *Eragrostis variabilis* (kawelu), *Panicum lineale* (panic grass *), *Carex meyenii* (sedge), *Carex wahuensis* subsp. *wahuensis* (sedge), and *Mariscus phleoides* subsp. *phleoides* (‘ahu'awa). Occasional grasses and sedges include: *Luzula hawaiiensis* var. *hawaiiensis* (wood rush), and *Poa mannii* (bluegrass *) The more common ferns observed include: *Doodia kunthiana*

(‘okupukupu lau’i’i), *Microlepia strigosa* (palapalai), and *Selaginella arbuscula* (lepelepe a moa). Vines: *Alyxia oliviformis* (maile). Succulent herbaceous plants in the Piperaceae family include: *Peperomia leptostachya* (‘ala’ala wai nui) and *Peperomia tetraphylla* (‘ala’ala wai nui). Invasive weeds include [in order of threat]: *Erigeron karvinskianus* (fleabane), *Kalanchoë pinnata* (air plant), *Psidium guajava* (guava), *Setaria gracilis* (yellow foxtail), *Pluchea symphytifolia* (sourbush), *Ageratum conyzoides* (maile hohono), *Vulpia bromoides* (brome fescue), and *Plantago lanceolata* (narrow-leaved plantain).

Band-rumped Storm-Petrel call counts from ridges above Na Pali coast (2002).

	16 Aug Kalalau hi wind	22 Aug Kalalau hi wind	23 Aug Awa’awapuhi lo wind	13 Sep Awa’awapuhi lo wind	14 Sep Honopu hi wind
7:30-7:40			**62**	**155**	**0**
7:40-7:50	**0**	**0**	**211**	**182**	**0**
7:50-8:00	**1**	**0**	**201**	**190**	**0**
8:00-8:10	**0**	**1**	**247**	**162**	**2**
8:10-8:20	**0**	**0**	**228**	**205**	**0**
8:20-8:30	**0**	**3**	**145**	**186**	**0**
8:30-8:40	**0**	**1**	**136**	**155**	**0**
8:40-8:50	**0**	**0**	**124**	**110**	**0**
8:50-9:00	**0**	**0**	**185**	**133**	**0**
9:00-9:10			**102**	**96**	**0**
9:10-9:20			**73**	**84**	**0**
9:20-9:30					**0**

Waimea Canyon. Kauai resident David Kuhn has documented a significant population of Band-rumped Storm-Petrels near the Waimea Canyon Overlook during the period of 1999—2002. Listening and triangulating with a parabolic microphone (Telinga Pro V Stereo), he determined the general area of greatest activity to be in the head of an eastward trending tributary canyon approximately 150 meters south of the Overlook. On 6 October 2001, he descended ca. 100 m of rope from the canyon rim along the ridge on the southern boundary of this tributary to afford a view into the head of the canyon’s potential Band-rumped Storm-Petrel nesting habitat. Based on Harris’ (1969) observations in the Galapagos that Band-rumped Storm-Petrel nestlings during the last month before fledging (*i.e.* Oct-Nov) are known to wander from the nest, Kuhn searched with a spotting scope (Kowa TSN 823 20-60x Zoom) among the talus slopes and shallow cavities in the cliff faces for nestlings, dead chicks, whitewash on rocks, or other evidence of a nesting colony. No such evidence was observed.

Over 40 listening-nights were conducted by Kuhn during 2001. Storm-petrels were heard throughout the upper Waimea Canyon from the Waimea Canyon Overlook, six miles northeast to Po`omau Canyon Trail, and north to Kalalau Valley. These sites include Waimea Canyon drive (*i.e.*, between the Waimea Canyon overlook and 13 mile marker); Pu`u Hinahina lookout; Kalalau Valley overlook; end of Kunuwela Rd; and Po`omau Canyon trail. Only at the Waimea Canyon Overlook site did he hear a concentration of calls that might indicate a nesting colony.

In 2002, Boynton visited Waimea Canyon Lookout once or twice weekly from the beginning of April through the end of May, during the evening hours when petrels typically are heard. Although Newell's shearwaters were heard from mid-April onwards, no Band-rumped Storm-Petrel calls were heard until 5 June. Kuhn heard the first calls on May 31, 2002, and in the year 2001 he first heard their calls on 1 June.

The following table lists data collected between June and August of 2002 from the Waimea Canyon Lookout. Band-rumped Storm-Petrel calls were counted in 10 minute intervals, for listening periods ranging from 30 minutes to 90 minutes during the evenings as petrels were flying in to the canyon to tend nests. The site was visited at different time periods of the evening as schedule allowed. Data reflects total number of calls heard, many of which may be repeat calls from the same individual bird.

Band-rumped Storm-Petrel call counts from Waimea Canyon Lookout (2002).

