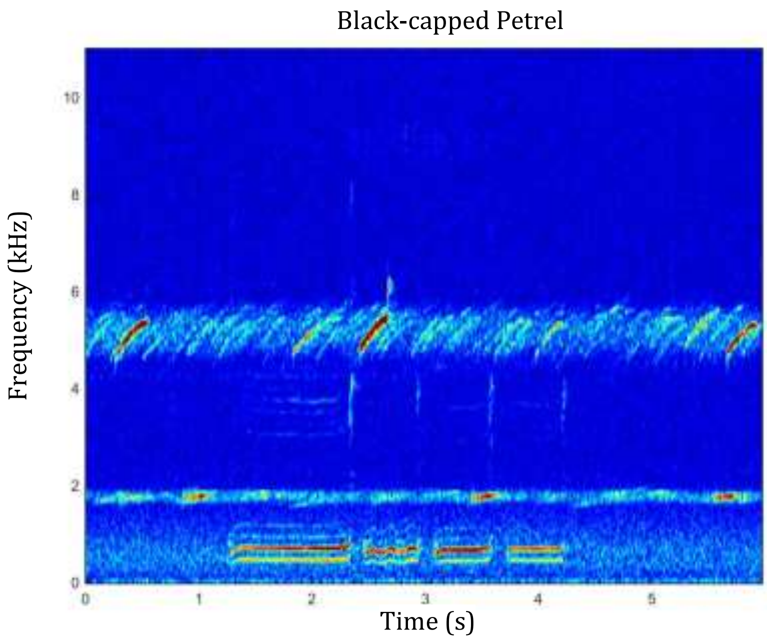

Spectrogram of Black-capped petrel calls recorded in Valle Nuevo, Dominican Republic. CM27 02-28-2016 21:22:00

Acoustic Surveys for Black-capped Petrel on Hispaniola and Dominica - *2016*

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Introduction

The Black-capped Petrel (*Pterodroma hasitata*), a seabird endemic to the Caribbean basin, is listed as Endangered by the International Union for the Conservation of Nature because of its restricted range, declining population, and continued threats (BirdLife International 2016). Key obstacles to conserving the species are 1) ongoing habitat loss, introduced predators, natural disasters, and over-harvesting throughout its historical breeding range, 2) limited knowledge of extant colony locations in its historical range, 3) a lack of information about population sizes at breeding aggregations, and 4) a dearth of reliable, cost-effective, and logistically-feasible tools for detecting undiscovered breeding sites, quantifying impacts, and estimating population trends.

Acoustic surveys are increasingly being used as a cost-effective tool to detect and monitor seabirds (Buxton & Jones 2012; Borker et al. 2014; Oppel et al. 2014). This report summarizes data collected from two acoustic survey projects to detect undiscovered Black-capped Petrel breeding aggregations on Hispaniola and Dominica. Specifically, these exploratory acoustic surveys were carried out to listen for petrel vocalizations in locations where radar surveys had previously detected radar targets with flight characteristics similar to that of petrels attending breeding colonies (relatively high-speeds, strait-line trajectories to and from the sea followed by circling flight, activity after sunset). The goal of these surveys was to find independent evidence that these radar targets were petrels, and to quantify patterns of acoustic activity that could help direct ground searches for undiscovered breeding aggregations.

Methods

Recording equipment

Hispaniola

Surveys on Hispaniola were conducted with Song Meter 2 (Wildlife Acoustics, Inc.) acoustic sensors. Sensors were deployed with one 32 GB SD memory card to store all field recordings, four D-cell alkaline batteries, and placed on the ground. All sensors recorded with one SMX-II omni-directional microphone installed on the left channel. Sound files were stored as uncompressed ".wav" files.

Dominica

Surveys on Dominica were conducted with Song Meter 3 (Wildlife Acoustics, Inc.) acoustic sensors donated by Conservation Metrics. Sensors were deployed with two 32 GB SD memory card to store all field recordings, four D-cell alkaline batteries, and placed on the ground. All sensors recorded with the internal microphones on the SM3. Sound files were stored as compressed ".WAC0" files.

Survey Design

Hispaniola

Grupo Jaragua deployed seven acoustic sensors at exploratory sites in Valle Nuevo in the Cordillera Central of the Dominican Republic, an area where radar surveys (Adam Brown, EPIC) had detected potential petrel flight activity in 2014 (Table 1; Figure 1 & Figure 2). No breeding aggregations have previously been discovered in that region of the island.

Dominica

Adam Brown (EPIC) and Stephen Durand (Department of Forestry) deployed song meters at three exploratory survey points on Dominica in areas were 2015 radar surveys showed potential petrel radar targets, as well as a few observations of petrels in flight (Table 1; Figure 3). Petrels were thought to have been extirpated from Dominica and no breeding aggregations are currently known to exist on the island.

Table 1 : Acoustic deployment periods at exploratory survey sites on Hispaniola and Dominica.

