Nocturnal Acoustic Monitoring of Bird Migration

South Canoe Wind Farm

Spring 2016

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For:

South Canoe Development Partnership

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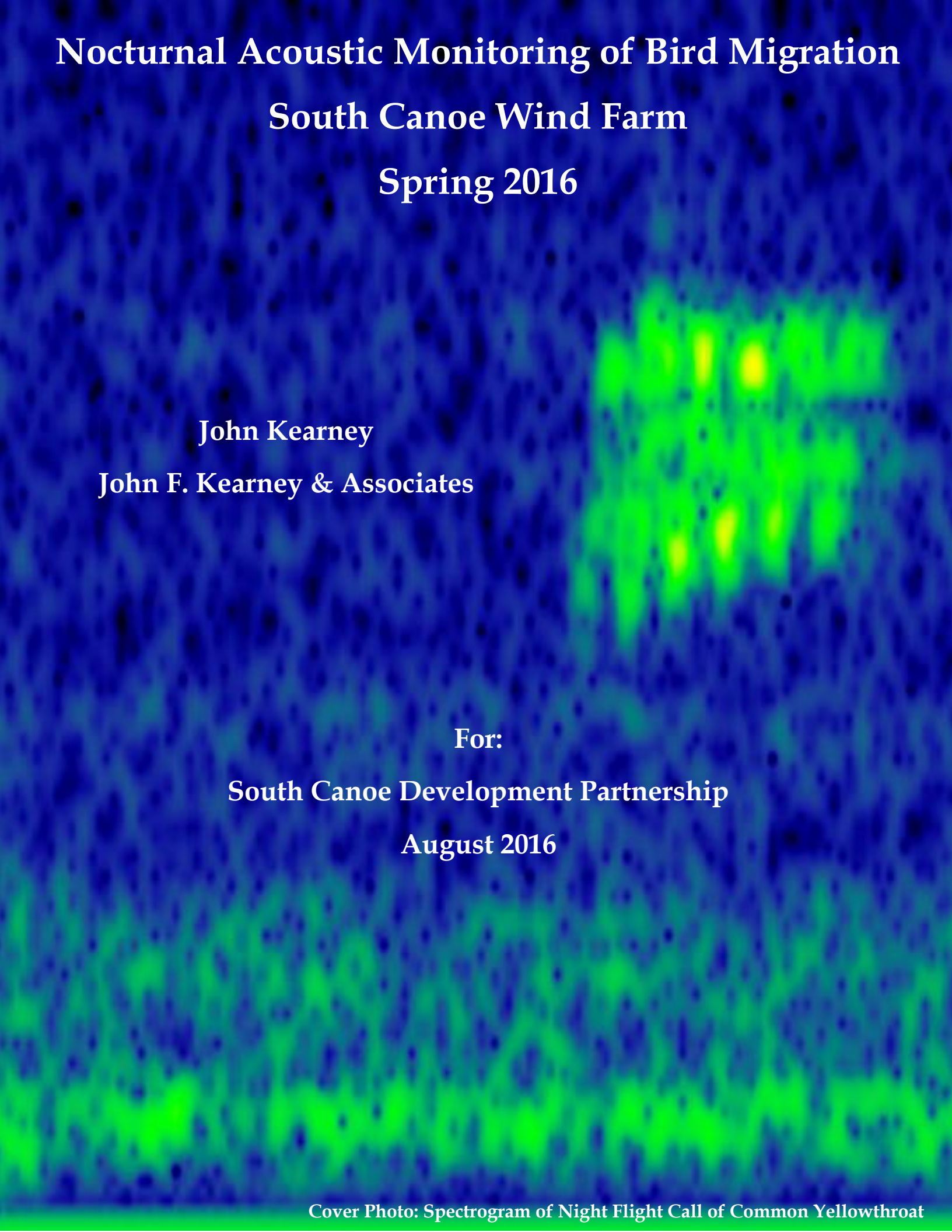


Cover Photo: Spectrogram of Night Flight Call of Common Yellowthroat

Abstract

Nocturnal acoustic monitoring near South Canoe Lake in the spring of 2016 indicated high numbers of migrating birds with no statistically significant difference in the total number of calls from late April to early June. Warblers, sparrows, thrushes, and nightjars were well represented in the species composition. High call counts during the spring and previous autumn for the Common Nighthawk, a species listed as threatened by the Species at Risk Act, demonstrate the need for further study of this species in the project area.

Introduction

The South Canoe Wind Farm consists of 34 wind turbines with a 102 megawatt capacity on 2,800 hectares of land located 25 kilometers southwest of Windsor, Nova Scotia.

This study reports on the results of the first spring season of nocturnal acoustic monitoring of bird migration as part of a two-year post-construction bird and bat study. Most of the birds that fly over a wind energy facility do so at night during their spring and autumn migration. Thus it is important to measure the intensity of this migration that is at or near the level of the blade sweep of the wind turbines. Specially designed microphones and recording equipment can be used to determine this migration density. The night flight calls made by birds, mostly small to medium-sized songbirds, can be classified through spectrographic analysis and identified, often to the species level (see cover photo for an example of a night flight call spectrogram).

