Kawailoa Habitat Conservation Plan FY 2015 Annual Report

Kawailoa Wind, LLC

61-488 Kamehameha Hwy

Haleiwa, Hawaii 96712

August, 2015

ITL 14/ TE59861A-0

I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate and complete.

Mitchell Craig

Hawaii HCP Manager
SunEdison, LLC

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Executive Summary

This report summarizes work performed by Kawailoa Wind, LLC (KAW) under the terms of the approved Habitat Conservation Plan (HCP) dated October 27, 2011 and pursuant to the obligations contained in the project's Incidental Take License ITL-14 (ITL) and Federal Incidental Take Permit TE-59861A-0 (ITP) at the conclusion of the State of Hawaii 2015 fiscal year (FY 2015: July 1, 2014 – June, 30 2015). The project was constructed in late 2011 and throughout 2012, and was commissioned to begin operating (COD) on November 2, 2012. Species covered under the HCP include six threatened and endangered birds and one endangered bat.

SunEdison, LLC (SunEdison) acquired First Wind Energy, LLC officially on January 29, 2015. HCP program employees have not changed and are now considered SunEdison employees. The HCP, ITL and ITP remain unchanged and in the project owner's name, Kawailoa Wind, LLC. The wind project is owned by D.E. Shaw Renewable Investments, LLC (DESRI). SunEdison is contracted by DESRI to operate KAW.

Fatality monitoring plots were reduced in size on September 1, 2014 from 113m radius circular plots (the 75% plots) to 75m radius circular plots (the 50% plots) searched twice weekly centered on the wind turbine generators (WTGs). The 50% downed wildlife search plot mean and standard deviation (SD) in days for search intervals during FY 2015 Q4 was 3.50 (SD = 0.86) and for all FY 2015 is 3.50 (SD = 0.91).

Two 28 day carcass retention (CARE) trials were conducted in FY 2015 Q4 using 10 small (rat) and 2 medium (WTSH) size carcasses in short vegetation and 9 small (rat) size carcasses in medium vegetation. Considering only the first 14 days as the trial length in order to compare current trials to past trials that lasted only 14 days, the FY 2015 Q4 site CARE mean and SD in days for all small carcasses is 8.1 (SD = 5.5) and for medium carcasses is 14.0 (SD = 0). The overall FY 2015 small carcass CARE in days is 8.4 (SD = 5.5) and medium carcass CARE in days is 14.0 (SD = 0).

The overall searcher efficiency (SEEF) in FY 2015 Q4 for small (N = 61) and medium size carcass trials (N = 11) combining both vegetation classes is 86.9% and 100%, respectively, and for FY 2015 overall for small (N = 188) and medium carcasses (N = 42) is 84.6% and 100%, respectively.

In FY 2015 an overhaul of the scavenger control program led to a redeployment and redistribution of all traps. For FY 2015 Q4 69 traps were active. We removed 45 mongoose, 11 rats and 28 pigs.

Two Hawaiian hoary bats were found in FY 2015 Q4 and a total of 10 bats were found in FY 2015. The project total observed bat take since operations began in November 2012 is 24 through the end of FY 2015. No bird species listed in the ITL and ITP were found.

The fatality estimate for 24 observed bats using the Evidence of Absence estimator (Huso et al, 2015) at the 80% credibility levels is 40 and the total indirect take (IDT) considering the credibility level is 3.28 juveniles. After dividing the IDT by 2.1 to determine adult from juvenile take the total bat take is 42 (80% credibility).

Also found in FY 2015 were 4 Migratory Bird Treaty Act (MBTA) species: three white-tailed tropicbirds, one Pacific golden-plover and 59 non-native introduced bird species including:, 17 spotted doves, eight nutmeg mannikins, 17 common myna, five common waxbill, three zebra dove, four red-crested cardinals, one Japanese white-eye, two Java sparrows, one orange cheeked waxbill and one house finch.

Thirty of 30 active Wildlife Acoustics™ SM2BAT+ ultrasonic detectors (SM2) with one SM3BAT™ microphone (mic) each located 75m from 30 WTGs detected Hawaiian hoary bats on 649 of 2688 detector nights (24.1% of detector nights) in FY 2015 Q4. Twelve of 12 active SM2s with one SM3 mic each positioned at various heights in or at the edge of gulches that are near to WTGs detected bats on 151 of 1004 detector nights (15.0% of detector nights). Twenty-two of 30 active SM2s in WTG nacelles at 100m above ground level with one SM3 mic each detected bats on 42 of 2587 detector nights (1.6% of detector nights.

‘Uko’a Wetland predator trapping, bat acoustic monitoring, insect assessment and fence maintenance as part of Tier 1 mitigation for waterbirds and bats continued through FY 2015. Vegetation management has been suspended pending authorization from the landowner. Seabird colony activity assessment on Kauai was completed for the breeding season in FY 2015 Q1 and a summary report was delivered in FY 2015 Q3. This assessment is part of a predator control project co-funded by Kahuku Wind Power and completes the seabird mitigation for KAW. Priorities for Tier 2 and 3 bat mitigation to be approved by USFWS and DOFAW will be determined in FY 2016 Q1.

SunEdison biologists conducted two Wildlife Education and Observation Program (WEOP) trainings in FY 2015 Q4 and a total of ten for FY 2015.

KAW monthly calls with the Division of Forestry and Wildlife (DOFAW) and the U.S. Fish and Wildlife Service (USFWS) continue to review bat mitigation and adaptive management progress. SunEdison biologists met with the Endangered Species Recovery Committee (ESRC) on October 24, 2014 to review the FY 2014 HCP annual report and on December 16, 2014 to review interim monitoring protocols and a Resource Equivalency Analysis for determining the amount of mitigation required to offset anticipated take of bats. SunEdison biologists met with the ESRC on March 31, 2015 to receive their determination on post-intensive downed wildlife monitoring protocols. A bat workshop organized by the DOFAW was held on April 14 and 15, 2015. Experts, ESRC members, consultants, and HCP permittees and applicants attended the workshop.

Introduction

This report summarizes work performed by SunEdison for KAW under the terms of the approved HCP dated October 27, 2011 and pursuant to the obligations contained in the project's ITL and ITP at the conclusion of the State of Hawaii 2015 fiscal year (FY2015: July 1, 2014-June 30, 2015).

The ITP and ITL were issued for the project in December 2011 and January 2012, respectively. The ITP and ITL cover six federally-listed threatened and endangered species and one state-listed endangered species: the Hawaiian stilt or ae'o (*Himantopus mexicanus knudseni*), Hawaiian coot or 'alae ke'oke'o (*Fulica alai*), Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*), Newell's shearwater or 'a'o (*Puffinus auricularis newelli*), Hawaiian hoary bat or 'ope'ape'a (*Lasiurus cinereus semotus*) and the Hawaiian short-eared owl or Pueo (*Asio flammeus sandwichensis*), respectively.

KAW was commissioned for operation on November 2, 2012. The KAW site layout, WTG and bat detector locations are depicted in Figure 1. Detailed descriptions of the following sections can be found in previous annual reports.

Fatality Monitoring

Searches are conducted by a team of trained HCP Compliance Technicians employed by SunEdison and based at the project site. Specially trained dogs assist personnel with searches. As of the end of FY 2015 four HCP Compliance Technicians, one Compliance Supervisor, one Canine Supervisor (a canine handler) and one Canine contractor were assigned to the site under the direction of the Hawaii HCP Compliance Manager. Searching was subsequently conducted with canines only (or visually on the occasion when enough canines are not available).

Fatality monitoring plots were reduced from full intensive monitoring on September 1, 2014 to 75 m radius circular plots (the 50% search plots) centered on the wind turbine generators (WTGs) searched twice weekly. Search dates for each WTG and the meteorological (MET) towers during FY 2015 Q4 are in Appendix 1. The FY 2015 Q4 50% plot mean for search intervals in days was 3.50 (SD = 0.86). For FY 2015 the 50% plot mean and SD for all WTGs combined for search interval in days was 3.50 (SD = 0.91).

Vegetation Management

Fatality monitoring plots around the WTGs and MET tower are mowed regularly.

Carcass Retention Trials

Two 28 day carcass persistence (CARE) trials were conducted in FY 2015 Q4 using 10 small (rat) and 2 medium (WTSH) size carcasses in short vegetation and 8 small (rat) size carcasses in medium vegetation (Q4 trials are shown in Appendices 2 and 3). CARE trials in the past and at other sites have only lasted for 14 days. Trial lengths recently have been standardized to one month. Since all CARE trials have lasted at least 14 days for comparison we present the mean here assuming trials lasted only 14 days.

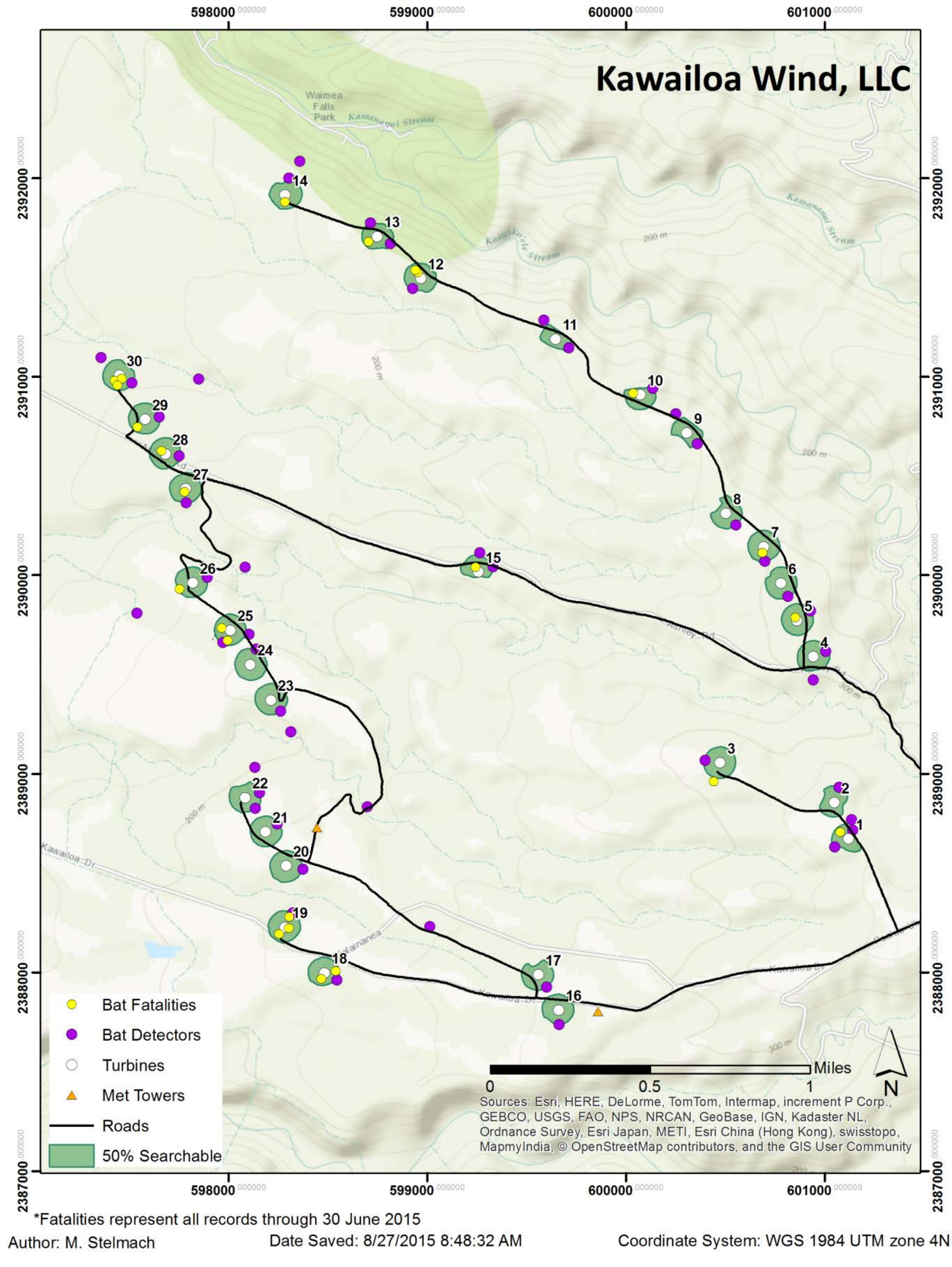


Figure 1. KAW roads, Turbines, MET towers, bat detector and fatality locations.

When estimating fatalities however we use the data as it has been collected (up to 30 day trials). Considering only the first 14 days as the trial length in order to compare current trials to past trials that lasted only 14 days, the FY 2015 Q4 site CARE mean and SD in days for all small carcasses is 8.1 (SD = 5.5) and for medium carcasses is 14.0 (SD = 0). The overall FY 2015 small carcass CARE in days is 8.4 (SD = 5.5) and medium carcass CARE in days is 14.0 (SD = 0).

Searcher Efficiency Trials

The overall searcher efficiency (SEEF) in FY 2015 Q4 for small (N = 61) and medium size carcass trials (N = 11) combining both vegetation classes is 86.9% and 100%, respectively (Appendix 4), and for FY 2015 overall for small (N = 188) and medium carcasses (N = 42) is 84.6% and 100%, respectively.

Scavenger Trapping

In FY 2015 an overhaul of the scavenger control program led to a redeployment and redistribution of all traps. We deployed traps considering the following criteria: Afternoon shade, Usable habitat (Not dense California grass), Repeat habitat use (trails or water sources), and some accessible form of cover (nearby brush). For FY 2015 Q4 we have a total of 69 traps deployed (Table 1). We removed one cat, 55 mongoose, 18 rats, and 28 pigs (Table 2).

Trap Type	# Active Traps
GoodNature A24	41
DOC 250	23
Corral	5

Take Species	Number Caught
Mongoose	45
Rat	11
Pig	28

Table 1 and 2. Trap deployments by trap type, Summary of trapping results for FY 2015 Q4.

Downed Wildlife

Of the seven species listed in the ITL we documented take of two Hawaiian hoary bats during FY 2015 Q4, on 29 May and 4 June, 2015. A total of 24 Hawaiian hoary bat fatalities (five in FY 2013, nine in FY 2014 and ten in FY 2015) have been found at the site since operations began Nov 2, 2012 through June 30, 2015.

In FY 2015 SunEdison biologists also found 63 bird carcasses. None were of species listed as state or federally endangered or threatened. These were four Migratory Bird Treaty Act (MBTA) species including three white-tailed tropicbirds, one Pacific golden plover and 59 non-native introduced bird species including 17 spotted doves, 17 common myna, eight nutmeg mannikins, five common waxbill, four red-crested cardinals, three zebra dove, two Java sparrows, one Japanese white-eye, one orange cheeked waxbill and one house finch.

For a complete list of fatalities for FY 2015 see Appendix 5.

Hawaiian Hoary Bat Take Estimation

Results are reported using Huso et al. (2015) to estimate unobserved direct take (UDT). Take is reported here at the 80% (more conservative) credibility level. The estimated direct take (observed direct take (ODT) plus UDT)) for the 24 Hawaiian hoary bat fatalities found between the start of operation (November 2, 2012) and June 30, 2015 is 40 bats (80% credibility) (Appendix 6).

In addition to direct take, indirect take (IDT) is estimated separately to account for the loss of dependent young that may occur indirectly as the result of the loss of an adult female during the breeding season. Adult female fatalities found during the breeding season are assumed to have dependent young, and an indirect take of 1.8 juveniles (2 pups X 0.9 survival rate) is assessed. The sex ratio of adult bats of known sex found on Oahu during April through September (the currently accepted breeding season) is nine male to four female (and 10 unknown). If we assume the male to female ratio applies to the three bats of unknown sex found during the breeding season then the likelihood is 0.31 that these bats were female. Therefore the IDT from these three observed adults of unknown sex is assumed to be 0.68 juveniles (3 X 0.31 X 1.8 = 1.68).

The UDT is 16 bats (40 minus 24) at the 80% credibility levels. The formula provided in the HCP for calculating IDT uses the UDT and multiplies the rate of 0.1 juvenile per one UDT. The calculated range of IDT considering the chosen credibility level is 1.6 juvenile bats. The IDT total through FY 2015 Q4 therefore is 3.28 juveniles (1.68 + 1.6 = 3.28).

Under the ITL/ITO clarification dated May 20, 2014, the range of juvenile take (80% credibility level) converted to adults is 3.28/2.1 or 1.6. The project's estimated take therefore is 40 plus two bats or 42 rounded up which is above the Tier 2 20-year range of 20-40.

Hawaiian Hoary Bat Monitoring

Thirty of 30 active Wildlife Acoustics™ SM2BAT+ ultrasonic detectors (SM2) with one SM3BAT™ microphone (mic) each located 75m from 30 WTGs detected Hawaiian hoary bats on 649 of 2688 detector nights (24.1% of detector nights) in FY 2015 Q4 (Appendix 7). Twelve of 12 active SM2s with one SM3 mic each positioned at various heights in or at the edge of gulches that are near to WTGs detected bats on 151 of 1004 detector nights (15.0% of detector nights) in FY 2015 Q4. Twenty-two of 30 active SM2s in WTG nacelles at 100m above ground level with one SM3 mic each detected bats on 42 of 2587 detector nights (1.6% of detector nights) in FY 2015 Q4.

Detectors on the ground and in gulches were not operational in November and December 2014 while mics were being upgraded from SM2 to SM3 mics. After the upgrade to Wildlife Acoustics SM3 mics only one mic per detector is active. Mics for detectors at nacelle height are also upgraded and only one mic per detector is active. That mic is horizontal to the ground and points directly behind the nacelle. The noticeable increase in detections in January through June 2015 compared to the same months in 2014 may be an artifact of having changed to the more reliable SM3 mic.

Wildlife Education and Observation Program

SunEdison biologists conducted two Wildlife Education and Observation Program (WEOP) trainings in FY 2015 Q4.

