Dominion Energy
600 Canal Street
Richmond, VA 23219
DominionEnergy.com

January 30, 2023

Ms. Karen Baker, Chief
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
45600 Woodland Road (VAM-OREP)
Sterling, Virginia 20166

RE: Dominion Energy CVOW Pilot Project – Avian and Bat 1st Annual Post-Construction Monitoring Plan Final Report

Dear Ms. Baker,

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion Energy) is pleased to submit the Final Report as required by the Post Construction Monitoring Plan (PCMP) for the Coastal Virginia Offshore Wind Pilot (CVOW Pilot) project under Research Lease OCS-A 0497 granted by the Bureau of Ocean Energy Management (BOEM).

Dominion contracted Normandeau to provide post-construction monitoring for the CVOW Pilot Project. Normandeau' s Acoustic and Thermographic Offshore Monitoring (ATOM™) system was deployed on each offshore wind turbine platform to continuously collect data within the rotor swept zone (RSZ) and the vicinity of the wind turbines during the monitoring periods. In addition, Normandeau was also contracted to conduct six boat-based surveys every other month during the first year of operations.

If you have any question of concerns regarding the enclosed report, please contact Scott Lawton at Scott.Lawton@dominionenergy.com or (804) 205-6077.

Sincerely,

Joshua J. Bennett

Vice President, Offshore Wind

Cc:

Dominion - Jason Ericson, Mitchell Jabs, Josh Bennett, Mike Lundsgaard, Kevin Carrol, Stewart Lamerdin, Matt Overton, Jen O'Donnell, Brian Stuver, CVOW Pilot Project

DMME – Al Christopher

BOEM – Dave MacDuffee, Bonnie Houghton, Jen Draher, Renewable Reporting

USFWS – Troy Andersen, Pam Loring, Emily Argo

VADWR – Ruth Boettcher, Rick Reynolds

Appendix A

Avian and Bat 1st Annual Post-Construction Monitoring Plan Final Report

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Postconstruction Bird and Bat Monitoring at the Coastal Virginia Offshore Wind Pilot Project

First Annual Report

Submitted to
Dominion Energy
707 East Main Street
Richmond, VA 23219

December 2022

Submitted by
Normandeau Associates, Inc.
4581 NW 6 ST, Ste H
Gainesville, FL 32609
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Postconstruction Bird and Bat Monitoring at the Coastal Virginia Offshore Wind Pilot Project

First Annual Report

Prepared For

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NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

December 2022

DISCLAIMER

This report represents the results from the first year of monitoring including three seasons: spring (April 1–June 15, 2021), fall (August 15–October 31, 2021), and winter (January 15–March 15, 2022). At the time of draft submission, we were unable to look at every track identified by the software and manually review for identification. This was largely due to the unexpected number of insects observed at the CVOW Pilot Project. There were approximately 2,600 tracks that had not been identified, most of which were expected to be insects. This is complete and the final version of the report is submitted.

REVISIONS

Version	Date	Author	Comment
1.0	Friday, October 14, 2022	Normandeau Associates	Video data analysis not complete
2.0	Monday, December 12, 2022	Normandeau Associates	• Video data analysis complete and reported • Calibration testing completed and reported • Two brown-headed cowbirds were removed from the draft report as they were placeholders for unidentified species at the time (now updated)

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Acronyms and Abbreviations

AI	artificial intelligence
ATOM	Acoustic and Thermographic Offshore Monitoring
BOEM	Bureau of Ocean Energy Management
CVOW	Coastal Virginia Offshore Wind
FAA	Federal Aviation Administration
IR	infrared
kHz	kilohertz
km	kilometers
kV	kilovolt
mb	millibars
MHz	megahertz
MW	megawatt
nmi	nautical miles
Normandeau	Normandeau Associates, Inc.
RAP	research activities plan
RSZ	rotor swept zone
SSD	solid-state drive
UAS	unmanned aircraft system
USFWS	US Fish and Wildlife Service
VE	Virginia Energy (formerly DMME)
VHF	very high frequency
WTG	wind turbine generators

Executive Summary

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion Energy), on behalf of Virginia Energy (VE, formerly Virginia Department of Mines, Minerals and Energy [DMME]), has developed the Coastal Virginia Offshore Wind (CVOW) Pilot Project in federal waters 24 nautical miles (nmi) (43 kilometers [km]) off the coast of Virginia. In 2019, Dominion contracted Normandeau Associates, Inc. (Normandeau), to provide postconstruction monitoring for the CVOW Pilot Project. Normandeau's Acoustic and Thermographic Offshore Monitoring (ATOM™) systems can be deployed on platforms underneath offshore wind turbines and collect data within the rotor swept zone (RSZ) and the vicinity of the wind turbine 24/7 during the monitoring period. This postconstruction monitoring annual report presents the results from the first year of ATOM monitoring, which lasted from April 1 to June 15, 2021(spring season), August 15 to October 31, 2021 (fall season), and January 15 to March 15, 2022 (winter season). A report presenting the results of the boat-based surveys was provided under separate cover.

The ATOM system represents a collection of multiple sensors designed to collect information about bird and bat activity in the RSZ. Each ATOM system combines four types of wildlife sensors analyzed in combination: thermal cameras operating in stereo, a visible-light camera, acoustic detectors for birds and bats, and a very high frequency (VHF) receiver to detect birds fitted with NanoTags™. The two ATOM systems were deployed during the second week of March 2021 to allow adequate commissioning and testing before the beginning of the spring monitoring period on April 1, 2021. Data retrieval trips occurred approximately monthly during the weeks of April 11, May 10, and June 1, 2021. The last data retrieval trip (June 14 to 18, 2021) also served as the decommissioning trip for the spring monitoring period. For the fall monitoring period, both ATOM systems were redeployed during the week of July 12, 2021, with data retrieval trips during the weeks of August 16, September 13, and November 15, 2021. The winter data retrieval trips occurred during the weeks of January 17, February 14, and March 28, 2022. Each data retrieval trip typically involved one day at each turbine and included the commute time from shore to the turbine.

Across all ATOM sensors and the entire monitoring period, there were 1,581 detections of birds and bats (521 bats, 1,011 birds, and 49 bird/bat). Most bird detections (91%) were observed during the day (sunrise–sunset) and 9% were observed at night (sunset–sunrise). We observed 45% of bats during the day and 55% at night. Between ATOM systems, 852 (54%) targets were detected on ATOM 1 (Turbine A01) and 729 (46%) targets were detected on ATOM 2 (Turbine A02).

Only two bat detections occurred in the spring and the remaining 519 detections occurred in the fall; no bats were detected in the winter. Bat detections include three bat species: silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), and eastern red bat (*Lasiurus borealis*). No federally or state listed bat species were detected during the study.

Bird detections included 5 shorebird species, 3 gull species, 1 tern species, 3 raptor species, 1 woodpecker species, and 18 passerine species. Skuas, corvids, and swallows were also identified but no individuals from these three groups were identified to species. The Peregrine Falcon (*Falco peregrinus*) is state listed as threatened by the Virginia Department of Wildlife Resources; there were 54 detections of this species and 53 detections occurred during the day in

the fall. The Kirtland's Warbler (*Setophaga kirtlandii*) is listed as federally endangered by the US Fish and Wildlife Service. This species breeds in jack pines in Michigan and winters in the Bahamas. One individual was observed during the fall in video and the identification was given a confidence level of "probable."

Both bat and bird activity seem to be related to wind speed. Bat activity declines above 6 m/s and passerine activity declines above 5 m/s. Non-passerine activity also declines above 4 m/s, though the rate of activity decline is less than for passerines. This is significant because the cut-in speed for the turbines at the CVOW Pilot Project is between 3 and 5 m/s, which suggests that most bat and bird activity could occur when the blades are not spinning. Less bat and bird activity when blades are spinning could reduce the likelihood of collisions.

Over 7,000 insect detections occurred during the spring, fall, and winter monitoring periods. Insects included many butterflies, moths, and dragonflies, though only select detections were identified to species. Across the spring, fall, and winter monitoring periods insect activity peaked during September and October and were much lower during other periods. Within-day activity showed that insect activity peaked during the early morning hours (6:00–8:00) and then again in the late afternoon (16:00–18:00). There was a moderate correlation between bat and insect activity ($\rho = 0.62$) as well as passerine and insect activity ($\rho = 0.48$). This correlation is not surprising given the high number of aerial foraging behaviors directed at insects observed in the video data. Aerial foraging was the most observed behavior for passerines and bats with high patrol flight being the most common for non-passerines. These behaviors have implications for collision risk because bats and birds are often distracted while chasing or looking for prey. However most aerial foraging for passerines and non-passerines occurs when the blades are not moving so an increase in collision risk could be minimal. More bat activity occurs when the blades are spinning, though bat activity still declines as wind speeds increase.

No collisions were observed in the video data. When the turbine blades were moving, all bats and birds avoided collisions while foraging within the RSZ. There was one observation of air-displacement for bats and one for birds. Air-displacement occurs when an individual gets displaced by air pressure waves from the passing blades. In both cases the bat and bird started to fall; the bird recovered and flew away and the bat returned to revisit the blades before exiting the turbine area. Microavoidance behaviors were observed 69 times in 9 bird species and 2 bat species. Microavoidance reflects avoidance of the blades while in proximity to the blade surface and prevents collision, which is an essential behavior for reducing collision mortality.

For the second and third years of the study, we have made improvements in two key areas to improve the reliability of the system:

1. upgraded disk storage to a full solid-state drive (SSD) array, and
2. improved our artificial intelligence (AI) algorithm to distinguish bats, birds, and insects with a high degree of accuracy.

Upgrading to SSDs has improved disk reliability by eliminating moving parts more likely to break over time. Improving the AI algorithm to distinguish bats, birds, and insects will improve analysis speed, reducing the need for manual review. More effort can be expended on bird and bat identifications and less on reviewing insect targets. Improvements in these areas make the ATOM system a more reliable and efficient postconstruction monitoring solution.

1.0 Introduction

Offshore wildlife surveys are challenging as conventional methodologies have limitations in adverse weather conditions and low visibility, particularly for gathering species-specific data. A remote operating ATOM™ system (Robinson Willmott and Forcey 2014; Robinson Willmott et al. 2015) for birds and bats coupled with visible-light cameras and a VHF receiver is one solution to this issue. This technology combination provides a cost-effective way to understand bird and bat occurrence within rotor swept altitudes at offshore wind sites. The rationale for this system is simple at its core and consists of four elements that drive the choice of detection equipment.

1. Only acoustic data can provide species-specific information for many bird species during low light or adverse weather conditions. This is also true for bats.
2. Thermal data are a necessary complement to acoustic data for risk studies as microphones cannot record silent birds or calculate flight heights. We use two cameras operating in stereo to calculate flight heights.
3. A visible-light camera can supplement target information from the thermal cameras during daylight. Some species-specific information will be possible at lower altitudes depending on the flight height and size of the target.
4. A VHF receiver and associated antenna system can provide occurrence data on radio-tagged birds as part of the Motus Wildlife Tracking System and is useful for providing information on activity and approximate location of tagged threatened and endangered species such as Roseate Tern (*Sterna dougallii*), Red Knot (*Calidris canutus*), and Piping Plover (*Charadrius melodus*).

Virginia Electric and Power Company, d/b/a Dominion Energy Virgnia (Dominion Energy), on behalf of Virginia Energy (VE, formerly DMME) has developed the CVOW Pilot Project in federal waters 24 nautical miles (nm) (43 kilometers [km]) off the coast of Virginia (Figure 1). The CVOW Pilot Project is a collaborative effort including the DMME as the lease holder, Dominion Energy as the designate operator, and Tetra Tech and Normandeau Associates, Inc. (Normandeau), as the environmental consultants. The CVOW Pilot Project consists of two 6-megawatt (MW) Siemens Gamesa wind turbine generators (WTGs) and a 34.5-kilovolt (kV) transmission cable through state and federal waters. Dominion Energy received approval from the Bureau of Ocean Energy Management (BOEM) on the most recent research activities plan (RAP) on June 20, 2019, and provisionally accepted the project on October 13, 2020 (Tetra Tech and Normandeau 2020).

Requirements in the RAP state that postconstruction monitoring must include:

- Thermal imaging on both WTGs
- Acoustic monitoring of bat activity on both WTGs
- Boat-based bird surveys

In addition to these requirements, Dominion Energy has added these sensors on each WTG to collect additional data and increase the research value of the project:

- Acoustic sensors for birds
- Backup acoustic detectors for both birds and bats
- A visible-light camera to supplement the thermal cameras during the day
- A VHF receiver to detect animals fitted with NanoTags™

In 2019, Dominion Energy contracted Normandeau to provide postconstruction monitoring for the CVOW Pilot Project. Normandeau's ATOM systems can be deployed on platforms underneath offshore wind turbines and collect data within the RSZ and the vicinity of the wind turbine 24/7 during the monitoring period.

Normandeau was also contracted to conduct six boat-based surveys every other month during the first year of operations. These surveys used the same methodology as the preconstruction surveys so comparisons can be made between pre- and postconstruction bird distributions and abundance. These data are presented in a report under separate cover and no further discussion will occur in this report. This postconstruction monitoring annual report presents the results of the first year (2022) of ATOM monitoring during the spring, fall, and winter monitoring periods.

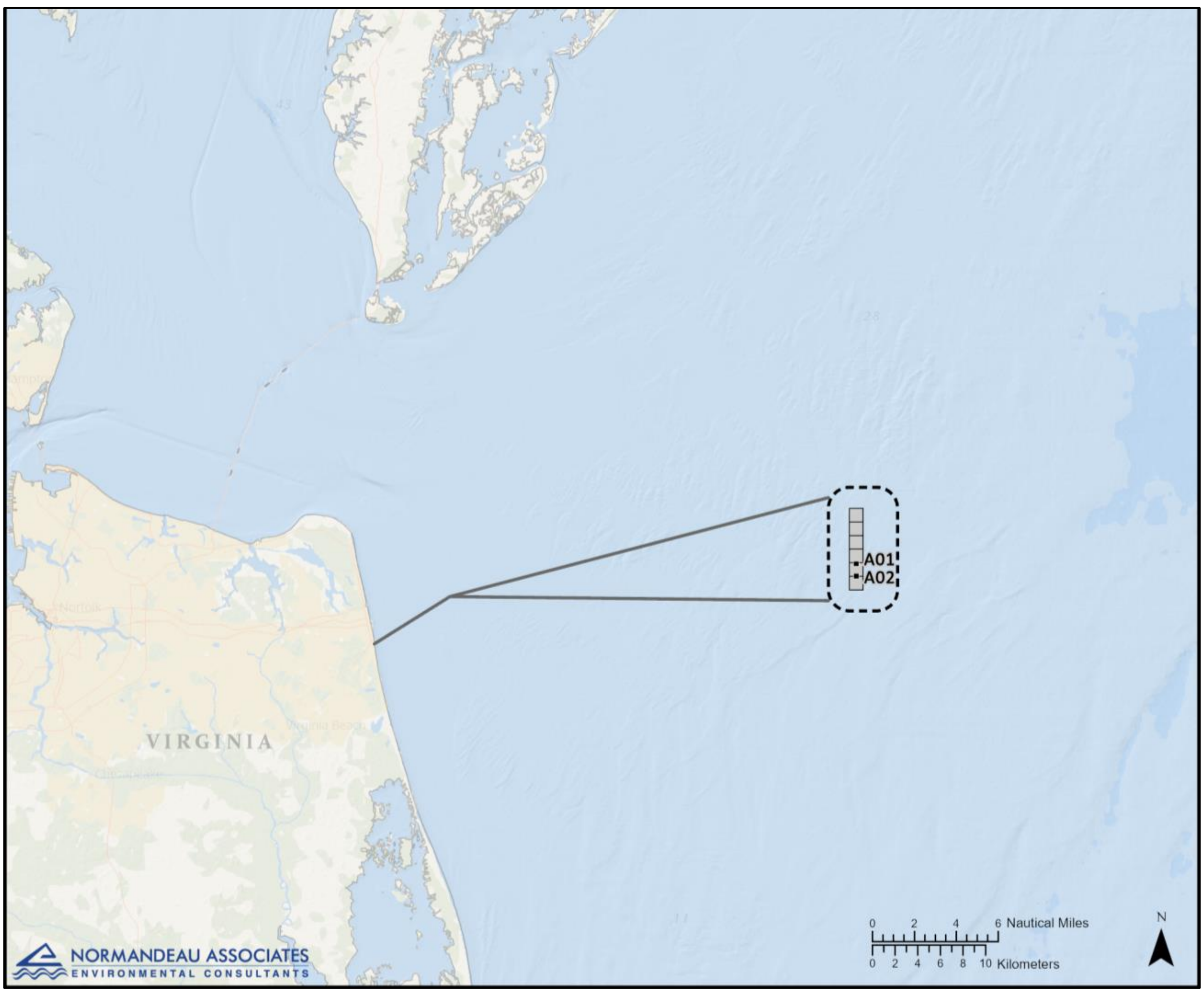


Figure 1. Location of the Coastal Virginia Offshore Wind Pilot Project and turbines.

2.0 Methods

2.1 Overview

The ATOM system provides critical species-specific, quantitative data on bird and bat occurrence at wind facilities that can fill data gaps for risk and impact studies and regulatory compliance. The ATOM system represents a collection of multiple sensors designed to collect information about bird and bat activity in the RSZ. Multiple detection approaches ensure comprehensive data collection within the area of interest. ATOM is designed for remote, marine weatherized, self-powered operation at a large marine buoy or fixed platform such as a wind turbine or meteorological tower. This design enables ATOM to collect data on birds and bats continuously for long-term deployments, providing essential information on day/night variation and seasonal variation of bird and bat occurrence at actual or proposed offshore wind facilities with minimum labor. Each ATOM system combines four types of wildlife sensors analyzed in combination:

- Audible sound detectors for bird vocalizations and ultrasonic detectors for bat vocalizations enable species-level identification, which is essential for species-specific regulatory drivers such as the Endangered Species Act and the Migratory Bird Treaty Act. Acoustic data also provide some species-specific identifications to targets detected with thermal cameras that cannot otherwise be identified.
- Thermal cameras provide data to quantify bird and bat passage rates during low visibility or when individuals are not vocalizing; two cameras operating in stereo permit calculation of flight heights.
- A visible-light camera permits some species identification at lower altitudes depending on the size of the target and flight altitude.
- A VHF receiver can detect NanoTagged animals as part of the Motus network.

The computers that form the central core of the ATOM system are housed in two custom-fabricated weatherproof containers: one for the storage computer (including the storage drives) and one for the power supply, networking components, and the two thermal cameras. The core ATOM components are mounted to a custom metal chassis attached to the turbine platform (Figure 2). The dimensions of the chassis were constrained to allow transportation in a pickup truck and to be carried by two people.

Acoustic detectors and VHF antennas are mounted away from the chassis. Location of the chassis on the platform is critical for the thermal and visible-light cameras so they have an optimal view of the rotor swept area. Based on the available locations, we selected the position that provided the most comprehensive view of the RSZ while still permitting turbine maintenance operations without constraints (Figure 2). During the initial deployment, bird deterrents were installed on the ATOM box to discourage perching; however, these were determined to be a safety hazard and were removed during a subsequent data retrieval trip.