SPID	*Recording Unit*	*Site Name*	*Latitude*	*Longitude*	*First Recording*	*Last Recording*
HISPANIOLA						
Chorriosa	CM27	Loma La Chorriosa	18.738944	-70.592184	12/2/2015 20:02	2/2/2016 1:30
Fresa	CM25	Camino de la Fresa	18.659869	-70.590989	2/29/2016 10:11	5/4/2016 22:24
Fresa 1	CM27	Loma de las Fresas 1	18.640637	-70.600203	2/28/2016 13:53	5/2/2016 23:58
Fresa 2	CM26	Camino de la Fresa 2	18.654525	-70.593669	2/29/2016 10:40	5/4/2016 0:45
Fresa 3	CM23	Camino de la Fresa 3	18.641132	-70.596094	2/29/2016 11:42	3/7/2016 6:55
Fresa 4	11207	Camino de la Fresa 4	18.642435	-70.596969	2/29/2016 12:03	4/23/2016 1:20
La Nuez	CM26	Cañon próximo la Nuez	18.686533	-70.595154	12/3/2015 20:04	1/29/2016 23:58
N Espinas	3693	Arriba Caseta las Espinas	18.682422	-70.588782	2/29/2016 9:21	5/1/2016 23:58
N Piramide	CM24	Norte Piramide	18.701443	-70.592781	2/28/2016 10:33	5/3/2016 4:35
Neblinas	11207	Las Neblinas	18.696536	-70.589682	12/2/2015 19:56	1/29/2016 23:58
Pinar Parejo	3693	Carretera Pinar Parejo	18.842937	-70.731077	12/2/2015 20:59	1/26/2016 23:57
Piramide	CM24	Mirador Piramide	18.703825	-70.610173	12/5/2015 15:27	1/19/2016 3:45
Tetera	CM25	La Tetera	18.648516	-70.621215	12/2/2015 21:04	2/1/2016 4:20
Yoyo	CM23	Curva del Yoyo	18.692549	-70.588914	12/2/2015 20:08	1/27/2016 23:57
DOMINICA						
Diablotin	DOM01	Morne Diablotin	15.509583	-61.407722	1/17/2015 9:54	7/29/2015 21:36
Micotrin	DOM02	Morne Micotrin	15.342728	-61.318508	1/20/2015 13:48	8/17/2015 6:40
Trois Piton	DOM03	Morne Trois Piton	15.373461	-61.335171	1/23/2015 12:13	8/13/2015 23:29

Hispaniola

Figure 1: Valle Nuevo study region (red box) in the Cordillera Central of the Dominican Republic

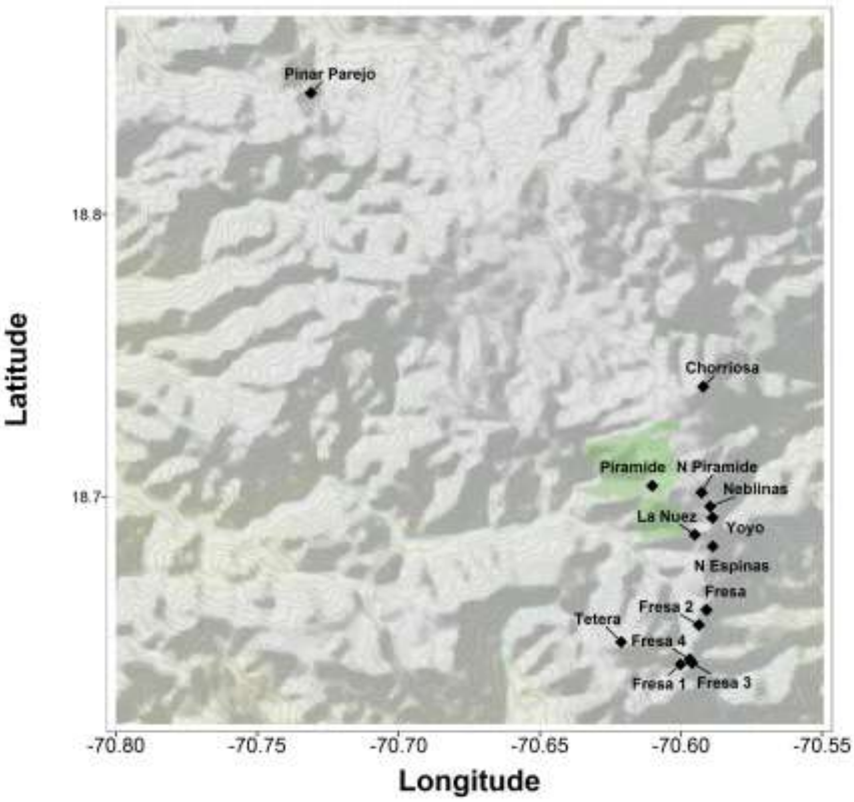

Figure 2: Exploratory acoustic survey sites in Valle Nuevo, Dominican Republic (zoomed in).