Mitigation and Adaptive Management

Hawaiian Hoary Bats and Waterbirds

‘Uko’a Wetland predator trapping, bat acoustic monitoring, insect assessment and fence maintenance as part of Tier 1 mitigation for waterbirds and bats continued through FY 2015. A Conservation License is currently being negotiated between the owners of KAW and the landowner, Kamehameha Schools, to confirm long term access to the ‘Uko’a Wetland mitigation site. In the interim a short-term Right of Entry agreement has been signed to allow SunEdison and its sub-contractors access to the ‘Uko’a Wetland mitigation site. The wetlands invasive vegetation removal part of the mitigation plan for waterbirds and bats has been delayed pending execution of the Conservation License. Grey Boar Wildlife Services contract was renewed for a year to continue to control pigs, cats, Mongoose and rats at ‘Uko’a.

Insect assessment for FY 2014-15 is complete and the results of the collections have been analyzed by Dr. Karl Magnacca.

Vegetation

Priorities for Tier 2 and 3 bat mitigation to be approved by USFWS and DOFAW will be determined in FY 2016 Q1.

Newell’s Shearwater

Seabird colony activity assessment funded by KAW and implemented by the Kaua'i Endangered Seabird Recovery Project (KESRP) on Kauai using Wildlife Acoustics Songmeters™ was completed for the 2014 breeding season in FY 2015 Q1. Analysis was completed in FY 2015 Q2 and the final report provided in FY 2015 Q3 (Appendix 8). This assessment is part of a predator control project co-funded by Kahuku Wind Power. Seabird colony activity assessment on Kauai was completed for the breeding season in FY 2015 Q1 and a summary report was delivered in FY 2015 Q3.

Adaptive Management

Low wind speed curtailment (LWSC) that had been required in the original HCP to span March 1-November 30 annually and at 5 m/s at KAW now spans February 6 to December 15. As an adaptive management response to a greater than expected rate of bat take, the original span was extended to December 15 in December 2012 and to February 10 and then February 6 in February 2013 and February 2015, respectively. Adaptive management continues as site wide bat activity assessment and weather data recording. See also *Hawaiian Hoary Bat Monitoring* above regarding Adaptive Management.

Agency Meetings and Visits

KAW monthly calls with DOFAW and USFWS continue to review bat mitigation and adaptive management progress. SunEdison biologists met with the ESRC on October 24, 2014 to review the FY 2014 HCP annual report and on December 16, 2014 to review interim monitoring protocols and a Resource Equivalency Analysis for determining the amount of mitigation required to offset anticipated take of bats. SunEdison biologists met with the ESRC on March 31, 2015 to receive their determination on post-intensive downed wildlife monitoring protocols. The ESRC agreed that reducing the size of the search plots was appropriate and that the extent of the reduction would be determined by the state and federal wildlife agencies. A bat workshop organized by the DOFAW was held on April 14 and 15, 2015. Experts, ESRC members, consultants, and HCP permitees and applicants attended the workshop.

Expenditures

KAW total HCP related expenditures in FY 2015 were $875,255 (Appendix 9).

Citations

Manuela M. P. Huso, Daniel H. Dalthorp, David A. Dail, and Lisa J. Madsen. 2015. Estimating wind-turbine caused bird and bat fatality when zero carcasses are observed. Ecological Applications. http://dx.doi.org/10.1890/14-0764.1

Appendix 1. Fatality Monitoring Plot Search Dates at KAW in FY 2015 Q4. All dates are for the area within the 50% perimeter.

WTG															
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/30	3/31
4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/1	4/2
4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/6	4/7
4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/9	4/10
4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/13	4/14
4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/16	4/17
4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/20	4/21
4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/23	4/24
4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/27	4/28
4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	4/30	5/1
5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/5
5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/7	5/8
5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/11	5/12
5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/15
5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/18	5/19
5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/21	5/22
5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/27
5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/28	5/29
6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/1	6/2
6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/3	6/4
6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/8	6/9
6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/11	6/12
6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/15	6/16
6/19	6/19	6/19	6/18	6/19	6/19	6/19	6/18	6/18	6/18	6/18	6/18	6/18	6/18	6/18	6/19
6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/22	6/23
6/25	6/25	6/25	6/25	6/25	6/25	6/25	6/24	6/24	6/24	6/25	6/25	6/25	6/25	6/25	6/25
6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/29	6/30

Appendix 1. (cont.)

WTG															
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**Met1**	**Met2**
3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31	3/31
4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2
4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7	4/7
4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10	4/10
4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14	4/14
4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17	4/17
4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21	4/21
4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24	4/24
4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28	4/28
5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1	5/1
5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12	5/12
5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15	5/15
5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19	5/19
5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22	5/22
5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27	5/27
5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29
6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2
6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4	6/4
6/9	6/8	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9	6/9
6/12	6/9	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12
6/16	6/12	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16
6/19	6/16	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19	6/19
6/23	6/19	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23	6/23
6/25	6/23	6/26	6/25	6/26	6/26	6/26	6/26	6/26	6/26	6/26	6/26	6/26	6/26	6/26	6/26
6/30	6/26	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30	6/30
	6/30														

Appendix 2. CARE Trial T at KAW in FY 2015 Q4.

CARE T FY2015		1		2		3		4		5		6		7		8		9		10	
Carcass Type		Rat		Rat		Bird		Rat		Rat		Rat		Rat		Rat		Rat		Rat	
WTG		10		20		10		18		24		21		15		5		7		21	
Vegetation		Short		Short		Short		Short		Short		Medium		Short		Medium		Short		Medium	
Distance (m)		66		44		58		73		41		67		28		63		39		51	
SEEF ID pt #		1808		4924		1967		6340		6972		5166		142		581		1171		5052	
Day	Date	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes
day 0	21-Apr	P		P		P		P		P		P		P		P		P		P	
day 1	22-Apr	P		P		P		P		P		P		P		P		P		P	
day 2	23-Apr	P		P	A	P		P		P	I	P		P	A	P		P		**P**	I
day 3	24-Apr	P		P	I,A	P	I	P		P	I	P		P	A	P		P	I	A	
day 4	25-Apr	P	I	P		P	I	P	M	P	I	P		P	D	P		P	I		
day 5	26-Apr	P		P		P		P	M	**P**		P		P		P	I	P	H		
day 6	27-Apr	P		**P**	H	P	I	**P**		A		P	I	P		P		P			
day 7	28-Apr	P		A		P	I	A				P	I	**P**		P		P			
day 8	29-Apr	P	I			P						P		A		P	I	P	I		
day 9	30-Apr	P				P						P				P		P			
day 10	1-May	P				P						P				P	Mowed	P			
day 11	2-May	P				P						P				P	S	P			
day 12	3-May	P				P	M					P				**P**		P	S		
day 13	4-May	P	D			P	M					P				A		**P**	S		
day 14	5-May	P				P						**P**						A			
day 21	12-May	P				P						A									
day 28	19-May	**P**				**P**															
Retention (days)		***28***		***6***		***28***		***6***		***5***		***14***		***7***		***12***		***13***		***2***	

Appendix 3. CARE Trial U at KAW in FY 2015 Q4.

CARE U FY2015		1		2		3		4		5		6		7		8		9		10	
Carcass Type		Rat		Rat		Rat		Rat		Rat		Rat		Bird		Rat		Rat		Rat	
WTG		19		18		8		9		27		24		15		14		18		7	
Vegetation		Medium		Medium		Medium		Short		Medium		Short		Short		Short		Medium		Short	
Distance (m)		42		44		69		74		69		31		46		63		37		62	
SEEF ID pt #		6104		6458		1404		1618		4661		6901		93		2973		6447		1006	
Day	Date	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes	P/A	Notes
day 0	2-Jun	P		P		P		P		P		P		P		**P**		P		P	
day 1	3-Jun	**P**		P		P		**P**		**P**		P		P		A		P		P	
day 2	4-Jun	A		P		P		A		A	Pigs	P	H	P	I			P		P	
day 3	5-Jun			P		P						P		P				P		P	
day 4	6-Jun			P		P						P	H	P				P		P	
day 5	7-Jun			P		P						P		P	M			P		P	
day 6	8-Jun			P		P						P		P	D			P		P	
day 7	9-Jun			P		P						**P**	H	P				P		P	S
day 8	10-Jun			P		P						A		P				P		P	
day 9	11-Jun			P		P								P				P		P	
day 10	12-Jun			P		P								P				P		P	
day 11	13-Jun			P		P								P				P		P	
day 12	14-Jun			P		P								P				P		P	
day 13	15-Jun			P		P								P				P		P	
day 14	16-Jun			P		P								P				**P**		**P**	
day 21	23-Jun			P		P								P				A		A	
day 28	30-Jun			**P**		**P**								**P**							
Retention (days)		***1***		***28***		***28***		***1***		***1***		***7***		***28***		***0***		***14***		***14***	

Appendix 4. SEEF Trials at KAW in FY 2015 Q4.

Trial date	WTG	VegType	Carcass type	Found	K9/Human	Distance	Point ID
4/1/2015	01	Short	Rat	True	K9	10	KW 459
4/1/2015	01	Short	Rat	True	K9	70	KW461
4/1/2015	03	Short	Rat	True	K9	12	KW464
4/1/2015	13	Short	Rat	True	K9	50	KW458
4/9/2015	10	Short	Bird	True	K9	55	KW448
4/9/2015	12	Short	Rat	True	K9	60	KW449
4/9/2015	14	Short	Rat	True	K9	10	KW452
4/10/2015	16	Short	Rat	True	K9	62	888
4/10/2015	18	Short	Bird	True	K9	26	887
4/10/2015	19	Short	Rat	True	K9	32	886
4/10/2015	26	Short	Rat	True	K9	5	891
4/10/2015	29	Short	Rat	True	K9	73	893
4/14/2015	17	Short	Bird	True	K9	31	906
4/14/2015	20	Short	Rat	True	K9	35	909
4/14/2015	22	Short	Rat	True	K9	39	903
4/14/2015	24	Short	Rat	True	K9	18	901
4/14/2015	25	Short	Rat	True	K9	41	905
4/14/2015	26	Short	Rat	True	K9	71	910
4/14/2015	27	Short	Rat	True	K9	73	904
4/14/2015	29	Short	Rat	True	K9	66	902
4/16/2015	03	Medium	Rat	True	K9	60	KW447
4/16/2015	05	Short	Rat	True	K9	35	KW445
4/16/2015	12	Short	Rat	True	K9	18	KW441
4/21/2015	19	Short	Rat	True	K9	65	KW457
4/21/2015	19	Medium	Rat	True	K9	55	KW460
4/21/2015	28	Short	Rat	True	K9	11	KW465
4/21/2015	29	Short	Rat	True	K9	50	KW462
4/23/2015	01	Short	Rat	True	K9	22	938
4/23/2015	03	Medium	Rat	True	K9	29	940
4/23/2015	14	Short	Bird	True	K9	30	939
4/23/2015	07	Short	Rat	False	K9	48	946
4/23/2015	09	Short	Rat	False	K9	62	944
4/27/2015	04	Short	Bird	True	K9	65	KW437

4/27/2015	04	Short	Rat	False	K9	48	KW436
4/27/2015	05	Short	Rat	True	K9	55	KW438
5/4/2015	01	Short	Rat	True	K9	2	978
5/4/2015	04	Short	Rat	True	K9	22	982
5/4/2015	05	Short	Bird	True	Human	7	984
5/4/2015	07	Short	Rat	True	Human	27	980
5/4/2015	09	Short	Rat	True	K9	17	985
5/4/2015	13	Short	Rat	True	K9	1	983
5/5/2015	20	Short	Rat	True	K9	60	KW455
5/5/2015	21	Short	Bird	True	K9	70	KW454
5/5/2015	21	Short	Rat	True	K9	46	KW456
5/5/2015	29	Short	Rat	True	K9	53	KW453
5/21/2015	04	Short	Rat	True	K9	11	1063
5/21/2015	06	Short	Rat	True	K9	26	1067
5/21/2015	06	Short	Rat	True	K9	18	1068
5/21/2015	08	Short	Rat	True	K9	49	1058
5/22/2015	28	Short	Rat	True	K9	20	KW451
5/22/2015	28	Short	Bird	True	K9	15	KW450
5/22/2015	30	Short	Rat	True	K9	30	KW444
5/22/2015	22	Short	Rat	False	K9	71	KW446
5/29/2015	20	Short	Rat	True	K9	6	1086
5/29/2015	21	Short	Rat	True	K9	54	1087
5/29/2015	22	Short	Rat	False	Human	14	1090
6/4/2015	24	Short	Bird	True	K9	6	1112
6/4/2015	22	Short	Rat	True	K9	24	1116
6/8/2015	04	Short	Rat	True	K9	42	1128
6/8/2015	07	Short	Rat	True	K9	23	1136
6/8/2015	03	Short	Rat	False	K9	60	1135
6/8/2015	10	Short	Bird	True	Human	0	1131
6/12/2015	17	Short	Rat	True	K9	36	KW443
6/12/2015	25	Short	Rat	True	Human	40	KW442
6/12/2015	26	Short	Rat	True	K9	30	KW435
6/12/2015	23	Short	Rat	False	K9	56	KW439
6/16/2015	16	Medium	Rat	True	K9	40	KW430
6/16/2015	24	Short	Rat	False	K9	42	KW432
6/16/2015	28	Short	Bird	True	K9	40	KW433
6/16/2015	28	Short	Rat	True	K9	21	KW434
6/19/2015	16	Short	Rat	True	K9	40	1188
6/19/2015	16	Short	Rat	True	K9	47	1186

Appendix 5. All fatalities at KAW in FY 2015 Q4.

Hawaiian Hoary Bat Fatalities in FY 2015					
Age	Sex	Fatality Date	Turbine	Distance to WTG(m)	Bearing from WTG (deg)
Unknown	Unknown	Friday, July 18, 2014	30	51	192
Adult	Male	Tuesday, August 26, 2014	27	17	205
Adult	Unknown	Friday, August 29, 2014	19	20	103
Adult	Female	Monday, September 08, 2014	12	33	331
Adult	Male	Monday, September 15, 2014	7	30	192
Adult	Unknown	Tuesday, November 04, 2014	18	35	208
Adult	Female	Friday, February 06, 2015	19	58	22
Adult	Male	Thursday, March 12, 2015	12	50	327
Adult	Male	Friday, May 29, 2015	28	27	310
Unknown	Unknown	Thursday, June 04, 2015	18	57	81

Migratory and Non-listed Fatalities for FY 2015				
Common Name	Fatality Date	Turbine	Distance to WTG(m)	Bearing from WTG (deg)
Acridotheres tristis (Common Myna)	7/10/2014	14	3	10
Acridotheres tristis (Common Myna)	7/10/2014	13	3	10
Lonchura punctulata (Nutmeg Mannikin)	7/11/2014	18	27	222
Paroaria coronata (Red Crested Cardinal)	7/14/2014		*	*
Lonchura punctulata (Nutmeg Mannikin)	7/14/2014	04	17	200
Acridotheres tristis (Common Myna)	7/22/2014	30	3	51
Acridotheres tristis (Common Myna)	7/25/2014	18	2	90
Acridotheres tristis (Common Myna)	7/25/2014	25	3	90
Acridotheres tristis (Common Myna)	7/25/2014	25	3	90
Acridotheres tristis (Common Myna)	7/25/2014	28	3	90
Acridotheres tristis (Common Myna)	7/25/2014	28	3	90
Acridotheres tristis (Common Myna)	7/25/2014	28	3	90
Acridotheres tristis (Common Myna)	7/29/2014	20	4	90
Acridotheres tristis (Common Myna)	7/29/2014	22	3	61
Acridotheres tristis (Common Myna)	7/31/2014	14	1	90
Lonchura punctulata (Nutmeg Mannikin)	8/26/2014	23	34	280
Lonchura punctulata (Nutmeg Mannikin)	8/26/2014	23	32	260
Spilopelia chinensis (Spotted Dove)	9/16/2014	25	1	270
Spilopelia chinensis (Spotted Dove)	9/18/2014	04	1	90
Paroaria coronata (Red Crested Cardinal)	9/19/2014	19	1	120
Spilopelia chinensis (Spotted Dove)	9/30/2014	29	0	90
Lonchura punctulata (Nutmeg Mannikin)	9/30/2014	27	60	240

Migratory and Non-listed Fatalities for FY 2015				
Common Name	Fatality Date	Turbine	Distance to WTG(m)	Bearing from WTG (deg)
Acridotheres tristis (Common Myna)	10/2/2014	04	2	90
Acridotheres tristis (Common Myna)	10/2/2014	05	50	270
Estrilda astrild (Common Waxbill)	10/9/2014	06	1	105
Acridotheres tristis (Common Myna)	10/14/2014	05	4	90
Acridotheres tristis (Common Myna)	10/14/2014	06	4	90
Spilopelia chinensis (Spotted Dove)	10/14/2014	08	1	170
Spilopelia chinensis (Spotted Dove)	10/15/2014	19	1	130
Paroaria coronata (Red Crested Cardinal)	10/21/2014	18	1	350
Spilopelia chinensis (Spotted Dove)	10/31/2014	21	0	165
Zosterops japonicus (Japanese White-eye)	11/10/2014	08	48	159
Lonchura oryzivora (Java Sparrow)	12/1/2014	22	100	180
Lonchura oryzivora (Java Sparrow)	12/1/2014	22	100	180
Geopelia striata (Zebra Dove)	12/2/2014	20	1	45
Unknown (Unknown)	12/24/2014	21	20	225
Haemorhous mexicanus (House Finch)	1/9/2015	17	30	210
Spilopelia chinensis (Spotted Dove)	1/22/2015	04	1	210
Geopelia striata (Zebra Dove)	1/23/2015	21	1	40
Spilopelia chinensis (Spotted Dove)	2/10/2015	24	2	
Estrilda astrild (Common Waxbill)	2/23/2015	02	1	135
Spilopelia chinensis (Spotted Dove)	2/23/2015	02	1	50
Spilopelia chinensis (Spotted Dove)	3/10/2015	27	1	170
Estrilda astrild (Common Waxbill)	3/12/2015	01	26	180
Estrilda astrild (Common Waxbill)	3/12/2015	03	69	110
Spilopelia chinensis (Spotted Dove)	3/20/2015	18	1	14
Spilopelia chinensis (Spotted Dove)	3/24/2015	18	1	315
Paroaria coronata (Red Crested Cardinal)	3/31/2015	28	1	90
Spilopelia chinensis (Spotted Dove)	4/14/2015	23	2	170
Pluvialis fulva (Pacific Golden-Plover)	4/14/2015	25	58	112
Lonchura punctulata (Nutmeg Mannikin)	5/1/2015	25	21	144
Spilopelia chinensis (Spotted Dove)	5/4/2015	11	1	75
Phaethon lepturus (White-tailed Tropicbird)	5/5/2015	23	39	300
Spilopelia chinensis (Spotted Dove)	5/11/2015	12	1	145
Lonchura punctulata (Nutmeg Mannikin)	5/12/2015	23	60	300
Spilopelia chinensis (Spotted Dove)	5/29/2015	16	1	90
Acridotheres tristis (Common Myna)	6/8/2015	06	2	90
Lonchura punctulata (Nutmeg Mannikin)	6/8/2015	07	55	315
Estrilda melpoda (Orange Cheeked Waxbill)	6/11/2015	04	255	255