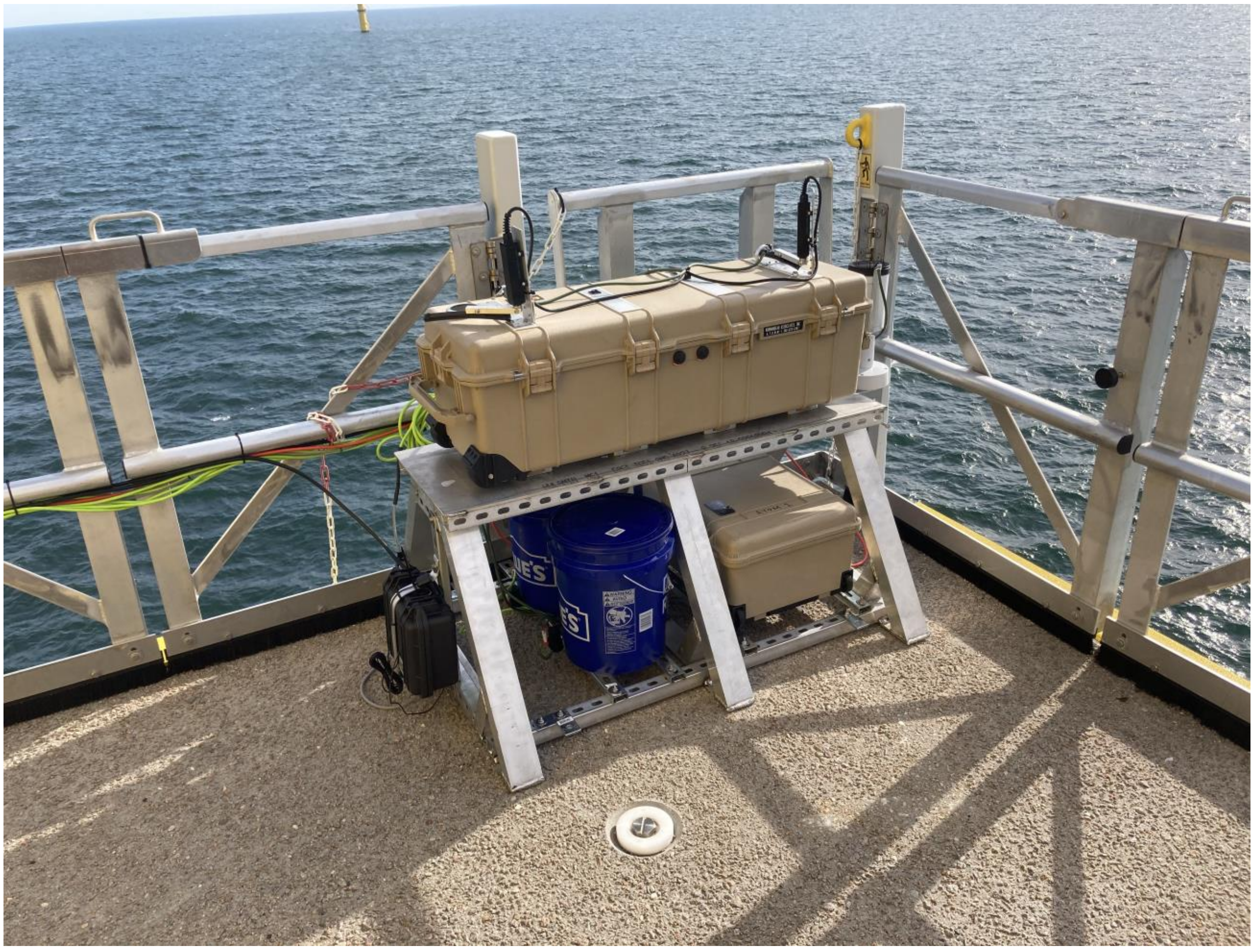


Figure 2. The core ATOM system components installed on the CVOW turbine platform.

The ATOM system operates continuously, and all sensors record information 24/7 throughout the monitoring period. Video data from the thermal and visible-light cameras are stored on the drives in the internal storage box. Data from the bird and bat acoustic detectors are stored internally on the detectors' SD cards. VHF receiver data are stored internally on the VHF receivers' internal storage. Data retrieval trips were performed on each ATOM system during which drive boxes for the video were swapped with new ones with fresh storage capacity, and data storage cards were swapped out with empty ones. All data were transferred to network attached storage for processing and analysis.

2.2 Video

The thermal camera array on the ATOM system consists of two vertically oriented thermal imaging cameras operating in stereo. The camera array was adjusted during the initial setup and calibrated in stereo for an optimal view of the RSZ. Cameras were re-evaluated for quality assurance during the data download trips. To supplement the viewshed surveyed by thermal cameras, each ATOM system also includes one visible-light camera to provide additional data on targets detected during the day.

Before video review, all data are cataloged and processed to note any gaps due to turbine power outages, system outages, or corrupted files. Normandeau has developed a process to review video data using automatic target detection software and manual review of potential targets by human analysts. Software performs an initial track detection in 100% of the thermal camera video data and flags all potential movement of interest. Manual review of potential targets is then performed using Normandeau's ReMOTe data portal and analysis tool. Using ReMOTe, analysts can simultaneously review thermal and visible-light video for the periods flagged by the automated software. The human analysts can determine and note the target type (wildlife, airplane, cloud, turbine blade) and have their observations saved automatically into a central database. The results of the manual review are instantly available via the ReMOTe data portal, and wildlife are then characterized into bird, bat, or insect. Birds and bats are sent to taxonomic experts (>10 years of experience) for identification when the thermographic track is simultaneously visible in the visible-light video. Identifications are made to the lowest taxonomic level possible. Birds marked as unidentified are birds that either could not be identified because they only appear in the thermographic cameras or that key morphological characteristics needed for identification are not apparent in the visible-light camera. During identification, behaviors and whether the turbine blades are moving are noted. Behaviors are described as:

- Attraction (comes to check-out turbine then continues)
- Hawking (sallies from perch on short flights to capture flying insects)
- Microavoidance (blade interactions when blades are moving)
- Perching
- Aerial foraging (prolonged continuous flight capturing prey items)
- Low patrol (direct flight below the RSZ)
- High patrol (direct flight within or above the RSZ)
- Flyover (very high flight visible above turbine, usually large birds for detection reasons)
- Thermaling (no flapping)
- Monopole gleaning (taking insects off the monopole)

The flight height and speed calculations of targets are based on a track detection and particle analysis process. The track detection process outputs a series of particles with each track. Each particle has a center coordinate that corresponds to the pixel position of the particle within the video frame. Once tracks from the left and right cameras are paired, the distance of the object from the cameras can be determined from the relative position of the object in each camera. Specifically, the distance from the camera will be inversely proportional to the offset of the X coordinates from the full width of the camera frame.

Once the distance (D) to an object has been determined, the absolute location of the object can be determined. The X-Y coordinates of the object in the camera frame correspond linearly to the object location within a plane a distance D to the camera.

Object velocities are determined by comparing the object location in sequential video frames. The object velocity between two video frames is the difference in absolute location multiplied by the video frame rate. To reduce noise in the distance and velocity data, a smoothing filter is applied to particle locations prior to calculations. To improve the accuracy of the calculations, a translation is applied to the particles to account for slight deviations from a perfectly parallel camera alignment. For each system, the coefficients of this translation have been derived from the tracks of airplanes, which fly high enough that they should appear at the same location in each camera. With a large collection of airplane particles distributed across the image field, the difference in relative orientation between the two cameras can be determined.

After tracks have been paired, particle locations have been smoothed and translated, and distance and velocity have been calculated for each video frame, a median distance and velocity are recorded for the track. Note that it is not possible to calculate distance and speed if targets are detected in only one of the cameras in the stereo pair.

2.3 Acoustic

Acoustic monitoring of birds and bats on the ATOM system includes four recorders on each turbine platform: two acoustic recorders with microphones to capture bird calls and two full spectrum ultrasonic bat recorders with microphones to capture bat calls. Each pair of bird and bat detectors is sampling the same airspace; the extra detector is for redundancy in case of equipment failure. The video collection system sends hourly status reports via satellite modem connection. In addition, the satellite modem connection allows remote inspection of the electronics to ensure proper functioning and data collection. These remote inspections are typically done weekly to ensure the status messages accurately reflect the state of system. The acoustics data collection and the Lotek Motus data collection are not capable of remote connection and inspection. These systems are inspected during each trip to the turbine where all systems are inspected for physical damage, routine wear and tear, and proper electronic functioning. In addition, the acoustic and Motus equipment clocks are checked for accuracy. During the processing of data, any gaps in the data are calculated by automated processing and noted.

Bat call files were uploaded to the Normandeau ReMOTe server for storage and processing. We ran all .wav files through bat acoustic identification software SonoBat (Arcata, USA). After all .wav files were processed, we manually vetted any call that SonoBat's auto-identification algorithm designated as a potential bat.

A broad review of the bird acoustic data showed some excessive clipping in many of the call files. This can be due to high amplitude wind, water, or mechanical noise. Data were used to create an automated .wav file clipping check algorithm in MATLAB (Mathworks, Natick, MA). This algorithm was run on data from the CVOW Pilot Project to determine which files contained the least amount of clipping and could be processed. Bird acoustic data were processed with Wildlife Acoustics Kaleidoscope Pro (v 5.4.8) software using automated detection parameters determined for the flight calls of species in Table 1 using flight call audio data in the Cornell Lab of Ornithology Macaulay Library archives (https://search.macaulaylibrary.org/catalog). These species were chosen based on sightings noted in ebird.org for the eastern US region and cross-referenced with the Migratory Bird Treaty Act. Note that detection parameters for the species listed do not necessarily exclude other species or non-bird sounds, so manual auditory (headphones) and visual (spectrogram) review of the detections is necessary to confirm any bird call within or outside the list and to exclude false alarms. Additional bird species were confirmed from any detections that did not fall within those listed in Table 1, focusing on but not limited to gulls, terns, and sandpipers. This species list is not to be taken as exhaustive as the Kaleidoscope settings can also detect species outside this list.

Manual auditory (headphones) and visual (spectrogram) review was conducted on every detection generated by the Kaleidoscope Pro software auto-detection cluster analysis. Any detections that were not birds are not listed. For this analysis, one call corresponds to at least one confirmed detection within any 1-minute span. Two calls from the same species within the same minute are counted as one occurrence.

Table 1. Bird Species Whose Flight Calls were Used for Automatic Detection Parameter Selection

Cape May Warbler	Northern Parula	Bobolink
Ovenbird	American Redstart	Palm Warbler
Gray-cheeked Thrush	Black-throated Blue Warbler	Black-and-white Warbler
Blackpoll Warbler	Common Yellow Throat	Bay-breasted Warbler
Least Bittern	Green Heron	Veery
Swainson’s Thrush	Wood Thrush	Northern Waterthrush
Magnolia Warbler	Blackburnian Warbler	Yellow Warbler
Chestnut-sided Warbler	Yellow-rumped Warbler	Savannah Sparrow
White-throated Sparrow	Blue Grosbeak	Indigo Bunting

2.4 VHF Receivers and Antennas

Each ATOM system includes a VHF receiver and associated antennas to detect NanoTagged birds as they fly near the wind turbine. This setup includes two omnidirectional whip antennas positioned on opposite sides of the monopole to maximize range and address signal interference and a Lotek SRX800-D1 receiver configured to detect NanoTagged wildlife flying near the turbines. These two components have been able to detect a beacon test tag up to 1.25 miles (2 km) from the turbine platform.

Tag data from the VHF receivers were uploaded to the Motus website (motus.org). These data are processed on the Motus webserver, and the tag identifications are determined by matching any tags detected to tag deployments in the Motus database. Once data processing was complete, species identifications were determined by querying the Motus database using the R package *motus* or by manually reviewing the detections at each receiver location (Motus 2021).

2.5 Deployment, Data Retrieval, and Decommissioning

The ATOM systems were deployed during the second week of March to allow adequate commissioning and testing before the beginning of the spring monitoring period on April 1, 2021. Data retrieval trips occurred during the weeks of April 11, May 10, and June 14, 2021. The last data retrieval trip (June 14 to 18, 2021) also served as the decommissioning trip for the spring monitoring period. For the fall monitoring period, both ATOM systems were redeployed during the week of July 12, 2021, with data retrieval trips during the weeks of August 16, September 13, and November 15, 2021. The winter data retrieval trips occurred during the weeks of January 17, February 14, and March 28, 2022. Each data retrieval trip typically involved one day at each turbine and included the commute time from shore to the turbine.

2.6 Data Analysis

Insect detections were quantified along with bat and bird activity for the monitoring period. We examined relationships of insect detections with bird and bat detections by using Spearman's rank correlations to look for associations.

To relate bat and bird activity to weather variables, we used modeled wind speed, wind direction, temperature, and sea level pressure data from StormGeo. StormGeo is a weather forecasting service that provides route planning, operational, and risk assessment services to the offshore wind sector. Weather variables were related to the bird and bat call data by matching the animal detection timestamps to the closest value found in the weather data. For each weather variable, we examined relationships between variability in weather variables with bird and bat activity by examining frequency histograms of detections with the range of values for each weather variable.

3.0 Results

3.1 Video

Within a season, video sensor uptime ranged from 59% to 97% (Figure 3). Downtime of ATOM 2 (Turbine A02) from April 20 to May 12, 2021, was due to a wiring fault in the system; this was repaired during a data retrieval trip. Visible-light video was only recorded during the day from April 1 to 7, 2021, due to a storage system wiring problem, which was also corrected during a subsequent data retrieval trip. Thermal data from ATOM 1 (Turbine A01) was missing from May 29 to June 1, 2021, due to a software issue that was patched when the system came back online after power was cycled at the turbines (Appendix A). Reliability was good during the fall with downtime mostly attributable to power being unavailable at the turbines. During winter, damage to the satellite modem prevented a remote fix during a 15-day period (January 26 to February 9, 2022) where ATOM 1 (Turbine A01) recorded data but was not saved to the drives. Other periods of downtime were minor and could be attributed to turbine maintenance (Appendix A).

Results of the calibration testing showed that a large bird should be able to be detected out to 280 m (drone size) while a small bird (tennis ball size) should be able to be detected out to 130-144 m (Appendix B).

There were 109 bat detections in the video data throughout the spring, fall, and winter monitoring periods, but only 6% of the detections were identified to species due to the difficulty of identifying visual field marks on bats. Bats accounted for <10% of all detections (including birds and bats) in the video (Table 2); however, video data were still useful for characterizing bat behaviors including blade interactions and microavoidance. These discussions are presented later in the report.

Video data revealed 975 bird detections throughout the spring, fall, and winter monitoring periods. Individuals from 8 bird groups were identified including shorebirds, skuas, gulls, raptors, woodpeckers, corvids, hirundines (swallows), and passerines. Species identifications were possible for 3 species of gulls, 3 species of raptors, 1 species of woodpecker, and 17 species of passerines. Passerines accounted for 71% of the individuals detected in the video, raptors were

7% of the observations, and gulls were 5% of the observations. Unidentified birds were 16% of the observations, and other species groups were <1% of the observations (Table 2).

There were 49 observations identified as bird/bat (Table 2) and 831 observations identified as bird/bat/insect (not presented in Table 2). We performed a second review of 10% of the observations initially classified as a bird/bat/insect: 86% were insects, 7% were unidentified birds/bats, 5% were unidentified birds, and 2% were unidentified bats. None of the initially identified bird/bat/insects could be identified to species. Extrapolating these results out to the entire 831 bird/bat/insects, we estimate 742 insects, 57 unidentifiable bird/bat, 37 unidentifiable birds, and 19 unidentifiable bats.

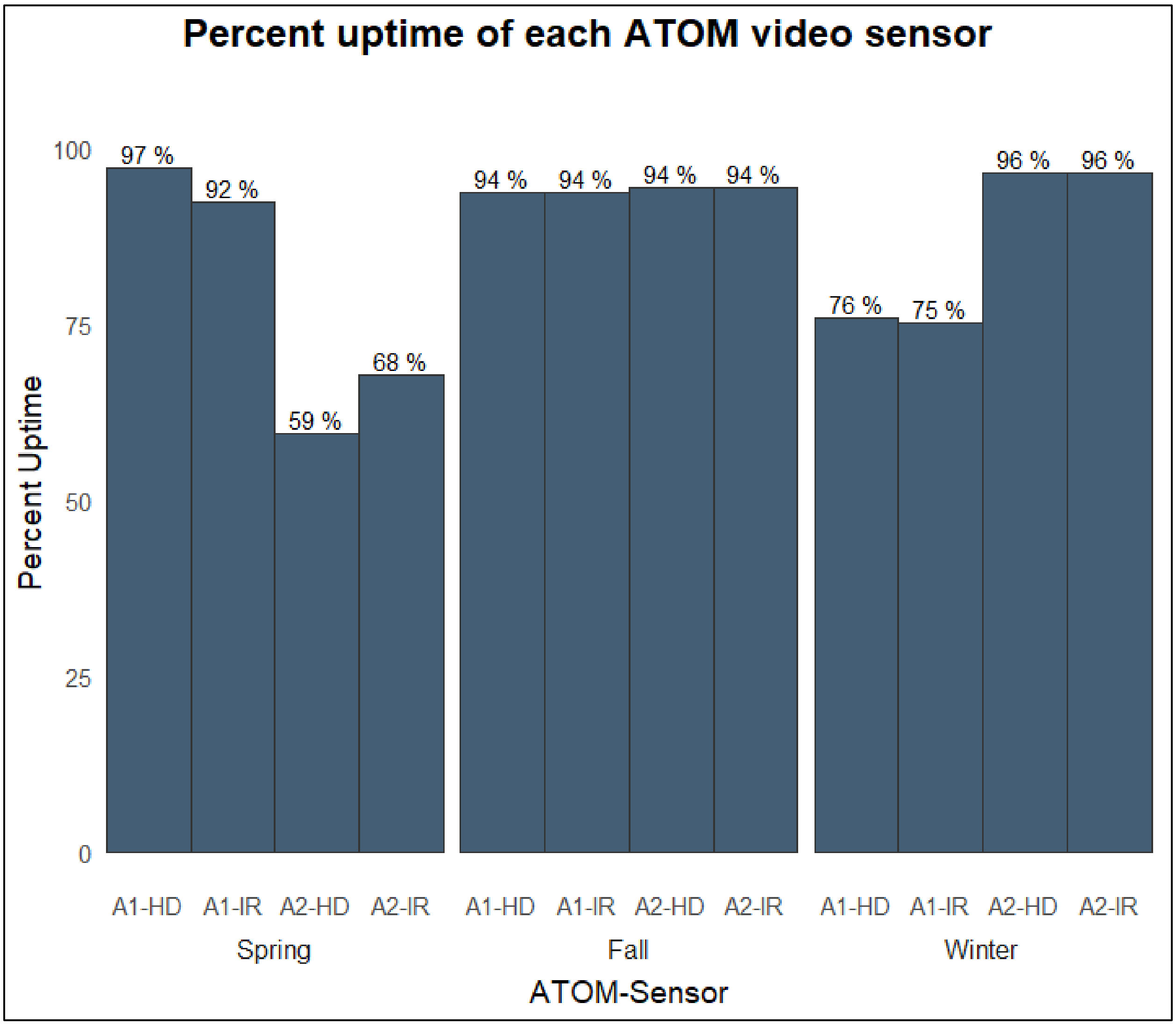


Figure 3. Uptime of the video sensors on the two ATOM systems.
A1 = ATOM 1, A2 = ATOM 2, HD = HD Visible-light Camera, IR = Thermal Camera Pair

Table 2. Bird and Bat Observations Collected Using a Combination of the Thermal and Visible-light Video Sensors during the Spring, Fall, and Winter Monitoring Periods

Type	Subtype	Common Name	Scientific Name	Video
Bird	Shorebird	Shorebird species		3
Bird	Skua	Skua species		1
Bird	Gull	Laughing Gull	*Leucophaeus atricilla*	10
Bird	Gull	Herring Gull	*Larus argentatus*	8
Bird	Gull	Great Black-backed Gull	*Larus marinus*	3
Bird	Gull	Large Gull species		16
Bird	Gull	Small Gull species		3
Bird	Gull	Gull species		10
Bird	Raptor	Osprey	*Pandion haliaetus*	8
Bird	Raptor	Merlin	*Falco columbarius*	1
Bird	Raptor	Peregrine Falcon	*Falco peregrinus*	53
Bird	Raptor	Raptor species		3
Bird	Woodpecker	Northern Flicker	*Colaptes auratus*	1
Bird	Corvid	Corvid species		2
Bird	Hirundine	Hirundine species		3
Bird	Passerine	Brown Creeper	*Certhia americana*	10
Bird	Passerine	Winter Wren	*Troglodytes hiemalis*	17
Bird	Passerine	Wren species		1
Bird	Passerine	American Robin	*Turdus migratorius*	2
Bird	Passerine	American Pipit	*Anthus rubescens*	1
Bird	Passerine	Blue-winged warbler	*Vermivora cyanoptera*	1
Bird	Passerine	Black-and-white Warbler	*Mniotilta varia*	13
Bird	Passerine	American Redstart	*Setophaga ruticilla*	3
Bird	Passerine	Cape May Warbler	*Setophaga tigrina*	112
Bird	Passerine	Northern Parula	*Setophaga americana*	1
Bird	Passerine	Magnolia Warbler	*Setophaga magnolia*	4
Bird	Passerine	Bay-breasted Warbler	*Setophaga castanea*	7
Bird	Passerine	Blackburnian Warbler	*Setophaga fusca*	5
Bird	Passerine	Palm Warbler	*Setophaga palmarum*	13
Bird	Passerine	Pine Warbler	*Setophaga pinus*	27
Bird	Passerine	Yellow-rumped Warbler	*Setophaga coronata*	16
Bird	Passerine	Kirtland’s Warbler	*Setophaga kirtlandii*	1
Bird	Passerine	Setophaga species		171
Bird	Passerine	Parulidae species		6
Bird	Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	10
Bird	Passerine	Passerine species		271
Bird	Unid. Avian	Unidentified bird species		158
Bat	Bat	Silver-haired bat	*Lasionycteris noctivagans*	1
Bat	Bat	Hoary bat	*Lasiurus cinereus*	2
Bat	Bat	Eastern Red bat	*Lasiurus borealis*	4
Bat	Bat	Bat species		102
	Bird/Bat	Bird/Bat		49
Total				**1,133**

3.2 Acoustic

During the spring, fall, and winter monitoring periods, 3 species of bats were detected: silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), and eastern red bat (*Lasiurus borealis*) (Table 3). Silver-haired bats were detected 233 times, hoary bats 80 times, and eastern red bats 86 times. There were also 13 unidentified low-frequency species recorded. Bat abundance peaked in September with 89% of detections across both ATOM systems (Figure 4, Figure 5). During fall, eastern red bats occurred earliest in the season and hoary bats occurred latest in the season (Figure 6).