Dominica

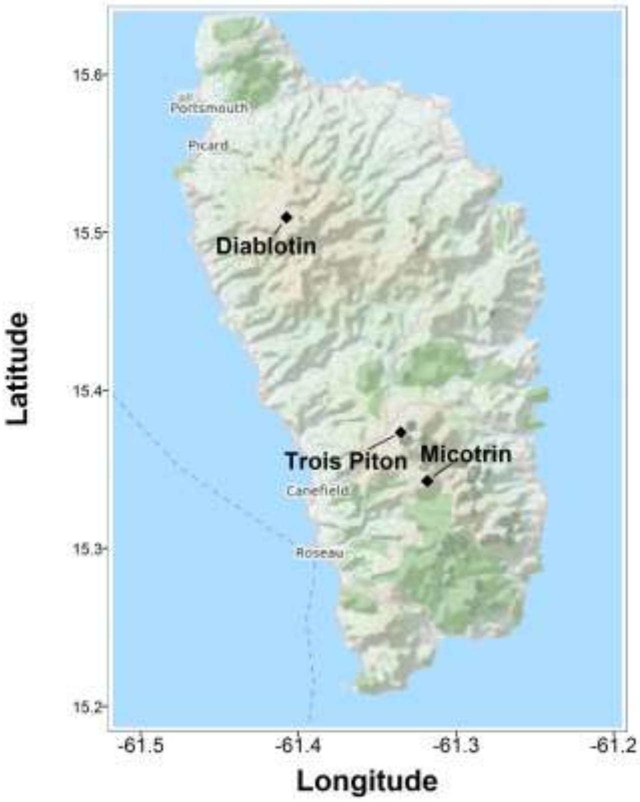

Figure 3: Exploratory acoustic survey sites on Dominica.

Recording Schedule

Hispaniola

All Song Meter 2+ sensors deployed on Hispaniola were programmed to record one minute of every five-minutes from local sunset to local sunrise. This schedule was expected to last for 43 nights before requiring new batteries. Sunrise/sunset times were calculated based on a central location of 18.32 N, 71.51 W and GMT-4. Data were recorded on the left channel at a sampling rate of 22,000 Hz and 16 bits, in the ".wav" format. The units were set with a gain setting of +48dB.

Dominica

The Song Meter 3 sensors deployed on Dominica were programmed to record a four-hour continuous block starting one hour after local sunset, and then record one minute out of every ten minutes until one dawn. This schedule was repeated on every other night to increase deployment times. This schedule extended the expected battery life to 60 nights. Sunrise/sunset times were calculated based on a central location of 15.5 N, 61.35 W and GMT-4. Data were recorded on the left channel at a sampling rate of 24,000 Hz and 16 bits, in the WAC0 compression format (Wildlife Acoustics, Inc.). The units were set with a gain setting of+24dB.

Automated acoustic analysis

Conservation Metrics has developed a machine-learning approach for detecting calls of interest on field recordings. The method leverages Deep Neural Network (DNN) classification models, a technique where an algorithm is trained to detect a unique combination of spectro-temporal features found in target sounds (i.e. calls from the species of interest). These models can then be used to search field recordings for sounds with the same combination of features. Deep Neural Networks are the current state of the art for detection and classification problems in many fields including speech recognition (Deng et al. 2013), computer vision, image recognition (Ciresan et al. 2012), as well as other classification problems.

All events flagged by the Black-capped Petrel automated classification model were reviewed by a human observer during the analysis process to confirm true calls and/or remove all sounds misidentified by the computer.

In addition, acoustic filters were applied to all data to search for sounds with tonal features between 400 and 800 Hz. These spectral features are typical components of many petrel calls (Black-capped Petrel, Galapagos Petrel, Juan Fernandez Petrel, and etc.) and were applied to try to detect any call variants not described well by the DNN classification model developed from Black-capped Petrels on Hispaniola.

Results

Hispaniola

Survey Effort

A total of seven acoustic sensors were deployed at 14 exploratory survey sites in Valle Nuevo from from 12/2/2015 to 5/4/2016 (Table 1 and Figure 4). A total of 1,891 hours were recorded on a 783 combined survey nights (Table 2). Measurements of microphone quality during analysis indicated that microphones were slightly affected by moisture duing the first round of deployments (Figure 4), with four sensors losing more than 20% of recording hours. However, data loss was sporadic, and there was adequate surevy effort across sites. Microphone quality was improved during the second round of surveys.