	5 Jun hi wind	6 Jun	16 Jun	19 Jun	7 Jul	22 Jul	30 Jul	31 Jul
7:30-7:40								
7:40-7:50								
7:50-8:00								
8:00-8:10								
8:10-8:20			**2**					
8:20-8:30			**18**				**26**	
8:30-8:40	**3**		**4**				**11**	**20**
8:40-8:50							**1**	**13**
8:50-9:00		**16**		**14**	**24**		**38**	**7**
9:00-9:10				**1**	**12**		**18**	**50**
9:10-9:20							**26**	**75**
9:20-9:30							**10**	**17**

9:30-9:40							**2**	
9:40-9:50						**45**		
9:50-10:00						**10**		
10:00-10:10						**33**		

Band-rumped Storm-Petrel call counts from Waimea Canyon Lookout (2002 [continued]).

	5 Aug	**6 Aug**	**11 Aug**	**13 Aug**	**14 Aug**	**31 Aug no wind**	**12 Sep**	**20 Sep**
7:30-7:40								
7:40-7:50								
7:50-8:00						**88**	**4**	
8:00-8:10						**113**	**10**	
8:10-8:20						**136**	**2**	
8:20-8:30				**6**		**65**	**4**	**0**
8:30-8:40	**69**			**4**	**42**	**49**		**0**
8:40-8:50	**17**		**79 ***	**0**	**86**	**33**		**0**
8:50-9:00	**5**	**21**		**4**	**40**	**52**		**0**
9:00-9:10		**11**		**3**	**28**	**35**		**0**
9:10-9:20		**13**		**4**	**29**			
9:20-9:30		**47**			**15**			
9:30-9:40		**43**			**9**			
9:40-9:50		**10**			**4**			
9:50-10:00					**2**			
10:00-10:10								

*Data recorded on 11 August is included even though time allowed for only one 10-minute period of listening that evening. The call count in that interval exceeded any recorded up to that point. Data for Sept. 20 was included because of excellent listening conditions (no wind), and indicates that adult birds are infrequent by this time

The same location was visited on 12 additional evenings which are not listed in the table above. Wind conditions on those evenings made it difficult to discern calls, so the count was abandoned after 5 to 30 minutes of listening while hoping the wind might settle. As the listener realized how much impact the consistent tradewinds might be having on the usefulness of the data, attempts were made to try to catch the best conditions at the canyon, in the hopes of more truly reflecting the bird nesting activity there. Also, the observations were made from two locations, one site being the “tourist” overlook itself and the other site about 75M south, where koa trees along the Canyon rim help provide some protection from the wind. The best (lowest wind) conditions for which data was recorded occurred on 31 August. On a

number of evenings in the weeks before and after this date, tradewinds made it difficult to hear birds from the location over the canyon. This is an important consideration in interpreting this data, as the number of calls heard may be greater due to lesser wind conditions, rather than due to an increase in activity in that time of the season.

Comparisons of aural surveying with and without a parabolic dish indicated that listeners without amplifying equipment were not hearing all the bird calls, especially when wind sounds created difficult listening conditions. To insure accuracy, Band-rumped Storm-Petrel surveys should utilize amplifying equipment. This is especially important at sites like Waimea Canyon, where the calls are at quite a distance, and often barely discernible. It should be noted however, that parabolic dishes are very directional, and may not be picking up sounds peripheral to the direction where the dish is pointed.

Two of the authors (KW & DB) spent the evening of 4-5 Oct 2002 in Waimea Canyon investigating potential nesting sites around the Poo Kaehu Region (1100—1200 ft elev.; UTM 432664 - 2440826). Between 8:30—8:40 four calls were heard and these calls represent the latest date of the season.

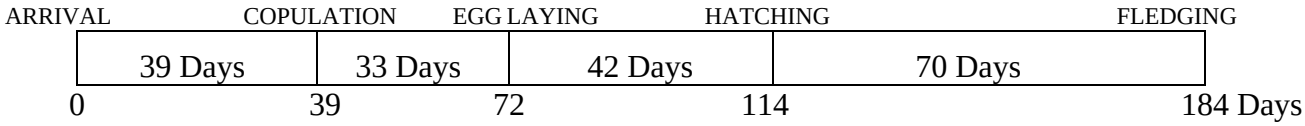
The Poo Kaehu site represented a *Sapindus oahuensis-Erythrina sandwicensis* lowland dry forest associated with *Metrosideros polymorpha* var. *glaberrima*, *Diospyros sandwicensis, Psydrax odorata, Acacia koa, Nesoluma polynesicum, Charpentiera obovata, Rauvolfia sandwicensis*, *Peperomia blanda* var. *floribunda, Korthalsella complanata*, *Alyxia oliviformis, Ipomoea sp.*, *Carex meyenii*, *Bromus sp, Eragrostis variabilis, Microlepia strigosa, Psilotum nudum, Pteridium decompositum*, *Doryopteris decora,* and *Macrothelypteris torresiana*. Adjacent cliffs with *Nototrichium sandwicense, Artemisia australis, Bidens sandvicensis, Lipochaeta connata* var. *acris, Lobelia niihauensis, Schiedea spergulina,* and *Chamaesyce celastroides* var. *hanapepensis*. The main threats to this ecosystem include habitat degradation by feral goats, competition with non-native plant taxa such as *Grevillea robusta*, *Melia azedarach, Aleurites moluccana, Hyptis pectinata, Ageratum conyzoides, Kalanchoë pinnata, Rubus rosifolius, Adiantum hispidulum, Abutilon grandifolium, Crotalaria pallida, Triumfetta semitriloba, Stachytarpheta jamaicensis*, and fire.

