



Inventory of Bat Activity at Pearl Harbor National Memorial

To Inform Historic Preservation and Compliance



‘Ōpe‘ape‘a (Hawaiian hoary bat; *Lasiurus semotus*) in flight.

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Inventory of Bat Activity at Pearl Harbor National Memorial: To Inform Historic Preservation and Compliance

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Abstract

We examined ‘ōpe‘ape‘a, or Hawaiian hoary bat (*Lasiurus semotus*; Chiroptera: Vespertilionidae), acoustic activity and surveyed potential roost trees at the Ford Island Chief Petty Officer’s (CPO) Bungalows Neighborhood of Pearl Harbor National Memorial (PERL) on the island of O‘ahu. We established four acoustic monitoring stations (PERL1–PERL4) that operated nightly to survey for ‘ōpe‘ape‘a echolocation activity from June to December 2024. Tree physiognomy data were collected at 12 potential roost trees and included tree species, tree height, diameter at breast height (DBH), percent canopy cover, distance to nearest tree, elevation, and canopy geometry. We collected 357,802 acoustic files over 672 station-nights across the four acoustic monitoring stations. ‘Ōpe‘ape‘a echolocation activity was detected over a total of 26 (4%) station-nights and during each month of the survey period except June. Echolocation activity peaked in September and October 2024, which is during the post-lactation and fledging period. These results represent a baseline for assessing ‘ōpe‘ape‘a acoustic activity and potential roosting resources in PERL.

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Introduction

The ‘ōpe‘ape‘a, or Hawaiian hoary bat (*Lasiurus semotus*; Chiroptera: Vespertilionidae), is the only extant, native, terrestrial mammal in Hawaii. It has been listed as endangered under the Federal Endangered Species Act and Hawai‘i Endangered Species Law (Hawai‘i Revised Statutes section 195D) since 1970. A U.S. Fish and Wildlife Service (USFWS) recovery plan for the species was published citing roost disturbance, threats from predation, alteration of prey availability, and lack of information among potential limiting factors (USFWS 1998).

‘Ōpe‘ape‘a are a solitary species, roosting among the foliage of mostly large stature and densely foliated trees that provide several critical functions including shelter, protection from predators, and sites to rear young (Montoya-Aiona 2020; Montoya-Aiona et al. 2023). They use aerial-hawking to catch and consume prey while in flight. Their diet consists mostly of moths (Lepidoptera), termites (Blattodea), and beetles (Coleoptera) (Bernard and Mautz 2016). Females typically give birth to twin pups during the reproductive season, which consists of a pregnancy period from April to June, lactation from June to August, and post-lactation and fledging from August to November, with pups usually fully fledged and independent of their mother by November (Tomich 1986; Kepler and Scott 1990; Jacobs 1994; Menard 2001). During the reproductive season, non-volant pups are particularly vulnerable as they are unable to escape if disturbed while at roost (Montoya-Aiona 2020). While information on the prevalence and potential effects of roost disturbance is unknown, the USFWS and Hawai‘i Division of Forestry and Wildlife (DOFAW) recommend suspending tree-trimming and felling activities for woody plants 15 feet or taller between June 1st and September 15th to avoid negative impacts to non-volant pups (USFWS 2021, 2023).

Previous acoustic studies of ‘ōpe‘ape‘a on O‘ahu have examined island-wide, long-term occupancy and detection rates (Thompson and Starceovich 2022), seasonal detection patterns and foraging activity (Montoya-Aiona et al. 2020; Pinzari et al. 2021), foraging habitat use and quality (Gorresen et al. 2018), and acoustic behavior trends (Gorresen et al. 2015, 2017). However, these studies have not specifically evaluated ‘ōpe‘ape‘a activity at Pearl Harbor National Memorial (hereafter PERL) on Ford Island (Moku‘ume‘ume). Acoustic surveys for bats at PERL can contribute information about ‘ōpe‘ape‘a presence, distribution, and behavior, which can be used for evaluation of their use of the area. This study includes (1) acoustic surveys to determine seasonal presence of bats using acoustic activity as a metric and (2) documenting of potential roost trees within a historic cultural landscape that will require preservation work. The National Park Service (NPS) may use results to inform decisions related to historic preservation activities and historic resources within the Ford Island Chief Petty Officer’s (CPO) Bungalows Neighborhood of PERL.

Methods

Study Area

‘Ōpe‘ape‘a acoustic activity and characterization of potential roost habitat was conducted at the Ford Island CPO Bungalows Neighborhood of PERL located on the leeward coast of O‘ahu (Figure 1). The Ford Island CPO Bungalows Neighborhood is an approximately 4.36-acre National Park Service-owned site and part of U.S. Naval Base Pearl Harbor National Historic Landmark (NHL) District.



Figure 1. Map of acoustic monitoring stations and potential roost trees sampled at the Ford Island Chief Petty Officer's Bungalows Neighborhood, Pearl Harbor National Memorial.

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We established four acoustic monitoring stations (PERL1–PERL4) ranging from 20 to 25 m above sea level (asl) (Table 1, Figures 1 and 2). Station PERL1 was located near Bungalow 68, near the southwest corner of the bungalow's lawn and adjacent to a parking lot. Station PERL2 was located near Bungalow 90 near the southwest boundary and a *Tabebuia* tree (*Tabebuia* spp.) and adjacent to a parking lot. Station PERL3 was located near Bungalow 31 along the eastern boundary. Station PERL4 was located near Bungalow 32 near a *Tabebuia* tree. Additionally, we evaluated 12 trees within the Ford Island CPO Bungalows Neighborhood of PERL (Table 1) for potential ‘ōpe‘ape‘a roost habitat and collected tree metric data.