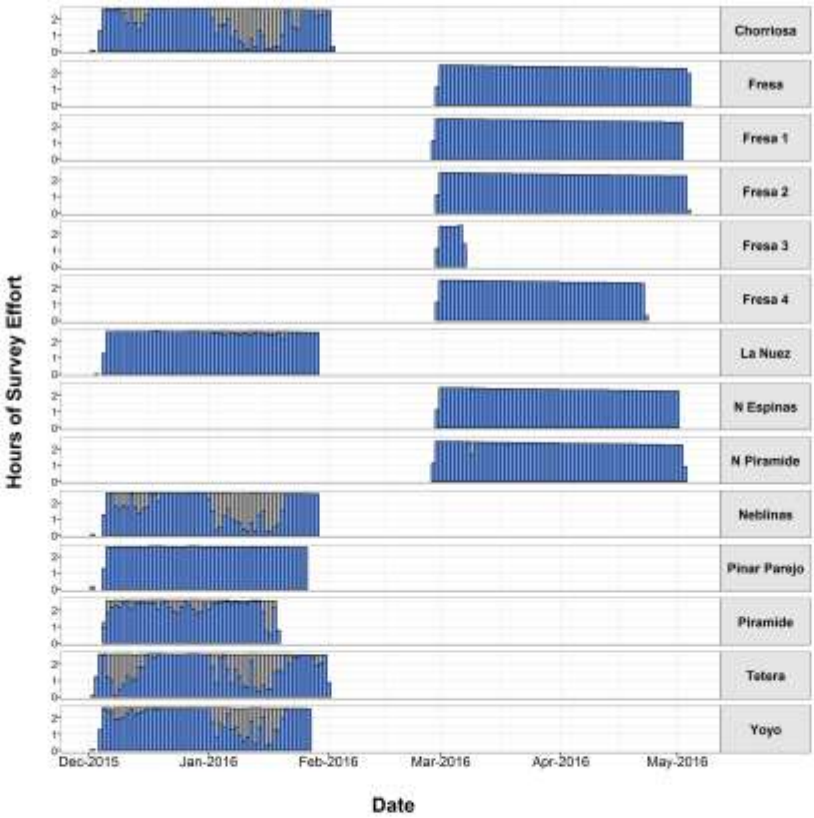

Figure 4 : Hours of recording effort at each site over the course of the 2016 survey season (12/02/2015 – 5/4/2016). Grey portions of bars represent data removed from analysis because it did not meet recording quality standards.

Table 2 : Effort table with total data collected and data after removal for flux sensitive.

SPID	*Total Nights*	*Total Hours*	*Corrected Nights*	*Corrected Hours*	*Nights Lost*	*Pct. Nights Lost*	*Hours Lost*	*Pct. Hours Lost*
Chorriosa	62	154.49	62	114.04	0	0%	40.45	26%
Fresa	66	153.31	66	153.16	0	0%	0.15	0%
Fresa 1	65	151.58	65	151.58	0	0%	0	0%
Fresa 2	66	151.53	66	151.35	0	0%	0.18	0%
Fresa 3	8	17.3	8	17.3	0	0%	0	0%
Fresa 4	55	126.81	55	126.81	0	0%	0	0%
La Nuez	57	143.88	57	141.45	0	0%	2.43	2%
N Espinas	63	146.88	63	146.78	0	0%	0.1	0%
N Piramide	66	152.51	66	151.43	0	0%	1.08	1%
Neblinas	57	143.94	57	101.28	0	0%	42.66	30%
Pinar Parejo	54	136.38	54	136.38	0	0%	0	0%
Piramide	46	116.38	46	100.25	0	0%	16.13	14%
Tetera	62	155.03	62	111.65	0	0%	43.38	28%
Yoyo	56	141.45	56	111.92	0	0%	29.53	21%

Acoustic Activity

Black-capped Petrel calls were detected at four of the 14 exploratory survey sites in Valle Nuevo (Figure 5, Figure 6,
Figure 7). Survey sites at Fresa 1 and Las Nueses detected the highest number of calls - 19 calls and 17 calls, respectively. Activity was largely detected from 2 to 5 hours after local sunset (Figure 8).

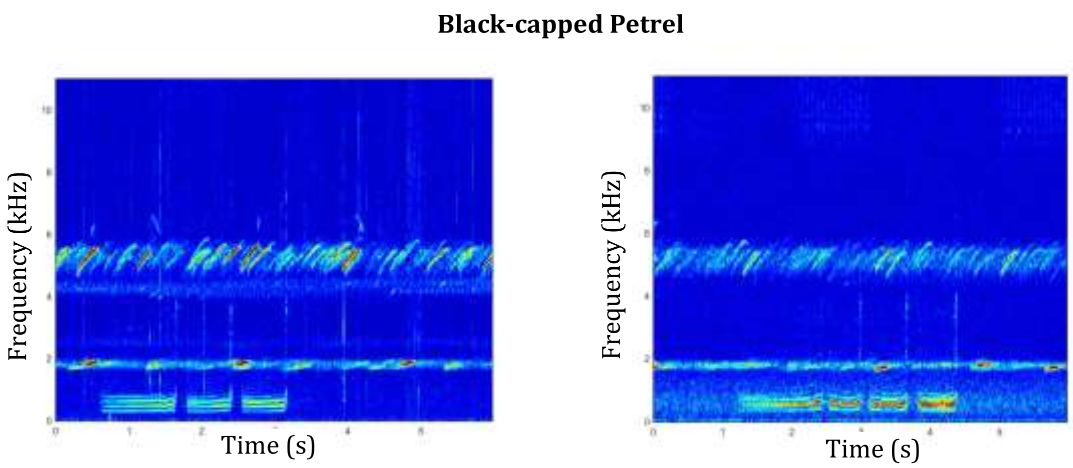

Figure 5: Spectrogram of Black-capped petrel calls recorded on Hispaniola. (a) CM23 03-01-2016 22:57:00; (b) CM27 03-01-2016 22:22:00

Detection rates were low, with sporadic detections of activity on one to three nights per site (Figure 6). Call rates were orders of magnitude lower than that measured at breeding aggregations elsewhere on Hispaniola in 2015 (Table 4).

Table 3: Black-capped Petrel acoustic activity detected at exploratory sites in Valle Nuevo, Dom. Rep.

SPID	*Total Detections*	*Calls Per Min.*	*N*	*sd*
Chorriosa	0	0.0000	62	0
Fresa	0	0.0000	66	0
Fresa 1	19	0.0030	65	0.0166
Fresa 2	0	0.0000	66	0
Fresa 3	2	0.0017	8	0.0048
Fresa 4	0	0.0000	55	0
La Nuez	17	0.0019	57	0.011
N Espinas	0	0.0000	63	0
N Piramide	0	0.0000	66	0
Neblinas	3	0.0003	57	0.0019
Pinar Parejo	0	0.0000	54	0
Piramide	0	0.0000	46	0
Tetera	0	0.0000	62	0
Yoyo	0	0.0000	56	0

Table 4 : Mean call rate per minute by site for Black-capped Petrels on Hispaniola during the seasonal peak of activity, 15 January – 15 February 2015.