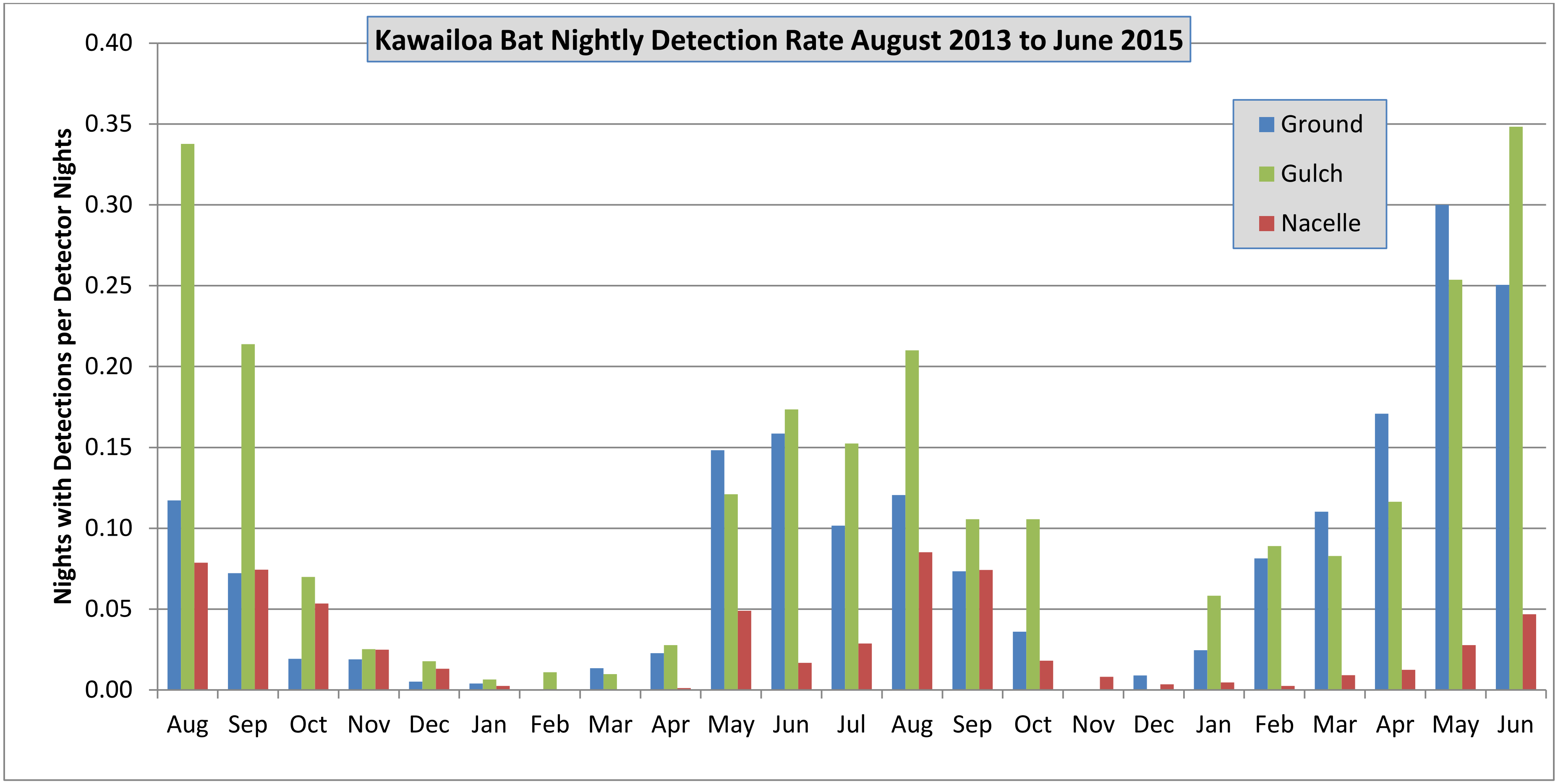
Migratory and Non-listed Fatalities for FY 2015				
Common Name	Fatality Date	Turbine	Distance to WTG(m)	Bearing from WTG (deg)
Spilopelia chinensis (Spotted Dove)	6/19/2015	28	1	2
Geopelia striata (Zebra Dove)	6/19/2015	28	34	2
Phaethon lepturus (White-tailed Tropicbird)	6/26/2015	24	43	240
Estrilda astrild (Common Waxbill)	6/29/2015	07	20	65
Phaethon lepturus (White-tailed Tropicbird)	6/30/2015	20	52	203

*****Carcass found inside the O&M building, not associated with a turbine.

Appendix 6. Huso et al (2015) Fatality Estimation for Hawaiian hoary bats at KAW through FY 2015.

Credibility level (1 - ?)						Posterior distribution for total fatality for 3 years.				
0.8						g = P(observe| arrive):	0.673	95% CI:	0.628	0.717
Yr	Obs. Fat.	g	min(g)	max(g)	Years	80% credible maximum:	**40**			
1	5	0.540	0.430	0.648	0.67	m	P(total = m)	P(total > m)		
2	9	0.676	0.637	0.713	1	0	0	1		
3	10	0.760	0.724	0.794	1	1	0	1		
						35	0.092	0.529		
						36	0.090	0.439		
						39	0.064	0.216		
						40	0.053	0.163		

Appendix 7. Ground, gulch and nacelle bat detections at KAW between August 2013 and June 2015.



Appendix 8.

Acoustic Surveys for Newell's Shearwater, Hawaiian Petrel, Band-rumped Storm-petrel, and Barn Owl at First Wind conservation action sites – Kaua'i and Lehua

Final Report
December 17, 2014

For: **Mitchell Craig, Hawaii HCP Manager, First Wind**
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Summary

This report contains results and analysis of 2014 acoustic monitoring efforts for four species - Newell's Shearwater, Hawaiian Petrel, Band-rumped Storm-petrel, and Barn Owl - at survey sites on Kaua'i and Lehua where Barn Owl *Tyto alba* control actions are due to be undertaken under funding from First Wind as part of their on-going mitigation efforts. Barn Owl control will be undertaken by DOFAW while seabird monitoring is being carried out by the Kaua'i Endangered Seabird Recovery Project.

Surveys were conducted at 11 sites - 8 on Kaua'i and 3 on Lehua Island. Newell's Shearwater calls were detected at all sites on Kaua'i, with the highest activity detected at ROVFW7 (Mean call rate of 12.86 calls per minute +/- 6.96 S.D. throughout the entire survey period) and with consistent activity at ROVFW1, ROVFW4, ROVFW8, and ROVFW9. No Newell's Shearwater calls were detected on Lehua in 2014. Hawaiian Petrel calls were detected intermittently only at ROVFW2 and ROVFW3 on Kaua'i. Microphone failures at these two sites likely reduced detection rates in 2014. No Hawaiian Petrel calls were detected on Lehua in 2014. Band-rumped Storm-petrel calls were detected at all Kaua'i sites except ROVFW2 and ROVFW3, as well as at Lehua1 survey site (though at relatively low-rates). The site with the greatest amount of Band-rumped Storm-petrel activity was ROVFW7, where the mean call rate was 1.56 calls per minute (+/- 1.65 S.D.) during the entire survey period. Barn Owl calls were detected at all sites on Lehua, as well as at ROVFW1, ROVFW2, ROVFW4, ROVFW7, ROVFW8, ROVFW9. The highest Barn Owl activity was at ROVFW7, with an average call rate of 1.72 calls per night (+/- 1.93 S.D.) over the entire survey period.

Introduction

Seabirds play an important ecological role on many islands throughout the Pacific Ocean. In the main Hawaiian Islands there are three nocturnal burrow nesting seabird species of conservation concern. The Hawaiian Petrel (*Pterodroma sandwichensis* or 'Ua'u) is an endangered species and the Newell's Shearwater (*Puffinus newelli* or 'A'o) is a threatened species under the U.S. Endangered Species Act. The Band-rumped Storm-petrel (*Oceanodroma castro* or 'Ake'ake) is listed as a Least Concern species by IUCN, but the Hawaiian breeding population is a candidate species for listing under the U.S. Endangered Species Act. Recovery plans for these species require identification of critical breeding habitat, reliable estimation of population trends, documentation and quantification of threats (such as introduced predators), and robust metrics for comparing the efficacy of management and mitigation actions. These monitoring efforts are challenging because the seabird species in question only return to their breeding colonies only at night, nest in cryptic underground burrows, and generally breed in terrain that make traditional surveys very difficult. Automated acoustic surveys have been shown to be an effective tool for detecting and quantifying vocal activity rates at breeding sites for a variety of nocturnal seabirds (Wiley et al. 2011; Buxton & Jones 2012; Mckown 2013; Buxton et al. 2013; Mckown & Tarango 2014a, 2014b; Oppel et al. 2014a). This novel technology can help improve the statistical power of monitoring programs while reducing the expense, logistical challenges, and unintended impacts of field research.

In 2013, the Kaua'i Endangered Seabird Recovery Project (through funding from First Wind) initiated an acoustic monitoring effort to collect baseline data on Newell's Shearwater and Hawaiian Petrel vocal activity rates at potential Barn Owl management sites on Kaua'i. In 2014, a range of new sites were surveyed on Kaua'i and Lehua, and two new species were added to the analysis – Band-rumped Storm-petrel and Barn Owl (*Tyto alba*).

Here we summarize results from an acoustic survey program designed to create a baseline of target seabird species for the Kaua'i Endangered Seabird Recovery Project as well as a baseline of Barn Owl activity prior to control. This baseline will provide the metrics necessary to help managers measure the success of management actions (namely Barn Owl control) on seabird populations in the management areas in future years.

Automated acoustic sensors for ecological monitoring

Acoustic cues have long been an important part of bird monitoring projects (Sauer et al. 1994). Recent technological innovations now make it possible to deploy weatherproof acoustic sensors that can reliably sample the acoustic environment for months at a time without maintenance. Hundreds of hours of field recordings can then be processed with pattern recognition software using deep learning and artificial neural network techniques to derive measures of acoustic activity rates for species of interest. This combination of passive acoustic sensors and automated call detection is especially powerful for monitoring rare/elusive species and species in remote locations (Acevedo & Villanueva-Rivera 2006; Agranat 2007; Brandes 2008a, 2008b).

Automated acoustic sensors have been deployed to search for rare bird species including many seabirds (McKown 2008; Buxton & Jones 2012; Buxton et al. 2013; Oppel et al. 2014b; Borker et al. 2014). Conservation Metrics has been working with the Kaua'i Endangered Seabird Recovery Project on several monitoring projects on the island of Kaua'i since 2011.

Methods

Survey Sites

In 2014, 11 acoustic sensors were deployed by the Kauai Endangered Seabird Recovery Project, split between Kaua'i and Lehua Islet. Acoustic sensors were deployed at a total of 8 survey sites on Kaua'i - 6 on the Na Pali coast and two in the southern interior of the island (deployed from 1 April 2014 to 10 September 2014, Figure 1, Figure 3). Two of these survey sites were also monitored in 2013 -ROVFW2 and ROVFW3. A total of 3 sensors were placed on Lehua Island (deployed from 15 May 2014 to 29 August 2014, Figure 2).

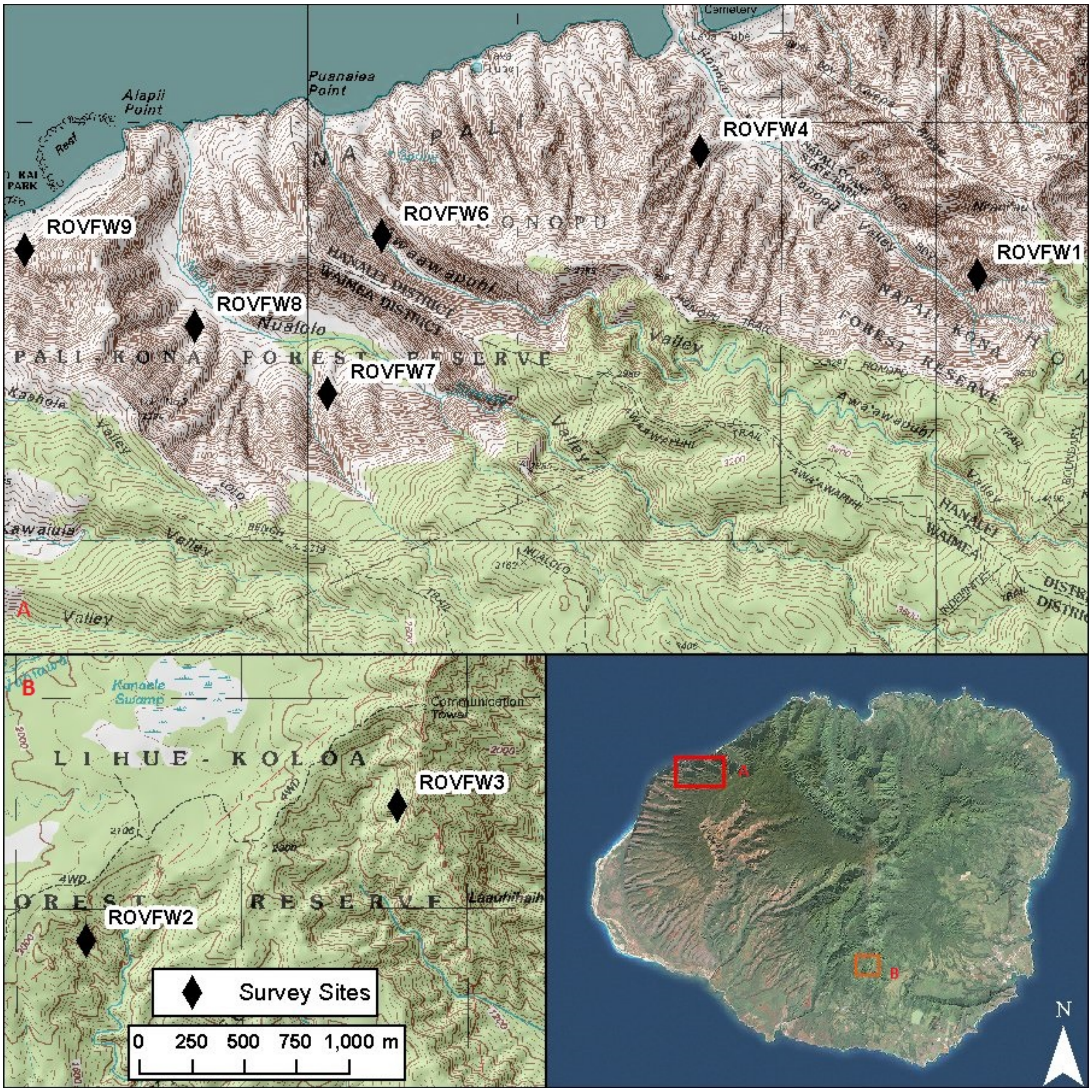

Figure 1: Survey sites on Kaua'i, HI

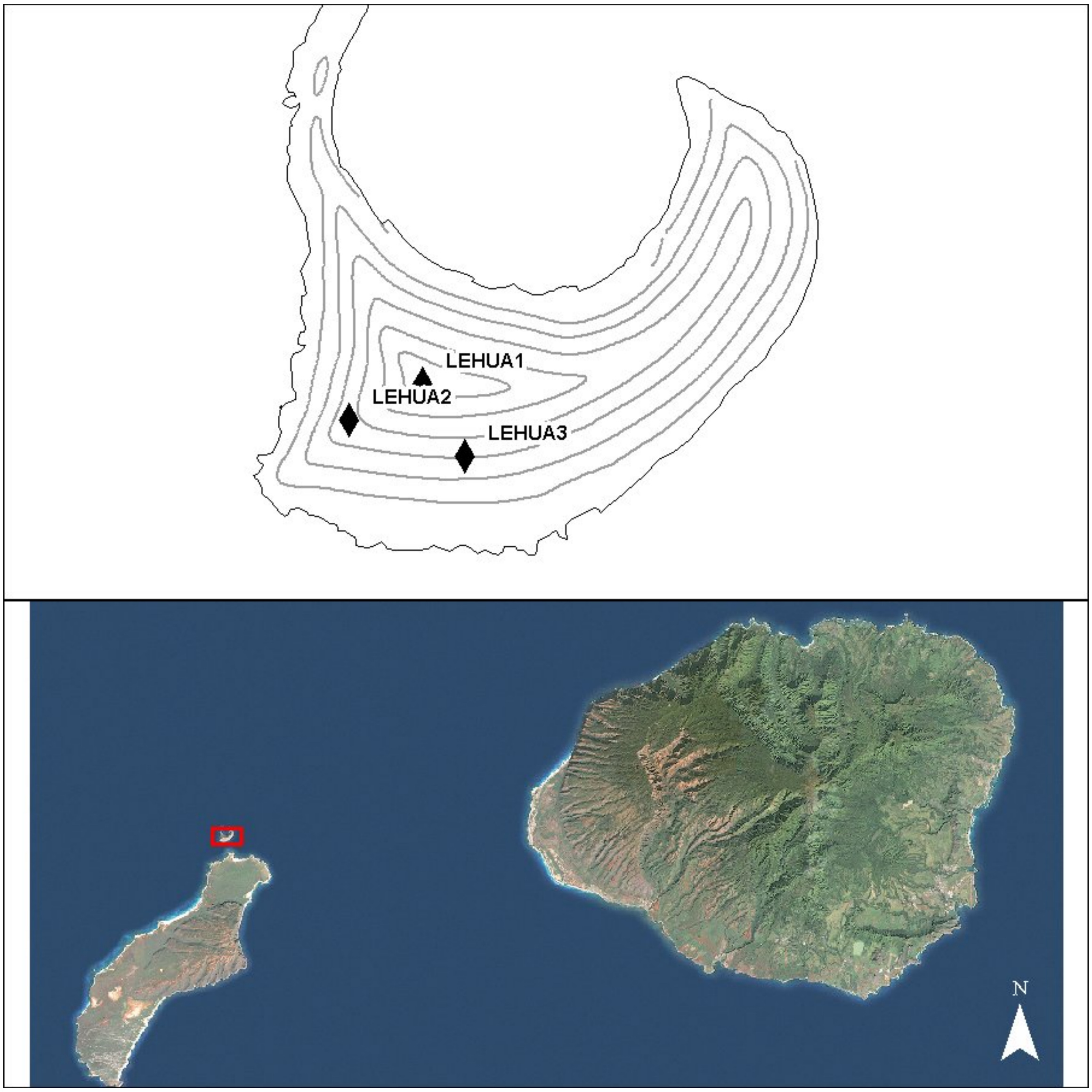

Figure 2: Survey sites on Lehua Island, located north of Ni'ihau and west of Kaua'i