Table 1. Details of ‘ōpe‘ape‘a acoustic monitoring stations and potential roost trees at the Ford Island CPO Bungalows Neighborhood, Pearl Harbor National Memorial, including station and tree ID, Universal Transverse Mercator (UTM, Zone 4) coordinates, elevation in meters above sea level, and a brief description of station location or tree type.

Sample Type	Tree or Station ID	UTM Easting	UTM Northing	Elevation (m)	Description
Acoustic Monitoring Station	PERL-1	608337	2362741	23.2	Located near Bungalow 68
	PERL-2	608466	2362721	20.7	Located near Bungalow 90
	PERL-3	608573	2362754	25.0	Located near Bungalow 31
	PERL-4	608543	2362798	21.3	Located near Bungalow 32
Potential Roost Tree	F19	608550	2362814	20.4	Umbrella (<i>Schefflera arboricola</i>)
	F114	608351	2362756	17.1	Monkeypod (<i>Samanea saman</i>)
	F143	608490	2362777	14.6	Ironwood (<i>Casuarina</i> spp.)
	F144	608521	2362791	13.7	Ironwood (<i>Casuarina</i> spp.)
	T4	608520	2362741	16.8	Earpod (<i>Enterolobium cyclocarpum</i>)
	T5	608532	2362743	20.7	Mimosa (<i>Albizia julibrissin</i>)
	T8	608566	2362736	21.0	Monkeypod (<i>Samanea saman</i>)
	T9	608545	2362750	15.2	Banyan (<i>Ficus</i> spp.)
	T31	608491	2362765	13.4	Monkeypod (<i>Samanea saman</i>)
	T32	608473	2362746	18.6	Earpod (<i>Enterolobium cyclocarpum</i>)
	T33	608440	2362757	16.2	Banyan (<i>Ficus</i> spp.)
	T34	608432	2362742	15.9	Banyan (<i>Ficus</i> spp.)



Figure 2. Bat acoustic monitoring stations within the Ford Island CPO Bungalows Neighborhood, Pearl Harbor National Memorial. Clockwise from top left: PERL1, PERL2, PERL3, and PERL4.

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Survey Techniques

Acoustic Monitoring

We used Song Meter model SM4BAT FS bioacoustics recorders (Wildlife Acoustics Inc., Concord, MA) for acoustic monitoring of ‘ōpe‘ape‘a ultrasonic vocalizations (echolocation calls) from June to December 2024. Each station consisted of a fully weatherproof SM4BAT FS and an SMM-U2 model ultrasonic microphone (Wildlife Acoustics Inc., Concord, MA). Microphones were placed at the top of a metal conduit approximately 3 meters above the ground and connected by a cable to the microphone port of the SM4BAT FS. Microphones were fully waterproof and omnidirectional, though the exact range of detection varies with weather conditions and orientation of a bat relative to the microphone (Agranat 2014). Triggered acoustic events were date and time stamped, and recorded without digital compression as full-spectrum Waveform Audio File format (.wav) sound files onto Secure Digital (SD) cards with the following settings: gain 12dB, high pass filter off, sampling rate of 192 kHz; min duration 1.5 ms, max duration none, min trig frequency 16 kHz, trigger level 12 dB, trigger window 3.0 s, max length 15 s. Firmware version 2.49 was used for the full duration of field data collection. The SM4BAT FS recorders were scheduled to record from one hour before local sunset until one hour after local sunrise and were configured to operate remotely in the field, powered by internal D-batteries for up to 6 weeks of continuous nightly recording. Bat acoustic monitoring stations were checked every 4–6 weeks when SD memory cards were collected, batteries were replaced, and routine maintenance and quality checks on all equipment were conducted.

Acoustic data were downloaded from SD memory cards and organized into folders by survey night using Kaleidoscope Pro software (version 5.6.8; Wildlife Acoustics Inc., Concord, MA). Kaleidoscope Pro software was used to filter acoustic background noise with the following settings: minimum and maximum frequency range 8–120 kHz; minimum and maximum length of detected pulses 2–500 ms; 500 ms maximum inter-syllable gap, and a minimum of 2 pulses per event. All additional noise filters were set to “off.” All acoustic files were visually and aurally inspected and proofed as spectrograms with Kaleidoscope Pro software to minimize false positives or negatives. Triggered events that did not conform to standard ‘ōpe‘ape‘a vocalization parameters (Gorresen et al. 2017) such as insect or other noise were classified as “noise.” Call-events or “bat passes” were defined as a sequence of ultrasonic pulses over a span of milliseconds (ms) detected by an ultrasonic microphone as an individual bat flew past the effective range of the microphone. Call-events may contain search phase calls made by a bat moving about an area often for the purpose of searching for prey and may end with a “feeding buzz” also referred to as terminal-phase calls (Griffin et al. 1960; Figure 3). Feeding buzzes, indicative of foraging activity, were characterized by a rapid series of pulses made by a bat closely approaching a prey item. The presence of multiple bats was determined when more than one echolocation call-event occurred simultaneously at different frequencies and in some instances may nearly overlap (Figure 4). All echolocation call-events, feeding buzzes, and occurrences of multiple bats were counted and verified by audio and visual inspection.