SPID	*N*	*Calls Per Min.*	*sd*
LAVI01 (Seguin, Haiti)	16	4.02	2.96
LAVI02 (Seguin, Haiti)	16	6.85	5.64
NV (Baoruco, Dom. Rep.)	13	0.03	0.03
TRO abajo (Baoruco, Dom. Rep.)	13	0.37	0.73
TRO arriba (Baoruco, Dom. Rep.)	14	0.25	0.50
TTRO (Baoruco, Dom. Rep.)	11	0.00	0.00

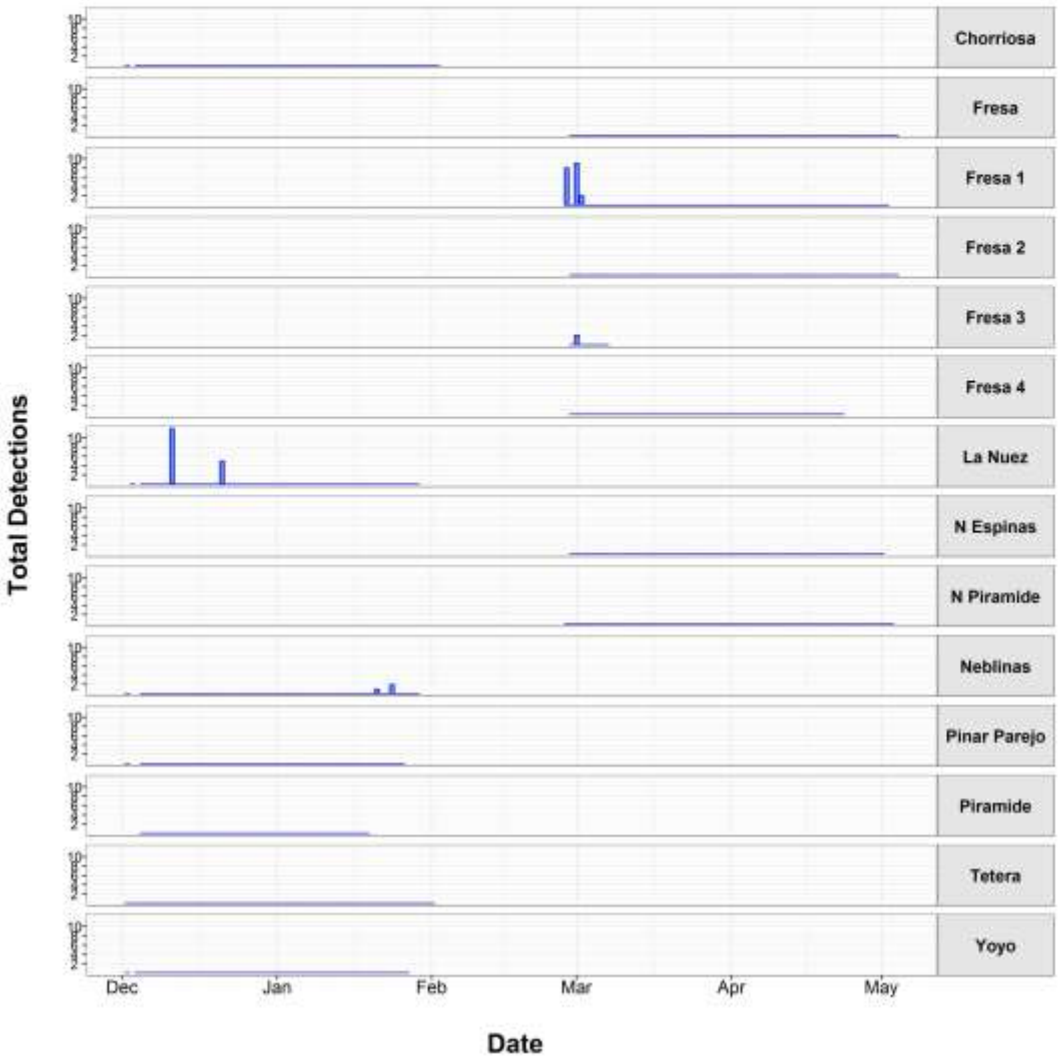

Figure 6: Total Black-capped Petrel calls detected by night and site in Valle Nuevo, Dom. Rep.