Acoustic sensor hardware

All 11 acoustic sensors deployed were Song Meter II sensors (Wildlife Acoustics, Inc.) purchased by First Wind and deployed by the Kaua'i Endangered Seabird Recovery Project. The Song Meter II is a weatherproof housing containing a single-board computer, powered by four D-cell alkaline batteries, and fitted with a single SMX-II omni-directional microphone (Wildlife Acoustics, Inc.). For this project, each sensor was deployed with a single 32 GB SD memory card to store all field recordings.

Recording schedule

Song Meters were programmed using the SMCONFIG program (Version 2.2.4, Wildlife Acoustics, Inc.) to record 1 minute every 5 minutes for 3 hours after sunset, and 1 minute every 10 minutes for three hours before sunrise. All sensors were programmed to record exclusively on the left channel to reduce memory storage, and all files were recorded at a sampling rate of 22,050 Hz (16-bit). Song Meter sensors were estimated to be able to record for 76 days without new batteries or memory cards. Song Meters were deployed with microphones on the horizontal plane.

An electronic copy of the Song Meter program file (KESRP_Kauai_2014.SET) was submitted to KESRP.

Automated call detection

Automated acoustic analysis of all field recordings was carried out with a custom set of detection and classification tools built by CMI for use within the Matlab software environment. The approach uses machine learning algorithms known as Deep Neural Networks to detect sounds on field recordings with spectro-temporal properties that are similar to signals produced by target species. Deep Neural Networks (DNNs) are a powerful classification tool used in speech recognition(Deng et al. 2013) and for image recognition (Krizhevsky et al. 2012; Ciresan et al. 2012) and computer vision (Deng et al. 2013) problems.

CMI's approach splits field recordings into 2-second clips and extracts measurements of 10 spectro-temporal features typically found in animal sounds. A DNN classification model is then trained for each species of interest using training and cross-validation datasets containing examples of positive sounds (vocalizations from target species) and a representative example of negative sounds from the soundscape at all survey sites. The DNNs learn which spectral features best differentiate target sounds from other sounds in the environment, and each model can then be applied to raw acoustic data. The models return a probability that a given 2-second window contains a sound produced by the target species. This method has proven better at finding target sounds than the previous acoustic detection algorithm based on Spectrogram Cross Correlation (SCC).

Identification and removal of unusable recordings

We remove poor quality recordings from the 2014 dataset based on a multivariate metric of recording quality (measured in 1-minute blocks). This metric is a measure of "non-flat" signal activity, which is common when the microphone is not functioning. Values range from 0 to ~120. The average value for recordings made with defective microphones from Kaua'i projects was 2.4 (+/- 4 s. d.). The average value of recordings with a functioning microphone was 33 (+/- 19 s. d.). An analysis of sample data from Kaua'i scored by CMI analysts showed that a threshold of 8 was effective at removing recordings in which the microphone was either dead or only registering broadband electrical noise (static), while keeping good recordings from quiet locations and/or time periods. Thus, the final filtered dataset used for analysis removed recordings which were unlikely to contain calls that could be detected by the DNN model, and therefore present a more accurate assessment of the survey effort and activity rates at each location.

Results

Survey Effort

This report includes an analysis of 2,447.7 hours of passive acoustic survey effort from 11 acoustic sensors deployed over a total of 1,600 combined survey nights in 2014 (Table 1 and Figure 3a). Several microphones malfunctioned during the survey period, resulting in a loss of data. Using a combination of spectral measurements averaged over 1-minute intervals we identified 687.6 (28.1%) hours of recording and 91 (5.7%) survey nights that did not meet the minimum recording quality threshold (Table 1 and Figure 3b). Thus our final analysis of call rates was calculated from 1,760.2 hours of recordings over 1,509 survey nights. There were six sites (Lehua1, ROVFW1, ROVW2, ROVFW3, ROVFW8, and ROVFW9) that experienced a failure rate greater than 20% (Table 1). An additional four sites (ROVFW1, ROVFW2, ROVFW3, and to a lesser extent ROVFW9) experienced dramatic reductions in recording quality in late May and early June (Figure 3).

At one site (ROVFW4), a large number of recordings, specifically those between mid-June and early August were not thrown out by our automated detection of bad recordings. However, upon subsequent review, it appears that the recording quality for ROVFW4 was comparatively poor. Quality appeared to increase dramatically after a storm on 8 August 2014.

Table 1: Acoustic Monitoring Effort Information

SPID	Deployment Date	Retrieval Date	Total Nights	Corrected Nights	Nights Lost	Total Hours	Corrected Hours	Hours Lost
LEHUA1	4/10/2014	8/29/2014	118	117	1	180.47	112.90	67.56
LEHUA2	4/10/2014	8/29/2014	118	118	0	180.47	173.42	7.05
LEHUA3	4/10/2014	8/29/2014	119	119	0	182.00	173.52	8.48
ROVFW1	4/1/2014	9/10/2014	156	148	8	238.72	109.98	128.74
ROVFW2	4/1/2014	9/10/2014	155	130	25	237.19	181.67	55.52
ROVFW3	4/1/2014	9/10/2014	155	98	57	237.19	83.88	153.31
ROVFW4	4/1/2014	9/10/2014	156	156	0	238.72	206.41	32.31
ROVFW6	4/1/2014	9/10/2014	156	156	0	238.71	217.44	21.26
ROVFW7	4/1/2014	9/10/2014	155	155	0	236.84	197.15	39.69
ROVFW8	4/1/2014	9/10/2014	156	156	0	238.72	187.39	51.34
ROVFW9	4/1/2014	9/10/2014	156	156	0	238.72	116.41	122.31
		Total	**1600**	**1509**	**91**	**2447.74**	**1760.17**	**687.57**

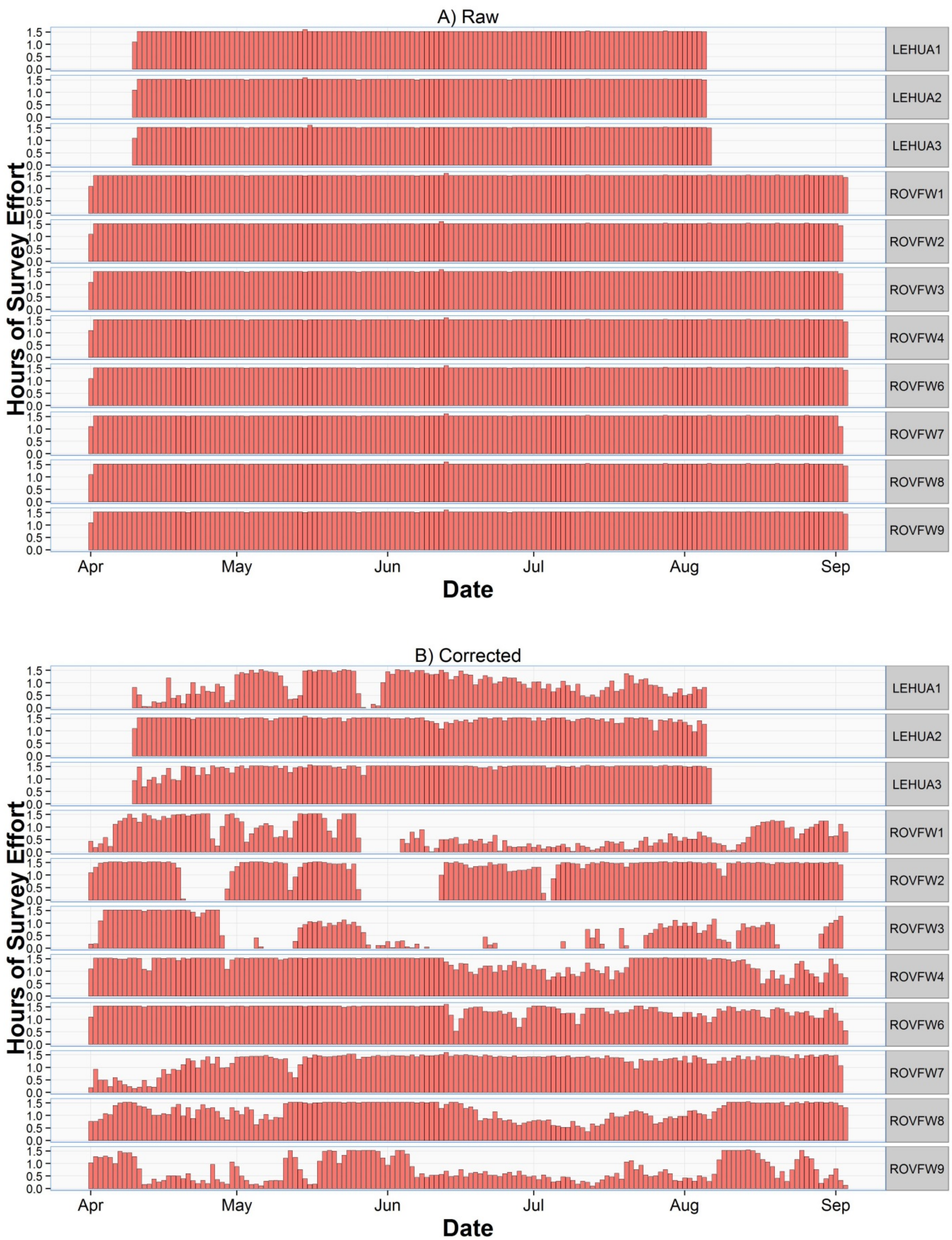

Figure 3: Survey effort by site over entire deployment period; A) Raw effort before unusable recordings were removed; B) Effort after unusable recordings were removed.

Newell's Shearwater

Newell's Shearwater activity was first detected 1 April, the first day of survey effort at sites ROVFW1 on Kaua'i, with regular vocal activity beginning at ROVFW1 on 15 April, and at ROVFW4, ROVFW 7, and ROVFW 8 on 20 April (Figure 4). Regular Activity continued throughout the entire survey period at all sites on Kaua'i. Sites ROVFW2, 3, and 6 exhibited low to intermittent levels of activity following no obvious pattern (Figure 4). Activity was highest at ROVFW7, followed closely by ROVFW1, with strong activity also detected at ROVFW4 and ROVFW8, (Figure 5 and Figure 8). At sites where Newell's Shearwater was detected, call rates peaked 30-90 minutes before sunrise, with a secondary lower peak of acoustic activity 40-100 minutes after sunset (Figure 6). Activity at ROVFW4 appears to decrease dramatically after mid-June; however, examination of those recordings reveals that quality was reduced in ways that likely impacted detector performance. Recording quality did, however, improve after a large storm on 8 August.

No Newell's Shearwater calls were detected on Lehua in 2014.

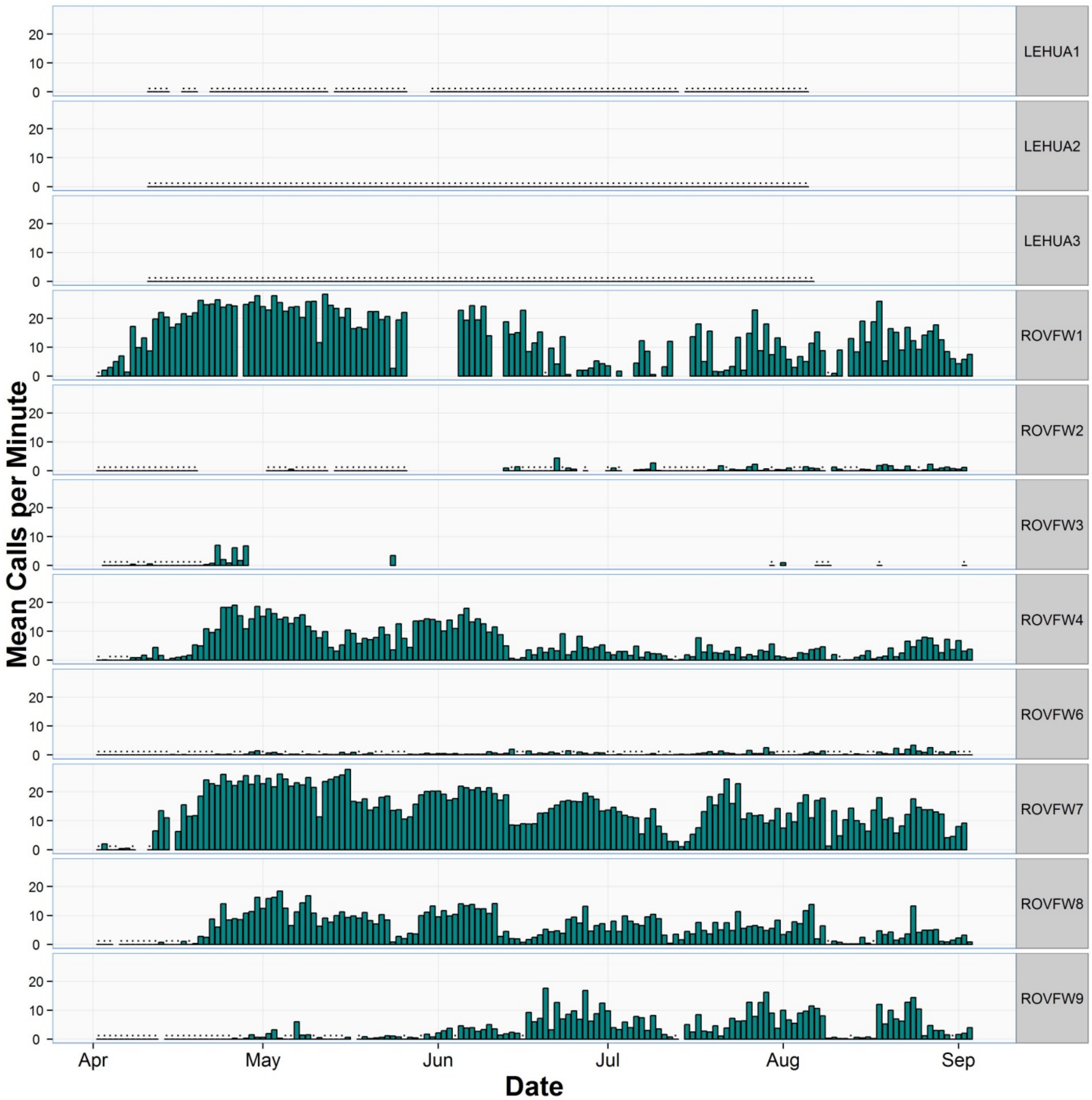

Figure 4: Newell's Shearwater activity at all sites across survey duration (4/1/2014 to 9/10/2014) during peak calling period (30-90 minutes before sunrise). Dates with a dot over the line represent dates where no activity was detected, while gaps represent periods for which data were thrown out.