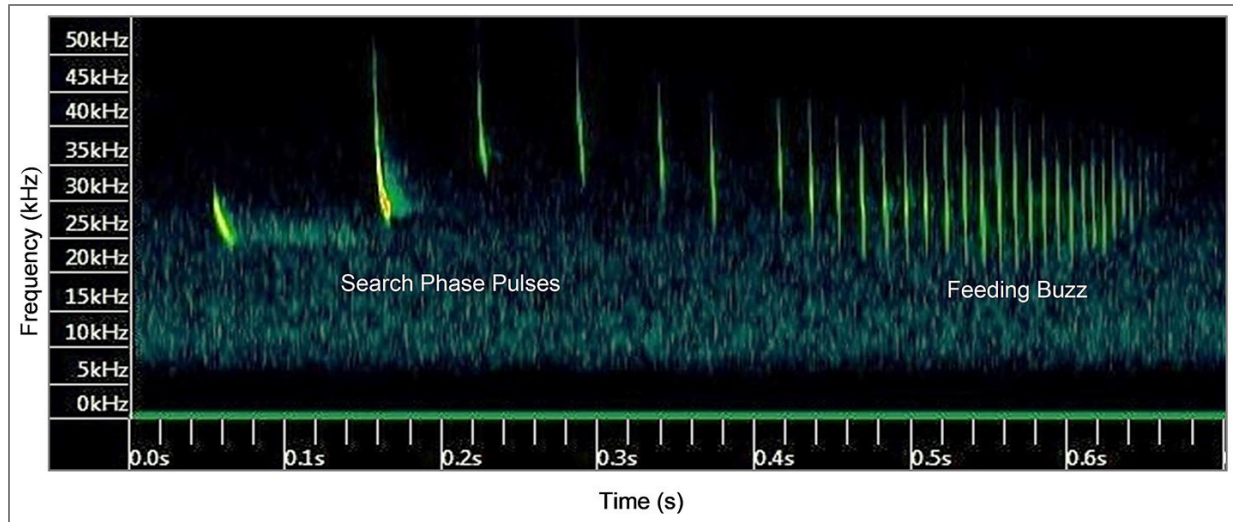


Figure 3. Example spectrogram of an 'ōpe'ape'a echolocation call-event with search phase echolocation pulses (left and center) followed by a feeding buzz (far right).

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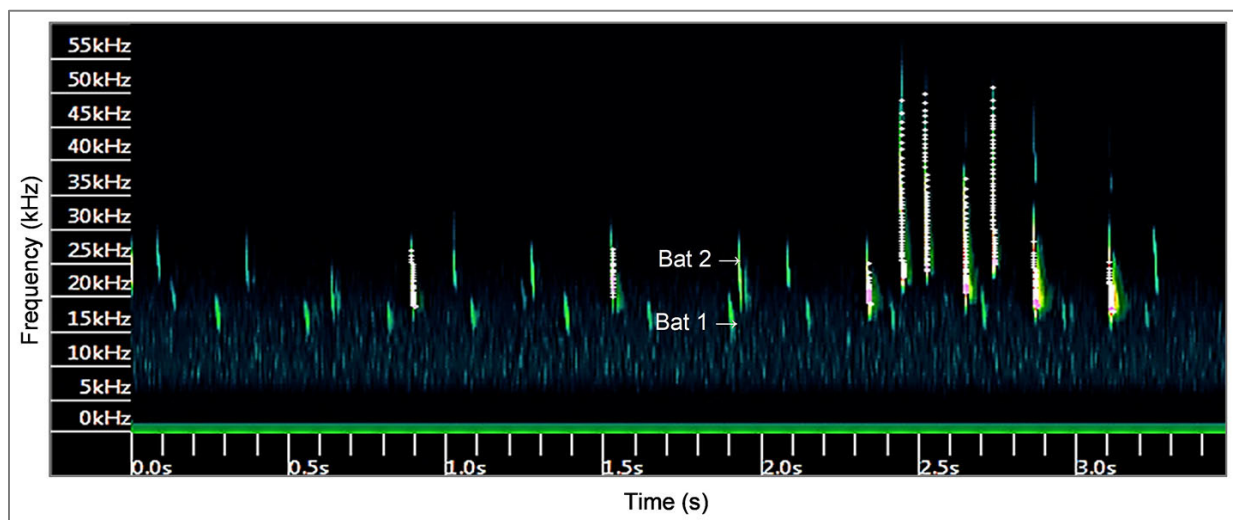


Figure 4. Example spectrogram of an 'ōpe'ape'a echolocation call file containing multiple bats where each arrow points to a series of echolocation pulses from different bats.

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The frequency of detection (f) was calculated for each station as the total number of nights with detections divided by the total number of nights surveyed, thus effectively weighting the values by survey effort. A frequency of detection equal to 1.0 is equivalent to recording bat calls at a station every night of the survey period. Zero represents no verifiable bat calls during the survey period. Frequency of detection, call-events, occurrence of multiple bats, and feeding buzzes were used to examine activity, and timing of nightly use at each station. Timing of nightly 'ōpe'ape'a acoustic activity was determined by timestamps of echolocation call-events and pooled over the duration of the survey for each station. Results are presented with mean and standard deviation (SD). Some

acoustic monitoring stations had equipment malfunctions that resulted in nights with no recording or lapses in continuous monitoring. Complete acoustic data are available at <https://doi.org/10.5066/P1RCD4TL> (Montoya-Aiona 2025).