Table 3. Acoustic Calls from Birds and Bats Identified during the Spring, Fall, and Winter Monitoring Periods

Type	Subtype	Common Name	Scientific Name	Acoustic
Bird	Shorebird	Spotted Sandpiper	*Actitis macularius*	1
Bird	Shorebird	Solitary Sandpiper	*Tringa solitaria*	1
Bird	Shorebird	Upland Sandpiper	*Bartramia longicauda*	3
Bird	Gull	Herring Gull	*Larus argentatus*	1
Bird	Tern	Royal Tern	*Thalasseus maximus*	1
Bird	Passerine	American Robin	*Turdus migratorius*	2
Bird	Passerine	Northern Waterthrush	*Parkesia noveboracensis*	1
Bird	Passerine	Black-and-white Warbler	*Mniotilta varia*	2
Bird	Passerine	American Redstart	*Setophaga ruticilla*	1
Bird	Passerine	Northern Parula	*Setophaga americana*	2
Bird	Passerine	Magnolia Warbler	*Setophaga magnolia*	1
Bird	Passerine	Bay-breasted Warbler	*Setophaga castanea*	2
Bird	Passerine	Palm Warbler	*Setophaga palmarum*	1
Bird	Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	12
Bat	Bat	Silver-haired bat	*Lasionycteris noctivagans*	233
Bat	Bat	Hoary bat	*Lasiurus cinereus*	80
Bat	Bat	Eastern Red bat	*Lasiurus borealis*	86
Bat	Bat	Unknown low-frequency species		13
Total				**443**

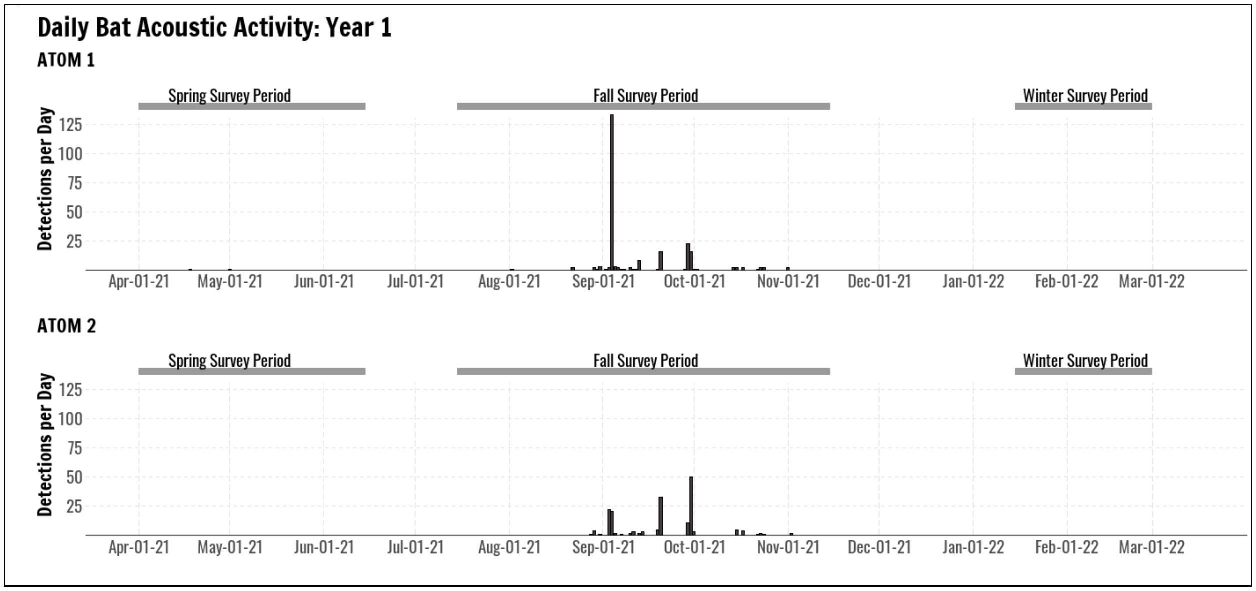


Figure 4. Number of bat calls per day during the spring, fall, and winter monitoring periods.

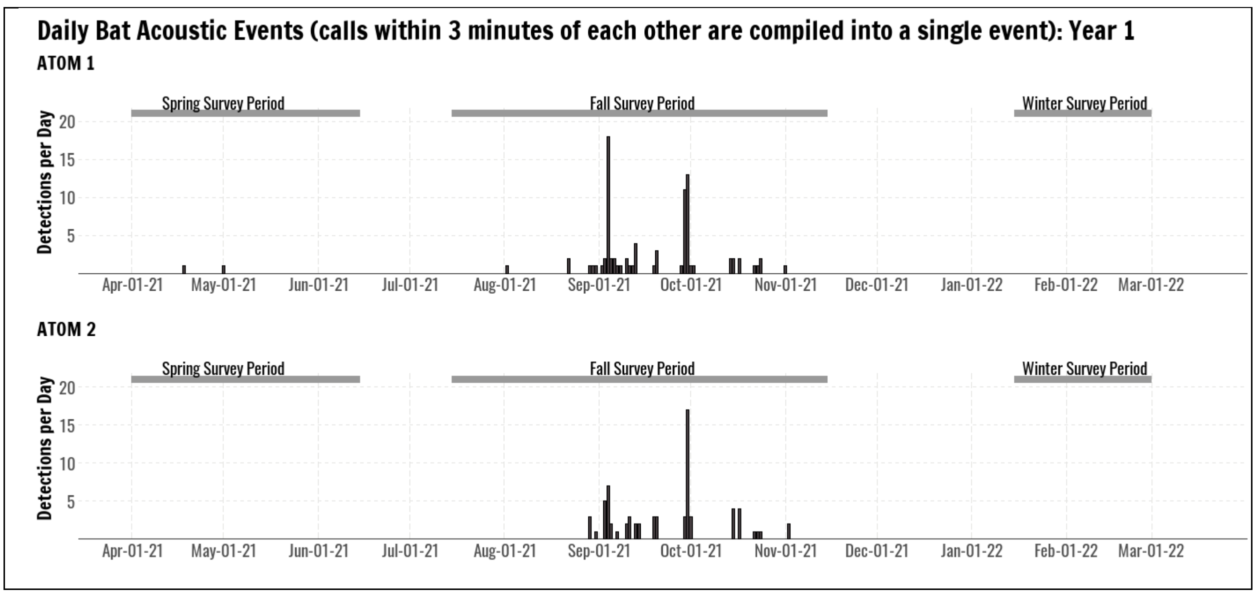


Figure 5. Number of bat acoustic events (calls within three minutes of each other are compiled in a single event) during the spring, fall, and winter monitoring periods

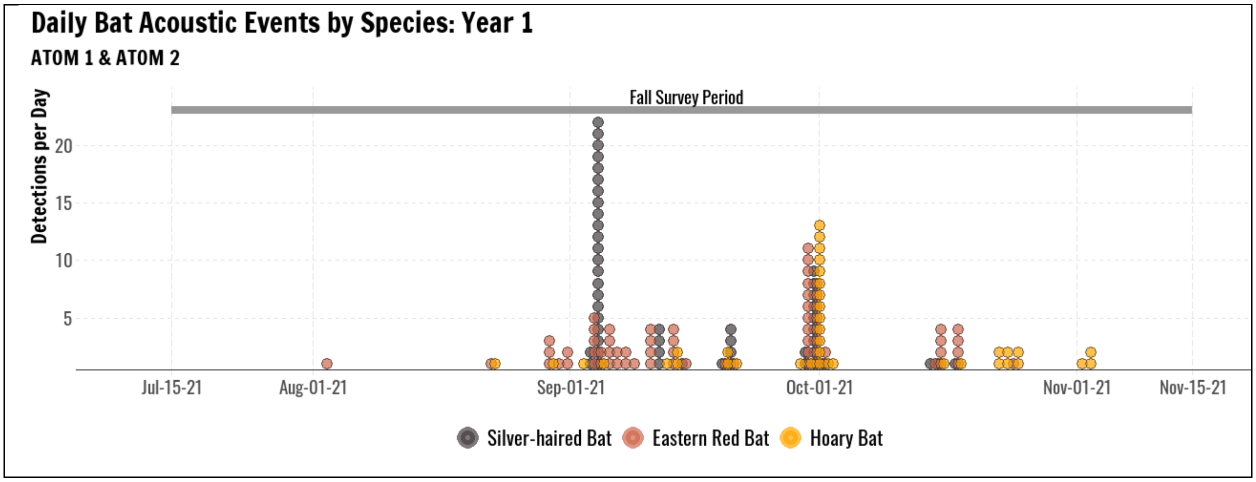


Figure 6. **Temporal distribution of bat species occurrence in the fall monitoring period for ATOM 1 and ATOM 2.**

There were 31 bird detections across 14 species that occurred during acoustic surveys in the fall; no bird acoustic detections occurred in the spring or winter (Appendix C). The most frequently detected species was Rose-breasted Grosbeak (*Pheucticus ludovicianus*) with 12 detections (Table 3). Between ATOM systems, numbers of detections were similar with 12 bird detections at ATOM 1 and 19 detections at ATOM 2. At a monthly level, 18 detections occurred during August, 8 during September, and 5 during October (Figure 7). Of the 31 bird calls, 19 were detected during the day (sunrise–sunset) and 12 were recorded at night (sunset–sunrise).

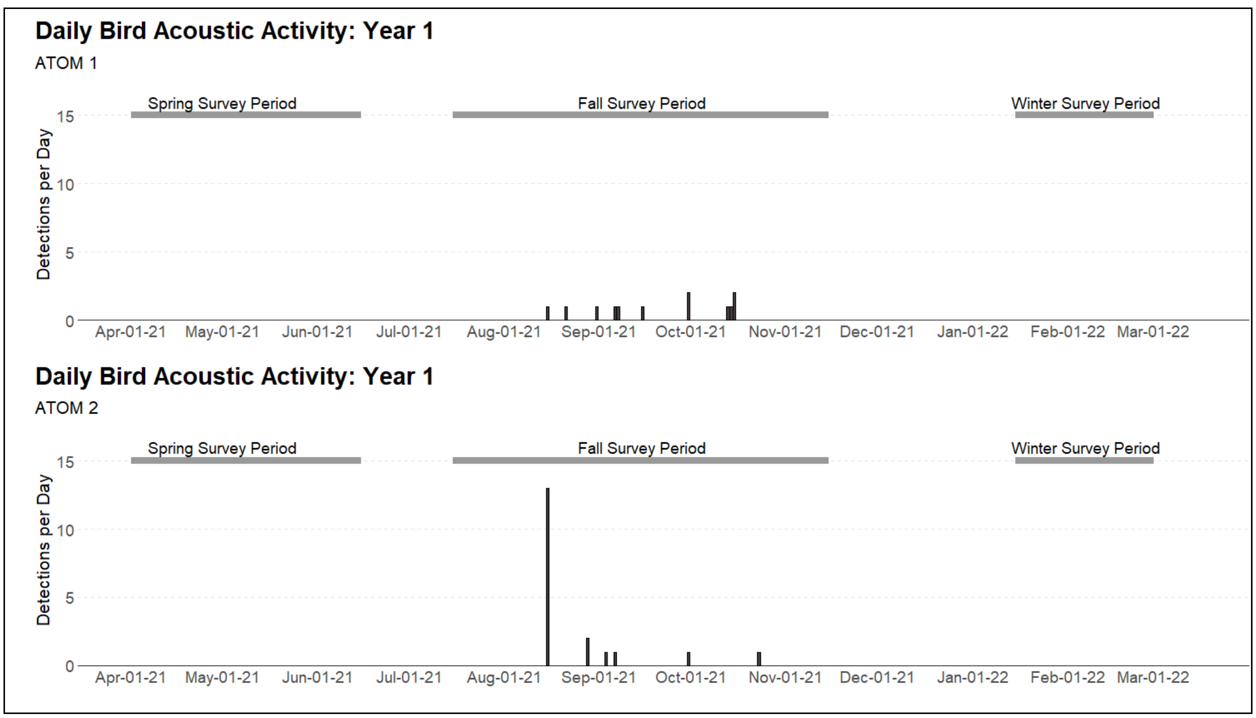


Figure 7. **Seasonal occurrence of bird acoustic detections at ATOM 1 and ATOM 2.**
No detections were recorded during spring and winter.

3.3 Motus

There were 2 bird detections recorded at the Motus systems during the fall survey period: a Semipalmated Sandpiper (*Calidris pusilla*) was recorded on September 24, 2021, at both turbines A01 and A02 (tag #55948) (Table 4). A Semipalmated Plover (*Charadrius semipalmatus*) (tag #45368) was recorded at turbine A02 on September 8, 2021, but was outside the survey periods and thus considered incidental.

Table 4. Motus Detections at Turbines A01 and A02 During the Spring, Fall, and Winter Monitoring Periods

Turbine	Detection Date	Species	Tag
A01	9/24/2021	Semipalmated Sandpiper	55948
A02	9/24/2021	Semipalmated Sandpiper	55948

3.4 Combined Sensors

Across all ATOM sensors and the entire monitoring period, there were 1,581 detections of birds and bats (521 bat, 1,011 bird, and 49 bird/bat). We observed 91% of bird detections during the day and 9% were observed at night. We observed 45% of bats during the day and 55% were detected at night (Figure 8). Between ATOM systems, 852 (54%) targets were detected on ATOM 1 and 729 (46%) targets were detected on ATOM 2 (Table 5, Table 6).

There were 303 bat detections at turbine A01 and 218 bat detections at turbine A02. Bat detections include 3 bat species: silver-haired bat, hoary bat, and eastern red bat. There were 115 bat detections that could not be identified to species including both video and acoustic detections (Table 5, Table 6). Only 2 bat detections occurred in the spring and the remaining 519 detections occurred in the fall; no bats were detected in the winter (Table 6). No federally or state listed bat species were detected during the study.

There were 522 bird detections at turbine A01 and 489 bird detections at turbine A02. Bird detections included 5 shorebird species, 3 gull species, 1 tern species, 3 raptor species, 1 woodpecker species, and 18 passerine species. Skuas, corvids, and hirundines were also identified but no individuals from these three groups were identified to species. Skuas, woodpeckers, and hirundines were all observed during the day. There were 90% of gulls, 98% of raptors, and 95% of passerines observed during the day. There were 50% of shorebirds observed during the day and 50% observed at night (Table 5). Among seasons, only 9 birds were observed in the spring and 5 birds were observed during the winter; all other birds were observed during the fall (Table 6).

The Peregrine Falcon (*Falco peregrinus*) is state listed as threatened by the Virginia Department of Wildlife Resources; there were 54 detections of this species, and 53 detections occurred during the day in the fall. It is likely that many of these detections are the same bird as Peregrine Falcons were only observed on 11 distinct dates. At least 3 individuals were present throughout this time as could be determined by unique plumage characteristics including juvenile plumage and distinct tail-wear and molt observable from the visible-light camera images.

The Kirtland's Warbler (*Setophaga kirtlandii*) is listed as federally endangered by the USFWS. This species breeds in jack pines in Michigan and winters in the Bahamas. One individual was observed during the fall on October 1 in video and the identification was given a confidence level of "probable" (Figure 9). The following field marks led to this identification:

- Light speckling along flanks and creating a light necklace
- Clean yellow throat and center of belly
- Whitish undertail coverts
- White edging to outer tail feathers fitting Kirtland's Warbler

This confidence level was given based on the field marks on the bird; however, the lack of a sharp image precluded us from giving the confidence level of "definite."

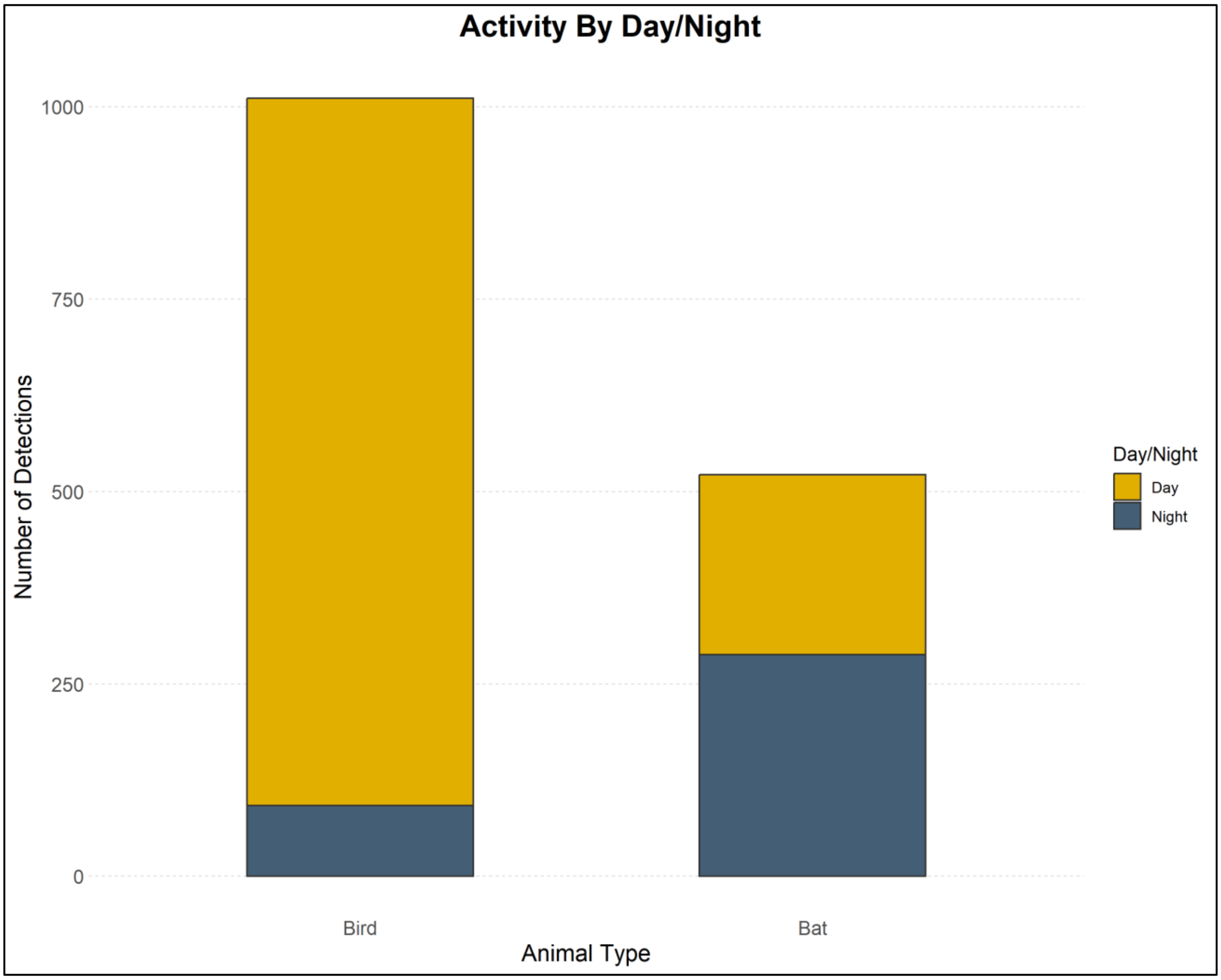


Figure 8. Bird and bat detections by day and night

Table 5. Bird and Bat Species Recorded at Individual ATOM Systems During the Day vs. During the Night