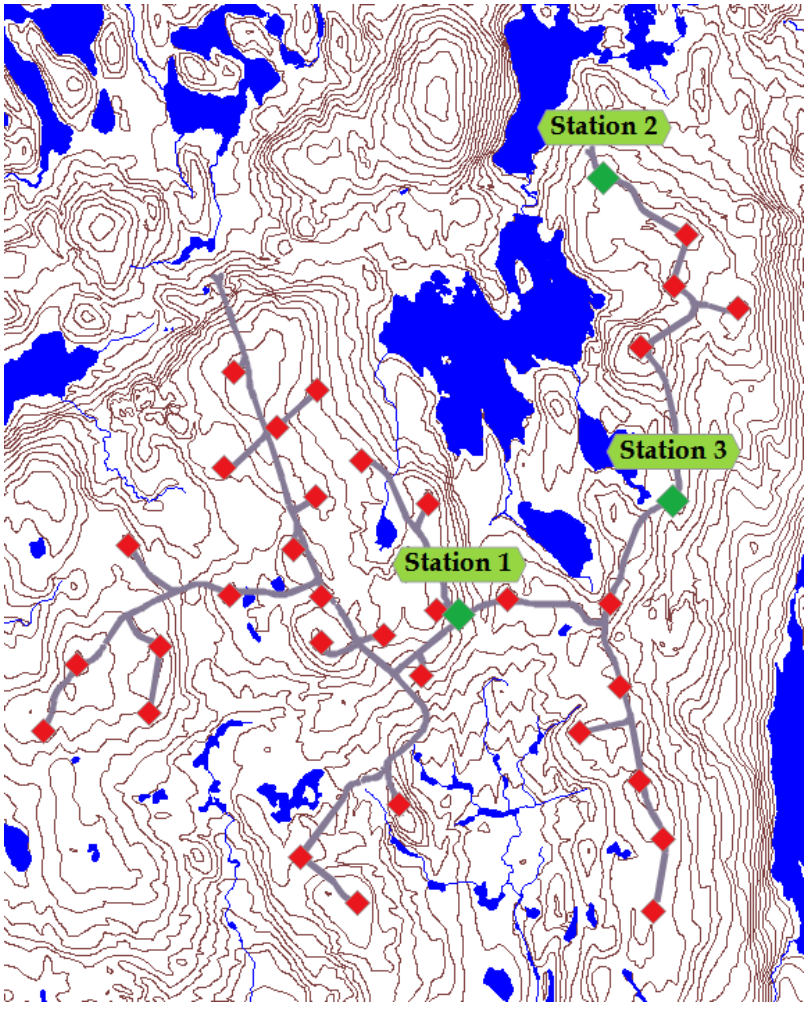
Location of Monitoring Stations

There is a total of three acoustic monitoring stations at the South Canoe Wind Farm. These are shown in Figure 1. Station 1 was deployed during the autumn of 2015

and was found to have too much noise interference from the nearby turbine #17 that is 219 meters from the station. Station 2 was also deployed in the autumn of 2016 and is located at the northernmost periphery of the project lands with the closest turbine being 971 meters (#24) from the station. Station 2 was chosen for analysis for the 2015 autumn season since it was less affected by wind turbine noise and was more likely to detect southbound birds before they might change flight paths to avoid the wind farm.

Station 3 was established in the spring of 2016 as a backup site for Station 2. Station 3 is 1,142 meters from the closest wind turbine (#30) and is also on the outer perimeter of the wind energy site. However, for comparative purposes, Station 2 was chosen for analysis of the 2016 spring acoustic data.

Figure 1: Location of Monitoring Stations



Acoustic Methods

Acoustic monitoring of nocturnal passage provides data on the species of birds migrating through an area, their relative abundance, and migration timing. Recording took place every night from civil sunset to civil sunrise from 24 April to 3 June 2016 (inclusive). At both sites, a Song Meter SM2, made by Wildlife Acoustics, was used as a recording device. The Song Meter is powered by 2 AA and 4 D alkaline batteries. Settings were as follows:

Sampling format: 16 bit

Sampling rate: 24,000 Hz

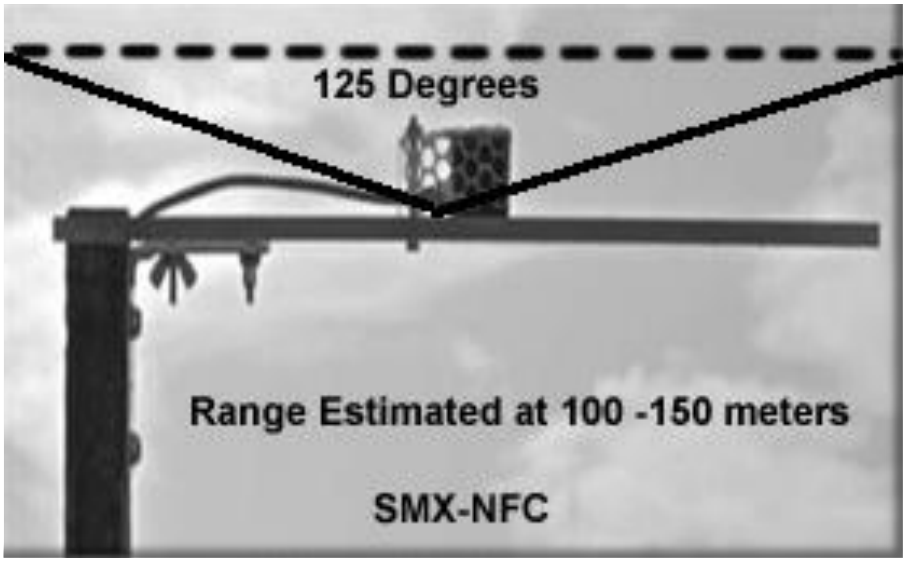
High pass filter: 1,000 Hz

Pre-amp: 60 dB gain

Storage: 2-32GB SD cards

A night flight call microphone, the SMX-NFC, also made by Wildlife Acoustics, can be used with the Song Meter. This weather-resistant microphone rests on a flat horizontal plate creating a pressure zone resulting in a 3-6 dB gain within a beam angle of 125 degrees (see Figure 2). Based on experience in Nova Scotia, the range is estimated at 100-150 meters in altitude.