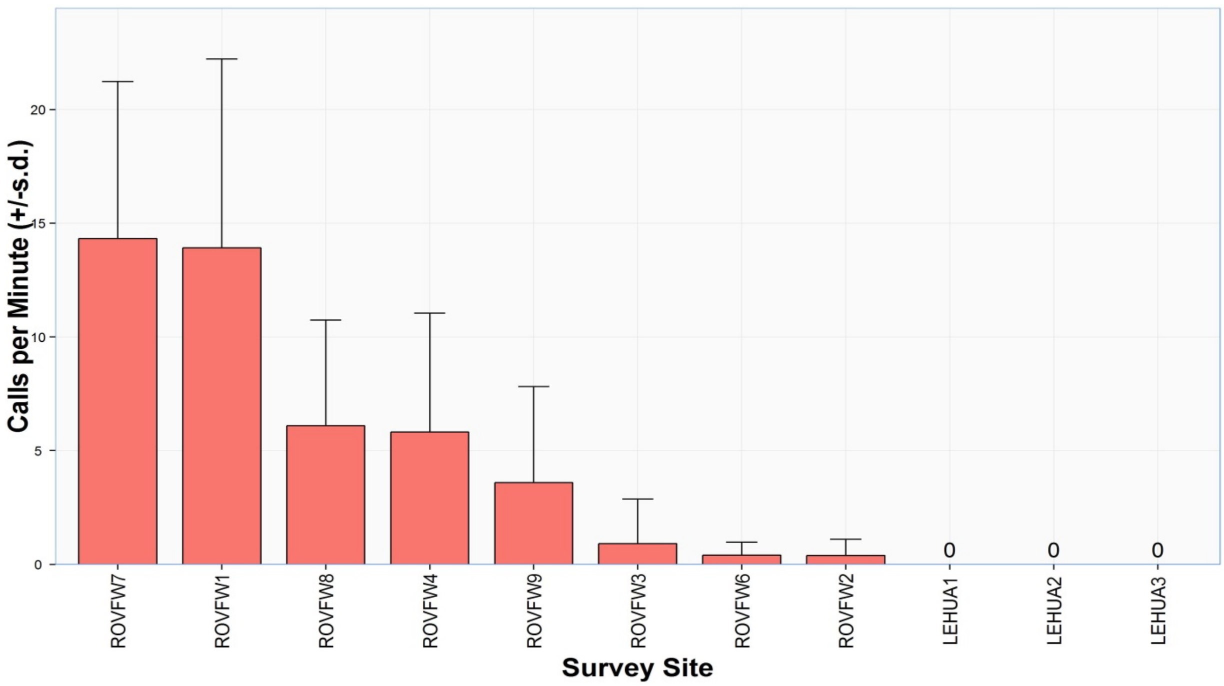

Figure 5: Newell's Shearwater activity by site during the hour of peak calling activity (30-90 minutes before sunrise) across entire survey duration (4/1/2014 to 9/10/2014)

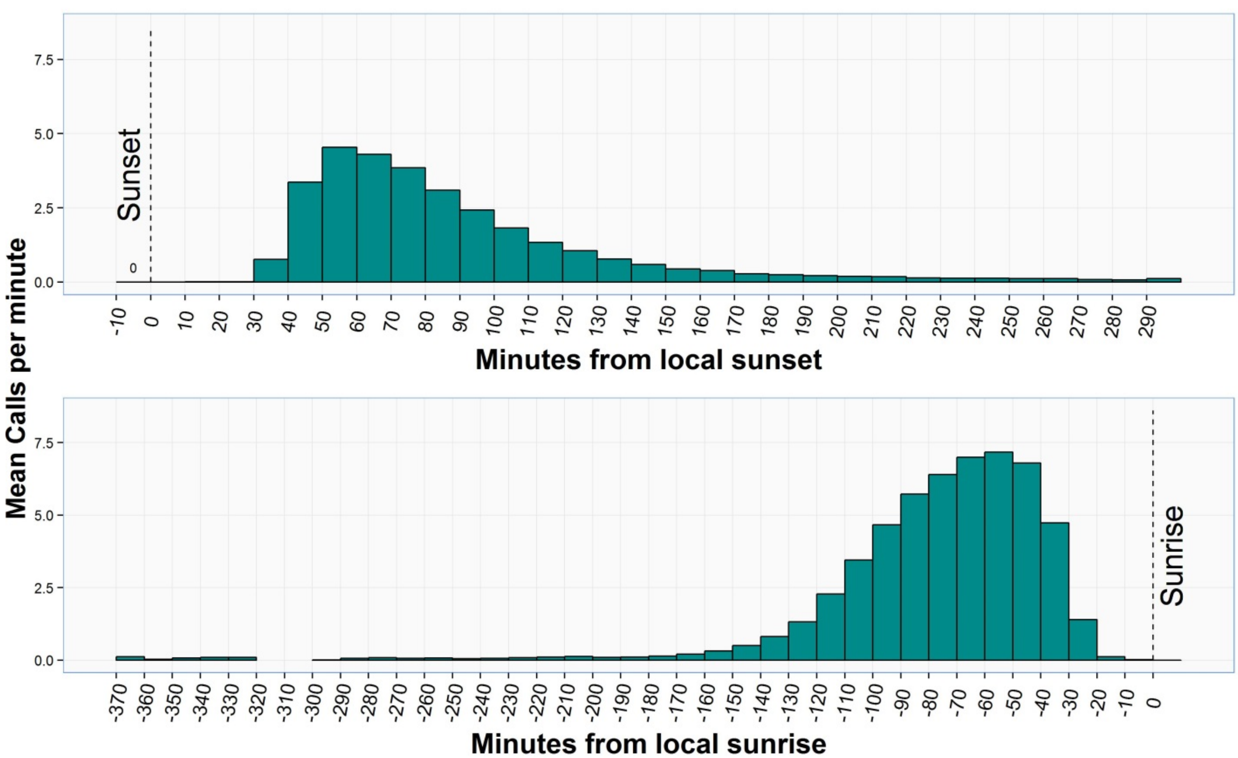

Figure 6: Newell's Shearwater activity as a function of time from sunrise and sunset during entire survey duration (4/1/2014 to 9/10/2014)

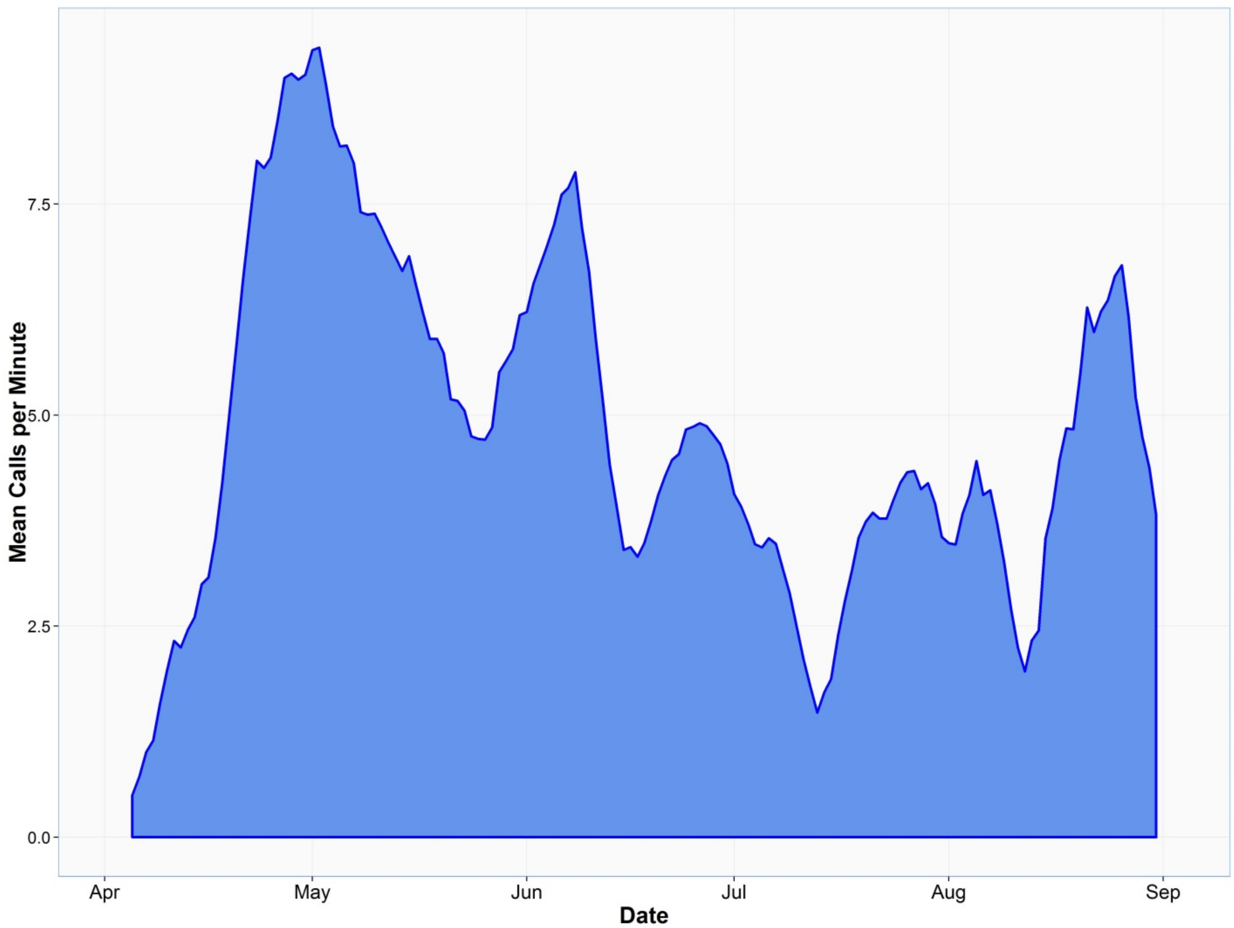

Figure 7: Seven-day rolling mean of Newell's Shearwater acoustic activity during peak calling period before dawn - All sites.

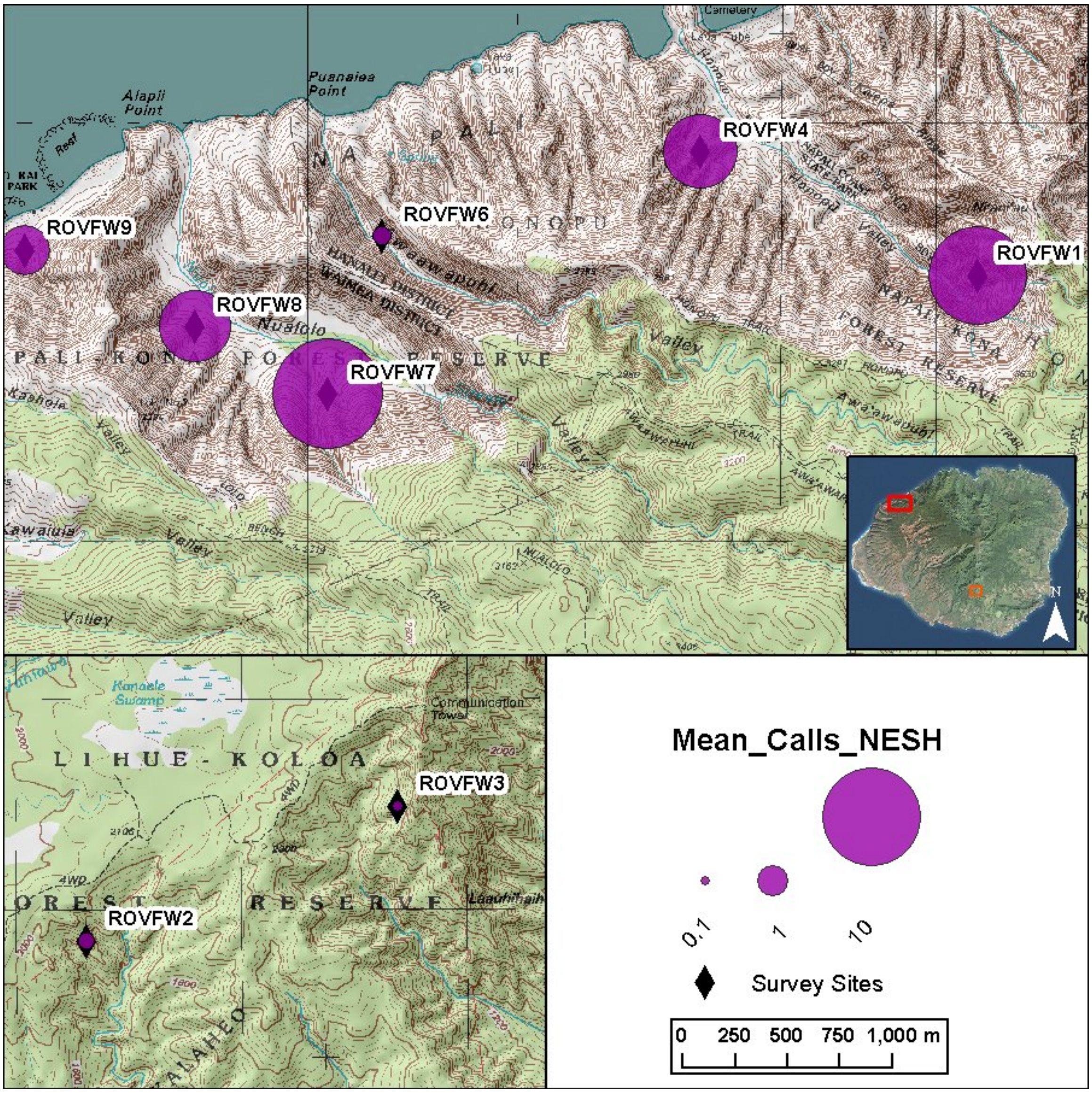

Figure 8: Map of Newell's Shearwater call rates during peak calling hour (30-90 minutes before sunrise) across entire survey duration. Note, no calls were recorded on Lehua Islet in 2014.

Table 2: Newell's Shearwater and Hawaiian Petrel mean call rates during peak calling periods (90-30 minutes before sunrise and 40-100 minutes after sunset respectively)

	NESH					HAPE			
SPID	N	Call per min.	sd	se		N	Call per min.	sd	se
LEHUA1	117	0	0	0		118	0	0	0
LEHUA2	117	0	0	0		118	0	0	0
LEHUA3	118	0	0	0		119	0	0	0
ROVFW1	155	10.05	8.78	0.71		156	0	0	0
ROVFW2	154	0.29	0.61	0.05		155	0.0021	0.0210	0.0017
ROVFW3	154	0.16	0.79	0.06		155	0.0139	0.0948	0.0076
ROVFW4	155	5.66	5.26	0.42		156	0	0	0
ROVFW6	155	0.38	0.51	0.04		156	0	0	0
ROVFW7	154	12.86	6.96	0.56		155	0	0	0
ROVFW8	155	5.49	4.34	0.35		156	0	0	0
ROVFW9	155	2.55	3.02	0.24		156	0	0	0

Hawaiian Petrel

Hawaiian Petrel activity was first detected during the survey period on 3 April, and was then detected sporadically thereafter at sites ROVFW2 and ROVFW3 (Figure 9). Acoustic activity rates peaked 20-80 minutes after sunset and tailed off approximately 3 hours after sunset (Figure 10).

No Hawaiian Petrel calls were detected on Lehua in 2014.

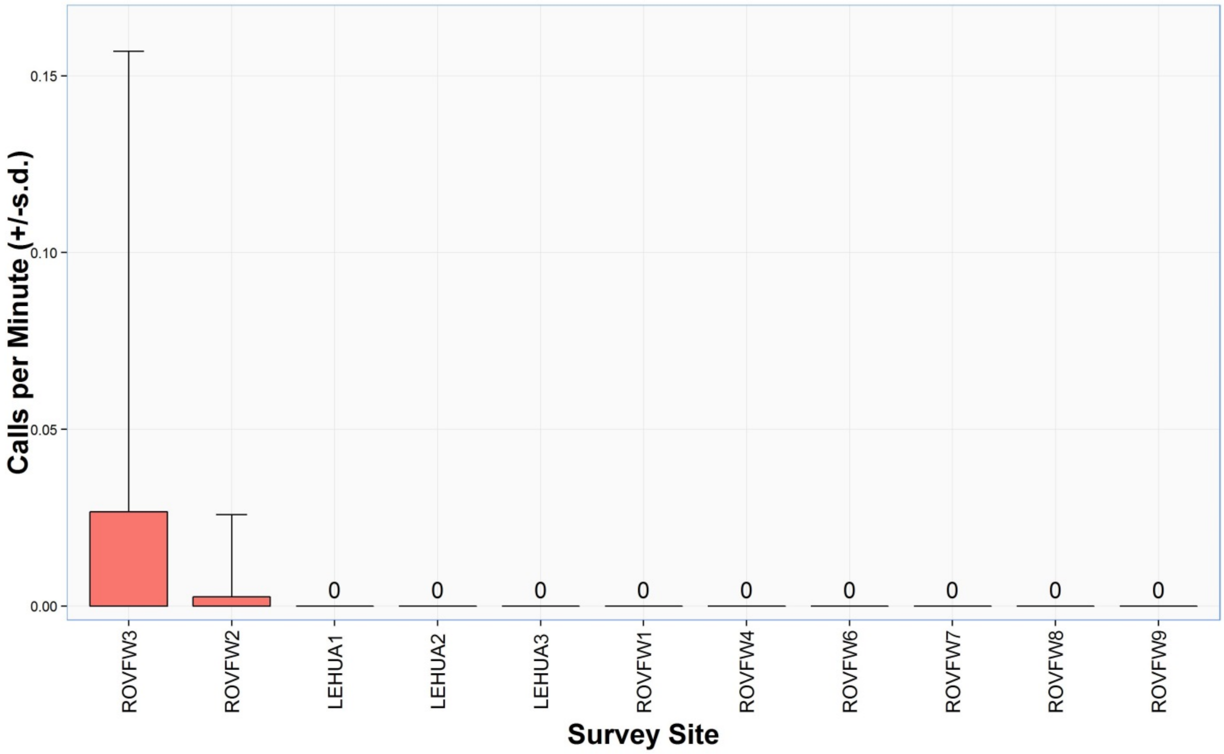

Figure 9: Hawaiian Petrel call rates by site during peak calling period

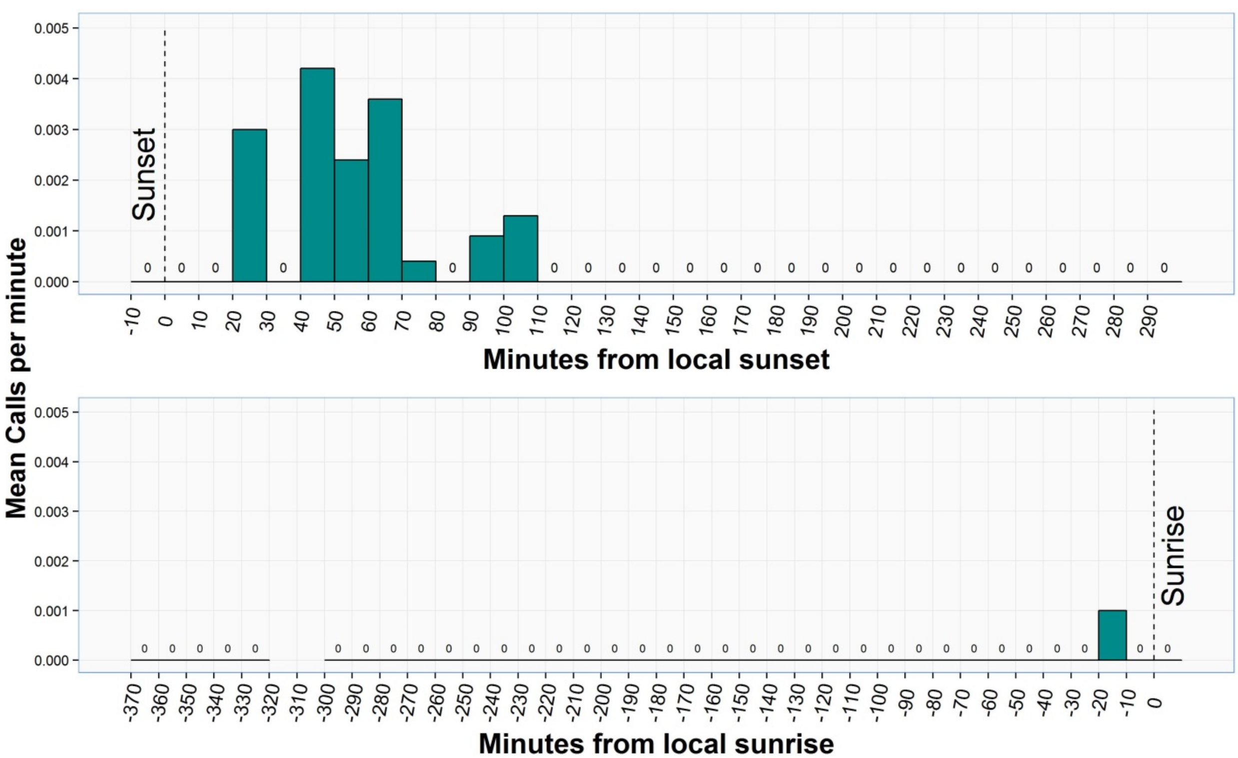

Figure 10: Hawaiian Petrel activity as a function of time from sunrise and sunset