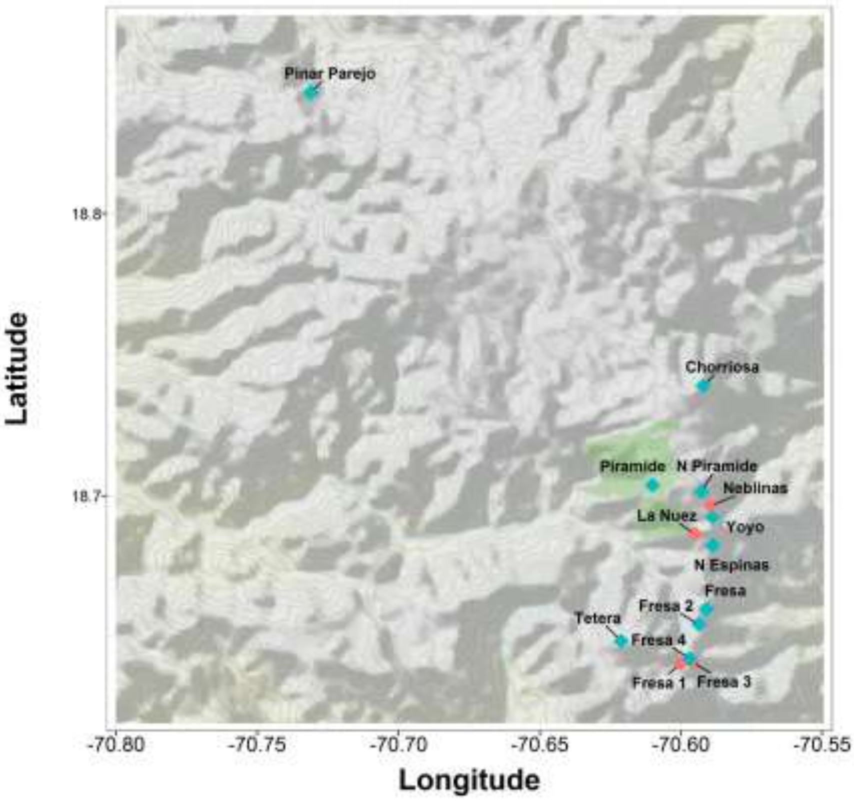

Figure 7: Black-capped Petrel calls were detected at 4 exploratory survey sites (Pink) in Valle Nuevo, while no calls were detected at the other 10 survey sites (Black).

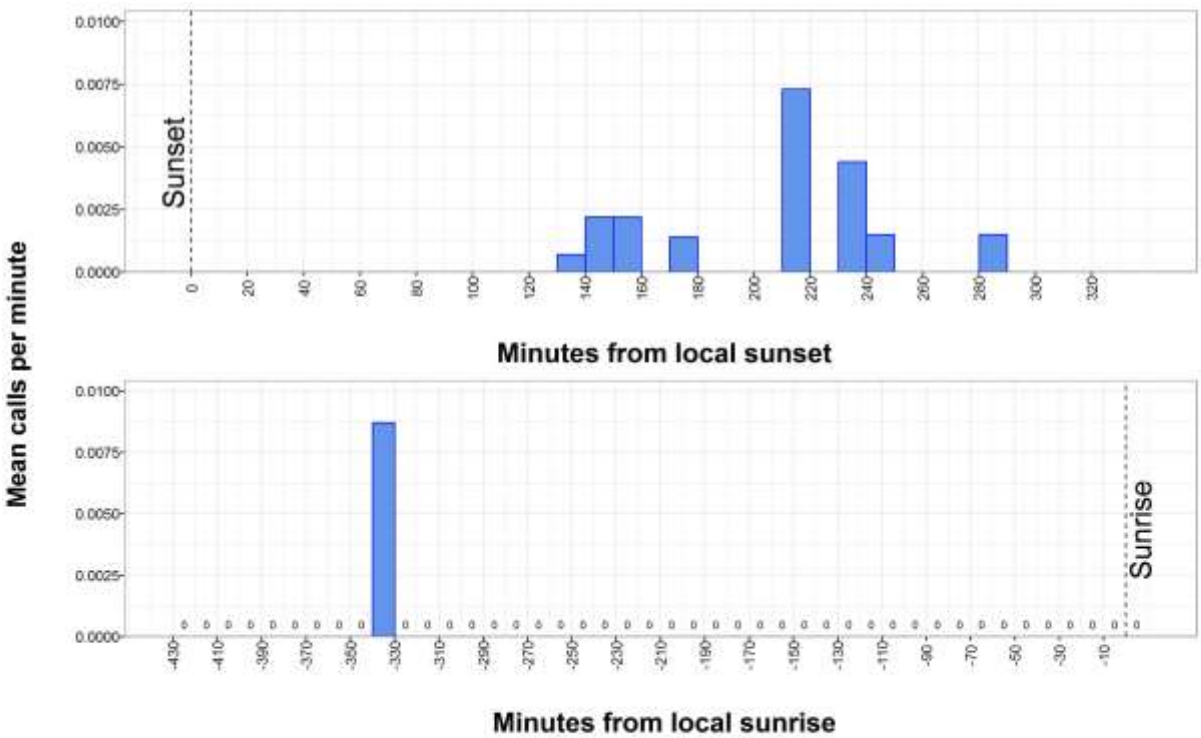

Figure 8: BCPE acoustic activity on Hispaniola as a function of minutes from sunset and sunrise

Dominica

Survey Effort

Song meters were deployed at the three exploratory survey sites on Dominica from January to August 2015 (Figure 9). A total of 587 hours of survey effort were analyzed from over 261 combined nights of survey effort.