Subtype	Common Name	Scientific Name	ATOM 1			ATOM 2			Total		
			Day	Night	Total	Day	Night	Total	Day	Night	Total
BIRD											
Shorebird	Semipalmated Plover	*Charadrius semipalmatus*	-	-	**1**	-	-	**1**	-	-	**2***
Shorebird	Semipalmated Sandpiper	*Calidris pusilla*	-	-	**1**	-	-	**-**	-	-	**1***
Shorebird	Spotted Sandpiper	*Actitis macularius*	-	1	**1**	-	-	**-**	-	1	**1**
Shorebird	Solitary Sandpiper	*Tringa solitaria*	-	-	**-**	-	1	**1**	-	1	**1**
Shorebird	Upland Sandpiper	*Bartramia longicauda*	1	2	**3**	-	-	**-**	1	2	**3**
Shorebird	Shorebird species		2	-	**3**	-	-	**-**	2	-	**3***
Skua	Skua species		1	-	**1**	-	-	**-**	1	-	**1**
Gull	Laughing Gull	*Leucophaeus atricilla*	3	-	**3**	6	1	**7**	9	1	**10**
Gull	Herring Gull	*Larus argentatus*	4	-	**4**	5	-	**5**	9	-	**9**
Gull	Great Black-backed Gull	*Larus marinus*	1	-	**1**	2	-	**2**	3	-	**3**
Gull	Large Gull species		5	1	**6**	9	1	**10**	14	2	**16**
Gull	Small Gull species		2	1	**3**	-	-	**-**	2	1	**3**
Gull	Gull species		1	1	**2**	8	-	**8**	9	1	**10**
Tern	Royal Tern	*Thalasseus maximus*	1	1	**2**	-	-	**-**	1	1	**2**
Raptor	Osprey	*Pandion haliaetus*	8	-	**8**	-	-	**-**	8	-	**8**
Raptor	Merlin	*Falco columbarius*	1	-	**1**	-	-	**-**	1	-	**1**
Raptor	Peregrine Falcon	*Falco peregrinus*	26	1	**27**	27	-	**27**	53	1	**54**
Raptor	Raptor species		2	-	**2**	1	-	**1**	3	-	**3**
Woodpecker	Northern Flicker	*Colaptes auratus*	1	-	**1**	-	-	**-**	1	-	**1**
Corvid	Corvid species		-	-	**-**	1	1	**2**	1	1	**2**
Hirundine	Hirundine species		2	-	**2**	1	-	**1**	3	-	**3**
Passerine	Brown Creeper	*Certhia americana*	7	-	**7**	3	-	**3**	10	-	**10**
Passerine	Winter Wren	*Troglodytes hiemalis*	11	-	**11**	6	-	**6**	17	-	**17**
Passerine	Wren species		1	-	**1**	-	-	**-**	1	-	**1**
Passerine	American Robin	*Turdus migratorius*	2	-	**2**	2	-	**2**	4	-	**4**
Passerine	American Pipit	*Anthus rubescens*	-	-	**-**	1	-	**1**	1	-	**1**

Subtype	Common Name	Scientific Name	ATOM 1			ATOM 2			Total		
			Day	Night	Total	Day	Night	Total	Day	Night	Total
Passerine	Northern Waterthrush	*Parkesia noveboracensis*	-	-	**-**	1	-	**1**	1	-	**1**
Passerine	Blue-winged Warbler	*Vermivora cyanoptera*	1	-	**1**	-	-	**-**	1	-	**1**
Passerine	Black-and-white Warbler	*Mniotilta varia*	9	2	**11**	4	-	**4**	13	2	**15**
Passerine	American Redstart	*Setophaga ruticilla*	-	-	**-**	3	1	**4**	3	1	**4**
Passerine	Cape May Warbler	*Setophaga tigrina*	73	1	**74**	37	1	**38**	110	2	**112**
Passerine	Northern Parula	*Setophaga americana*	1	1	**2**	1	-	**1**	2	1	**3**
Passerine	Magnolia Warbler	*Setophaga magnolia*	3	-	**3**	1	1	**2**	4	1	**5**
Passerine	Bay-breasted Warbler	*Setophaga castanea*	4	1	**5**	3	1	**4**	7	2	**9**
Passerine	Blackburnian Warbler	*Setophaga fusca*	4	-	**4**	1	-	**1**	5	-	**5**
Passerine	Palm Warbler	*Setophaga palmarum*	6	-	**6**	8	-	**8**	14	-	**14**
Passerine	Pine Warbler	*Setophaga pinus*	24	-	**24**	3	-	**3**	27	-	**27**
Passerine	Yellow-rumped Warbler	*Setophaga coronata*	15	-	**15**	1	-	**1**	16	-	**16**
Passerine	Kirtland's Warbler	*Setophaga kirtlandii*	-	-	**-**	1	-	**1**	1	-	**1**
Passerine	Setophaga species		74	2	**76**	93	2	**95**	167	4	**171**
Passerine	Parulidae species		6	-	**6**	-	-	**-**	6	-	**6**
Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	2	1	**3**	19	-	**19**	21	1	**22**
Passerine	Passerine species		113	12	**125**	136	10	**146**	249	22	**271**
Unid. Avian	Unidentified bird species		59	12	**74**	59	25	**84**	118	37	**158***
BAT											
Bat	Silver-haired bat	*Lasionycteris noctivagans*	108	48	**156**	47	31	**78**	155	79	**234**
Bat	Hoary bat	*Lasiurus cinereus*	8	24	**32**	1	49	**50**	9	73	**82**
Bat	Eastern Red bat	*Lasiurus borealis*	20	26	**46**	29	15	**44**	49	41	**90**
Bat	Unknown low-frequency species		1	3	**4**	5	4	**9**	6	7	**13**
Bat	Bat species		7	58	**65**	8	29	**37**	15	87	**102**
BIRD/BAT											
Bird/Bat	Bird/Bat		1	20	**27**	1	21	**22**	2	41	**49***
TOTAL			621	219	**852**	534	194	**729**	1,155	413	**1,581***

*Data from Motus could not be matched to time so grand totals may not match individual day and night columns.

Table 6. Bird and Bat Species Recorded at Both ATOM Systems by Season During the Spring, Fall, and Winter Monitoring Periods

Subtype	Common Name	Scientific Name	Spring			Fall			Winter			Total		
			Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total
BIRD														
Shorebird	Semipalmated Plover	*Charadrius semipalmatus*	0	0	**0**	0	0	**2**	0	0	**0**	0	0	**2***
Shorebird	Semipalmated Sandpiper	*Calidris pusilla*	0	0	**0**	0	0	**1**	0	0	**0**	0	0	**1***
Shorebird	Spotted Sandpiper	*Actitis macularius*	0	0	**0**	0	1	**1**	0	0	**0**	0	1	**1**
Shorebird	Solitary Sandpiper	*Tringa solitaria*	0	0	**0**	0	1	**1**	0	0	**0**	0	1	**1**
Shorebird	Upland Sandpiper	*Bartramia longicauda*	0	0	**0**	1	2	**3**	0	0	**0**	1	2	**3**
Shorebird	Shorebird species		0	0	**0**	2	0	**3**	0	0	**0**	2	0	**3***
Skua	Skua species		0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Gull	Laughing Gull	*Leucophaeus atricilla*	0	0	**0**	9	1	**10**	0	0	**0**	9	1	**10**
Gull	Herring Gull	*Larus argentatus*	0	0	**0**	7	0	**7**	2	0	**2**	9	0	**9**
Gull	Great Black-backed Gull	*Larus marinus*	0	0	**0**	1	0	**1**	2	0	**2**	3	0	**3**
Gull	Large Gull species		0	0	**0**	14	2	**16**	0	0	**0**	14	2	**16**
Gull	Small Gull species		0	0	**0**	2	1	**3**	0	0	**0**	2	1	**3**
Gull	Gull species		0	0	**0**	9	1	**10**	0	0	**0**	9	1	**10**
Tern	Royal Tern	*Thalasseus maximus*	0	0	**0**	1	1	**2**	0	0	**0**	1	1	**2**
Raptor	Osprey	*Pandion haliaetus*	0	0	**0**	8	0	**8**	0	0	**0**	8	0	**8**
Raptor	Merlin	*Falco columbarius*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Raptor	Peregrine Falcon	*Falco peregrinus*	0	0	**0**	53	1	**54**	0	0	**0**	53	1	**54**
Raptor	Raptor species		0	0	**0**	3	0	**3**	0	0	**0**	3	0	**3**
Woodpecker	Northern Flicker	*Colaptes auratus*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Corvid	Corvid species		0	0	**0**	1	1	**2**	0	0	**0**	1	1	**2**
Hirundine	Hirundine species		0	0	**0**	3	0	**3**	0	0	**0**	3	0	**3**
Passerine	Brown Creeper	*Certhia americana*	0	0	**0**	10	0	**10**	0	0	**0**	10	0	**10**
Passerine	Winter Wren	*Troglodytes hiemalis*	0	0	**0**	17	0	**17**	0	0	**0**	17	0	**17**
Passerine	Wren species		0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Passerine	American Robin	*Turdus migratorius*	0	0	**0**	4	0	**4**	0	0	**0**	4	0	**4**
Passerine	American Pipit	*Anthus rubescens*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Passerine	Northern Waterthrush	*Parkesia noveboracensis*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**

Subtype	Common Name	Scientific Name	Spring			Fall			Winter			Total		
			Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total
Passerine	Blue-winged Warbler	*Vermivora cyanoptera*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Passerine	Black-and-white Warbler	*Mniotilta varia*	0	0	**0**	13	2	**15**	0	0	**0**	13	2	**15**
Passerine	American Redstart	*Setophaga ruticilla*	0	0	**0**	3	1	**4**	0	0	**0**	3	1	**4**
Passerine	Cape May Warbler	*Setophaga tigrina*	0	0	**0**	110	2	**112**	0	0	**0**	110	2	**112**
Passerine	Northern Parula	*Setophaga americana*	0	0	**0**	2	1	**3**	0	0	**0**	2	1	**3**
Passerine	Magnolia Warbler	*Setophaga magnolia*	0	0	**0**	4	1	**5**	0	0	**0**	4	1	**5**
Passerine	Bay-breasted Warbler	*Setophaga castanea*	0	0	**0**	7	2	**9**	0	0	**0**	7	2	**9**
Passerine	Blackburnian Warbler	*Setophaga fusca*	0	0	**0**	5	0	**5**	0	0	**0**	5	0	**5**
Passerine	Palm Warbler	*Setophaga palmarum*	0	0	**0**	14	0	**14**	0	0	**0**	14	0	**14**
Passerine	Pine Warbler	*Setophaga pinus*	0	0	**0**	27	0	**27**	0	0	**0**	27	0	**27**
Passerine	Yellow-rumped Warbler	*Setophaga coronata*	0	0	**0**	16	0	**16**	0	0	**0**	16	0	**16**
Passerine	Kirtland’s Warbler	*Setophaga kirtlandii*	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Passerine	Setophaga species		0	0	**0**	167	4	**171**	0	0	**0**	167	4	**171**
Passerine	Parulidae species		0	0	**0**	6	0	**6**	0	0	**0**	6	0	**6**
Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	0	0	**0**	21	1	**22**	0	0	**0**	21	1	**22**
Passerine	Passerine species		0	0	**0**	249	22	**271**	0	0	**0**	249	22	**271**
Unid. Avian	Unidentified bird species		1	8	**9**	116	29	**148**	1	0	**1**	118	37	**158***
BAT														
Bat	Silver-haired bat	*Lasionycteris noctivagans*	0	0	**0**	155	79	**234**	0	0	**0**	155	79	**234**
Bat	Hoary bat	*Lasiurus cinereus*	0	0	**0**	9	73	**82**	0	0	**0**	9	73	**82**
Bat	Eastern Red bat	*Lasiurus borealis*	0	2	**2**	49	39	**88**	0	0	**0**	49	41	**90**
Bat	Unknown low-frequency species		0	0	**0**	6	7	**13**	0	0	**0**	6	7	**13**
Bat	Bat species		0	0	**0**	15	87	**102**	0	0	**0**	15	87	**102**
BIRD/BAT														
Bird/Bat	Bird/Bat		0	0	**0**	2	41	**49**	0	0	**0**	2	41	**49***
TOTAL			1	10	**11**	1149	403	**1565**	5	0	**5**	1155	413	**1581***

Figure 9. A probable Kirkland's Warbler from the fall ATOM field studies at the Coastal Virginia Offshore Wind Pilot Project

3.5 Sensor Comparison

Across bats and birds and all sensor types, acoustic sensors found 443 (28%) detections and video found 1,133 (72%) detections. Totals for Motus and anecdotal observations from photos were <1% of detections. Acoustic sensors detected 79% of all bat detections but only 4% of bird detections. Video sensors found 96% of bird detections but only 21% of bat detections. Bat species identifications would have not occurred without the acoustic sensors as bat identification by sight alone is difficult. For birds, terns were only found using the acoustic sensors and anecdotal photos, suggesting terns avoided the area immediately around the turbine and were not in the video viewshed, while all other bird groups were represented by detections in the video data. Acoustic sensors alone would have only detected four bird groups while video sensors would have captured 8 groups. Combined sensors captured 9 bird species groups (Table 7).

3.6 Activity and Weather Associations

Bat activity had a bimodal distribution when related to barometric pressure, with activity peaking at both 1017 mb and 1022 mb (Figure 10). Bat activity was the highest when air temperatures were 22–23°C and lower at other temperatures (Figure 11). Bat activity was highest when winds were out of a north and northeast direction (Figure 12). Bat activity declined above wind speeds of 6 m/s and was minimal above 10 m/s (Figure 13).

Passerine activity was highest when barometric pressure was 1013–1014 mb (Figure 14), with non-passerine activity peaking between 1014 and 1016 mb (Figure 15). Most passerine activity occurred when air temperature was between 19°C and 22°C (Figure 16), with non-passerine activity peaking over the same range (Figure 17). With wind direction, passerines were most frequently recorded with winds out of the northwest and north (Figure 18), with non-passerines showing a similar trend (Figure 19). Passerine activity fell when wind speeds were greater than 5 m/s (Figure 20); a similar trend was observed with non-passerines but the decline in activity was less dramatic as wind speed increased (Figure 21). Most acoustic detections were limited at wind speeds above 5 m/s (Figure 20, Figure 21).

Table 7. Sensor Comparison Among Acoustic, Motus, Anecdotal Photos, and Video Sensors During the Spring, Fall, and Winter Monitoring Periods

Subtype	Common Name	Scientific Name	Acoustic	MOTUS	Photo	Video	Total
BIRD							
Shorebird	Semipalmated Plover	*Charadrius semipalmatus*	0	2	0	0	**2**
Shorebird	Semipalmated Sandpiper	*Calidris pusilla*	0	1	0	0	**1**
Shorebird	Spotted Sandpiper	*Actitis macularius*	1	0	0	0	**1**
Shorebird	Solitary Sandpiper	*Tringa solitaria*	1	0	0	0	**1**
Shorebird	Upland Sandpiper	*Bartramia longicauda*	3	0	0	0	**3**
Shorebird	Shorebird species		0	0	0	3	**3**
Skua	Skua species		0	0	0	1	**1**
Gull	Laughing Gull	*Leucophaeus atricilla*	0	0	0	10	**10**
Gull	Herring Gull	*Larus argentatus*	1	0	0	8	**9**
Gull	Great Black-backed Gull	*Larus marinus*	0	0	0	3	**3**
Gull	Large Gull species		0	0	0	16	**16**
Gull	Small Gull species		0	0	0	3	**3**
Gull	Gull species		0	0	0	10	**10**
Tern	Royal Tern	*Thalasseus maximus*	1	0	1	0	**2**
Raptor	Osprey	*Pandion haliaetus*	0	0	0	8	**8**
Raptor	Merlin	*Falco columbarius*	0	0	0	1	**1**
Raptor	Peregrine Falcon	*Falco peregrinus*	0	0	1	53	**54**
Raptor	Raptor species		0	0	0	3	**3**
Woodpecker	Northern Flicker	*Colaptes auratus*	0	0	0	1	**1**
Corvid	Corvid species		0	0	0	2	**2**
Hirundine	Hirundine species		0	0	0	3	**3**
Passerine	Brown Creeper	*Certhia americana*	0	0	0	10	**10**
Passerine	Winter Wren	*Troglodytes hiemalis*	0	0	0	17	**17**
Passerine	Wren species		0	0	0	1	**1**
Passerine	American Robin	*Turdus migratorius*	2	0	0	2	**4**

Subtype	Common Name	Scientific Name	Acoustic	MOTUS	Photo	Video	Total
Passerine	American Pipit	*Anthus rubescens*	0	0	0	1	**1**
Passerine	Northern Waterthrush	*Parkesia noveboracensis*	1	0	0	0	**1**
Passerine	Blue-winged Warbler	*Vermivora cyanoptera*	0	0	0	1	**1**
Passerine	Black-and-white Warbler	*Mniotilta varia*	2	0	0	13	**15**
Passerine	American Redstart	*Setophaga ruticilla*	1	0	0	3	**4**
Passerine	Cape May Warbler	*Setophaga tigrina*	0	0	0	112	**112**
Passerine	Northern Parula	*Setophaga americana*	2	0	0	1	**3**
Passerine	Magnolia Warbler	*Setophaga magnolia*	1	0	0	4	**5**
Passerine	Bay-breasted Warbler	*Setophaga castanea*	2	0	0	7	**9**
Passerine	Blackburnian Warbler	*Setophaga fusca*	0	0	0	5	**5**
Passerine	Palm Warbler	*Setophaga palmarum*	1	0	0	13	**14**
Passerine	Pine Warbler	*Setophaga pinus*	0	0	0	27	**27**
Passerine	Yellow-rumped Warbler	*Setophaga coronata*	0	0	0	16	**16**
Passerine	Kirtland's Warbler	*Setophaga kirtlandii*	0	0	0	1	**1**
Passerine	Setophaga species		0	0	0	171	**171**
Passerine	Parulidae species		0	0	0	6	**6**
Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	12	0	0	10	**22**
Passerine	Passerine species		0	0	0	271	**271**
Unid. Avian	Unidentified bird species		0	0	0	158	**158**
BAT							
Bat	Silver-haired bat	*Lasionycteris noctivagans*	233	0	0	1	**234**
Bat	Hoary bat	*Lasiurus cinereus*	80	0	0	2	**82**
Bat	Eastern Red bat	*Lasiurus borealis*	86	0	0	4	**90**
Bat	Unknown low-frequency species		13	0	0	0	**13**
Bat	Bat species		0	0	0	102	**102**
BIRD/BAT							
Bird/Bat	Bird/Bat		0	0	0	49	**49**
TOTAL			443	3	2	1133	**1581**

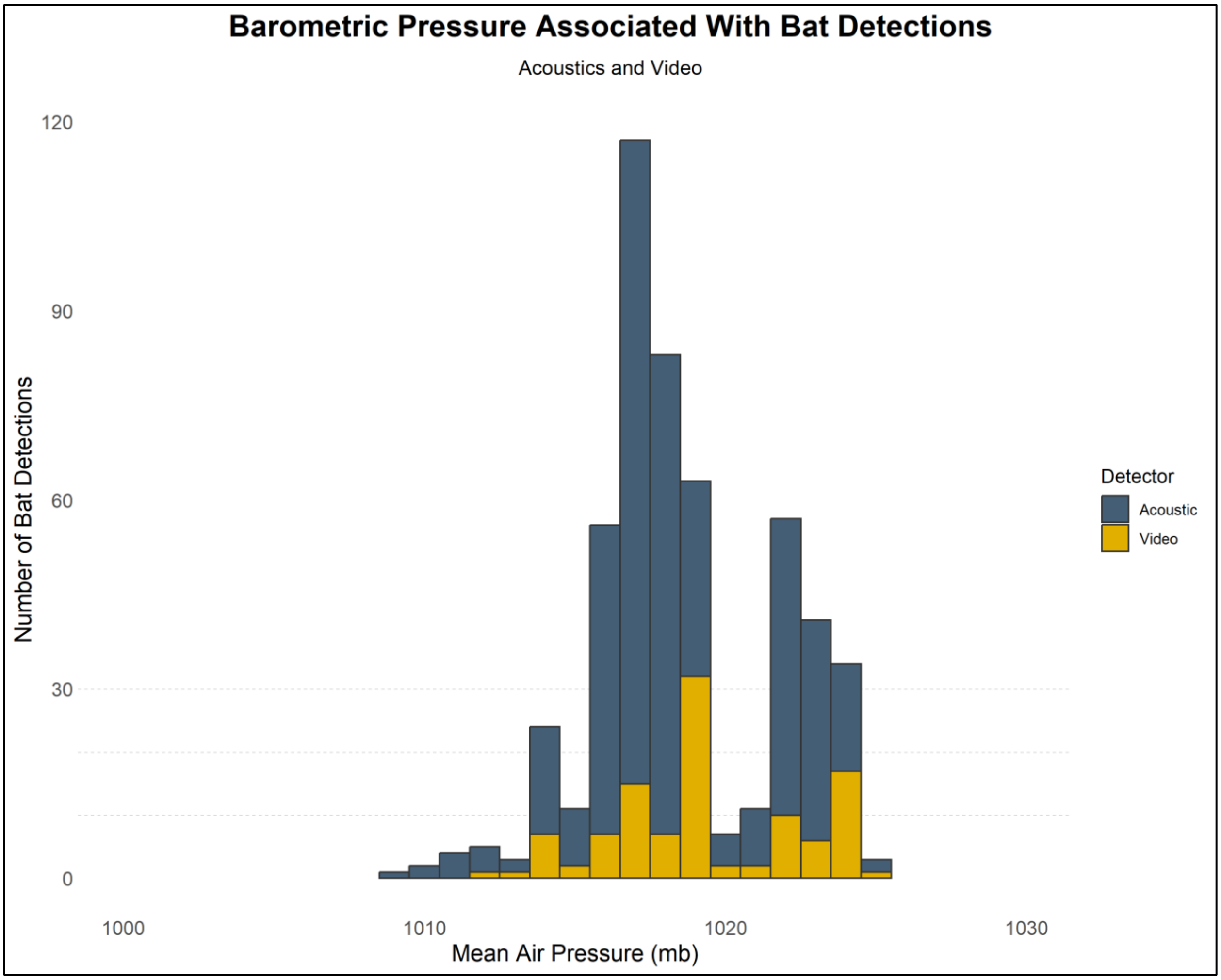


Figure 10. Number of bat detections at a range of barometric pressure levels using acoustic and video data at ATOM 1 and ATOM 2.