Figure 2: Flight Call Microphone



The Song Meter and SMX-NFC microphone were chosen for use in this study since they were also employed by the author at thirteen other existing or proposed wind energy facilities from 2011 to 2015 in Nova Scotia.

The detection of night flight calls was conducted using the Raven Pro sound analysis software produced by the Cornell Lab of Ornithology. The detection parameters for high frequency calls (sparrows and warblers) and low frequency calls (thrushes and shorebirds) are shown in Table 1. The review panel of Raven Pro allows for a standardized process to classify, identify, and store night flight calls.

Table 1: Detection Parameters

	High Frequency	Low Frequency
Target Signal Parameters		
Minimum Frequency	6000 Hz	2250 Hz
Maximum Frequency	11000 Hz	3750 Hz
Minimum Duration	29 ms	29 ms
Maximum Duration	400 ms	330 ms
Minimum Separation	104 ms	52 ms
Signal to Noise Ratio Parameters		
Minimum Occupancy	25.0	20.0
Threshold	3.5	4.0
Noise Power Estimation Parameters		
Block Size	5000 ms	1000 ms
Hop Size	250 ms	250 ms
Percentile	50.0	50.0

During periods of wind and/or rain, detection software can produce tens of thousands of false positives. This effect is more severe in the low frequency range. To overcome this problem, a number of bandwidth filters were employed when normal detector runs produced more than 5,000 detections. For the high frequency detector, a bandwidth filter with a minimum of 100 Hz, a maximum of 1000 Hz, and an energy percentile of 40% (the fraction of total energy in the specified bandwidth) proved to be the most effective. For the low frequency detector, a filter with a minimum bandwidth of 100 Hz, a maximum of 500 Hz, and an energy percentile of 40% or more was used.

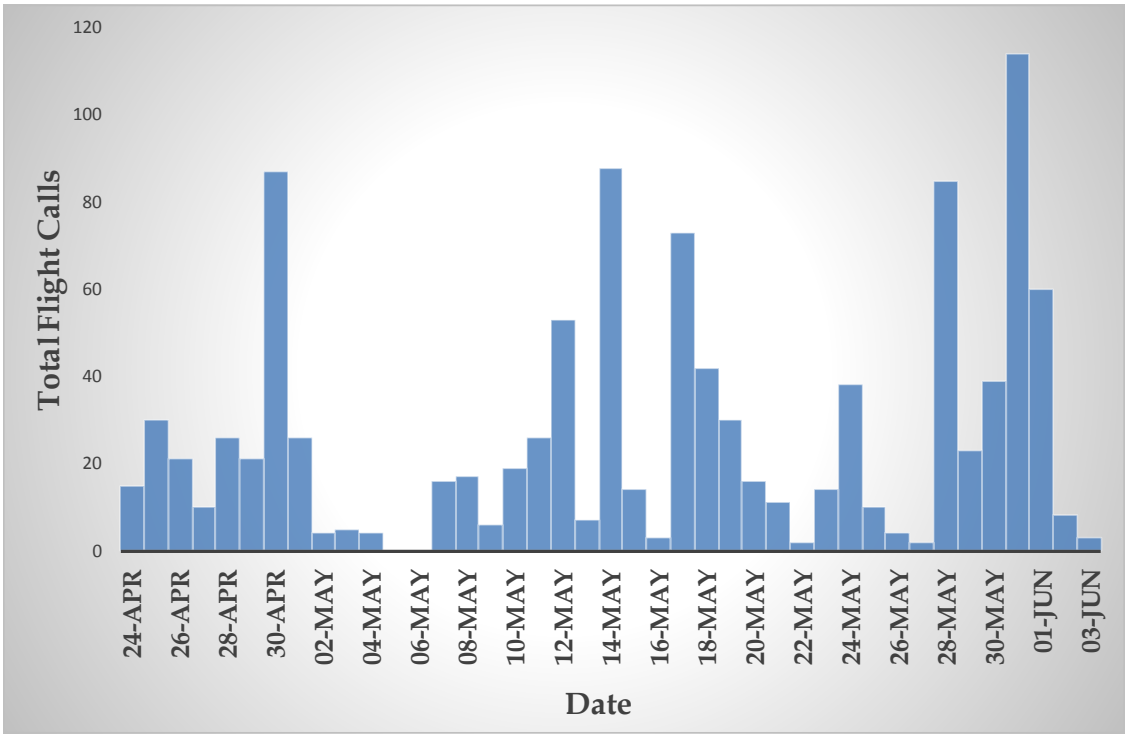
Past studies showed that the high frequency filter captured up to 98% of the true positives detected without the filter. For the low frequency detector, the bandwidth filter is less efficient but still captures the majority of night flight calls during the night. The use of the filters can be supplemented by a systematic search of those times of a given night where most of the night flight calls were detected.