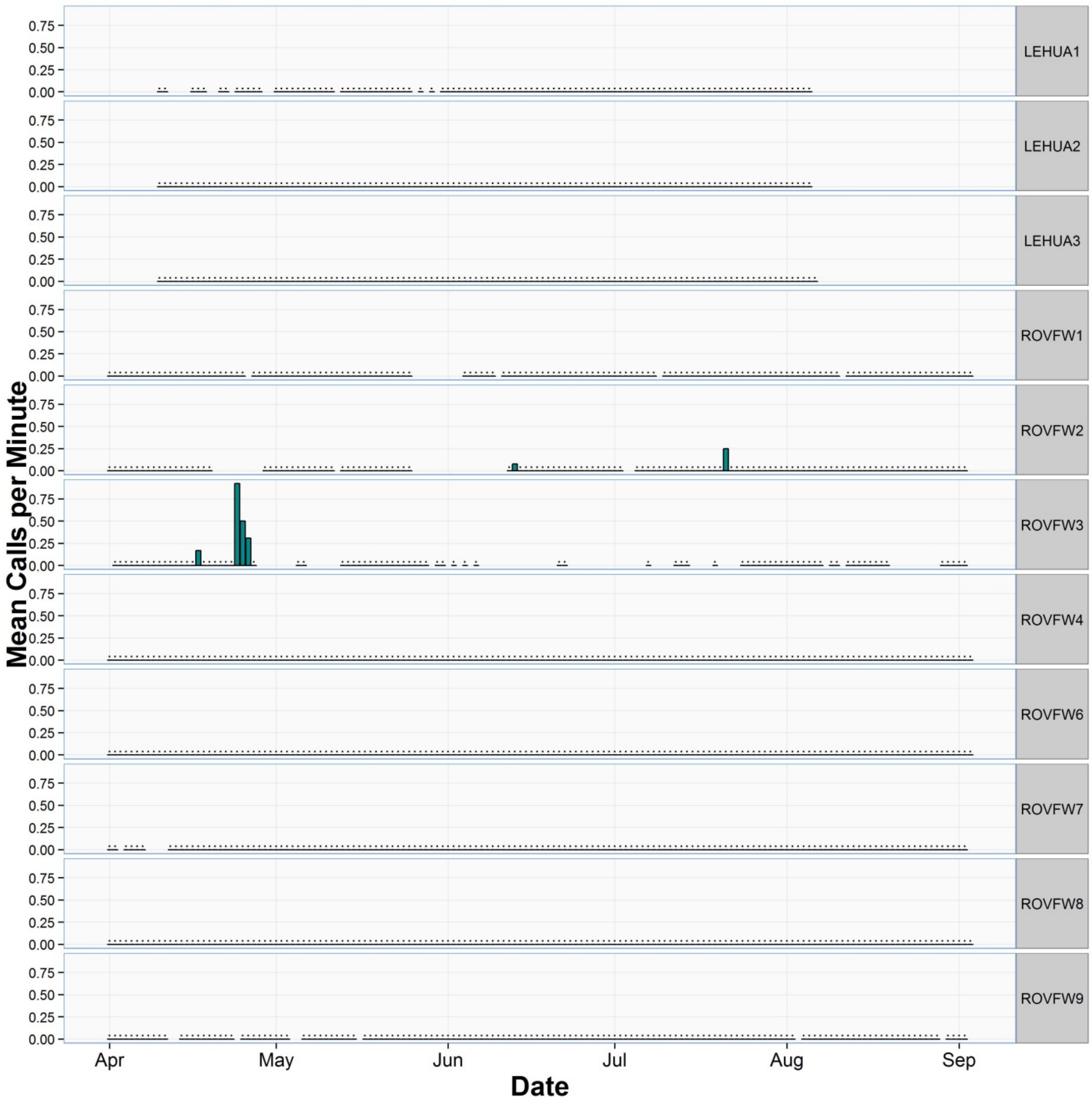

Figure 11: Hawaiian Petrel activity over the entire survey period during peak calling period (20-80 minutes after sunset). Dates with a dot over the line represent dates where no activity was detected, while gaps represent periods for which data were thrown out.

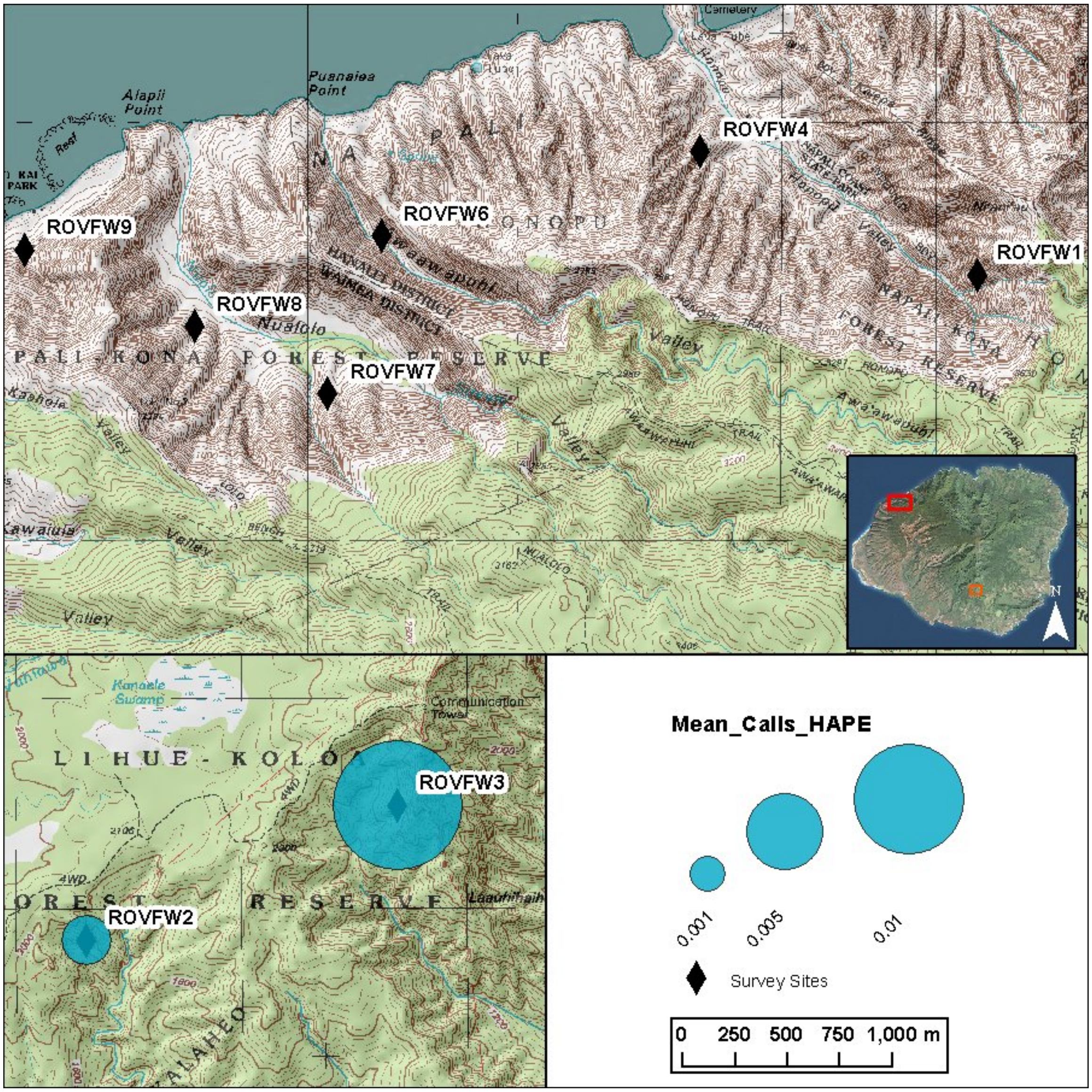

Figure 12: Map of Hawaiian Petrel activity during peak calling hour (20-80 minutes after sunset)

Band-rumped Storm-petrel

Band-rumped Storm-petrel activity was first detected during the survey period 20 May at multiple sites and continued throughout the remaining survey period at ROVFW1, ROVFW4, ROVFW7, and ROVFW8 (Figure 13 and Figure 16). Daily Band-rumped Storm-petrel activity peaked from 60-120 minutes after sunset, and trailed off dramatically by 200 minutes after sunset (Figure 14). As with Newell's Shearwater, much of the Band-rumped Storm-petrel activity at ROVFW4 before 8 August is masked by poor quality recordings that were above the threshold of our automated quality control algorithm. ROVFW4 also exhibited a different peak activity period 50-110 minutes after sunset, approximately 20 minutes earlier than the peak of the other sites 60-120 minutes after sunset.

Band-rumped Storm-petrel activity was only detected at Lehua1 on Lehua Island, and in very low numbers.

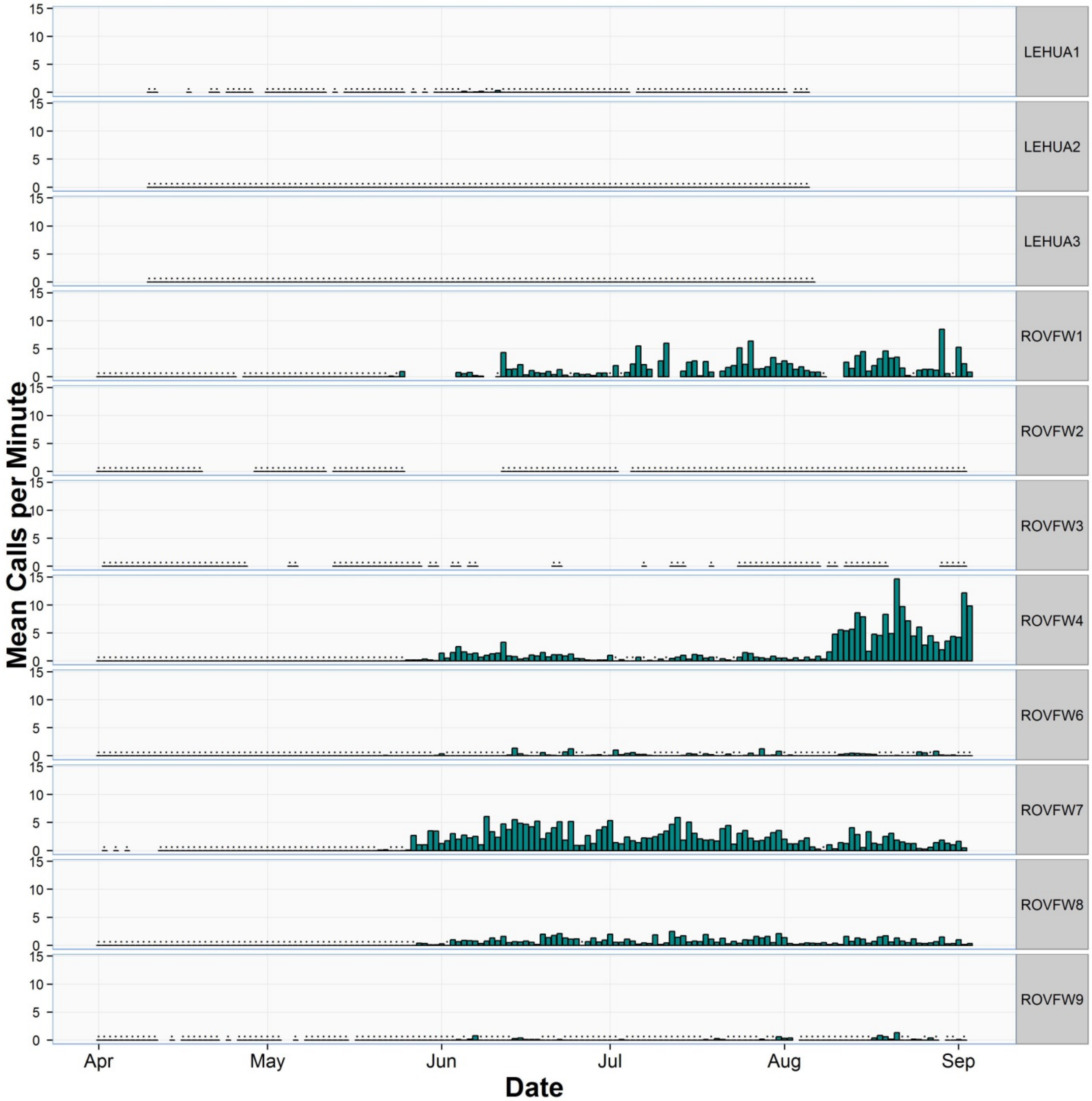

Figure 13: Band-rumped Storm-petrel activity at all sites across the entire survey duration. Dates with a dot over the line represent dates where no activity was detected, while gaps represent periods for which data were thrown out.