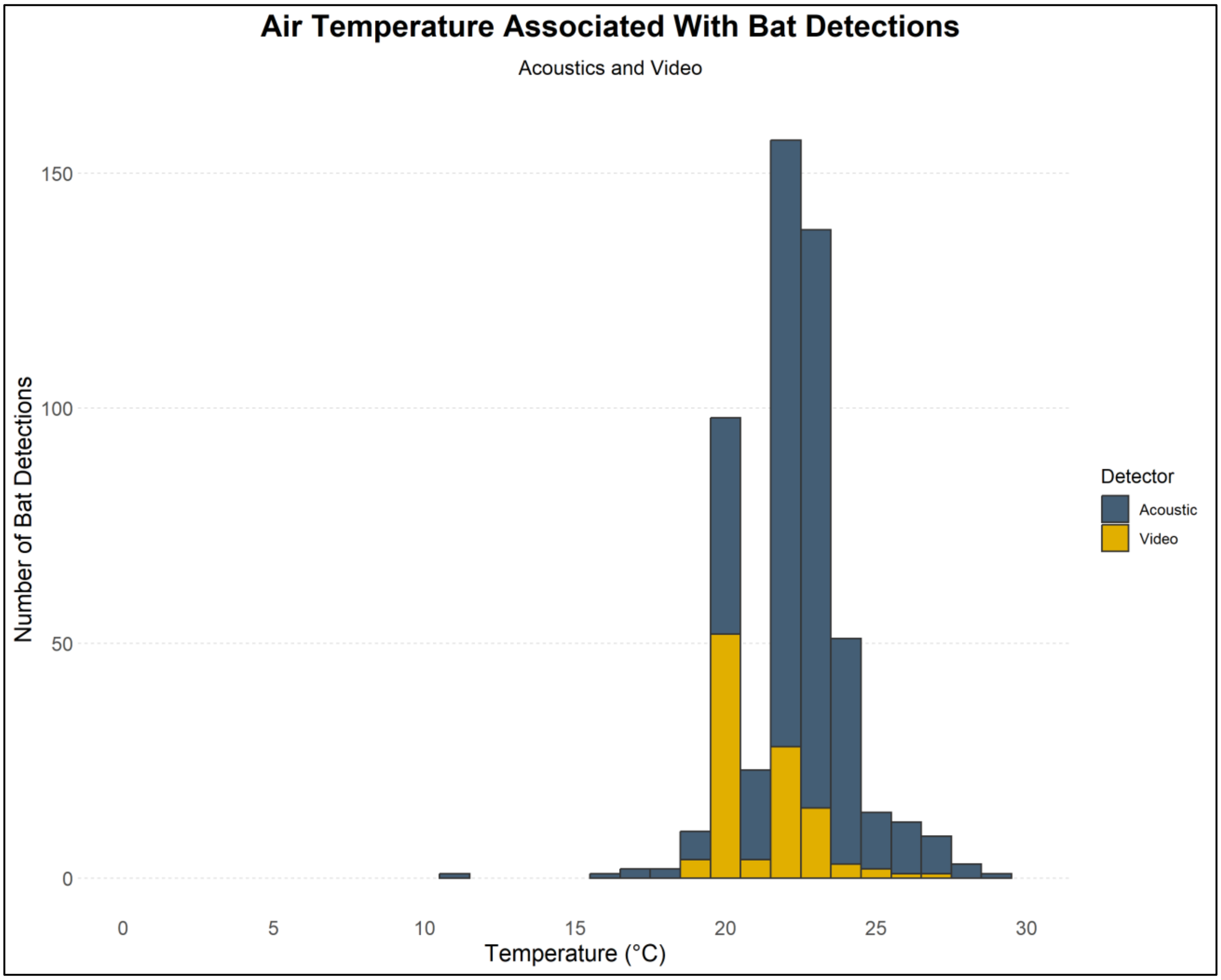


Figure 11. Number of bat detections at a range of temperature levels using acoustic and video data at ATOM 1 and ATOM 2.

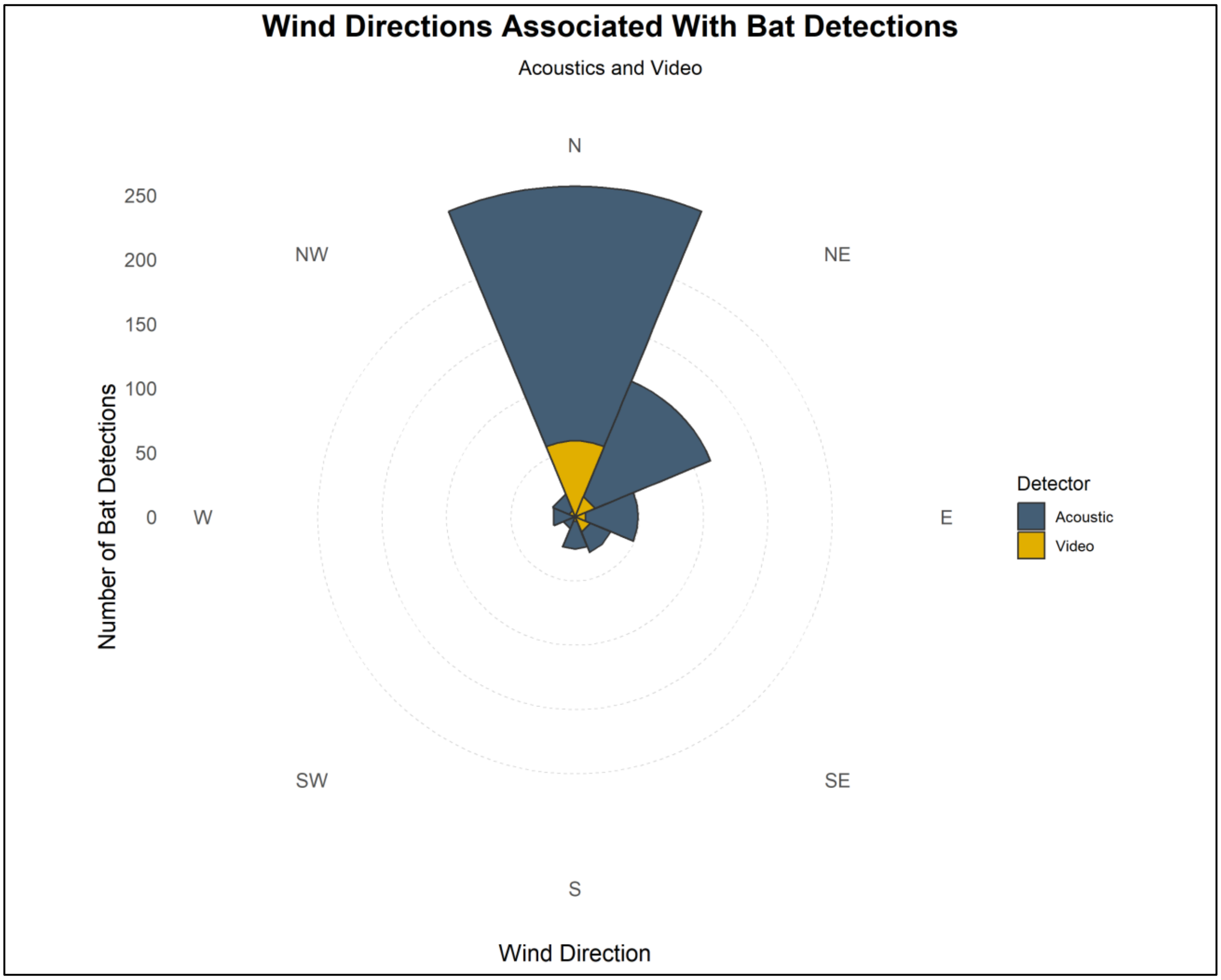


Figure 12. Number of bat detections at a range of wind directions using acoustic and video data at ATOM 1 and ATOM 2.

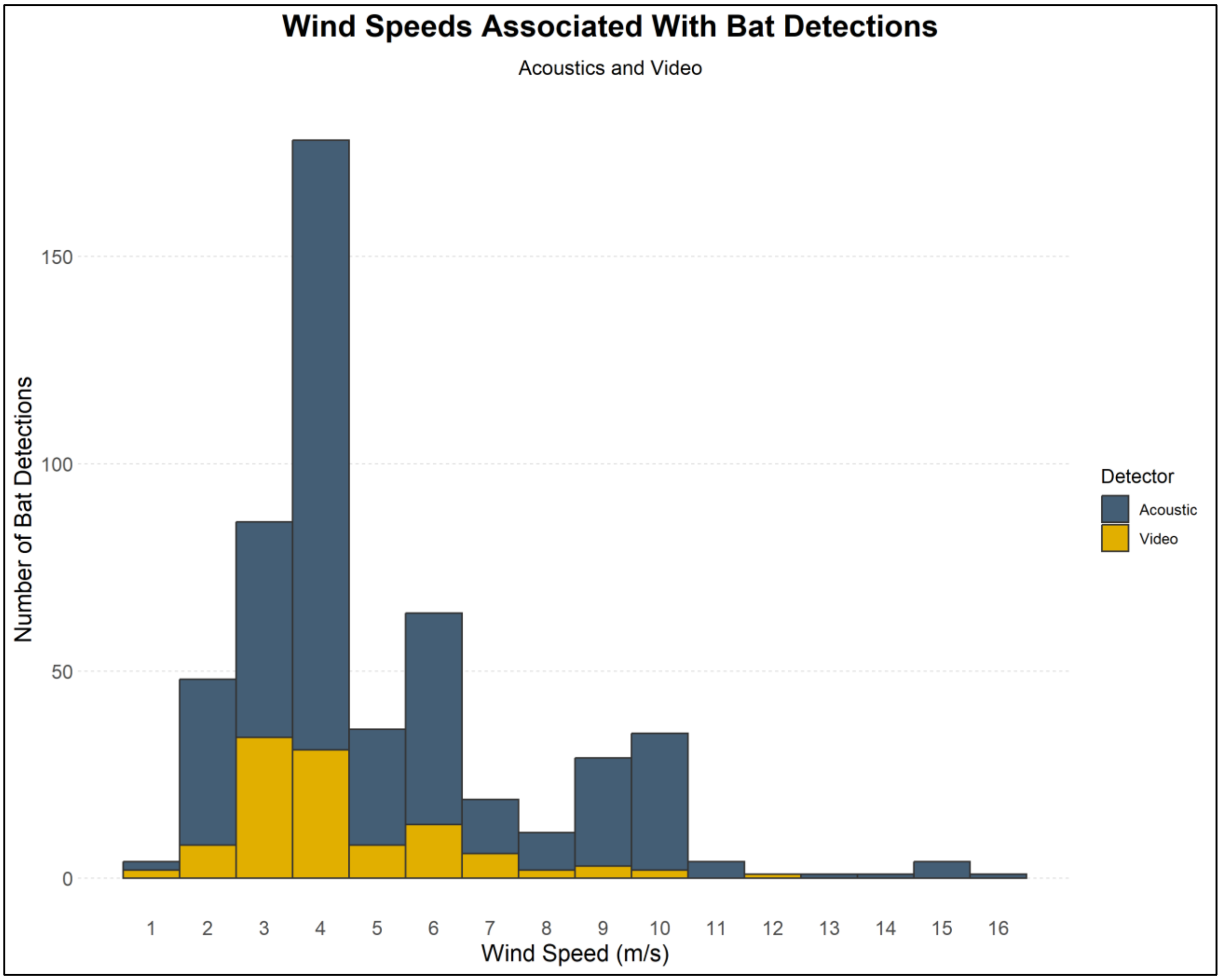


Figure 13. Number of bat detections at a range of wind speeds using acoustic and video data at ATOM 1 and ATOM 2.

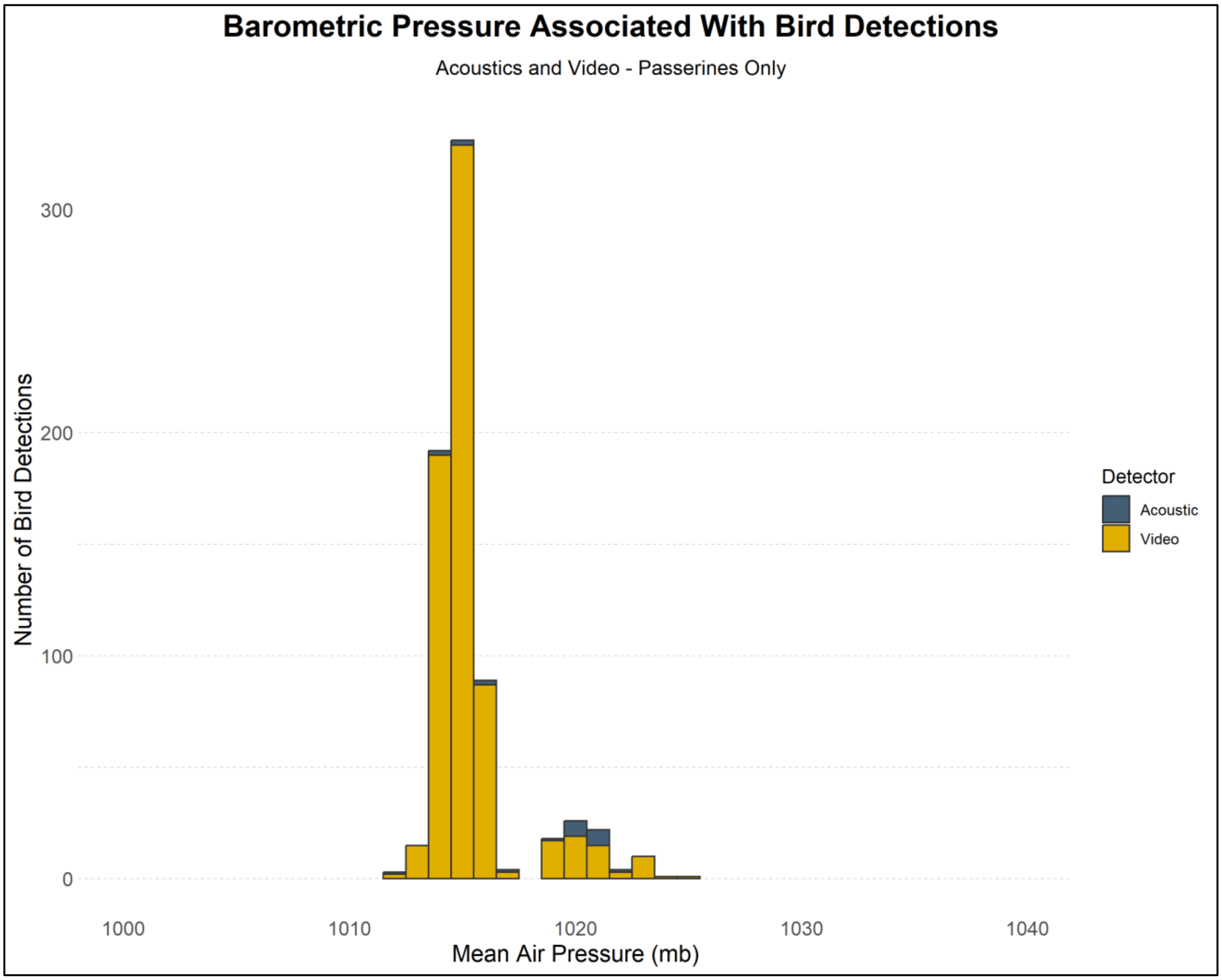


Figure 14. Number of passerine detections at a range of barometric pressure using acoustic and video data at ATOM 1 and ATOM 2.

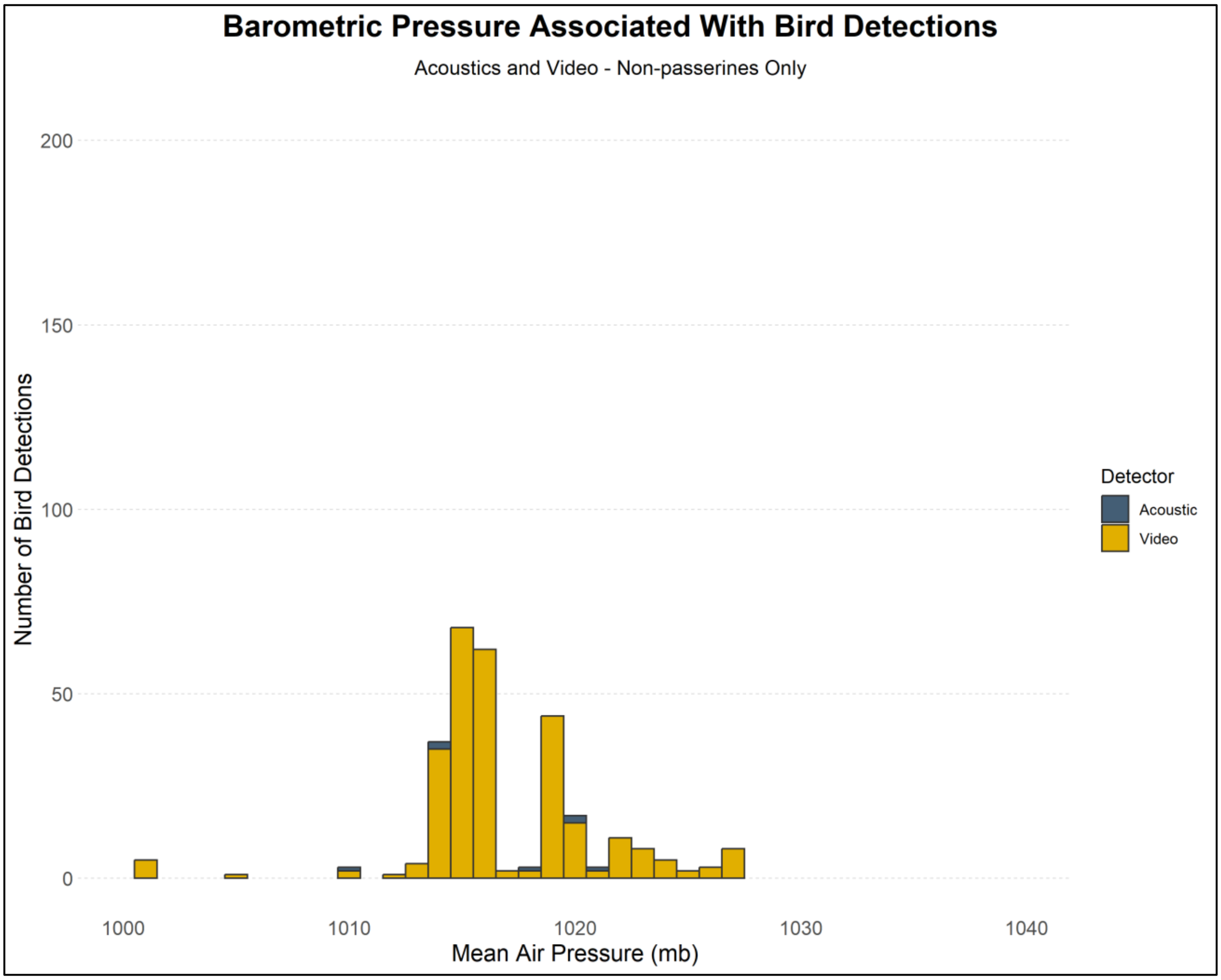


Figure 15. Number of non-passerine detections at a range of barometric pressure using acoustic and video data at ATOM 1 and ATOM 2.