Results

A total of 1,072 night-flight calls were recorded during the spring migration of 2016 at Station 2. Total high frequency calls (small songbirds like warblers and sparrows) were 628 while total low frequency calls (medium to large-sized birds like thrushes and water birds) were 444.

Figure 3 shows the total flight calls by date. The peak date was 31 May when 114 flight calls were recorded. This peak corresponds with the arrival of Common Nighthawks and late migrating warblers such as the Common Yellowthroat.

Figure 3: Total Calls by Date



However, Figure 3 also indicates somewhat smaller peaks at the end of April with the arrival of Hermit Thrushes and in mid-May with the movements of White-throated Sparrows and early migrating warblers.

Figure 4 shows the mean number of total calls by 10-day periods. This aggregation attenuates the effect of daily changes in weather and highlights seasonal trends. An Analysis of Variance (ANOVA) indicates, at the 95% confidence level, that in fact there is no significant difference in the number of calls throughout the spring season.

Figure 4: Mean Number of Calls per Ten-day Period

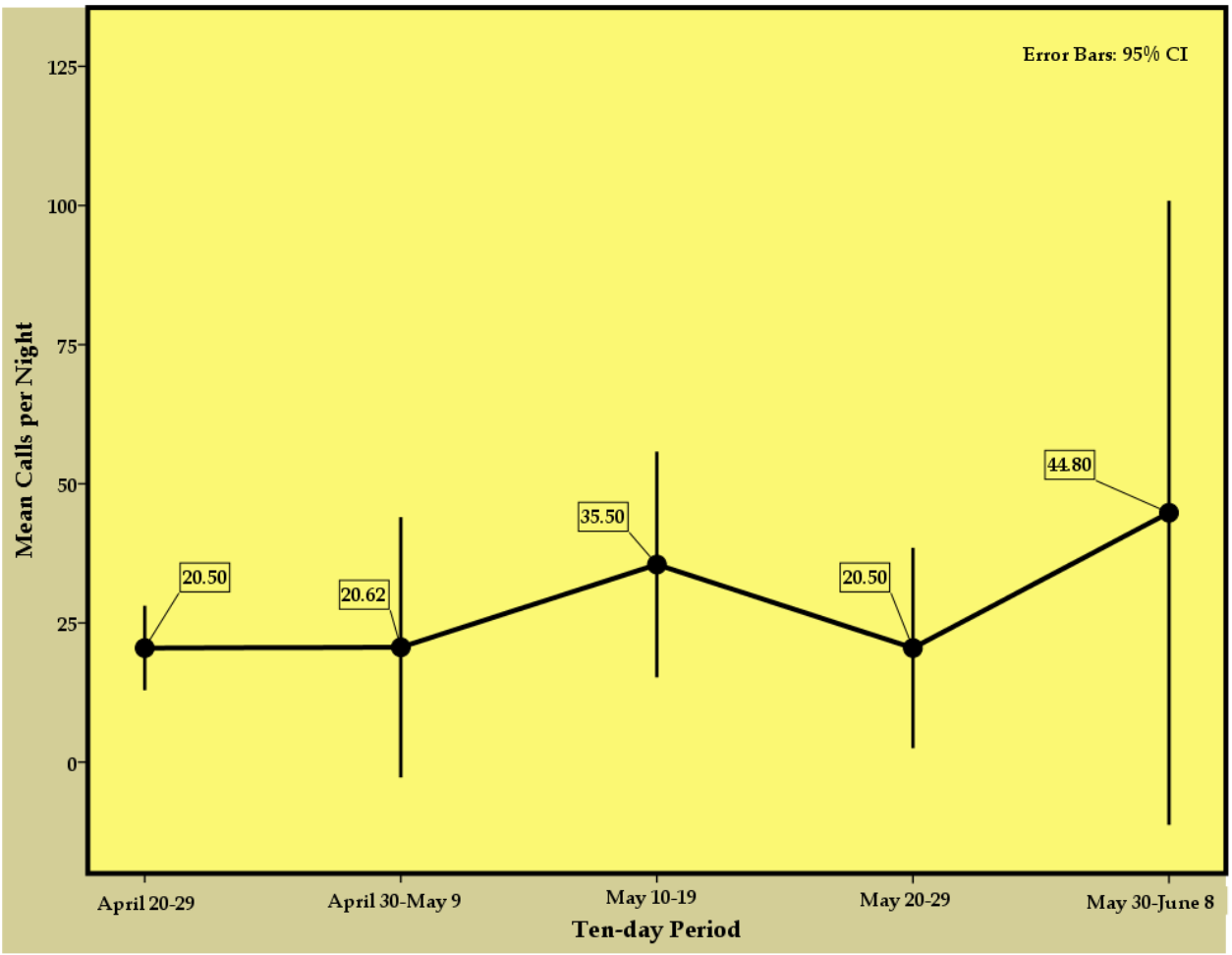
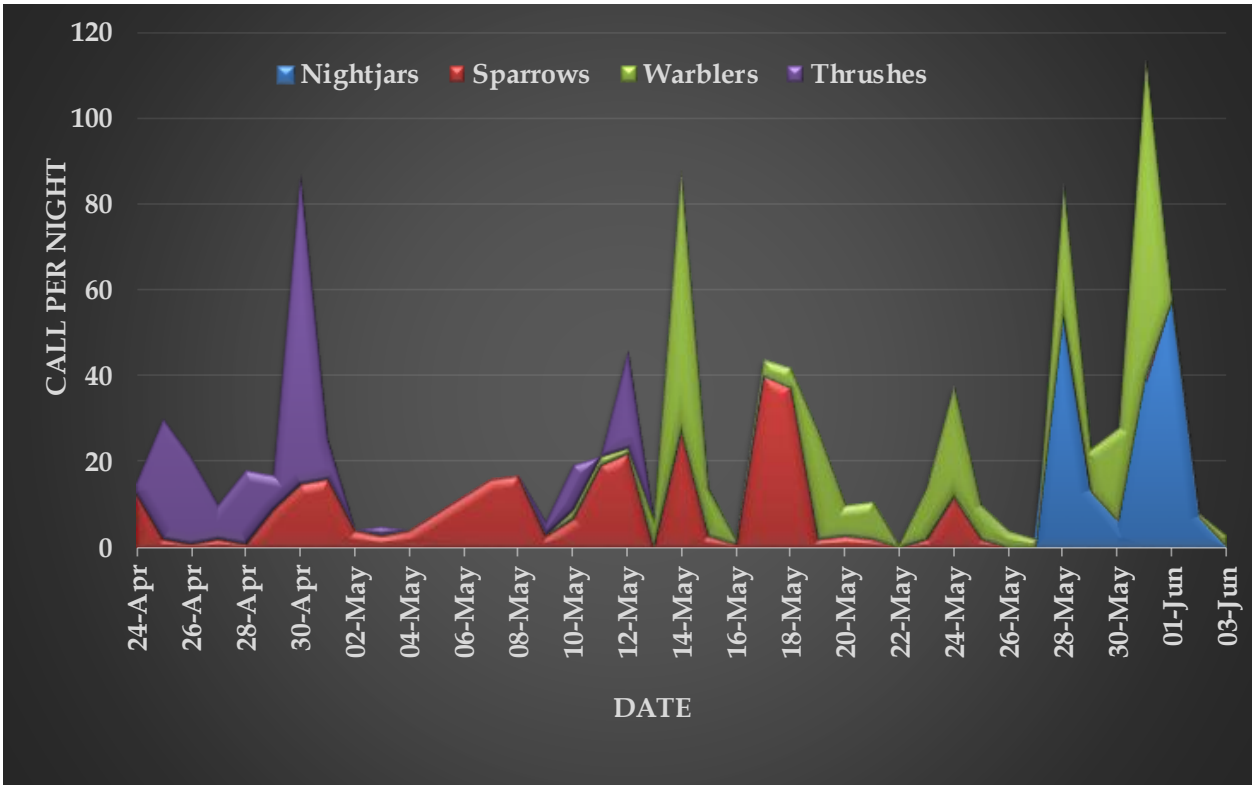