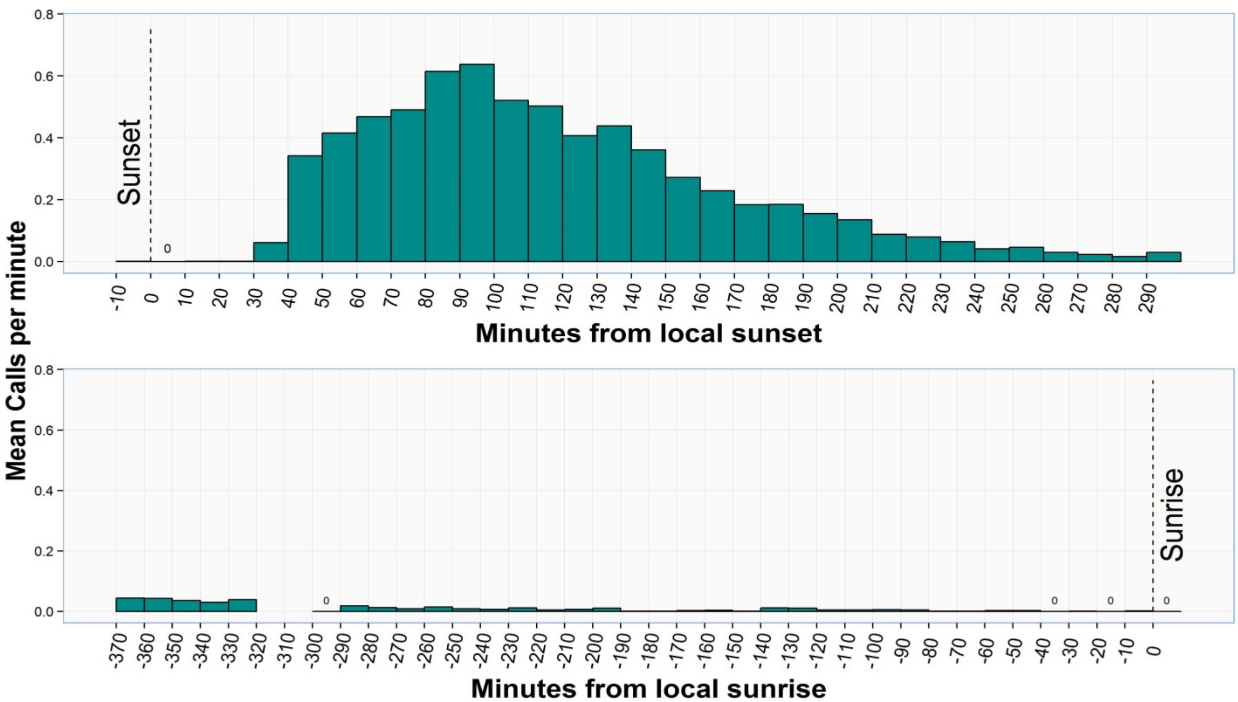

Figure 14: Band-Rumped Storm-petrel activity as a function of time from sunset and sunrise at all sites across entire survey duration

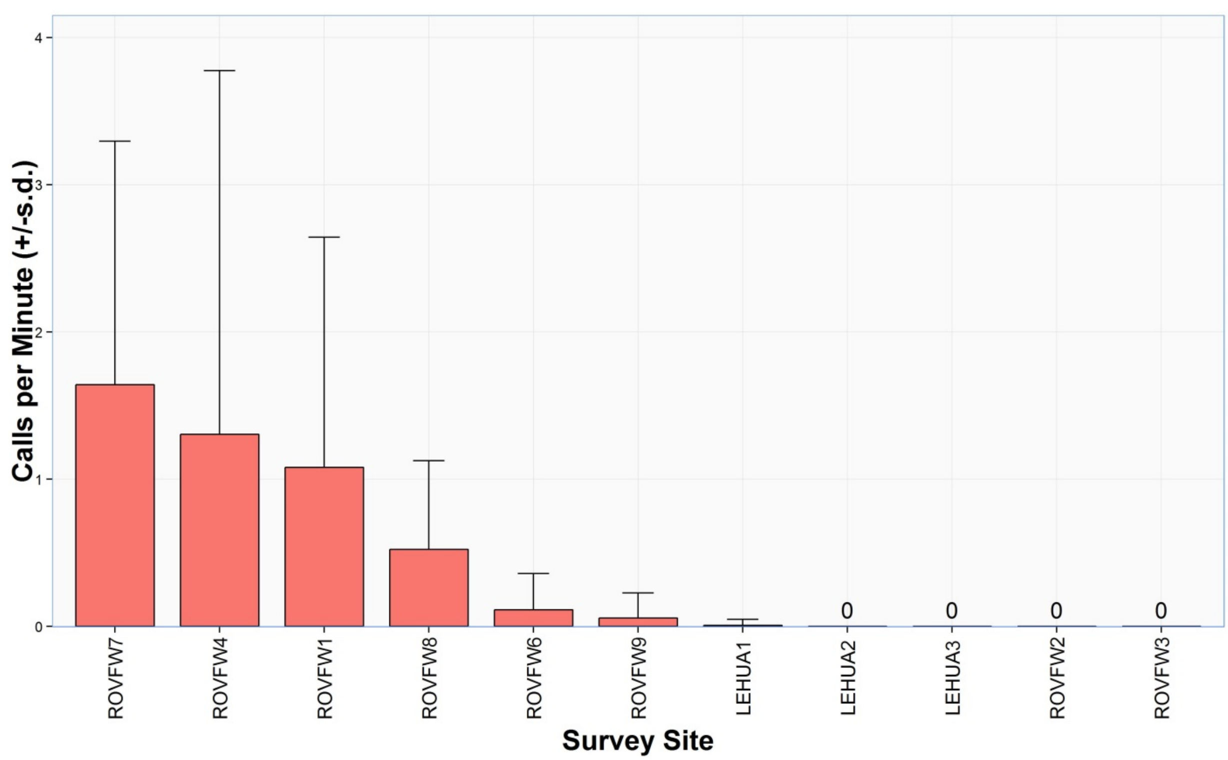

Figure 15: Mean call rates for Band-rumped Storm-petrel by site across entire survey duration during peak calling period (60-120 minutes after sunset)

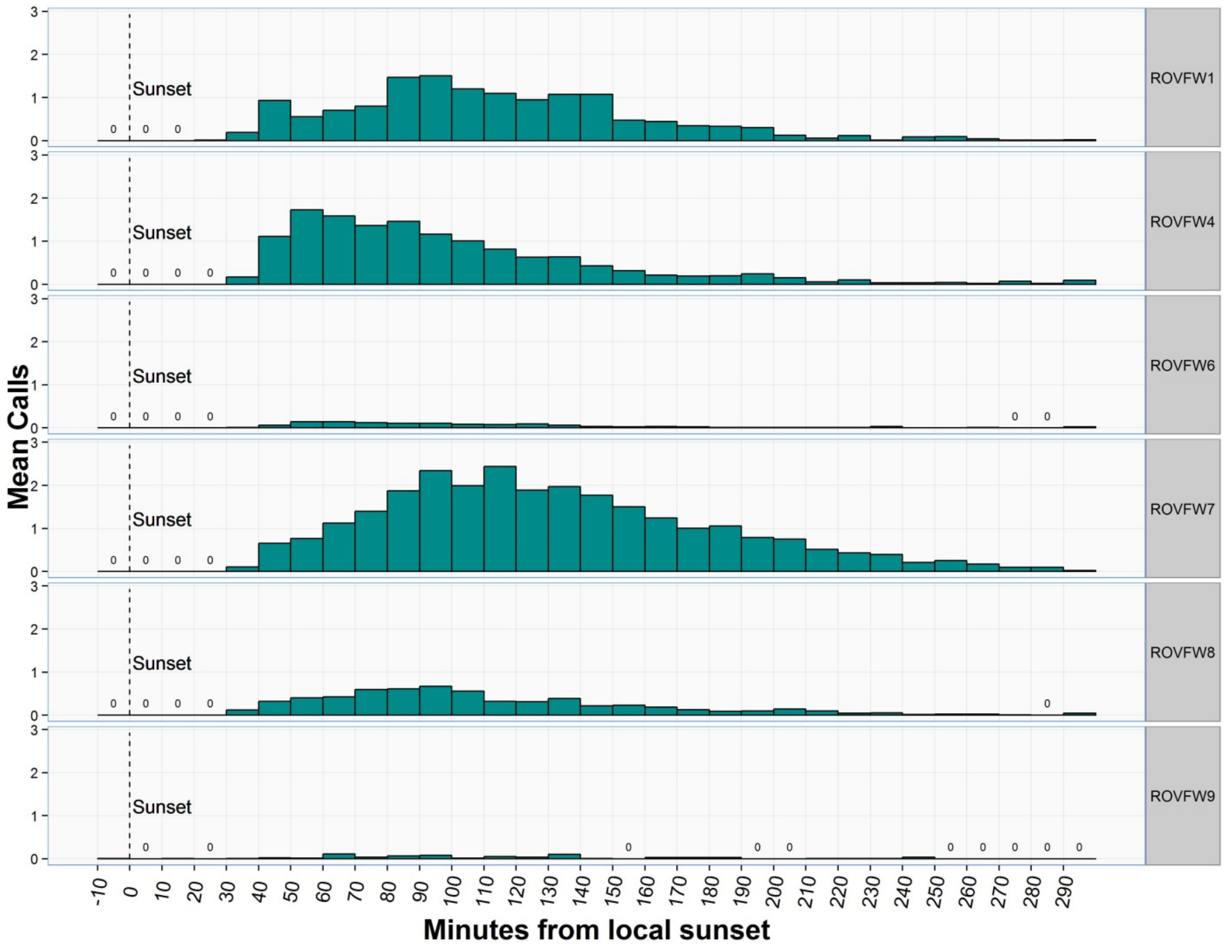

Figure 16: Band-rumped Storm-petrel activity at sites with activity in the hours following sunset

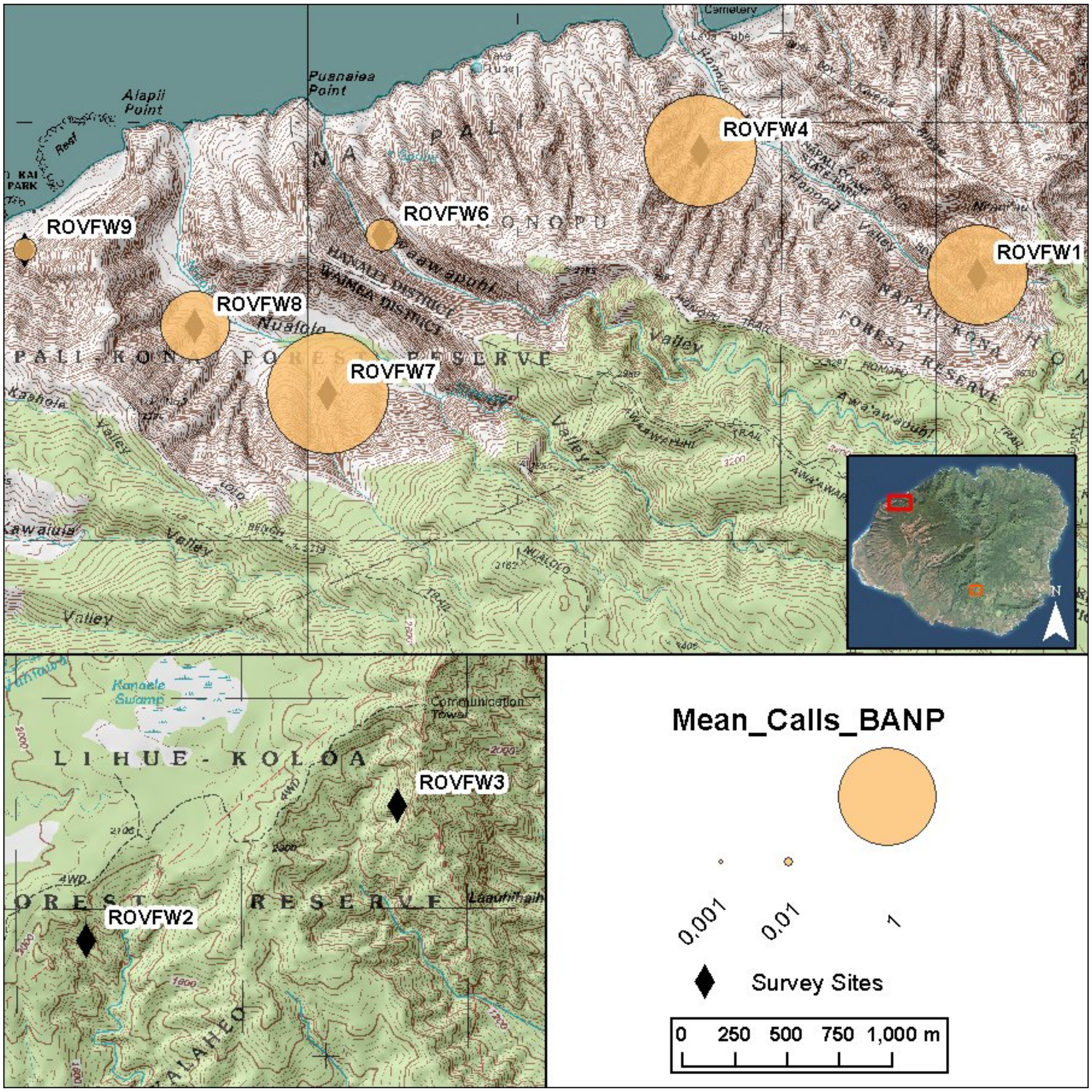

Figure 17: Map of Band-rumped Storm-petrel activity on Kaua'i during peak calling hour (60-120 minutes after sunset)

Figure 18: Map of Band-Rumped Storm-petrel activity on Lehua during peak calling period (60-120 minutes after sunset)

Table 3:Barn Owl and Band-rumped Storm-petrel activity at all sites during the period of Band-rumped Storm-petrel activity (20 May to 10 September).

	BAOW				BANP			
SPID	N	Calls per night	sd		N	Calls per min.	sd	se
LEHUA1	118	0.208	0.636		118	0.005	0.027	0.003
LEHUA2	118	1.081	1.509		118	0	0	0
LEHUA3	119	0.212	0.656		119	0	0	0
ROVFW1	156	0.031	0.185		156	1.075	1.508	0.121
ROVFW2	155	0.079	0.348		155	0	0	0
ROVFW3	155	0.000	0.000		155	0	0	0
ROVFW4	156	0.498	0.947		156	1.292	2.364	0.189
ROVFW6	156	0.000	0.000		156	0.117	0.254	0.020
ROVFW7	155	1.727	1.933		155	1.556	1.648	0.132
ROVFW8	156	1.120	1.998		156	0.496	0.559	0.045
ROVFW9	156	0.186	0.969		156	0.058	0.171	0.014

Barn Owl

Barn Owl vocalizations were relatively rare and sporadic compared to call rates of the other species of interest. For this reason we have presented result as totals, and also present "Nights with activity" as a metric for comparison across sites.

Barn Owl activity was first detected the first day of survey effort at sites on Kaua'i (1 April), and was also detected on the first day of survey effort on Lehua (10 April) (Figure 22). Barn Owl calls were detected the majority of survey nights at site ROVFW7 (Figure 20). There were no obvious seasonal (Figure 22) or diel (Figure 23) patterns in Barn Owl acoustic activity.

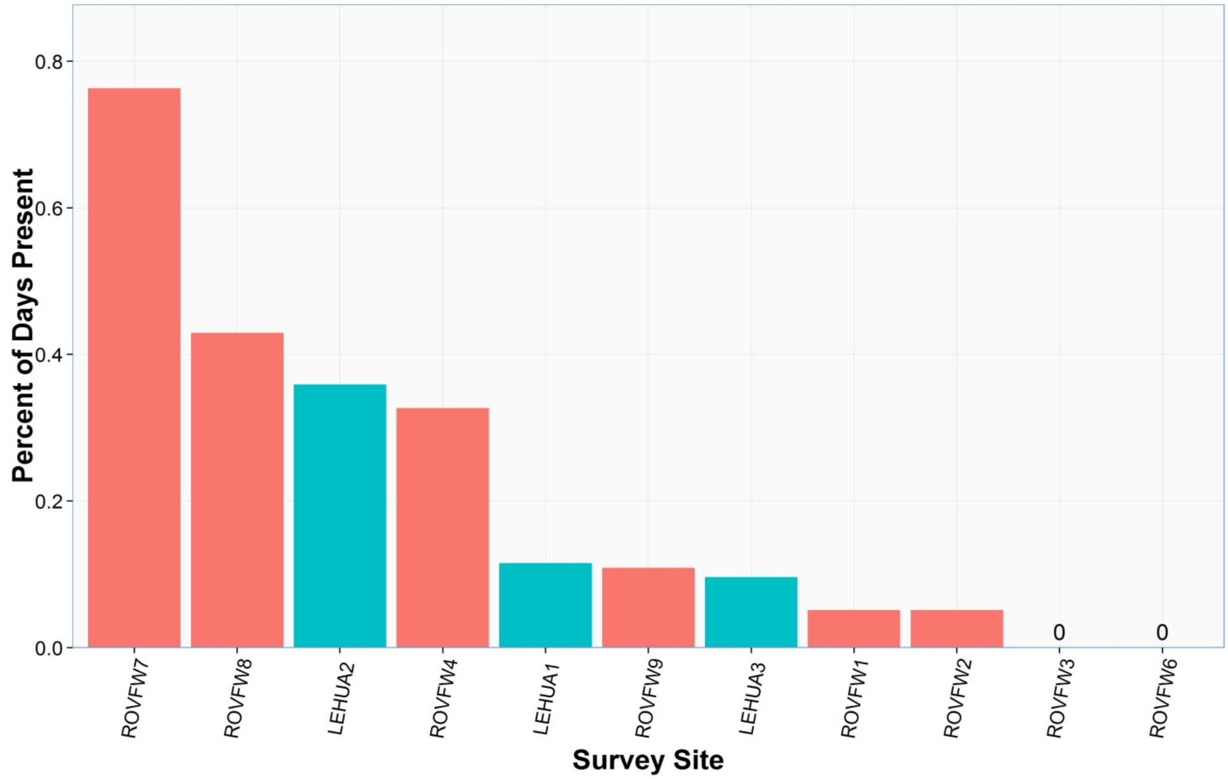

Figure 19: Percentage of nights where one or more Barn Owl call was detected at each site

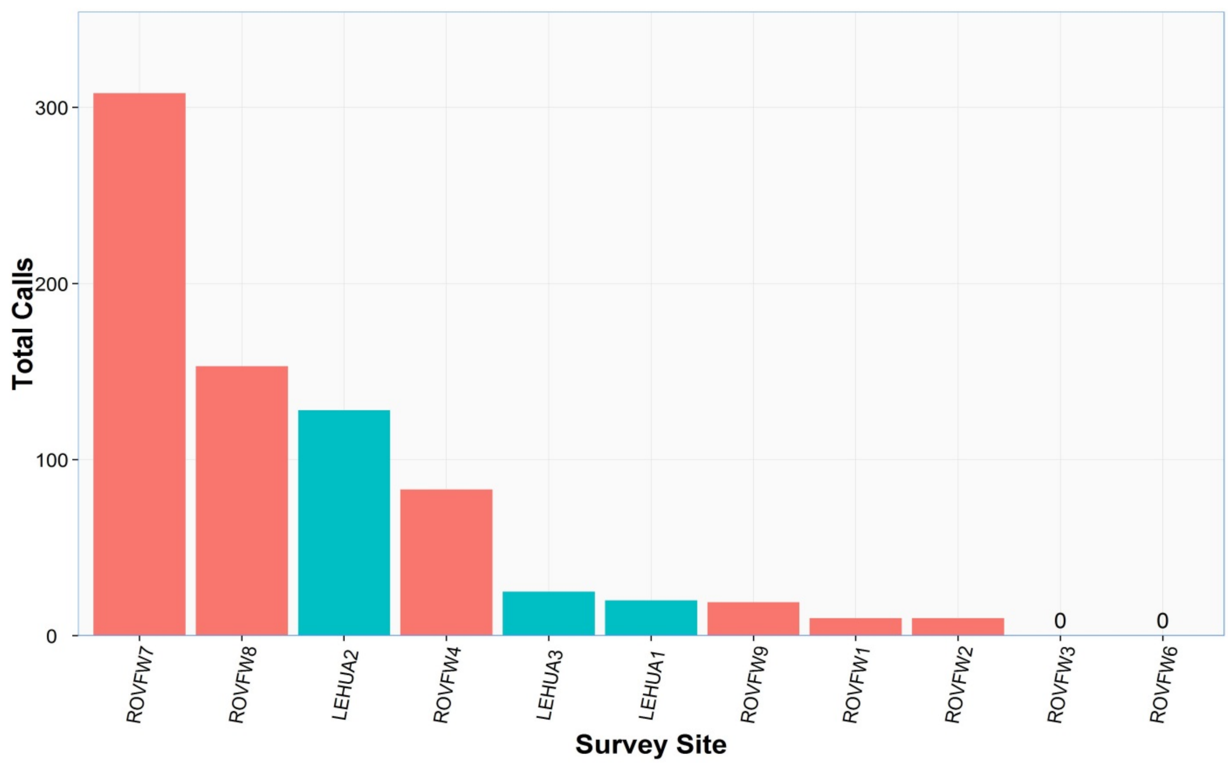

Figure 20: Total Barn Owl calls detected at each site across entire survey period