Potential Roost Tree Metrics

Tree physiognomy data were collected at 12 potential roost trees following methods described in Montoya-Aiona et al. (2023). Trees selected for data collection were those in the study area identified as potential ‘ōpe‘ape‘a roost habitat utilizing published information on roost tree characteristics (Amlin and Siddiqi 2015; Montoya-Aiona et al. 2023), and with consultation from NPS personnel on specific trees of interest due to proximity to structures that may require preservation or rehabilitation work (J. Sturdevant, written communication, National Park Service, November 19, 2024). Trees were classified to the species or genus level, and tree height, diameter at breast height (DBH), percent canopy cover, distance to nearest tree, elevation, and canopy geometry were measured. Tree height was measured using a laser range finder (Model Forestry Pro Laser Rangefinder/ Hypsometer, Nikon USA, Mellville, New York). Tree DBH was measured by wrapping a diameter tape (Model 283D/10M, Forestry Suppliers, Jackson, Mississippi) around the tree at breast height (1.3 m) from the base of the tree. A tree was measured and classified as a single-bole tree if multiple trunks forked at a point higher than 1.3 m. If the trunks forked at a point lower than 1.3 m, the tree was classified as multi-trunked and DBH was measured for each trunk and summed. Percent canopy cover was measured using a spherical densiometer (Convex Model A, Forestry Suppliers, Jackson, Mississippi) and averaged using four readings taken at each roost tree. Personnel positioned their back toward the reference tree and moved around the tree facing north, east, south, and west. Canopy geometry, as an estimate of overall tree geometry and shape, was measured using a laser range finder taking four distance measures from the bole of the tree to the furthest extent of the canopy (north, east, south, and west).

Results

We collected 357,802 acoustic files over 672 station-nights across four acoustic monitoring stations (PERL1–PERL4) from 13 June 2024 to 10 December 2024. ‘Ōpe‘ape‘a echolocation activity was detected over a total of 26 (4%) station-nights and during each month of the survey period except June. All stations detected ‘Ōpe‘ape‘a echolocation activity at some time during the survey period. Mean call-events across the four acoustic monitoring stations was greatest in September followed by October (Figure 5). Station PERL1 had the greatest total call-events (9) over the entire survey period, followed by PERL2 (8), PERL4 (7), and PERL3 (6) (Table 2). There were no feeding buzzes or occurrences of multiple bats detected at any station during the survey period.

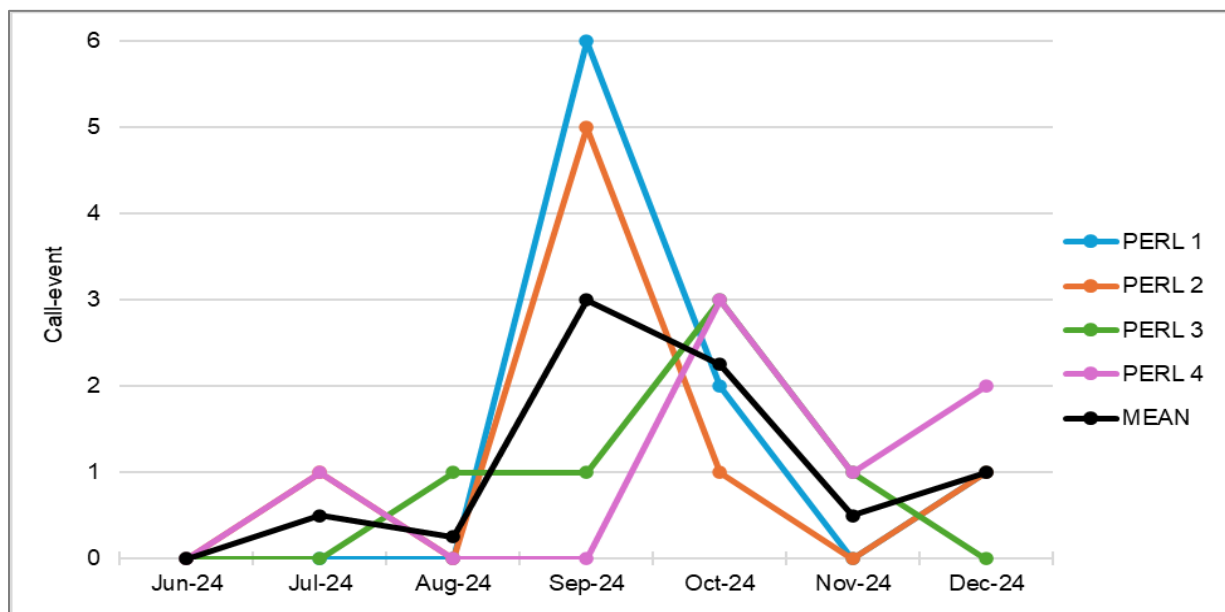


Figure 5. Total ‘Ōpe‘ape‘a call-events and mean call-events by month across all stations (PERL1–PERL4) at the Ford Island Chief Petty Officer’s Bungalows Neighborhood, Pearl Harbor National Memorial, 13 June–10 December 2024.

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Table 2. Survey effort by station at the Ford Island Chief Petty Officer’s Bungalows Neighborhood, Pearl Harbor National Memorial, 13 June–10 December 2024, including acoustic monitoring station name, total number of nights surveyed, total number of nights with bat echolocations detected, frequency of detection (f), total number of call-events, total number of feeding buzzes, and total occurrences of multiple bats.

Station ID	Total Nights Surveyed	Number of Nights Bats Detected	Frequency of Detection (f)	Number of Call-Events	Number of Feeding Buzzes	Number of Multiple Bats
PERL-1	178	7	0.0393	9	0	0
PERL-2	176	7	0.0398	8	0	0
PERL-3	152	6	0.0395	6	0	0
PERL-4	166	6	0.0361	7	0	0

Across all four acoustic monitoring stations, peak frequency of detection was generally observed from September (mean 0.08 ± 0.07) through October (mean 0.09 ± 0.05) coinciding with the post-lactation and fledging period for ‘ōpe‘ape‘a (Figure 6). The lowest frequency of detection was observed in June during the pregnancy and lactation period when no ‘ōpe‘ape‘a echolocation activity was detected.