Figure 5 graphs the total calls by the major families of birds detected in the acoustic recordings. The most common family is the warbler family with a total of 331 night flight calls during the spring. The next most common is the sparrow family with 287 calls. The thrushes are next with 203 calls and the nightjars account for 175 calls.

Figure 5: Total Calls by Family by Date



The thrushes are the first to peak in late April and early May. Sparrows build to a peak near mid-May, warblers peak from mid-May to early June, and the nightjars in late May and early June. The nightjars consist of one species, the Common Nighthawk. This species is listed as "threatened" by the Species at Risk Act (SARA) and will be discussed later in relation to species of conservation concern.

Table 2 lists all the species recorded during the spring of 2016. The table also provides an estimate of the minimum number of individual birds that these calls represent. One bird may call multiple times while passing within range of the microphone or multiple birds may be calling to each other as they pass within range of

the microphone. The estimate is based on counting any three calls that are less than one minute apart as one bird. Thus the given estimates are, in most cases, very conservative estimates of the number of birds of a given species.

Table 2: All Species Recorded

Species	Call Count	Estimated Minimum Individuals
White-throated Sparrow	198	109
Hermit Thrush	200	79
Common Nighthawk	175	72
Common Yellowthroat	68	60
Magnolia Warbler	49	45
Ovenbird	43	37
Savannah Sparrow	32	30
American Redstart	27	23
Northern Parula	22	20
Song Sparrow	19	16
Blackpoll Warbler	16	16
Black-and-White Warbler	14	13
Nashville Warbler	12	11
Alder Flycatcher	11	9
Yellow-rumped Warbler	10	9
Canada Warbler	8	8
Chestnut-sided Warbler	7	7
Yellow Warbler	6	5
Blackburnian Warbler	5	5
Chipping Sparrow	4	4
Spotted Sandpiper	35	3
Dark-eyed Junco	4	3
Black-throated Green Warbler	3	3
Lincoln's/Swamp Sparrow	3	3
Northern Waterthrush	3	3
American Robin	2	1
Bay-breasted Warbler	1	1
Swainson's Thrush	1	1
Tennessee Warbler	1	1
Wilson's Warbler	1	1

Four of the above species showed a statistically significant seasonal pattern of

abundance during the spring season. These are shown in Figure 6. The White-throated Sparrow peaks in mid-May while the Magnolia Warbler, Common Yellowthroat, and Common Nighthawk build, at varying rates, to a peak in late May and early June.