Lehua Islet. Band-rumped Storm-Petrels calls were heard on Lehua Islet on three occasions between 8:00—9:30 pm on 6 July 2002 (E. Vanderwerf & K. R. Wood pers. obs.). In the first two cases the bird

sounded as if it was on the slope above camp (south-central slopes), while in the third case the bird sounded as if it was in flight.

Phenology. The data from Waimea Canyon brings into question the breeding phenology of the Hawaiian population of *O. castro.* A review of the literature (Slotterback 2002) based on studies of two seasonally distinct populations in the Galapagos (Harris 1969) indicates a mean of 33 days between copulation and egg-laying; an average of 42 days for the incubation period (from egg-laying to hatching); and a mean of 70 days (hot season population) or 78 days (cool season population) from hatching to fledging. At Ascension Island, a mean of 64 days was determined (Allan 1962). Harrison, in Seabirds of Hawai'i (1990), states the band-rumps take 58-72 days to mature, while an article in the Elepaio (Harrison *et al.* 1990) refers to a 64-70 day fledging period. The time between first arrival at the burrow and copulation is not well documented, but data from Harris (1969) indicated that the longest time between arrival at the burrow and egg-laying was 72 days, hence the pre-copulation period may be as long as 39 days.

Table. Nesting Cycle of Band-rumped Storm-Petrels.



Adding the above figures (using 70 days as an estimate of hatching to fledging time) would indicate 184 days from first arrival at burrow to fledging. Telfer's data (Harrison *et al.* 1990) of fledglings recovered on Kaua'i from 1978-1989, where the earliest fledgling was picked up on October 4, was used to estimate when birds would first arrive at the nesting colonies. Since the earliest fledging date likely correlates with the earliest arrival at burrow date, subtracting 184 days from October 4th takes us to April 3, hence we should start hearing birds around the first week of April. It is difficult to understand why no birds were heard at Waimea Canyon Lookout until nearly two months later, despite once or twice weekly surveys from the beginning of April. However, if the time from first arrival to copulation (*i.e.*, pre-copulation or courtship period) is much shorter than 39 days, and perhaps the period from hatching to fledging is closer to 60 days rather than 70, then the expected arrival time for the Hawaiian birds would be around the middle of May.

Conducting listening surveys during the last two weeks of March may provide evidence of first arrival and courtship calls. Perhaps our failure to document birds from April to late May at Waimea Canyon Lookout might represent the pre-laying phase in which birds are once again out at sea. Clearly this is an aspect that needs further investigation.

Recommendations: Further investigation of the newly-discovered colonies at Awa'awapuhi vista, Nu'ololo Kai, Honopu, Kalalau rim, the back of Kalalau Valley, and Lehua Islet would provide a more accurate assessment of the total number of breeding pairs at these sites, each of which was only visited once or twice. Highest priority would be for Awa'awapuhi Vista and Nu'ololo Kai sites, as they had relatively large numbers of calls. Both of these sites provide reasonably safe conditions for rappelling into the cliff-face nesting zone. The Lehua Islet site, and the back of Kalalau Valley, offer opportunities to locate nesting burrows without rappelling down cliff-faces. Further observation at Miloli'i and Makaha Valleys are also recommended, as potential nesting locations. In addition, the cliff above Honopu beach should be investigated, as it is very similar to the site at Nu'ololo Kai where a very high frequency of calls was documented.

Further research could be planned on Mauna Loa of the Big Island where the availability of suitable habitat provides the potential for the existence of a sizeable population of *O. castro,* including the southwest rift zone, which will be within the new boundaries of the National Park.

As further data is gathered on the plant communities associated with nesting sites, it would be interesting to see how the occurrence of Band-rumped Storm-Petrels relate to those communities. Are storm-petrels found only in the most undisturbed sites and are their preferences on Kaua`i related to the inaccessibility of cliffs to rats and predators?

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