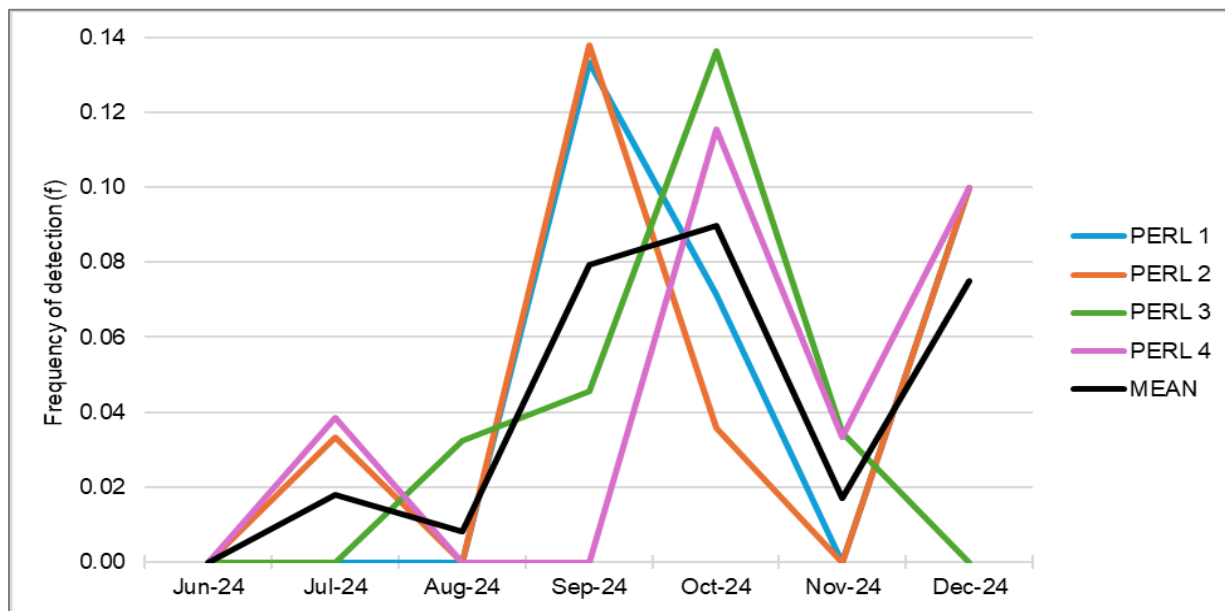


Figure 6. Frequency of ‘ōpe‘ape‘a detection across all stations (PERL1–PERL4) at the Ford Island Chief Petty Officer’s Bungalows Neighborhood, Pearl Harbor National Memorial, by survey month, 13 June–10 December 2024.

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Within-night acoustic activity, as measured by number of call-events pooled for all sampling nights at each station, varied among acoustic monitoring stations (Figure 7). Generally, nightly acoustic activity peaked five hours after local sunset time while all acoustic activity was confined to the first seven hours after local sunset time. There was no acoustic activity detected before sunset or within several hours of local sunrise.

We identified 12 potential roost trees within the Ford Island CPO Bungalows Neighborhood of PERL (Table 3). Tree species surveyed were composed of non-native, introduced ornamentals (e.g., Monkeypod (*Samanea saman*); $n = 3$). Of the trees measured, tree height ranged from 7.4 to 25.4 m (mean 14.1 ± 4.5 m) while DBH ranged from 109 to 242 cm (mean 159.7 ± 43.7 cm). Percent canopy cover ranged from 26.2 to 97.1 (mean $68.5 \pm 6.5\%$).

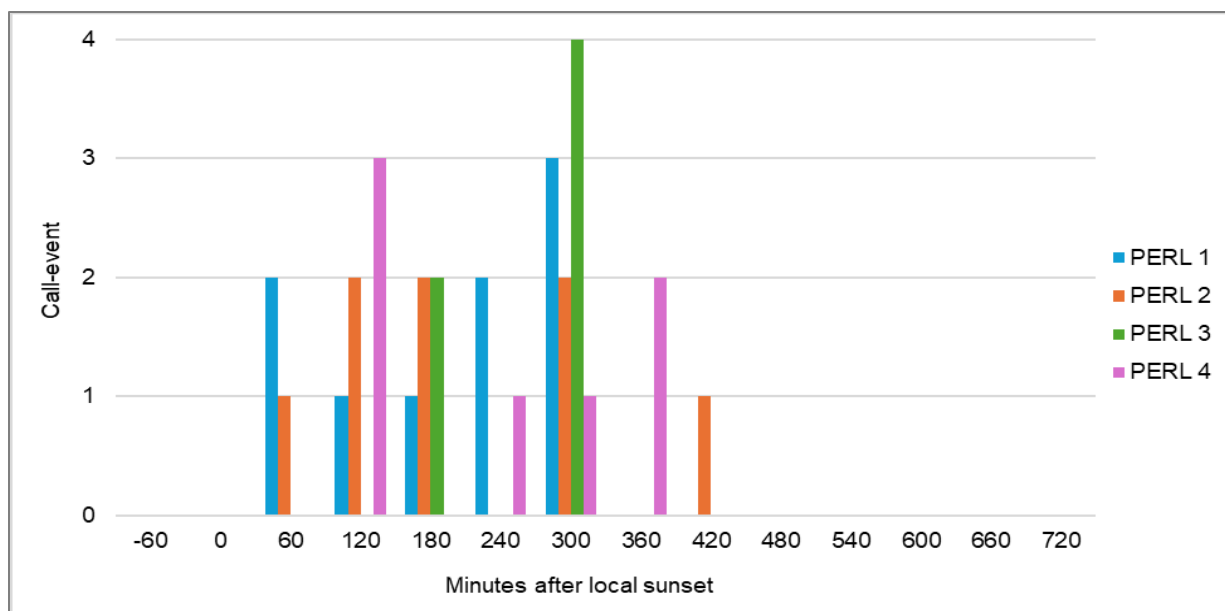


Figure 7. Total number of 'ōpe'ape'a call-events relative to local sunset pooled by station at the Ford Island Chief Petty Officer's Bungalows Neighborhood, Pearl Harbor National Memorial, for the entire sampling period, 13 June–10 December 2024.