Figure 6: Species with a Significant Pattern of Seasonal Abundance at 95% Confidence Level

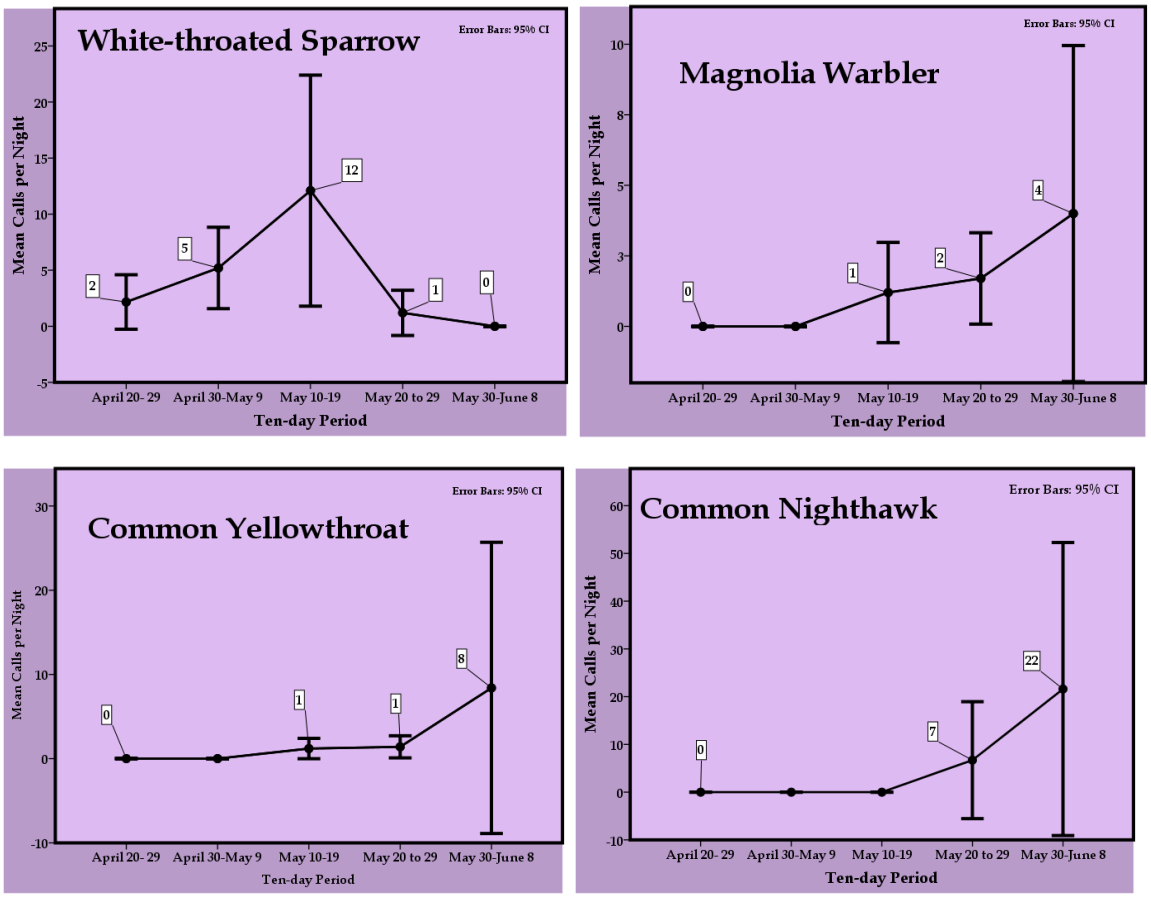


Table 3 indicates the status of those species that are of conservation concern as determined by the Nova Scotia Government, the Species at Risk Act (SARA), and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The last column in the Table 3 provides annotations on the occurrence of the species in the acoustic recordings in the spring of 2016.

Two species listed as "threatened" in Schedule 1 of the Species at Risk Act were recorded at the Station 2 at the South Canoe Wind Farm during the spring of 2016.

These are Common Nighthawk and Canada Warbler.

Table 3: Annotated List of Species of Conservation Concern

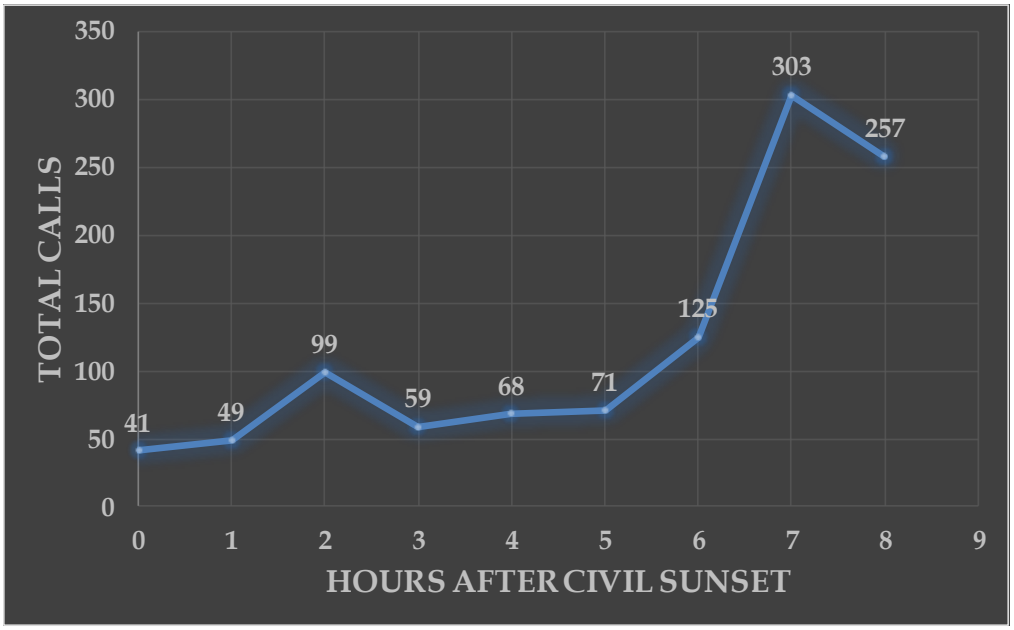
	NSDNR	SARA	COSEWIC	
Species	Rank	Schedule 1	Listed	Annotation
Common Nighthawk	Threatened	Threatened	Threatened	Present from 28 May to 2 June with call counts ranging from 6 to 57. It was estimated that there were up to 21 individual birds on some nights
Tennessee Warbler	Sensitive			1 on 23 May
Bay-breasted Warbler	Sensitive			1 on 28 May
Blackpoll Warbler	Sensitive			Recorded on 6 nights from 19 May to 3 June with 1 to 7 calls per night
Canada Warbler	Endangered	Threatened	Threatened	8 calls on 6 nights from 19-31 May. Peak was 3 calls on 28 May
Wilson's Warbler	Sensitive			1 on 19 May