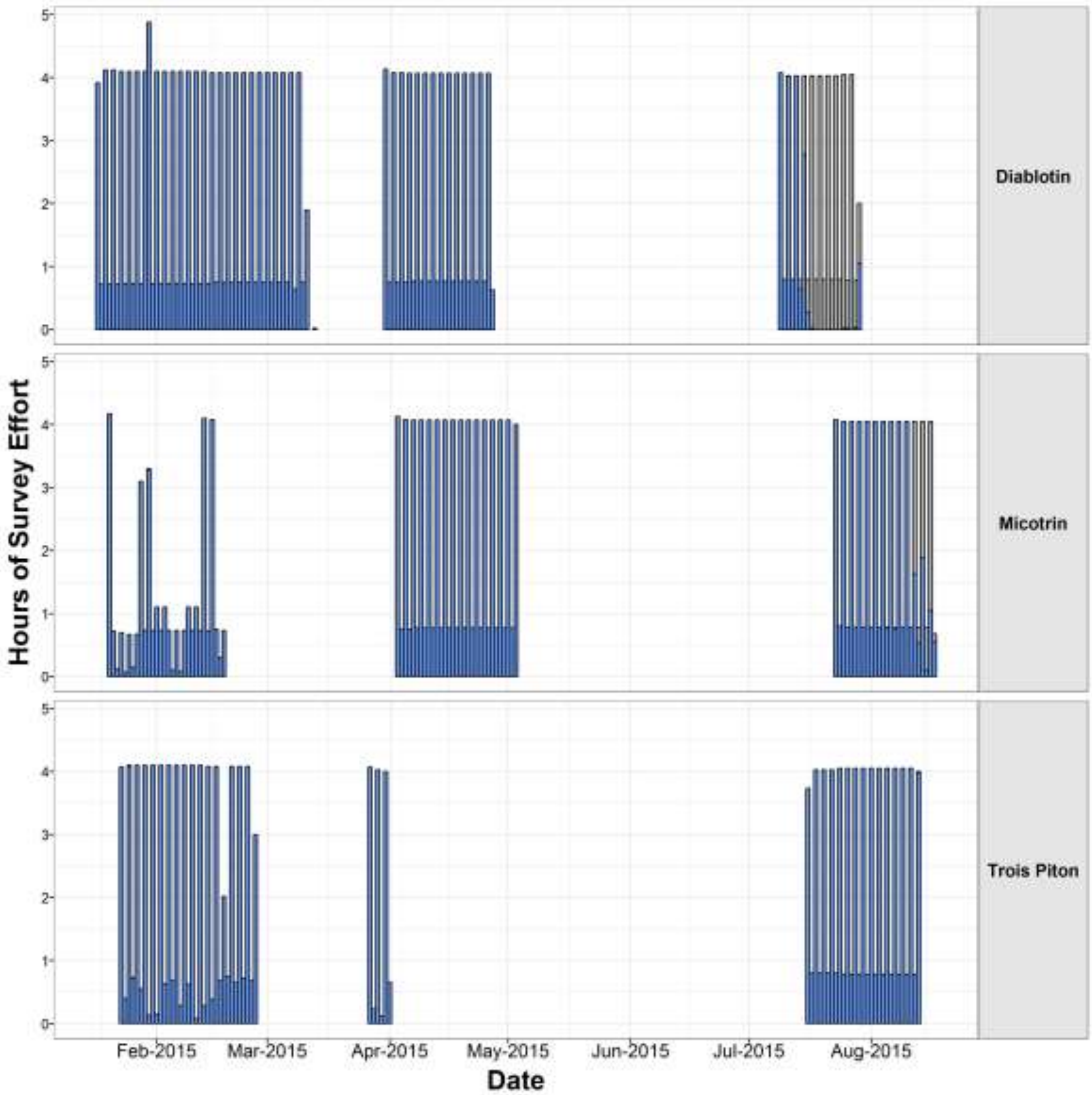

Figure 9: Hours of recording effort at each site over the course of the 2015 survey season (1/17/2015-8/17/2015). Grey portions of bars represent data removed from analysis because it did not meet our flux sensitive data quality metric standard.

Although the recording schedule was expected to last for ~ 60 nights per deployment, the sensors repeatedly recorded for shorter periods of time (~ 30 nights; Figure 9). This could be a result of Song Meter 3 firmware issues, SD memory card problems, or differences in D-cell battery specs in Dominica vs. those of batteries available in the U.S. The short deployment period in April at the Trois Piton survey site also suggests bad batteries. Finally, the effort plot from Micotrin suggests that there may be some missing data, as many of the longer bloacks of recording effort are missing. We should check backed-up files to confirm that CMI received all of the data.

Table 5: Effort table with total data collected and data after removal for flux sensitive

SPID	*Total Nights*	*Total Hours*	*Corrected Nights*	*Corrected Hours*	*Nights Lost*	*Pct. Nights Lost*	*Hours Lost*	*Pct. Hours Lost*
Diablotin	104	250.1	96	218.32	8	8%	31.78	13%
Micotrin	87	174.14	87	165.43	0	0%	8.71	5%
Trois Piton	70	163.3	70	163.25	0	0%	0.05	0%

Acoustic activity

No petrel calls were detected at the exploratory survey sites on Dominica.

Table 6: BCPE activity on Dominica including all data

SPID	*Calls Per Min*	*Total Detections*	*N*	*sd*
Diablotin	0	0	96	0
Micotrin	0	0	87	0
Trois Piton	0	0	70	0

Discussion

Radar surveys are a powerful tool for detecting elusive nocturnal seabirds (Brown 2015; Day & Cooper 1995). However, although the flight speed and behavior of radar targets are strong evidence of petrel activity, radar data do not provide other independent information to identify species, and radar activity, like acoustic activity, does not confirm breeding. Here we test the use of acoustic surveys as a method for providing additional corroborative evidence of species ID (on-top of flight characteristics, and visual surveys), and as a tool for helping field teams prioritize areas for on-the ground nest searches. Together these three methods (radar, acoustics, and targeted ground searches) can provide a powerful yet cost-effective way to search large areas for rare seabirds.