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Table 3. List of trees sampled at the Ford Island Chief Petty Officer's Bungalows Neighborhood, Pearl Harbor National Memorial, including the genus or species, height, diameter at breast height (DBH), and percent canopy cover.

Tree ID	Tree Species	Tree Height (m)	DBH (cm)	% Canopy Cover
F19	Umbrella (<i>Schefflera arboricola</i>)	7.4	109	84.4
F114	Monkeypod (<i>Samanea saman</i>)	15.3	121	90.1
F143	Ironwood (<i>Casuarina</i> spp.)	25.4	135	26.2
F144	Ironwood (<i>Casuarina</i> spp.)	11.1	159	20.7
T4	Earpod (<i>Enterolobium cyclocarpum</i>)	16.1	212	9.1
T5	Mimosa (<i>Albizia julibrissin</i>)	15.6	177	9.1
T8	Monkeypod (<i>Samanea saman</i>)	9.7	148	18.7
T9	Banyan (<i>Ficus</i> spp.)	12.8	112	9.0
T31	Monkeypod (<i>Samanea saman</i>)	13.6	123	15.6
T32	Earpod (<i>Enterolobium cyclocarpum</i>)	16.9	166	21.6
T33	Banyan (<i>Ficus</i> spp.)	13.9	242	17.7
T34	Banyan (<i>Ficus</i> spp.)	11.5	212	17.7

Discussion

‘Ōpe‘ape‘a echolocation activity at PERL showed peak activity during September and October 2024, which coincides with the post-lactation and fledging period. While the total survey period only spanned one reproductive season precluding long-term seasonal inferences, activity patterns generally followed previous acoustic studies on O‘ahu, which have overall lower detection frequency compared to other islands and higher levels of detection frequency during the post-lactation and fledging period (Montoya-Aiona et al. 2020; Pinzari et al. 2021; Thompson and Starceovich 2022). Gorresen et al. (2013) suggested that during the post-lactation and fledging period the total ‘ōpe‘ape‘a population is at its annual maximum with young of the year volant and fledging, thus contributing to increased bat activity. Furthermore, the comprehensive 5-year island-wide acoustic study on O‘ahu by Thompson and Starceovich (2022) found that during the post-lactation season the overall pattern in acoustic activity appeared most dispersed across the island and occupancy rates were highest.

Frequency of detection at all four sites was relatively low compared to statewide surveys (Pinzari et al. 2019; Montoya-Aiona et al. 2020) but were comparable to overall trends for O‘ahu (Montoya-Aiona et al. 2020; Pinzari et al. 2021; Thompson and Starceovich 2022). ‘Ōpe‘ape‘a have long been regarded as habitat generalists occurring in a wide variety of habitats and elevations from sea level to 3,600 m asl (Gorresen et al. 2013; Bonaccorso et al. 2016; Montoya-Aiona et al. 2023). Increased ‘ōpe‘ape‘a activity, higher frequency of detection, and foraging activity, have been mostly associated with forest and corridor habitat (Gorresen et al. 2013; Montoya-Aiona et al. 2019; Montoya-Aiona et al. 2023). However, bat activity has been detected in urban environments, military installations and other areas with sparse vegetation (e.g., Bonaccorso et al. 2019; Montoya-Aiona et al. 2020; Pinzari et al. 2021; Montoya-Aiona et al. 2023) similar to the habitat characteristics at PERL. Studies on the Island of Hawai‘i (Gorresen et al. 2013; Bonaccorso et al. 2016; Hoeh et al. 2023) indicate bats make seasonal movements from coastal lowlands at or below 1,000 m asl during the pregnancy through fledging periods (April–October) to interior highlands up to 3,600 m asl during the pre-pregnancy period (November–March). All acoustic monitoring stations at PERL were located well below 1,000 m asl and had increased acoustic activity during the post-lactation and fledging period compared to the rest of the survey period, which is consistent with documented seasonal elevation patterns. However, the topography of O‘ahu is quite different compared to the Island of Hawai‘i, and there are few locations higher than 1,000 m asl. Therefore, on O‘ahu, elevation alone may not have strong effects on seasonal patterns and ‘ōpe‘ape‘a may instead be driven by windward and leeward differences and resulting wet and dry habitats as documented by Thompson and Starceovich (2022).

Foraging activity and occurrences of multiple bats were not detected at PERL during the survey period. Similarly, occurrences of multiple bats were not detected and foraging activity was rarely detected at acoustic monitoring stations on O‘ahu during the survey periods in Bonaccorso et al. (2019), Montoya-Aiona et al. (2020), and Pinzari et al. (2021). Likewise, Thompson and Starceovich (2022) documented foraging activity at only approximately half of their acoustic monitoring stations over their 5-year survey period with most detections of foraging activity occurring at stations along

the leeward Wai‘anae Range and the north Ko‘olau Range. Notably, the Thompson and Starceovich (2022) station at the Joint Base Pearl Harbor Hickam, located across the channel and just south of the Ford Island CPO Bungalows Neighborhood, was the only acoustic monitoring station in the ‘Ewa coastal plain to record foraging activity (feeding buzzes) indicating that there may be some, even if occasional and limited, food prey resources near PERL.