Given that seasonally large numbers of Common Nighthawks occurred at Station 2 in both the autumn of 2015 and the spring of 2016, South Canoe Lake is most likely a breeding area, or migration stop-over/staging area, or both.

The eight Canada Warbler night flight calls at Station 2 is similar to those that have occurred at other monitoring stations in Nova Scotia during the spring migration.

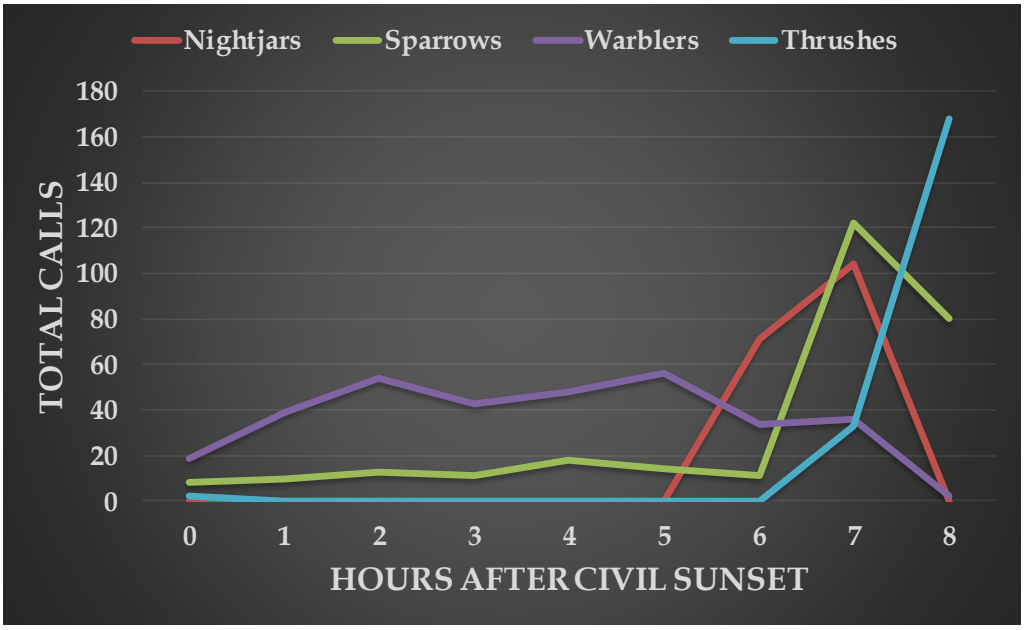
An analysis of the distribution of flight calls throughout the night is illustrated in Figure 7. During the spring migration period calls peaked once early in the evening, at 1-2 hours after civil sunset, and again later with a much greater peak at 7-8 hours after civil sunset. The early peak likely represents departing birds while the later peak, arriving birds.

Figure 7: Total Calls by Hour after Civil Sunset



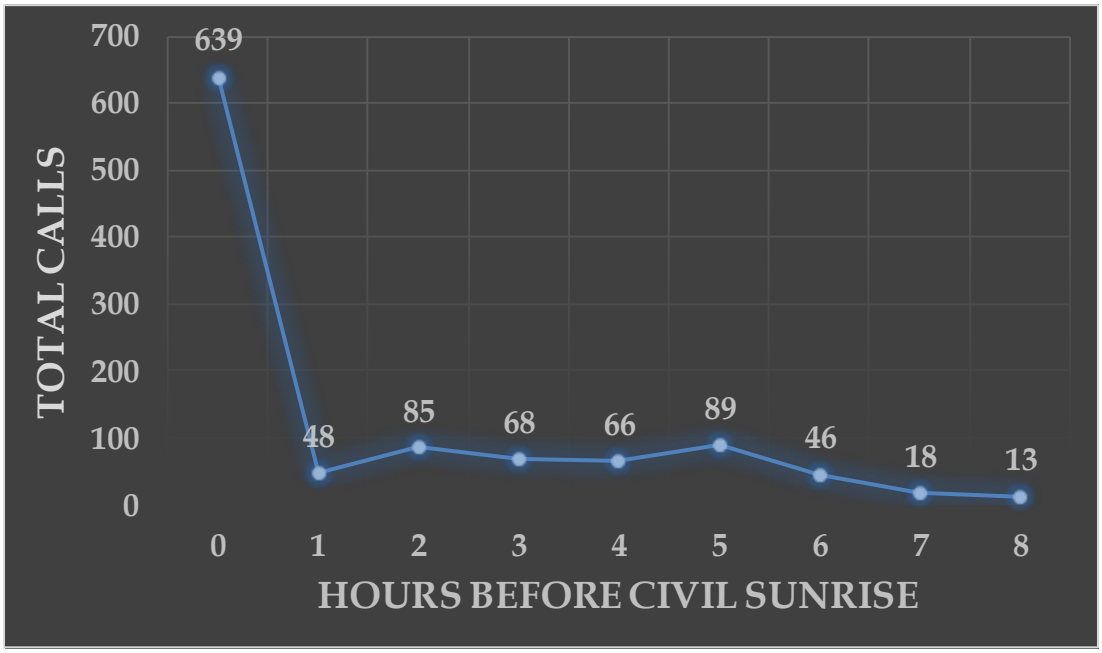
As seen in Figure 8, these peaks also correspond to differences in the abundance of different bird families through the night. Most notably, sparrows, nightjars, and thrushes peak 7 to 8 hours after civil sunset while warblers are more evenly distributed through the night.