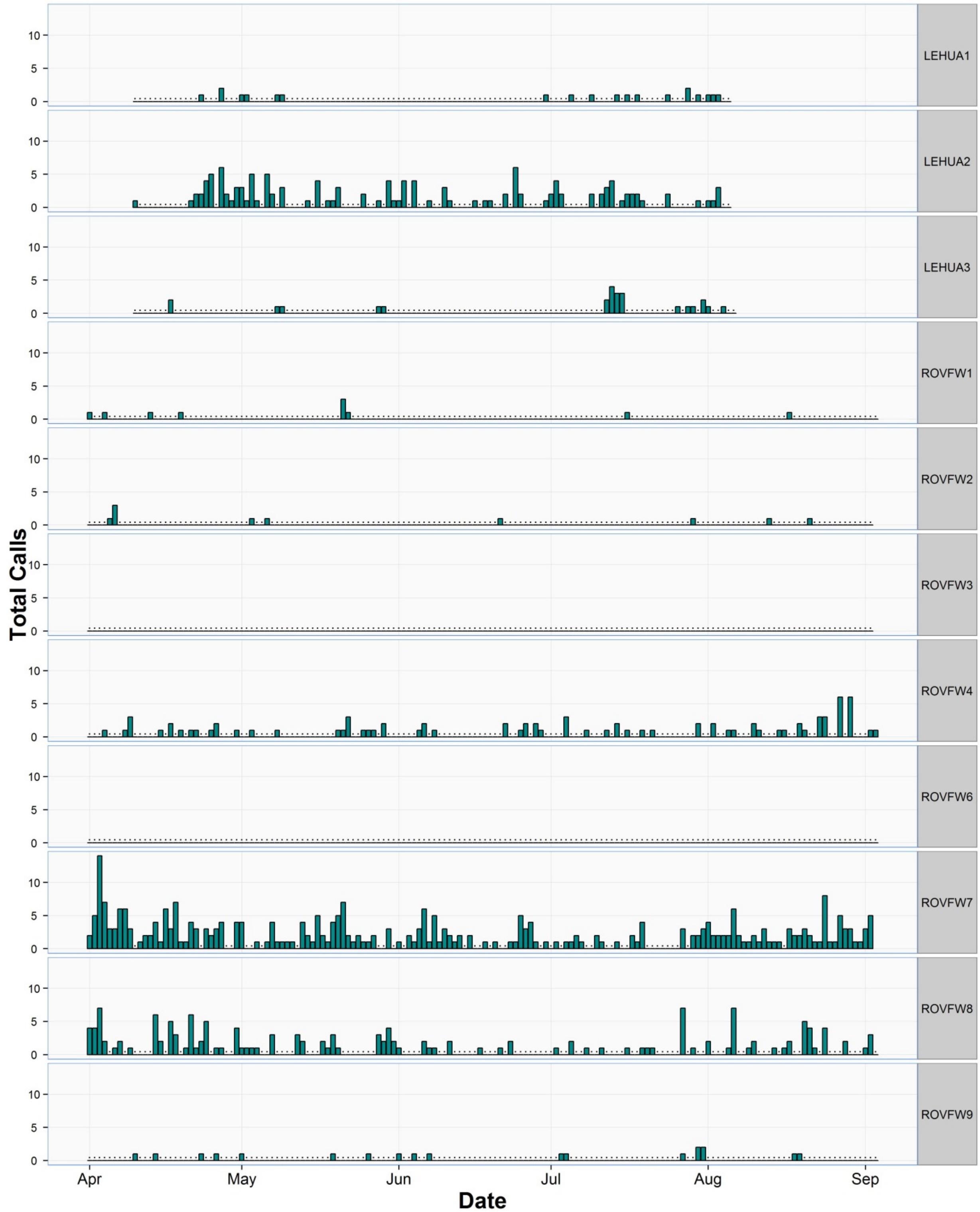

Figure 21: Total Barn Owl calls detected each day across entire survey period. Dates with a dot over the line represent dates where no activity was detected, while gaps represent periods for which data were thrown out.

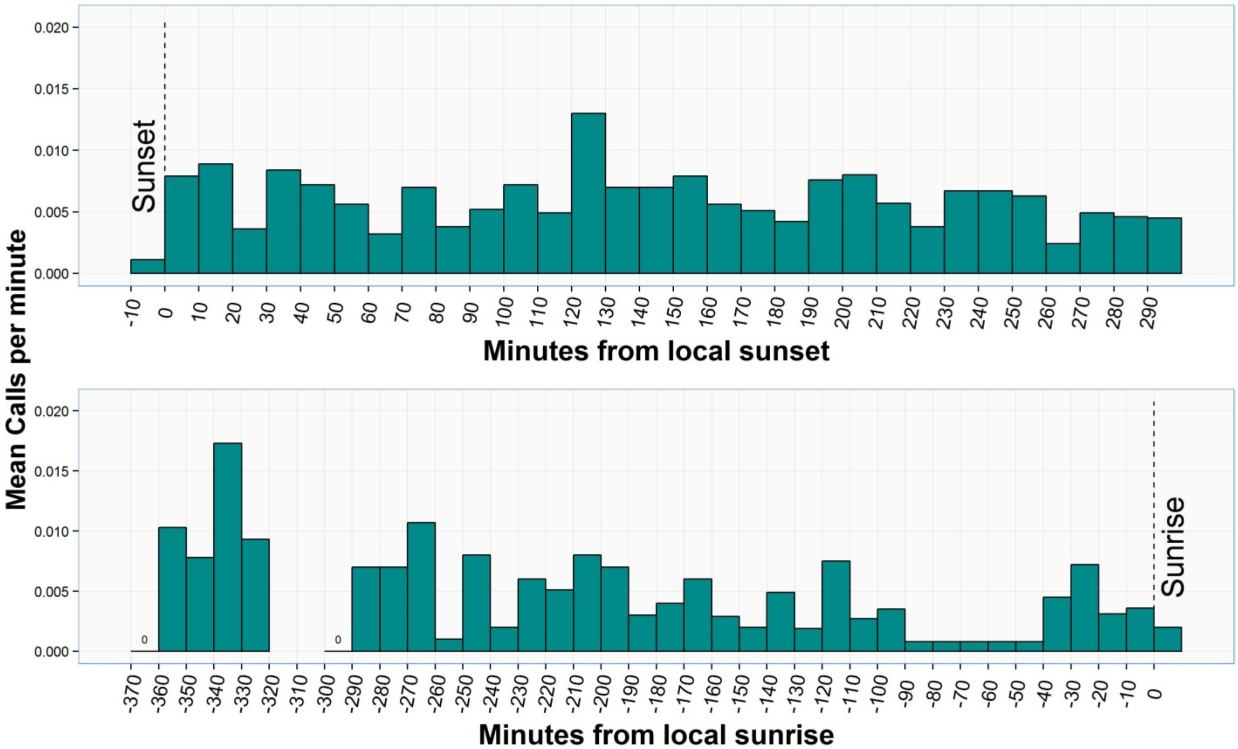

Figure 22: Barn Owl call rates as a function of time from sunrise and sunset

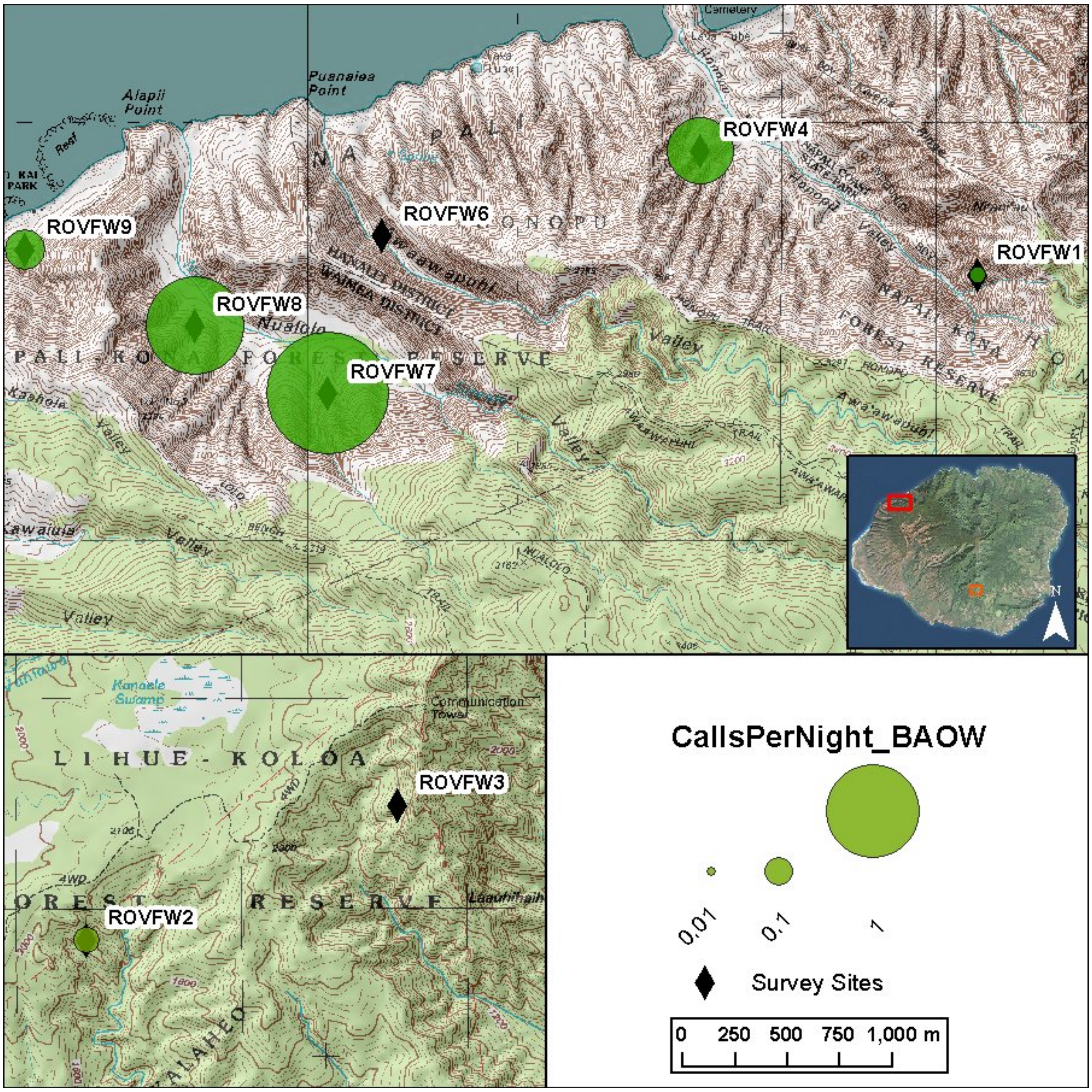

Figure 23: Barn Owl call rates per night at sites on Kaua'i

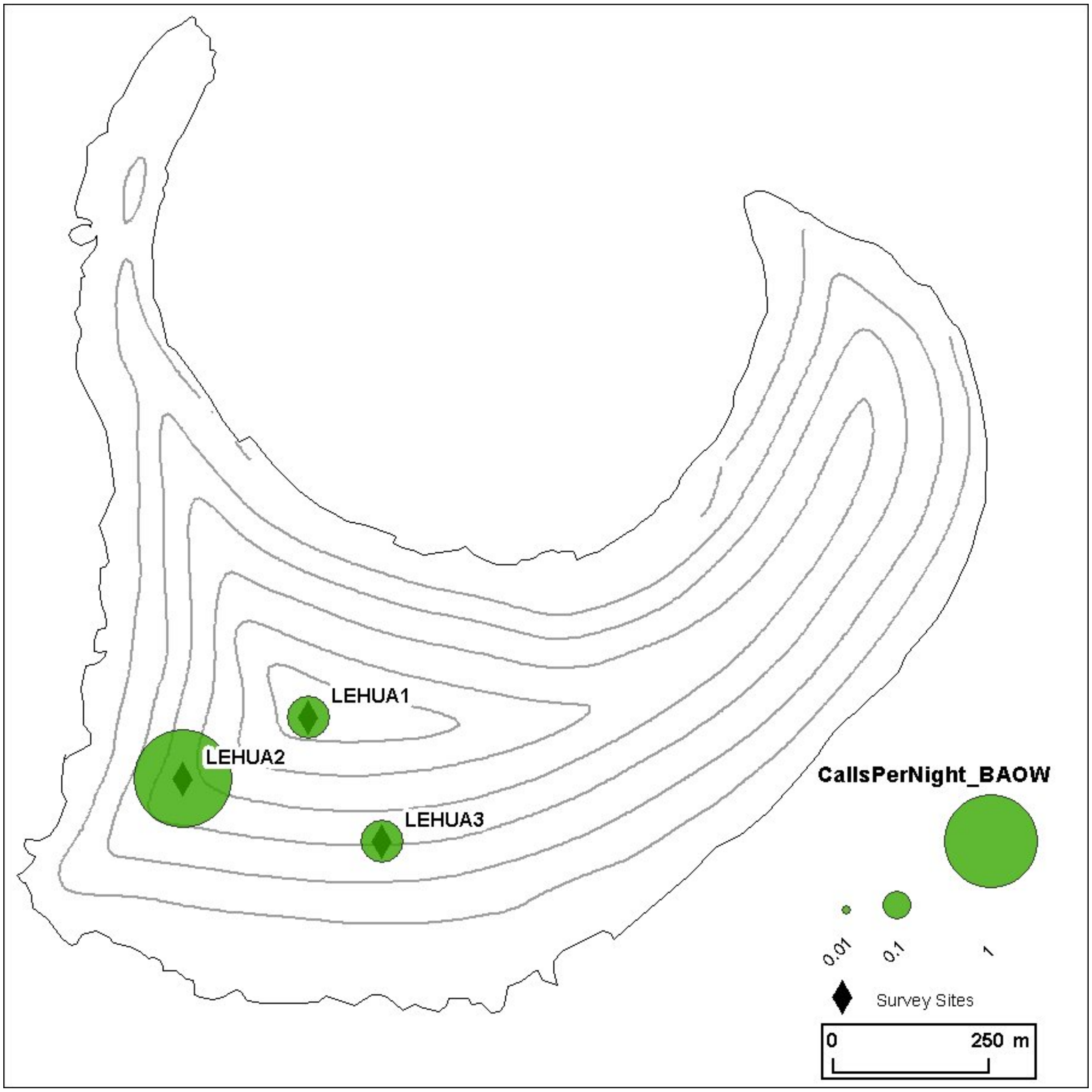

Figure 24: Barn Owl call rates per night at sites on Lehua

2013-2014 Comparison

Two sites (ROVFW2 and ROVFW3) were monitored in both 2013 and 2014. Mean call rates were lower in 2014 because of the large loss of survey effort from poor quality recordings. For example, the 2014 survey effort at ROVFW3 was 25% of that recorded in 2013. A manual review of data from ROVFW4 showed that its overall recording quality was very poor during the period of survey overlap in 2013 and 2014. Thus inter annual comparisons are not presented here.

Discussion

The data collected by the Kauai Endangered Seabird Recovery Project in 2014 has demonstrated that acoustic surveys are an effective tool for monitoring the three target seabird species and their avian predator – the Barn Owl - on Kaua'i. With this initial baseline data in hand, future years of survey effort will provide information about (i) how seabird populations react to the removal of an avian predator and (ii) how quickly Barn Owls re-appear after removal from seabird breeding sites. Song meters that pick up high calling rates of Barn Owls will also allow managers to more accurately target key Barn Owl hunting areas.

The 2014 data also highlight the primary challenge to long-term acoustic monitoring efforts – failures of sensor hardware. Poor quality recordings reduced the overall recording effort at sites monitored both in 2013 and 2014. This likely contributed to lower call rate estimates for NESH and HAPE in 2014. This sort of "sampling noise" reduces the statistical power of long-term trend monitoring. To control for this issue we recommend collecting data using 2 microphones on each deployed sensor. If one microphone fails, recordings from the second microphone can therefore act as back-up thus reducing data loss. Long-term, it will be important to identify a better microphone, or better sensor hardware to improve results.

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Oppel, S., S. Hervías, N. Oliveira, T. Pipa, C. Silva, P. Geraldes, M. Goh, E. Immler, and M. Mckown. 2014b. Estimating population size of a nocturnal burrow-nesting seabird using acoustic monitoring and habitat mapping. Nature Conservation **7**:1–13.

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Appendix 9. FY 2015 expenditures at KAW.

Kawailoa	Cost
Permit Compliance	$7,838
Seabird Management	$104,359
Vegetative Management	$2,200
Fatality Monitoring	$49,388
Equipment and Supplies	$45,538
Bat Mitigation	$147,582
First Wind Labor	$518,350
Total Cost for FY 2015	**$875,255**