Generally, within-night acoustic activity at PERL was confined to the first seven hours after local sunset and peaked at most stations at five hours after local sunset. Similar patterns of within-night acoustic activity on O‘ahu were found in Bonaccorso et al. (2019), Montoya-Aiona et al. (2020), and Pinzari et al. (2021). In contrast, within-night acoustic activity patterns on other Hawaiian Islands are highly variable with season and location (e.g., Montoya-Aiona et al. 2020). Overall, patterns of nightly activity may be influenced by many factors, including proximity to roosts, irruption events of insect prey, weather events, and localized habitat changes (Gorresen et al. 2013; Banko et al. 2022).

While the potential roost trees surveyed at PERL fit within the parameters of trees that may be used by ‘ōpe‘ape‘a (i.e., large stature, densely foliated) as documented in Montoya-Aiona et al. (2023), given the low levels of acoustic activity, and limited timing of within-night activity, there was no indication that ‘ōpe‘ape‘a were using the trees as roosts in the Ford Island CPO Bungalows Neighborhood during the survey period. Likewise, as a foliage roosting species, ‘ōpe‘ape‘a are not known to use anthropogenic structures and would not be expected to be found roosting in or on the historic structures at PERL. However, best management practices to minimize potential impacts to ‘ōpe‘ape‘a include suspending tree-trimming and felling activities for woody plants 15 feet or taller between June 1st and September 15th to avoid potential negative impacts to non-volant pups (USFWS 2021, 2023) whether or not there is direct evidence of ‘ōpe‘ape‘a roosting activity.

The overall low numbers of call-events, low frequency of detection, lack of foraging activity and occurrences of multiple bats, and constricted within-night activity perhaps indicate that ‘ōpe‘ape‘a may be traversing through PERL while searching for prey or moving to better foraging areas. These results represent a baseline for assessing ‘ōpe‘ape‘a acoustic activity and roosting resources in PERL. The NPS may use these results to inform decisions related to historic preservation activities and historic resources within the Ford Island CPO Bungalows Neighborhood of Pearl Harbor National Memorial (PERL).

Literature Cited

- Agranat, I. 2014. Detecting bats with ultrasonic microphones, understanding the effects of microphone variance and placement of detection rates. Wildlife Acoustics, Inc. Concord, MA.
- Amlin, A., and A. Siddiqi. 2015. Endangered Species Recovery Committee Hawaiian hoary bat guidance document. State of Hawai'i Department of Land and Natural Resources Division of Forestry and Wildlife, Honolulu, HI. 30 pp. https://dlnr.hawaii.gov/wildlife/files/2018/07/Bat-White-Paper-Guidance_2015-FINAL.pdf
- Banko, P.C., R.W. Peck, S.G. Yelenik, E.H. Paxton, F. Bonaccorso, K. Montoya-Aiona, R.F. Hughes, and S. Perakis. 2022. Hypotheses and lessons from a native moth outbreak in a low-diversity, tropical rainforest. *Ecosphere* 13(2): e3926. <https://doi.org/10.1002/ecs2.3926>
- Bernard, R.F., and W.J. Mautz. 2016. Dietary overlap between the invasive coquí frog (*Eleutherodactylus coqui*) and the Hawaiian hoary bat (*Lasiurus cinereus semotus*) on the Island of Hawai'i. *Biol Invasions* 18: 3409–3418. <https://doi.org/10.1007/s10530-016-1232-0>
- Bonaccorso, F.J., K. Montoya-Aiona, and C.A. Pinzari. 2019. Hawaiian hoary bat acoustic monitoring on U.S. Army O'ahu facilities. Hawai'i Cooperative Studies Unit Technical Report HCSU-089, University of Hawai'i at Hilo, Hawai'i. <http://hdl.handle.net/10790/4575>
- Bonaccorso, F.J., K. Montoya-Aiona, C.A. Pinzari, and C.M. Todd. 2016. Winter distribution and use of high elevation caves as foraging sites by the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus*. Hawai'i Cooperative Studies Unit Technical Report HCSU-068, University of Hawai'i at Hilo, Hawai'i. <http://hdl.handle.net/10790/2602>
- Gorresen, M.P., F.J. Bonaccorso, C.A. Pinzari, C.M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. A five-year study of Hawaiian hoary bat (*Lasiurus cinereus semotus*) occupancy on the Island of Hawai'i. Hawai'i Cooperative Studies Unit Technical Report HCSU-041, University of Hawai'i at Hilo, Hilo, Hawai'i. <http://hdl.handle.net/10790/2623>
- Gorresen, P.M., K.W. Brinck, M.A. DeLisle, K. Montoya-Aiona, C.A. Pinzari, and F.J. Bonaccorso. 2018. Multi-state occupancy models of foraging habitat use by the Hawaiian hoary bat (*Lasiurus cinereus semotus*). *PLoS ONE* 13:e0205150. <https://doi.org/10.1371/journal.pone.0205150>
- Gorresen, P.M., P.M. Cryan, K. Montoya-Aiona, and F.J. Bonaccorso. 2017. Do you hear what I see? Vocalizations relative to visual detection rates of Hawaiian hoary bats (*Lasiurus cinereus semotus*). *Ecology and Evolution* 7: 6669–6679. <https://doi.org/10.1002/ece3.3196>