Figure 8: Calls by Family by Hour after Civil Sunset



Due to the shortening of darkness as the spring advances, it is also fruitful to examine the nightly distribution of calls from the perspective of civil sunrise. As shown in Figure 9, there is a clear pattern of descent in the hour before civil sunrise.

Figure 9: Calls by Family by Hour before Civil Sunrise



A forward stepping, automatic linear model, using the Statistical Package for the Social Sciences (SPSS), was used to measure weather effects on the number of calls recorded on a spring night. Upper air data was derived from the Environment Canada station in Yarmouth and surface data was obtained from the Environment Canada weather station in Kentville. The model was able to account for 58.1% of the variability in the total number of flight calls per night (adjusted r^2).

As shown in Table 4, weather factors having a significant effect on total flight calls at the 95% confidence level were rising barometric pressure through the night, surface temperature of 16-20°C at civil sunset, and calm or very light wind at the time of the flight call. Other factors having an effect on the total number of calls during the night, in order of importance, were barometric pressure at civil sunset (>200.00 kPa), wind direction at 2100 hours at 1500 meters altitude (north, east, or southwest), seasonal

influence by 10-day period, and relative humidity at civil sunset (>80%).

Table 4: Forward Stepping Automatic Linear Model of Weather Factors Affecting Total Calls per Night

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	19,831.488	7	2,833.070	8.535	.000	
Change in Barometric Pressure during Night (>0 kPa)	4,186.353	1	4,186.353	12.612	.001	0.347
Temperature at Civil Sunset (16-20 C)	2,996.565	1	2,996.565	9.027	.005	0.249
Wind Speed at Time of Call (Calm or very Light)	2,328.442	1	2,328.442	7.015	.013	0.193
Barometric Pressure at Civil Sunset (>102.00 kPa)	795.098	1	795.098	2.395	.132	0.066
Wind Direction at 1500 Meters Altitude at 2100 Hours (N, E, SW)	770.218	1	770.218	2.320	.138	0.064
Seasonal Influence (10-day Period)	545.345	1	545.345	1.643	.209	0.045
Relative Humidity at Civil Sunset (>80%)	435.836	1	435.836	1.313	.261	0.036
Residual	10,290.256	31	331.944			
Corrected Total	30,121.744	38				

Discussion

Since 2012, the author has conducted acoustic monitoring at 13 stations on sites at or near wind energy facilities using the same equipment and methodology. Table 5 lists the total high frequency (warbler and sparrow) night flight calls recorded at these stations. Station 2 at the South Canoe Wind Farm ranks 3rd in the total number of calls per spring season and has 52% more calls than the spring average over 15 seasons at the 13 stations.

Table 5: Comparison of High Frequency Night Flight Calls in the Spring at Acoustic Monitoring Stations in Nova Scotia, 2011-2016

Location	Year	Total
Glasgow Head, Guysborough Co.	2016	795
Amherst Station 5, Cumberland Co.	2015	672
South Canoe Lake, Lunenburg Co.	2016	628
Glasgow Head, Guysborough Co.	2013	596
Amherst Station 3, Cumberland Co.	2014	428
Brown's Mountain, Antigonish Co.	2012	404
Spinney Gully, Guysborough Co.	2013	361
Loganville, Pictou Co.	2012	355
Weaver Mountain, Pictou County	2012	352
Digby Neck, Digby Co.	2012	321
Amherst Station 1, Cumberland Co.	2014	300
Amherst Station 4, Cumberland Co.	2015	276
Nuttby Mountain, Colchester Co.	2012	263
Winter Creek, Guysborough Co.	2015	255
Glasgow Head, Guysborough Co.	2015	195
Total		6,201
Average		413

The results of acoustic monitoring of nocturnal migration during the autumn of 2015 and the spring of 2016, indicate that South Canoe Lake may be on a migration corridor for birds over the centre of the province.

Given the relatively high numbers of Common Nighthawks detected in the recordings in late spring as well in the early autumn last year, it is recommended that ground investigations be conducted in the second year of post-construction monitoring about the use of the wind farm by this species. These investigations should be carried out by an observer during the morning and evening twilight hours from late May to mid-August.