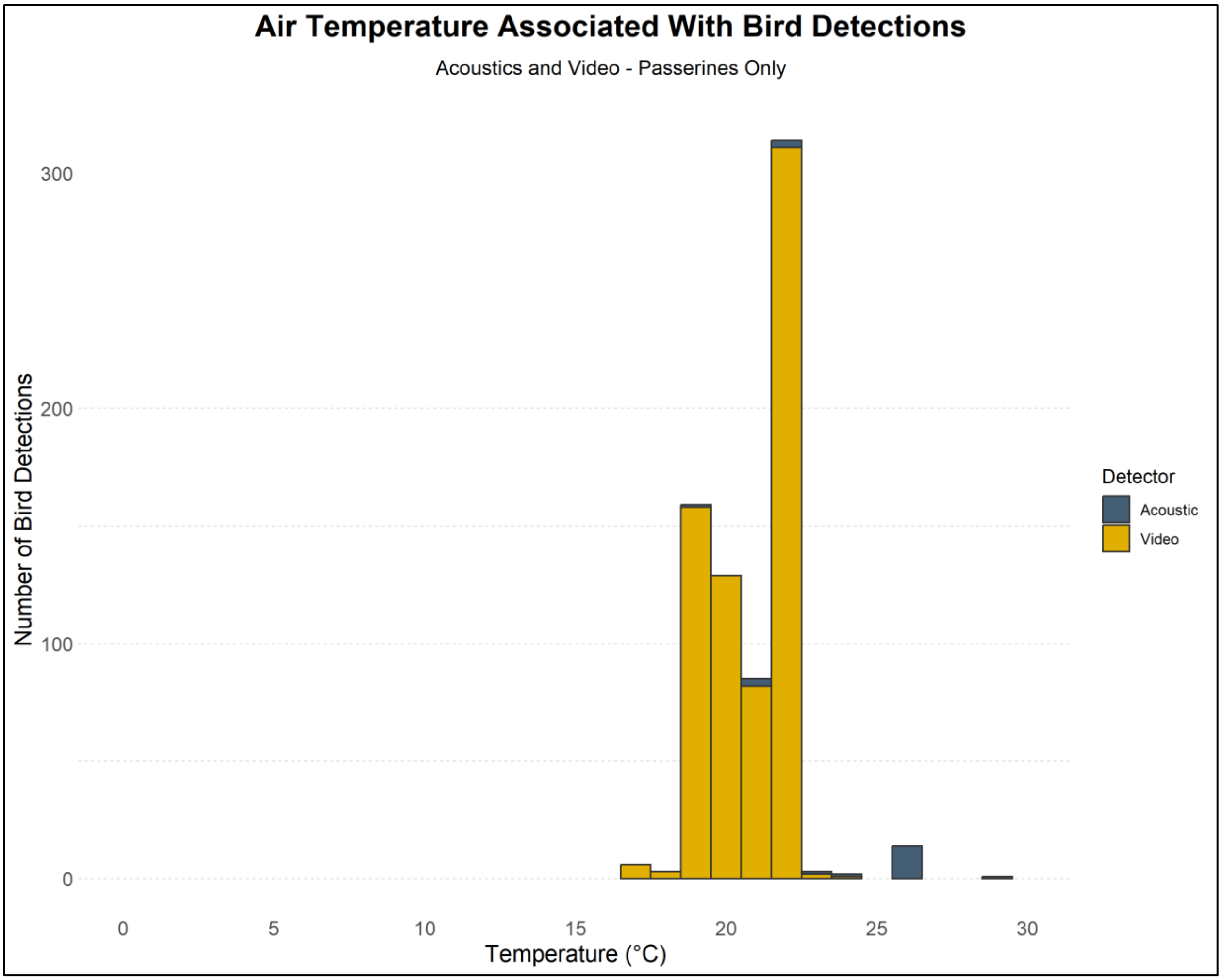


Figure 16. Number of passerine detections at a range of temperatures using acoustic and video data at ATOM 1 and ATOM 2.

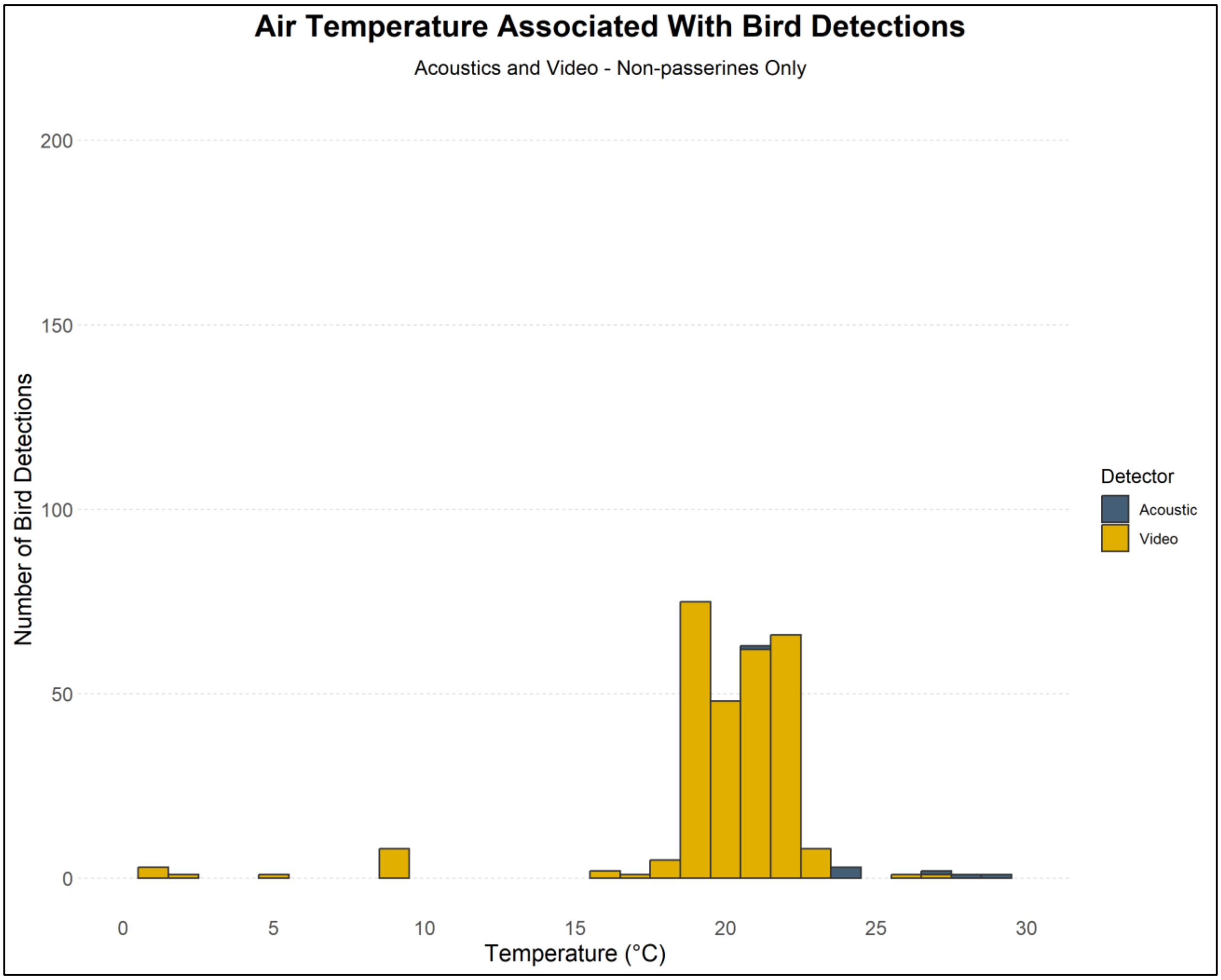


Figure 17. Number of non-passerine detections at a range of temperatures using acoustic and video data at ATOM 1 and ATOM 2.

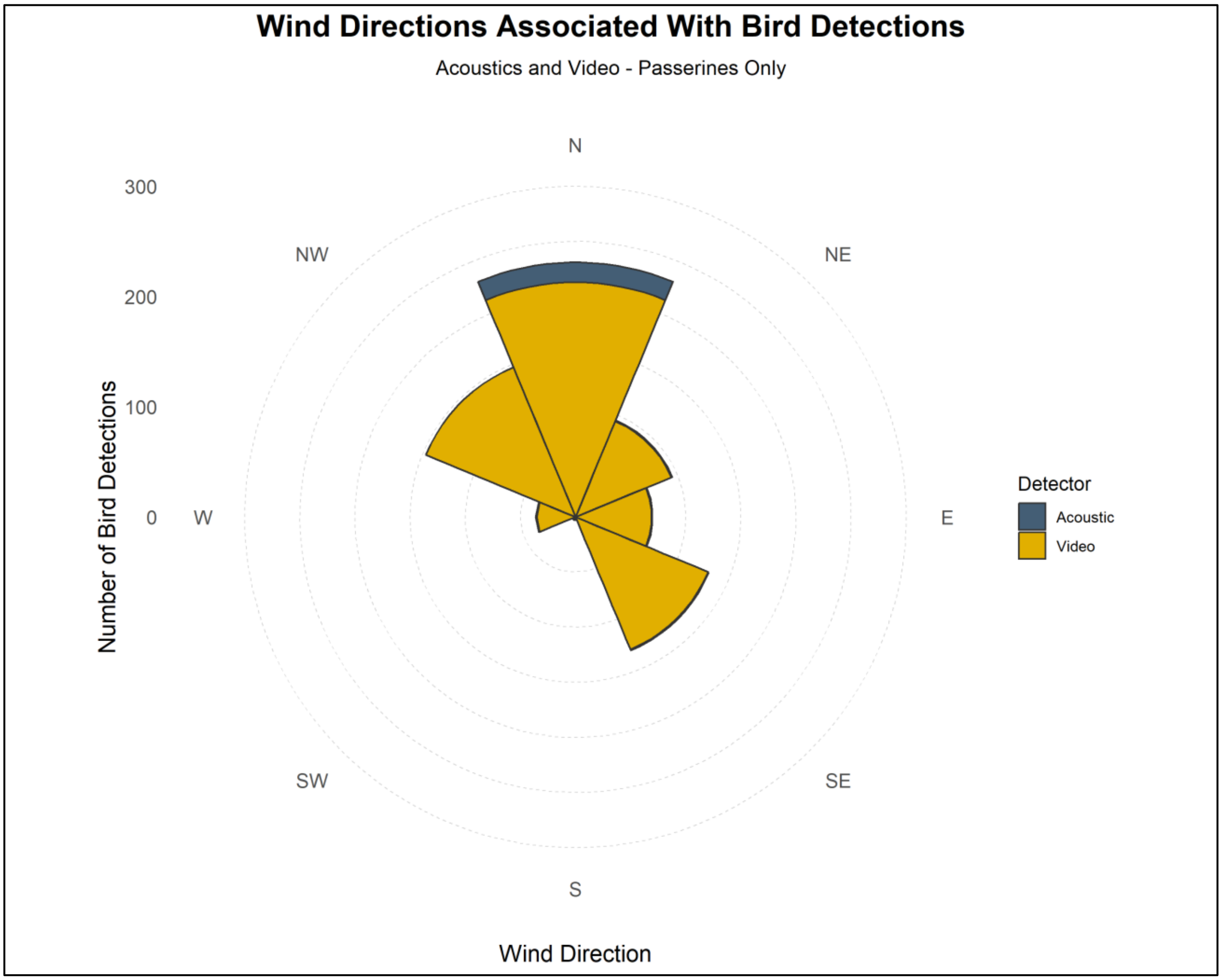


Figure 18. Number of passerine detections at a range of wind directions using acoustic and video data at ATOM 1 and ATOM 2.

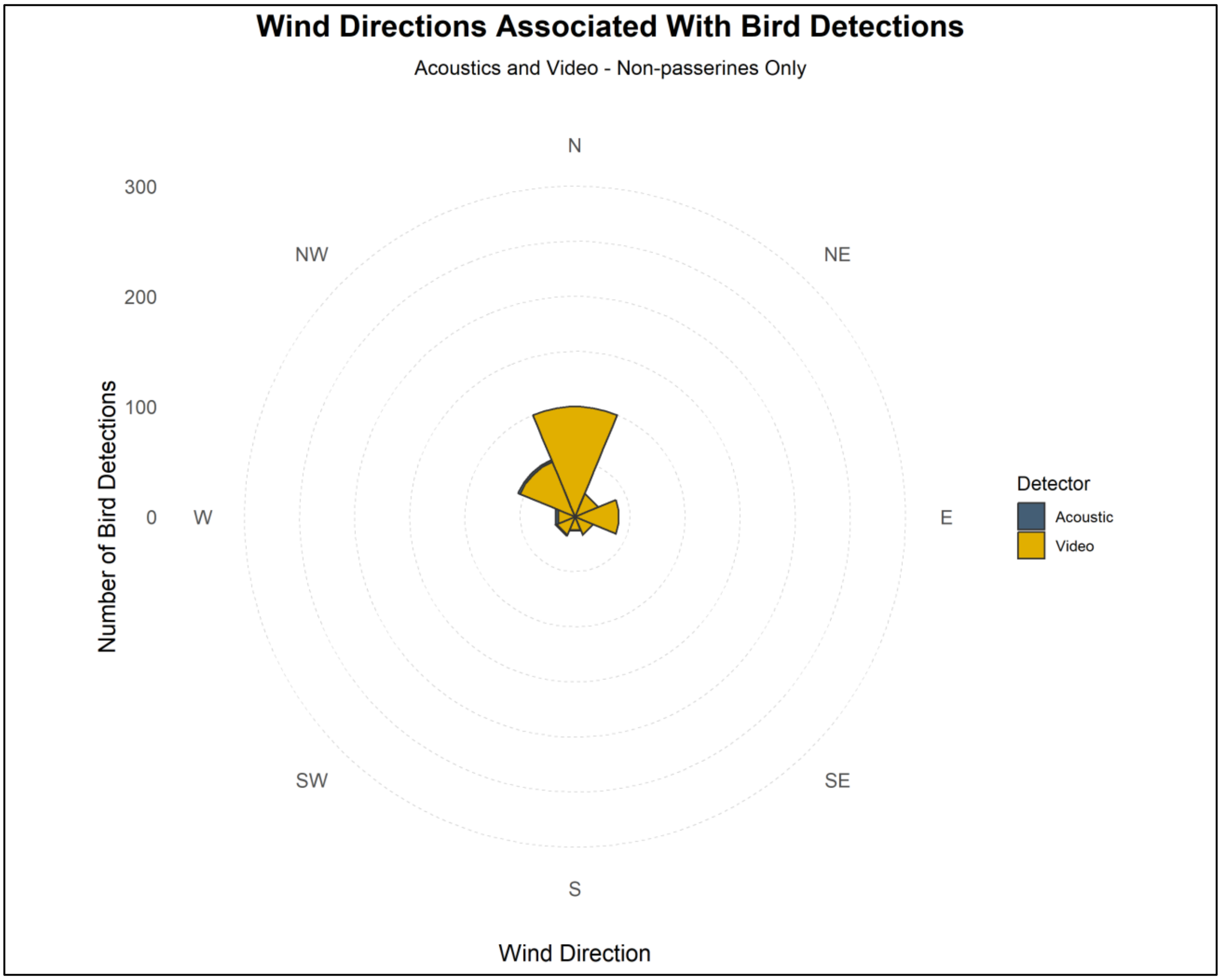


Figure 19. Number of non-passerine detections at a range of wind directions using acoustic and video data at ATOM 1 and ATOM 2.

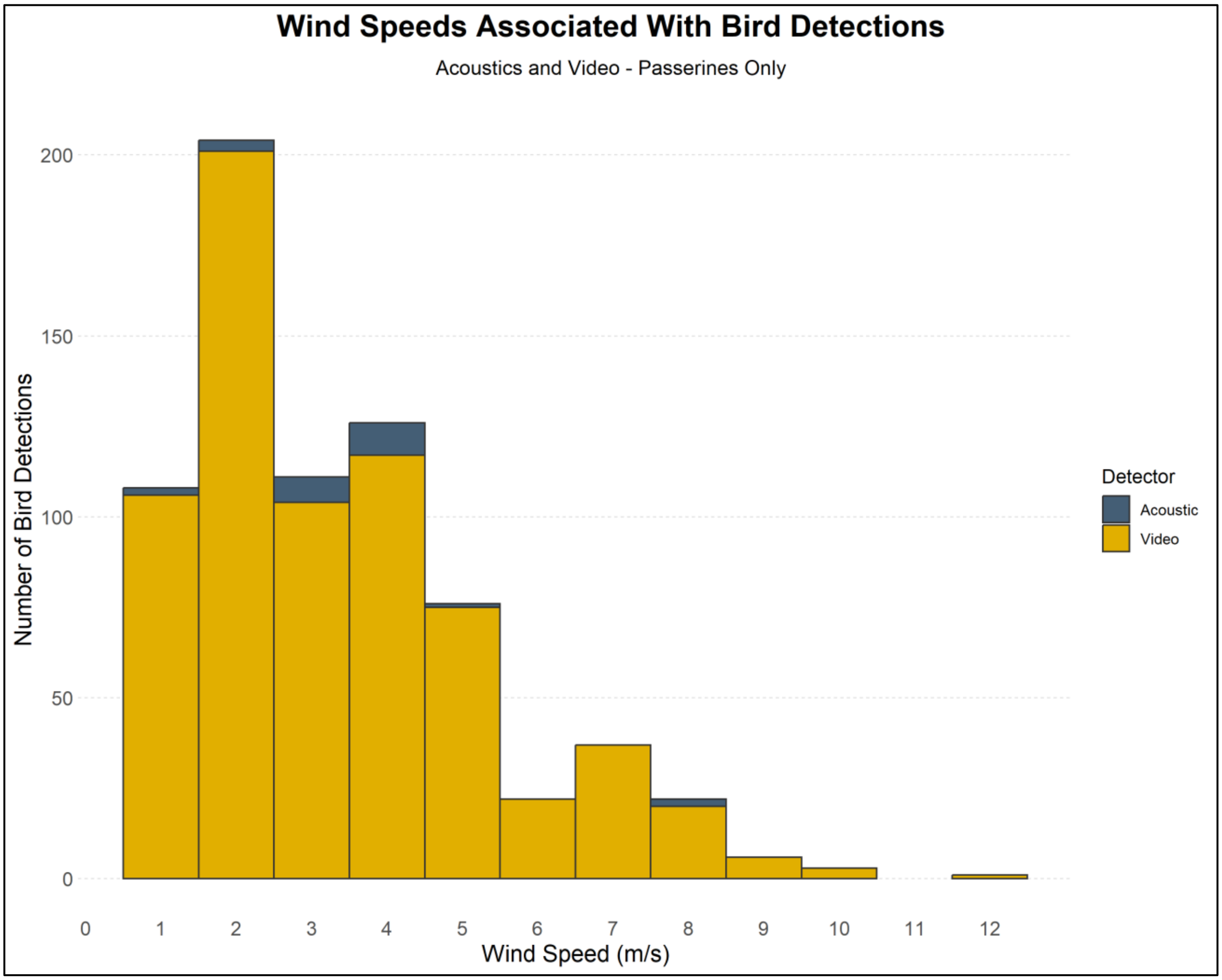


Figure 20. Number of passerine detections at a range of wind speed values using acoustic and video data at ATOM 1 and ATOM 2.

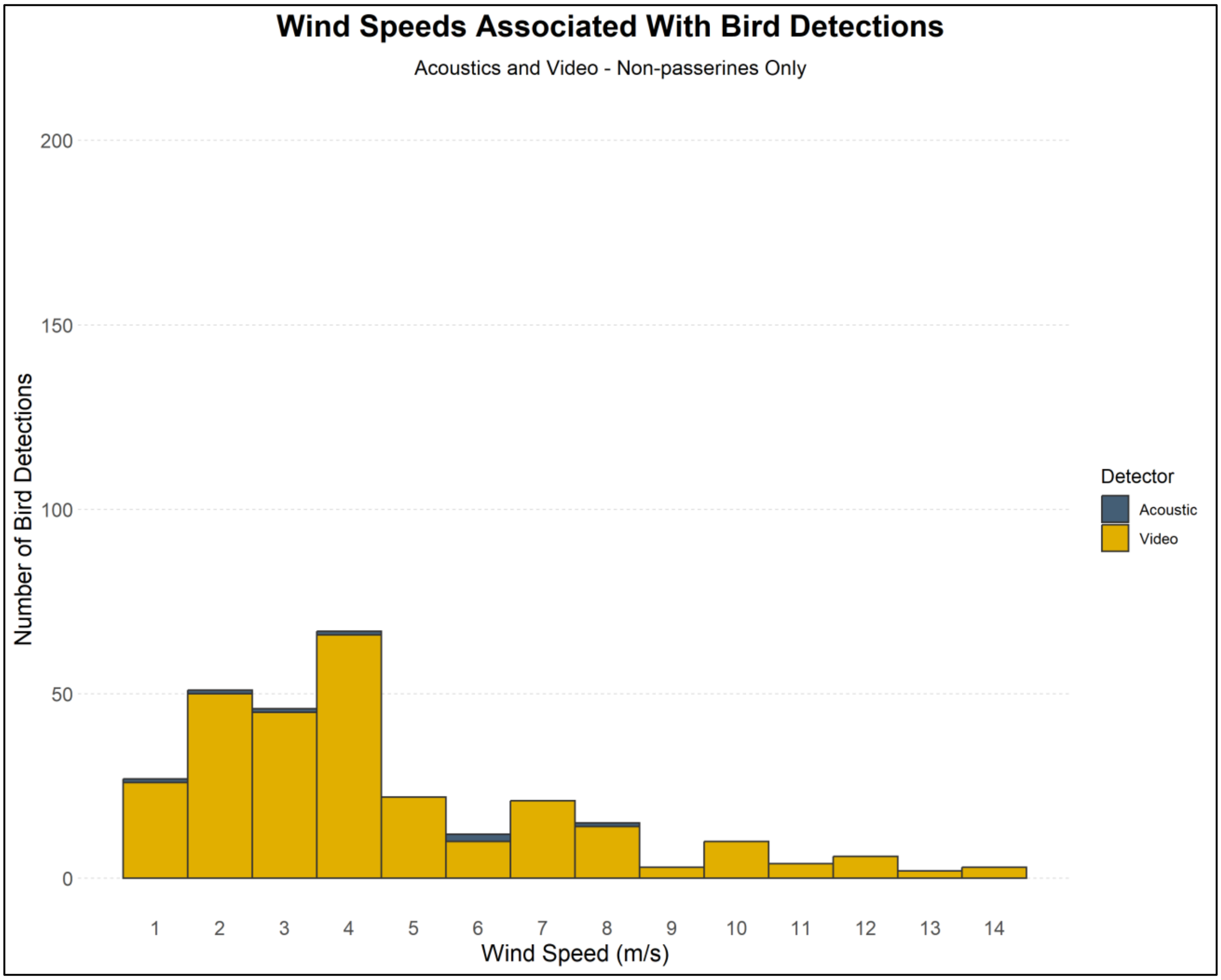


Figure 21. Number of non-passerine detections at a range of wind speed values using acoustic and video data at ATOM 1 and ATOM 2.