- Gorresen, P.M., P.M. Cryan, M. Huso, C. Hein, M. Schirmacher, J. Johnson, K. Montoya-Aiona, K.W. Brinck, and F.J. Bonaccorso. 2015. Behavior of the Hawaiian hoary bat at wind turbines and its distribution across the North Ko‘olau Mountains. Hawai‘i Cooperative Studies Unit Technical Report HCSU-064, University of Hawai‘i at Hilo, Hilo, Hawai‘i.
<http://hdl.handle.net/10790/2585>
- Griffin, D.R., F.A. Webster, and C.R. Michael. 1960. The echolocation of flying insects by bats. *Animal Behavior* 8: 141–154.
- Hoeh, J.P.S., A.A. Aguirre, F.A. Calderon, S.P. Casler, S.G. Ciarrachi, K.N. Courtot, K.M. Montoya-Aiona, C.A. Pinzari, and P.M. Gorresen. 2023. Hawai‘i Island ‘ōpe‘ape‘a (Hawaiian hoary bat; *Lasiurus semotus*) mist netting effort, capture, and tag retention, 2018–2021: U.S. Geological Survey data release, <https://doi.org/10.5066/P9G4A2E3>
- Jacobs, D.S. 1994. Distribution and abundance of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus*, on the Island of Hawai‘i. *Pacific Science* 48: 193–200.
- Kepler, C.B., and J.M. Scott. 1990. Notes on the distribution and behavior of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), 1964–1983. ‘Elepaio 50: 59–64.
- Menard, T. 2001. Activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods. Master’s Thesis. University of Hawai‘i at Mānoa, Honolulu, HI.
- Montoya-Aiona, K. 2025. Pearl Harbor National Memorial, O‘ahu Hawaiian Hoary bat acoustic activity and tree metric data, 2024. U.S. Geological Survey data release:
<https://doi.org/10.5066/P1RCD4TL>
- Montoya-Aiona, K., C. Pinzari, and F. Bonaccorso. 2019. Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity and prey availability at Kaloko-Honokōhau National Historical Park. Hawai‘i Cooperative Studies Unit Technical Report HCSU-088, University of Hawai‘i at Hilo, Hawai‘i.
<http://hdl.handle.net/10790/4598>
- Montoya-Aiona, K., P.M. Gorresen, K.N. Courtot, A. Aguirre, F. Calderon, S. Casler, S. Ciarrachi, J. Hoeh, J.L. Tupu, and T. Zinn. 2023. Multi-scale assessment of roost selection by ‘ōpe‘ape‘a, the Hawaiian hoary bat (*Lasiurus semotus*). *PLoS ONE* 18: e0288280.
<https://doi.org/10.1371/journal.pone.0288280>
- Montoya-Aiona, K.M. 2020. Roosting ecology and behavior of the solitary and foliage-roosting Hawaiian hoary bat (*Lasiurus cinereus semotus*). M.Sc. Thesis, The University of Hawai‘i at Hilo. <http://hdl.handle.net/10790/5306>

- Montoya-Aiona, K.M., C.A. Pinzari, R.W. Peck, K.W. Brinck, and F.J. Bonaccorso. 2020. Hawaiian hoary bat (*Lasiurus cinereus semotus*) acoustic monitoring at Hawai‘i Army National Guard (HIARNG) installations statewide. Hawai‘i Cooperative Studies Unit Technical Report HCSU-088, University of Hawai‘i at Hilo, Hawai‘i. <http://hdl.handle.net/10790/5206>
- Pinzari, C., K. Montoya-Aiona, D. Gross, and K. Courtot. 2021. Hawaiian hoary bat acoustic surveys on Marine Corps Base Hawaii, 2019–2021. Hawai‘i Cooperative Studies Unit Technical Report HCSU-100. University of Hawai‘i at Hilo, Hawai‘i. <http://hdl.handle.net/10790/6798>
- Pinzari, C., R. Peck, T. Zinn, D. Gross, K. Montoya-Aiona, K. Brink, M. Gorresen, and F. Bonaccorso. 2019. Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity, diet and prey availability at the Waihou Mitigation Area, Maui. Hawai‘i Cooperative Studies Unit Technical Report HCSU-090, University of Hawai‘i at Hilo, Hawai‘i. <http://hdl.handle.net/10790/4638>
- Thompson, J., and L.A. Starcevich. 2022. Oahu Hawaiian Hoary Bat. Occupancy and Distribution Study. Final Report. Prepared for Hawai‘i Endangered Species Research Committee. Prepared by Western EcoSystems Technology, Inc. Corvallis, OR. https://dlnr.hawaii.gov/wildlife/files/2024/03/Oahu-Hawaiian-Hoary-Bat-Occupancy-and-Distribution-Study-2022-Final-Report_WEST.pdf
- Tomich, P.Q. 1986. Mammals in Hawai‘i, 2nd ed. Bishop Museum Press, Honolulu, HI. 375 pp.
- U.S. Fish and Wildlife Service (USFWS). 1998. Recovery plan for the Hawaiian hoary bat (*Lasiurus cinereus semotus*). Region 1, U.S. Fish and Wildlife Service, Portland, OR. https://ecos.fws.gov/docs/recovery_plan/980511b.pdf
- U.S. Fish and Wildlife Service (USFWS). 2021. ‘Ōpe‘ape‘a or Hawaiian hoary bat (*Lasiurus cinereus semotus*) 5-year review summary and evaluation. Pacific Islands Fish and Wildlife Office, U.S. Fish and Wildlife Service, Honolulu, HI. 46 pp. https://ecos.fws.gov/docs/five_year_review/doc6844.pdf
- U.S. Fish and Wildlife Service (USFWS). 2023. Final avoidance and minimization measures (AMMs) ESA listed species. Pacific Islands Fish and Wildlife Office, U.S. Fish and Wildlife Service, Honolulu, HI. 13 pp. <https://www.fws.gov/media/animal-avoidance-and-minimization-measures-may-2023-0>

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