In the Dominican Republic, the 2016 acoustic surveys detected Black-capped Petrel vocalizations at four exploratory survey sites in Valle Nuevo, adding further evidence that the radar targets detected by Adam Brown and Grupo Jaragua in 2013 and 2014 were likely petrels. Vocal activity was sporadic at the 2016 survey sites, with only a few calls detected on a few nights of the season. Given that acoustic activity was detected on a nightly basis at known breeding aggregations on Hispaniola over the same time-period in 2014 and 2015, the dearth of calls detected at the exploratory sites in 2016 suggest that these sensors detected calls from individuals in transit through the valley. However, it is also possible that the calls detected could be from birds at small breeding aggregations, or from prospecting individuals exploring areas without extant breeding burrows. Additional surveys in 2017 could help determine if there are sites further up the valley with more consistent calling activity, one potential sign of a breeding aggregation.

Acoustic surveys on Dominica did not detect any petrel calls. The DNN classification model and manual filtering process did detect a lot of dove vocalizations with low frequency components, but no petrels. We do not, however, feel that the lack of acoustic detections diminishes the strength of the radar survey results reported by Brown (2015). They found strong quantitative radar patterns consistent with that observed on Hispaniola, they visually observed petrels in flight during radar surveys, and their results follow a series of recent records of downed petrels on Dominica. We feel there are several reasons why the acoustic surveys may have failed to detect calls. First, the sensors may not have been close to locations where petrels were most likely to be calling. Although many petrel species do call while transiting to and from breeding sites, our work in Hawaii, and the results from 2016 surveys on Hispaniola suggest that call rates are lower and less consistent in flyways than at breeding sites. Given the decreased activity, sensor placement is even more challenging, as surveys sites off the main flight corridor would be expected to have low detection probabilities. Depending on conditions, maximum detection distances for the acoustic sensors are likely not more than 500m (based on tests conducted on the Big Island of Hawaii, Moseley, Pers. Comm.). Thus, moving the sensors to new survey sites in 2017 would be advised. Sites in potential breeding habitat would be ideal, but may be logistically challenging. Sites below potential breeding habitat, or high on the sides of valleys used as flight corridors (where sensor microphones would be close to the same elevation as petrels) should be identified. Given that radar detections occurred within the first hour after sunset at many survey stations, we would suggest modifying the Dominica recording schedule to start at sunset, rather than delaying an hour (as has traditionally been done on Hispaniola).

One other unlikely possibility could be that behavioral differences could explain the lack of petrel detections on Dominica. Although there is no evidence at this time to support this hypothesis, it is possible that low-densities and/or ongoing threats could favor behaviors that reduce conspicuousness.

To close, we offer several suggestions that could help improve surveys on Hispaniola and Dominica in 2017. First, one of the biggest challenges has been getting data from field sites in the Caribbean to the U.S. for analysis. We have attempted electronic transfers through FTP, but these attempts were largely unsuccessful – tying up personal computers and internet connections, while failing to transfer most of the large hour-long files. DropBox transfers have worked for sending files from Haiti, but this method also caused some challenges for staff in the field. We therefore suggest pre-positioning several hard drives and extra SD memory cards on Hispaniola and Dominica along with prepaid courier pouches. Data could then be backed up locally without on the external hard-drives, and then the SD cards could be mailed to the U.S. for analysis.

Secondly, we should update the firmware on all Song Meters, format all SD cards with Song Meters before deployment, and update the Dominica recording schedule before deployment in January. Finally, Conservation Metrics should schedule more regular calls to coordinate field efforts, and fix challenges in a more-timely manner, something we feel we could improve on from previous years.

Literature Cited

BirdLife International, 2016. Species factsheet: Pterodroma hasitata.

Borker, A.L. et al., 2014. Vocal Activity as a Low Cost and Scalable Index of Seabird Colony Size. *Conservation Biology*, 28(4), pp.1100–1108. Available at: http://dx.doi.org/10.1111/cobi.12264.

Buxton, R.T. & Jones, I.L., 2012. Measuring nocturnal seabird activity and status using acoustic recording devices: applications for island restoration. *Journal of Field Ornithology*, 83(1), pp.47–60. Available at: http://www.mun.ca/serg/Buxton&Jones_JFO_2012.pdf.

Ciresan, D. et al., 2012. Multi-column deep neural networks for image classification. In *2012 IEEE Conference on Computer Vision and Pattern Recognition*. Providence, RI: IEEE, pp. 3642–3649.

Deng, L., Hinton, G. & Kingsbury, B., 2013. New types of deep neural network learning for speech recognition and related applications: an overview. In *2013 IEEE International Conference on Acoustics, Speech and Signal Processing*. Vancouver, BC: IEEE, pp. 8599–8603.

Oppel, S. et al., 2014. Estimating population size of a nocturnal burrow-nesting seabird using acoustic monitoring and habitat mapping. *Nature Conservation*, 7, pp.1–13.