3.7 Relationships with Insect Activity

Over 7,000 insect detections occurred during the spring, fall, and winter monitoring periods. Insects included many butterflies, moths, and dragonflies (Figure 22), though only select detections were identified to species. Across the spring, fall, and winter monitoring periods insect activity peaked during September and October and were much lower during other periods (Figure 23). Within-day activity showed that insect activity peaked during the early morning hours (6:00–8:00) and then again in the late afternoon (16:00–18:00) (Figure 24). There was a moderate correlation between bat and insect activity ($\rho = 0.62$) (Figure 25) as well as passerine and insect activity ($\rho = 0.48$) (Figure 26).

Spodoptera frugiperda *Vanessa virginiensis*

Polygonia interrogationis *Junonia coenia*

Figure 22. Select butterfly and moth species detected during the spring, fall, and winter monitoring periods.

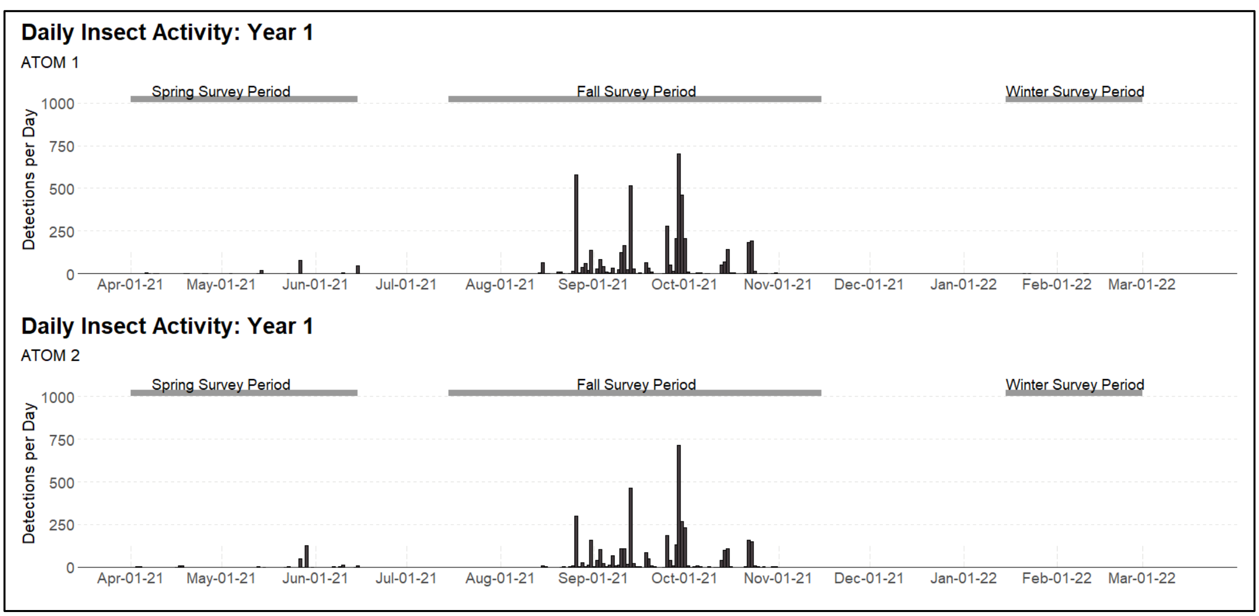


Figure 23. Temporal distribution of insect activity on turbines A01 and A02 during the spring, fall, and winter monitoring periods.

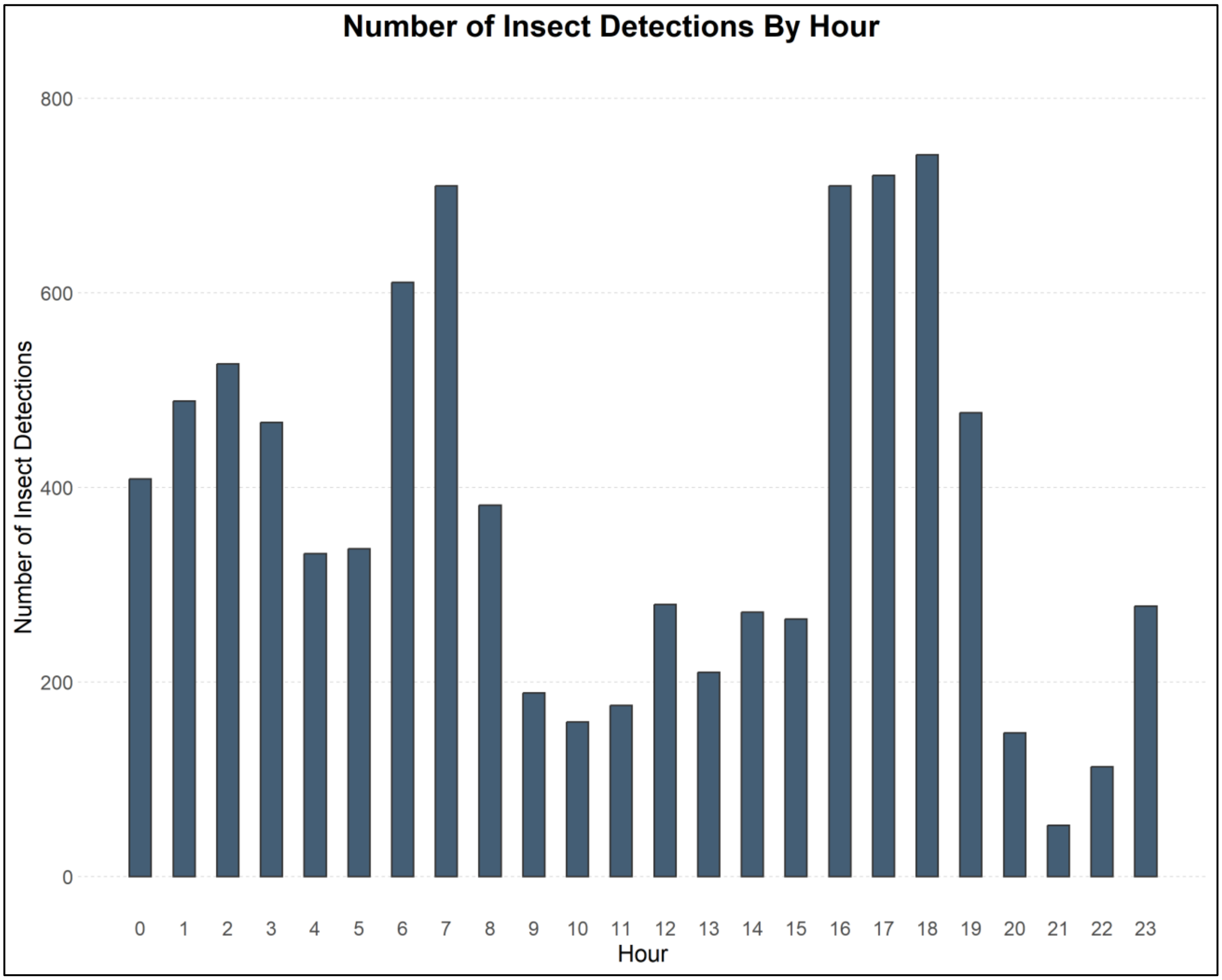


Figure 24. Within-day temporal distribution of insect activity during the spring, fall, and winter monitoring periods.

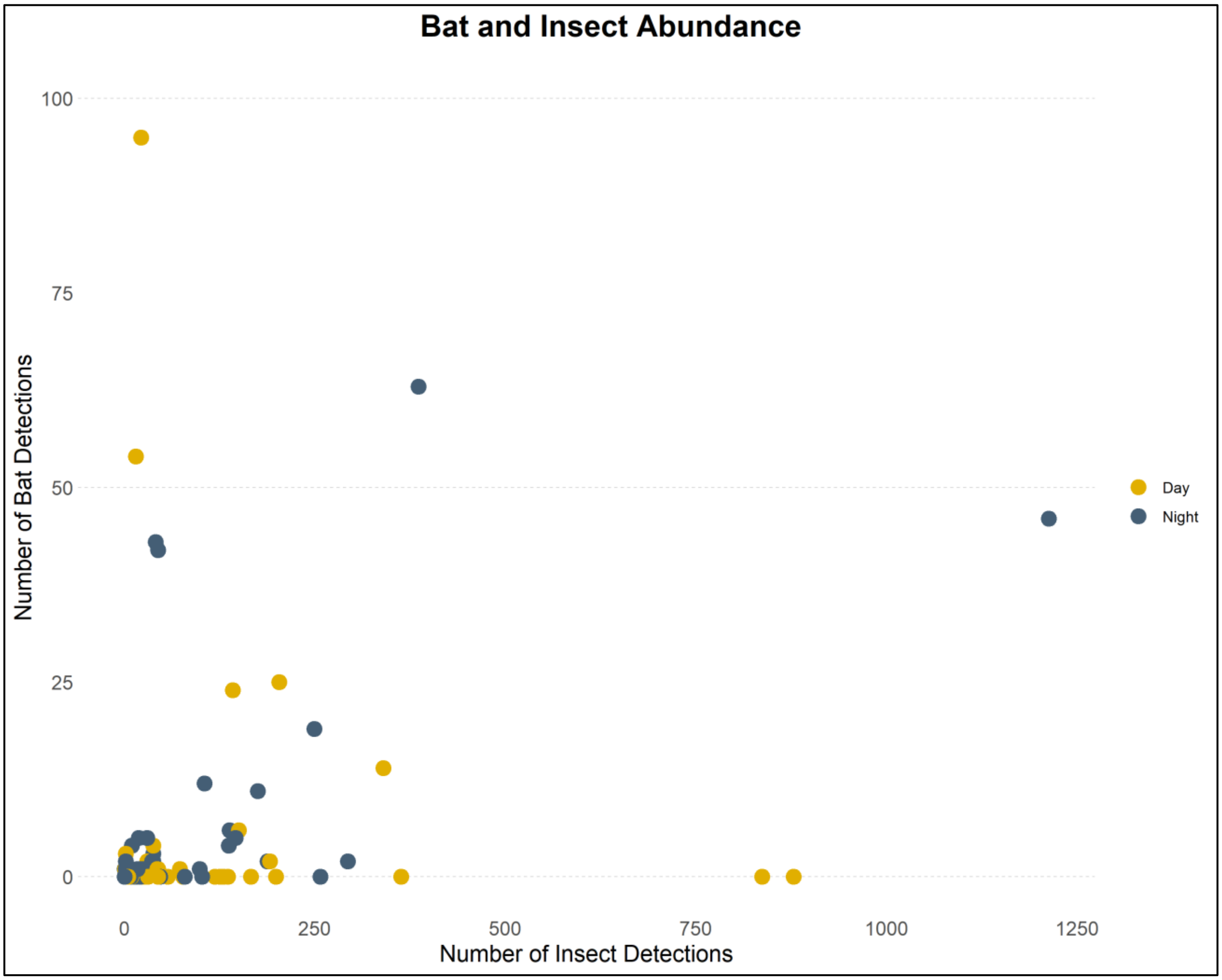


Figure 25. Relationship of bat and insect activity during the spring, fall, and winter monitoring periods.

Many overlapping points are not distinguishable.

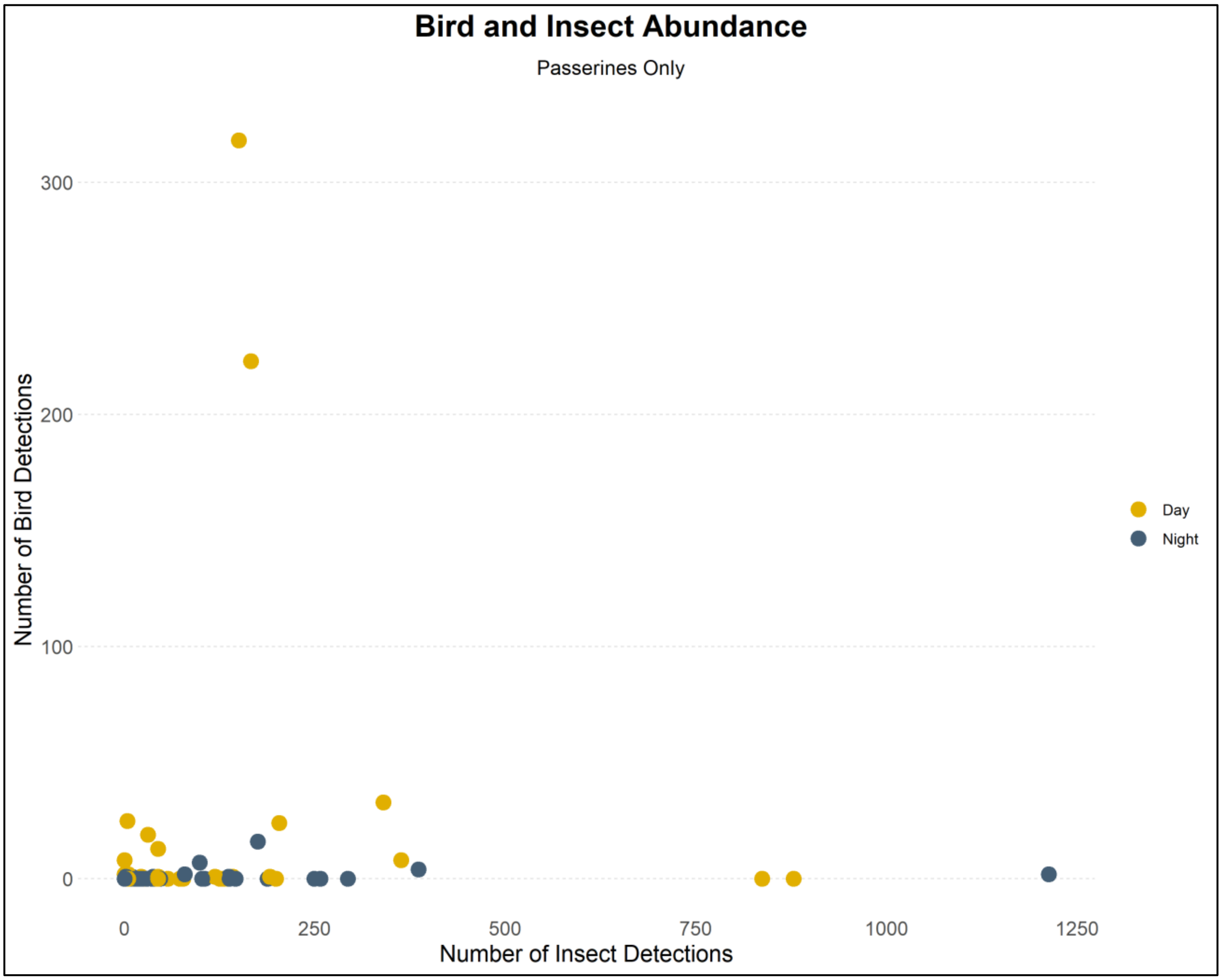


Figure 26. Relationship of passerine and insect activity during the spring, fall, and winter monitoring periods.

Many overlapping points are not distinguishable.

3.8 Behavior Characterization

Behavioral observations were categorized for all bats and birds observed in the video. As no collisions were observed, none are reported here. Analyses focused on microavoidance events when animals interacted with moving blades, foraging strategies, perching observed, attraction, and if animals flying over the turbine showed evidence of attraction or distraction caused by the turbine structure. Both flight heights and flight speeds averaged highest for gulls and lowest for passerines (Table 8).

Bat behavior was associated with evidence of foraging or traversing through the RSZ (Figure 27). Most (56%) bat activity occurred when turbine blades were moving (Figure 27), and bats avoided collisions while foraging within the RSZ using microavoidance behavior. There was one observation of air-displacement when a bat appeared to be pushed off course from the turbine blade by the force of the air movement and started to fall, but the bat recovered and continued flying. The bat revisited the blades before eventually leaving the turbine (Figure 28).

Table 8. Summary of Flight Heights and Velocities

Subtype	Common Name	Scientific Name	N	No. Null Values	No. with Value	Height (m above sea level)			Velocity (m/s)		
						Median	Min	Max	Median	Min	Max
Shorebird	Shorebird species		2	1	1	35.1	35.1	35.1	5.0	5.0	5.0
Skua	Skua species		1	0	1	107.9	107.9	107.9	32.1	32.1	32.1
Gull	Laughing Gull	*Leucophaeus atricilla*	5	3	2	100.0	86.7	113.4	30.5	19.3	41.7
Gull	Herring Gull	*Larus argentatus*	7	3	4	100.2	91.9	151.0	34.9	22.9	61.2
Gull	Great Black-backed Gull	*Larus marinus*	3	2	1	106.4	106.4	106.4	58.3	58.3	58.3
Gull	Large Gull species		8	3	5	131.0	78.7	174.0	36.9	16.8	71.7
Gull	Gull species		6	3	3	86.9	85.8	174.0	25.8	17.4	28.1
Raptor	Merlin	*Falco columbarius*	1	1	0						
Raptor	Peregrine Falcon	*Falco peregrinus*	24	10	14	74.4	33.0	114.2	21.6	4.0	35.8
Corvid	Corvid species		1	0	1	59.9	59.9	59.9	12.2	12.2	12.2
Hirundine	Hirundine species		2	0	2	46.8	45.4	48.1	6.7	6.3	7.1
Passerine	Brown Creeper	*Certhia americana*	8	3	5	32.0	28.0	78.8	9.8	4.8	35.1
Passerine	Winter Wren	*Troglodytes hiemalis*	6	3	3	27.2	27.1	28.6	3.5	3.0	5.6
Passerine	Wren species		1	0	1	31.0	31.0	31.0	9.1	9.1	9.1
Passerine	American Robin	*Turdus migratorius*	1	1	0						
Passerine	American Pipit	*Anthus rubescens*	1	1	0						
Passerine	Blue-winged Warbler	*Vermivora cyanoptera*	1	1	0						
Passerine	Black-and-white Warbler	*Mniotilta varia*	12	8	4	32.3	26.9	39.0	3.6	2.3	6.7
Passerine	American Redstart	*Setophaga ruticilla*	3	1	2	44.8	40.4	49.2	20.8	11.5	30.0
Passerine	Cape May Warbler	*Setophaga tigrina*	34	22	12	29.9	26.7	35.7	5.7	3.8	8.2
Passerine	Magnolia Warbler	*Setophaga magnolia*	4	4	0						
Passerine	Bay-breasted Warbler	*Setophaga castanea*	7	2	5	31.1	28.2	37.7	4.8	3.3	11.4
Passerine	Blackburnian Warbler	*Setophaga fusca*	4	2	2	29.1	26.7	31.5	7.0	6.4	7.6
Passerine	Palm Warbler	*Setophaga palmarum*	10	7	3	28.6	28.5	29.3	4.5	4.2	6.9
Passerine	Pine Warbler	*Setophaga pinus*	3	1	2	27.3	27.0	27.6	3.6	3.0	4.2
Passerine	Yellow-rumped Warbler	*Setophaga coronata*	11	8	3	37.7	28.8	41.9	5.9	4.0	6.7
Passerine	Setophaga species		37	25	12	37.2	27.5	55.3	7.4	2.7	11.4
Passerine	Parulidae species		6	3	3	33.4	31.4	46.9	6.1	5.0	6.6
Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	9	4	5	32.4	26.8	48.3	5.4	3.4	8.3
Passerine	Passerine species		59	33	26	37.8	24.0	110.0	7.9	0.1	49.1
Unid. Avian	Unidentified bird species		42	15	27	50.5	25.5	127.4	10.1	1.0	53.2
Bat	Bat species		36	10	26	97.8	39.7	130.4	29.2	5.8	50.0

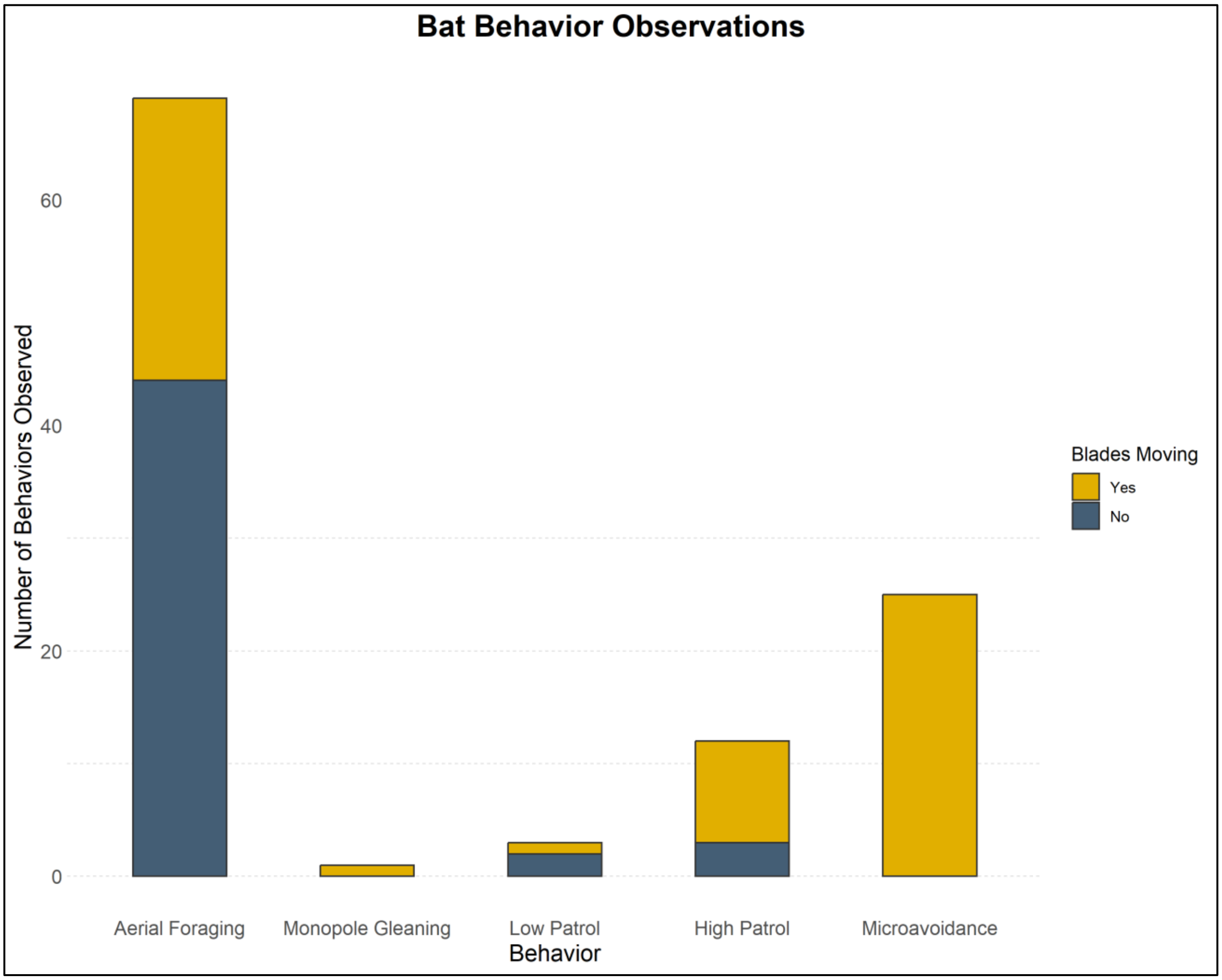
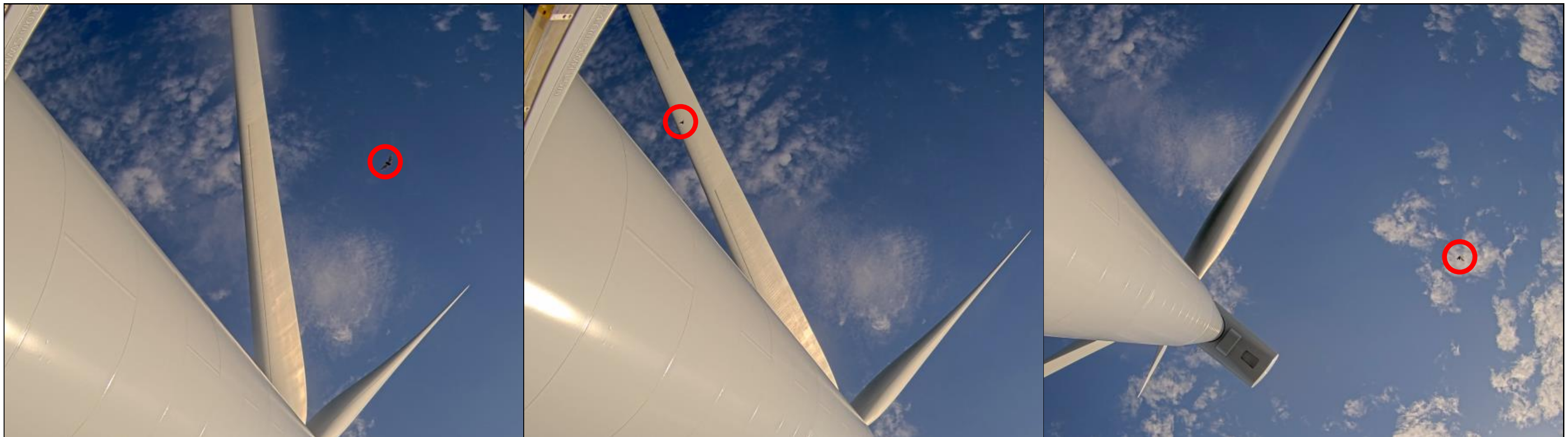


Figure 27. Bat behavior observations associated with moving and non-moving blades during the spring, fall, and winter monitoring periods.



Approaches blades	Encounters air force	Begins to fall

Figure 28. **Bat approaching turbine blade, experiencing air-displacement, and falling; the bat recovered and continued activity.**

Passerines were mainly observed foraging with most observations occurring when the turbine blades were stationary. The main foraging technique used was aerial, capturing insects on the wing while actively flying in pursuit (Figure 29, Figure 30, Figure 31). Another observed foraging behavior used by passerines was using the turbine as a perching base, sallying forth to capture insects, and returning (Figure 29). Both sallies and aerial foraging sometimes resulted in birds gleaning insects from the monopole (Figure 29). These foraging activities mostly occurred when turbine blades were not moving. Observations of flyover (no attraction or distraction from the turbine) mainly occurred when the turbine blades were moving, with high and low patrols again mostly occurring when turbine blades were stationary (Figure 29). In contrast to passerines, non-passerines were most frequently recorded exhibiting non-foraging behaviors (Figure 30).

No bird collisions were observed. When the turbine blades were moving, all birds observed avoided collisions while foraging within the RSZ. There was one observation of air-displacement when a bird appeared to be pushed off course from the turbine blade by the force of the air movement and started to fall, but the bird recovered and flew away (Figure 32). In addition, microavoidance behaviors were observed across 5 bird species groups while blades were moving (Table 9).

Most passerine activity occurred at temperatures above 15°C with microavoidance occurring almost exclusively above 20°C (Figure **33**). Non-passerine behavior occurred at a wider range of temperatures, though microavoidance mostly occurred at temperatures above 20°C (Figure 34).

Other than most detections occurring at wind speeds <5 m/s, there were no obvious correlations between behavior type and wind speed for passerines (Figure 35) or non-passerines (Figure 36).

Except for unidentified birds, 9 bird species groups were identified. Most birds observed were passerines (Table 5, Table 6). Passerines were mostly aerial foraging when observed in the cameras (Figure 31), and they were observed mainly hawking (sallying from a perch) and perching. Monopole gleaning for insects was another foraging behavior observed for passerines. Fewer birds were passing through and very few appeared attracted and then leaving without further investigation of the structure for foraging or perching (Figure 37).

Raptors were observed aerial foraging, perching, and high patrolling the airspace. Peregrine Falcons and Ospreys (*Pandion haliaetus*) regularly patrolled the airspace (Figure 38) and perched on the turbine (Figure 39), as did gulls and 1 woodpecker (Northern Flicker [*Colaptes auratus*]) (Figure 40). Perching by gulls was almost exclusively on the nacelle (Figure 41). The Peregrine Falcons, Ospreys, and woodpecker were observed mainly perched on the platform and the Peregrine Falcons and Ospreys occasionally approached the nacelle. On October 23, 2021, the ATOM system recorded many feathers drifting across the camera. On the same day a Peregrine Falcon was observed at the turbine and close to the cameras off and on for 6 hours as it sallied forth and returned. On the following day, a site visit to the turbine found the plucked remains of a Dickscissel (*Spiza americana*), suggesting that the Peregrine Falcon was successfully foraging from the turbine platform.

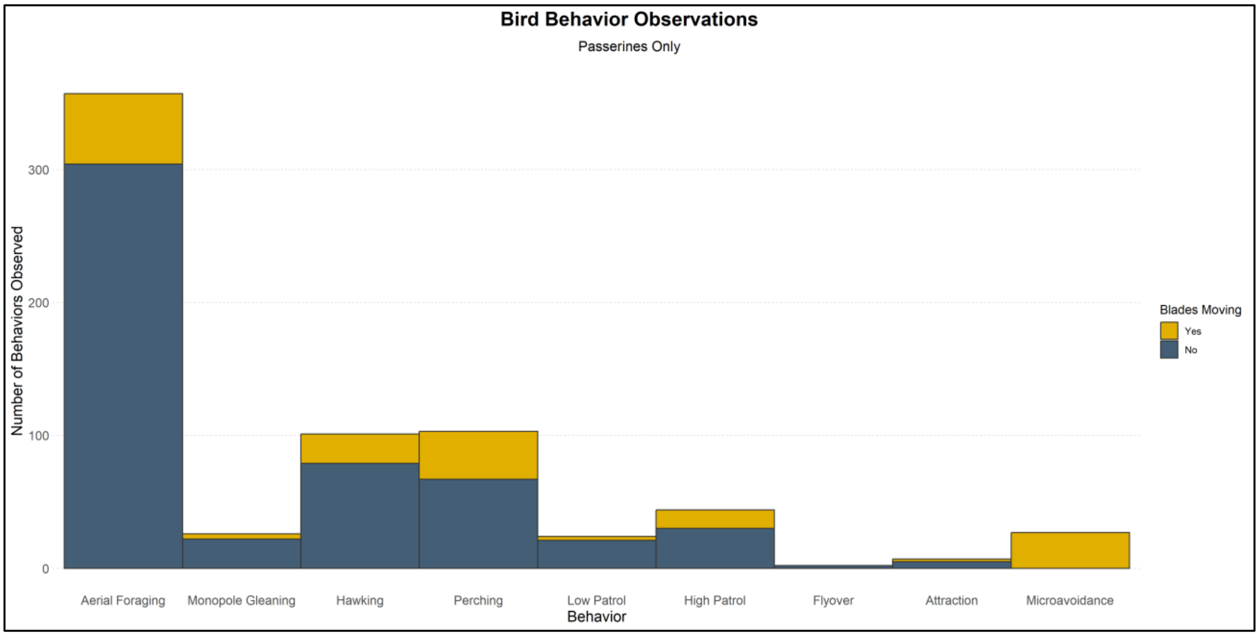


Figure 29. Passerine behavior associated with moving and non-moving blades during the spring, fall, and winter monitoring periods.

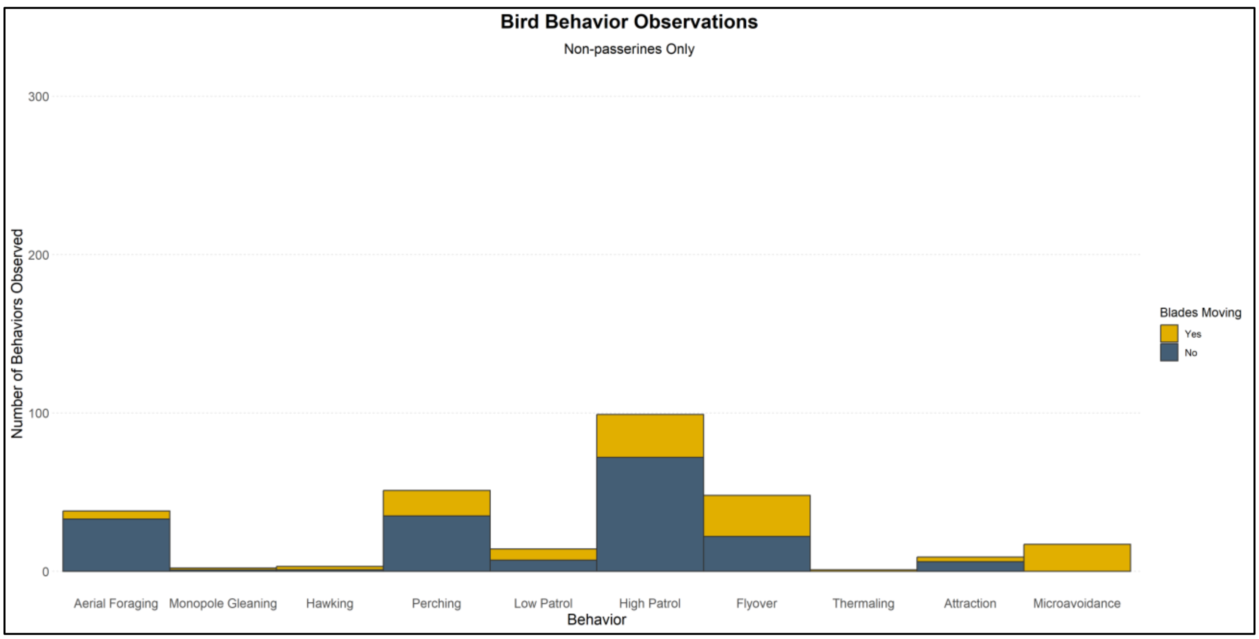


Figure 30. Non-passerine behavior associated with moving and non-moving blades during the spring, fall, and winter monitoring periods.

Table 9. Bird Behavior by Species Observed When Blades are Spinning

Subtype	Common Name	Scientific Name	No. of Observations by Species										% Micro-avoidance
			Perching	Flyover	Micro-avoidance	Hawking	Low Patrol	Aerial Foraging	High Patrol	Attraction	Thermaling	Monopole Gleaning	
Shorebird	Shorebird species		0	1	1	0	0	0	0	1	0	0	33.3
Gull	Laughing Gull	*Leucophaeus atricilla*	1	0	0	0	0	0	0	0	0	0	0.0
Gull	Herring Gull	*Larus argentatus*	0	2	0	0	0	0	0	0	0	0	0.0
Gull	Great Black-backed Gull	*Larus marinus*	0	2	1	0	0	0	0	0	0	0	33.3
Gull	Gull species		0	4	0	0	0	0	1	0	0	0	0.0
Gull	Large Gull species		0	1	0	0	0	0	2	0	1	0	0.0
Raptor	Osprey	*Pandion haliaetus*	2	0	0	0	0	0	0	0	0	0	0.0
Raptor	Peregrine Falcon	*Falco peregrinus*	7	0	5	1	1	0	0	0	0	0	35.7
Raptor	Raptor species		1	0	0	0	0	0	0	0	0	0	0.0
Woodpecker	Northern Flicker	*Colaptes auratus*	1	0	0	0	0	0	0	0	0	0	0.0
Corvid	Corvid species		0	1	1	0	0	0	0	0	0	0	50.0
Passerine	Brown Creeper	*Certhia americana*	0	0	3	0	0	2	0	0	0	0	60.0
Passerine	Winter Wren	*Troglodytes hiemalis*	0	0	2	0	0	7	3	0	0	0	16.7
Passerine	Wren species		0	0	1	0	0	0	0	0	0	0	100.0
Passerine	American Pipit	*Anthus rubescens*	0	0	1	0	0	0	0	0	0	0	100.0
Passerine	Black-and-white Warbler	*Mniotilta varia*	0	0	0	1	0	0	0	0	0	0	0.0
Passerine	American Redstart	*Setophaga ruticilla*	0	0	1	0	0	0	1	0	0	0	50.0
Passerine	Kirtland's Warbler	*Setophaga kirtlandii*	0	0	0	0	1	0	0	0	0	0	0.0
Passerine	Cape May Warbler	*Setophaga tigrina*	0	0	1	1	0	5	0	0	0	0	14.3
Passerine	Magnolia Warbler	*Setophaga magnolia*	0	0	0	0	0	1	0	0	0	0	0.0
Passerine	Bay-breasted Warbler	*Setophaga castanea*	0	0	1	0	0	1	0	0	0	0	50.0
Passerine	Palm Warbler	*Setophaga palmarum*	0	0	1	1	0	2	0	2	0	0	16.7
Passerine	Pine Warbler	*Setophaga pinus*	4	0	0	0	0	1	1	0	0	0	0.0
Passerine	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	0	0	0	0	0	0	1	0	0	0	0.0
Passerine	Setophaga species		11	0	3	11	0	14	1	0	0	1	7.3
Passerine	Passerine species		21	0	13	8	2	20	7	0	0	3	17.6
Unid. Avian	Unidentified bird species		4	15	9	1	6	5	24	2	0	1	13.4

Figure 31. **Cape May Warbler chasing a moth; the blades of the turbine were not moving.**

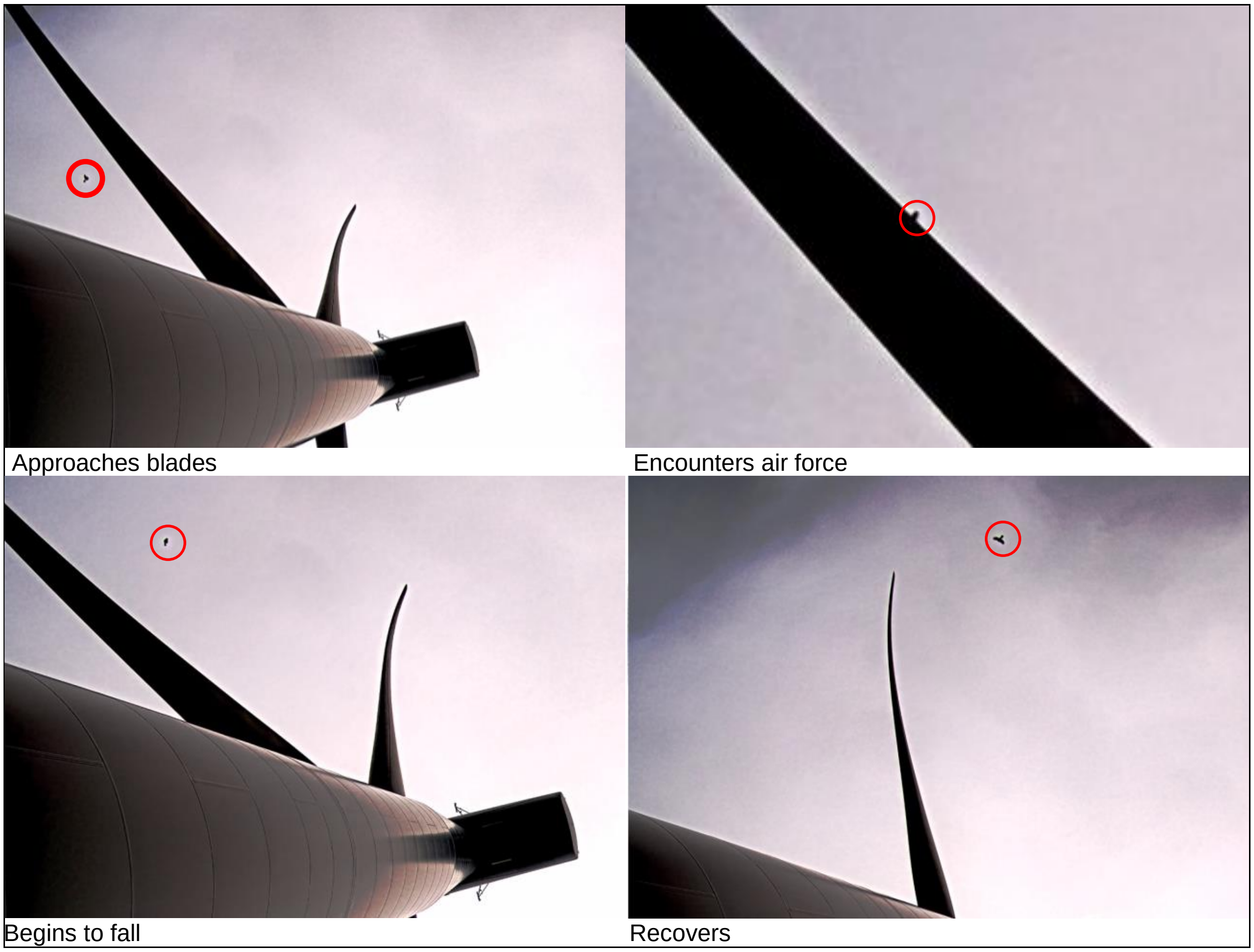


Figure 32. Bird approaching turbine blade, experiencing air-displacement, falling, and recovering.

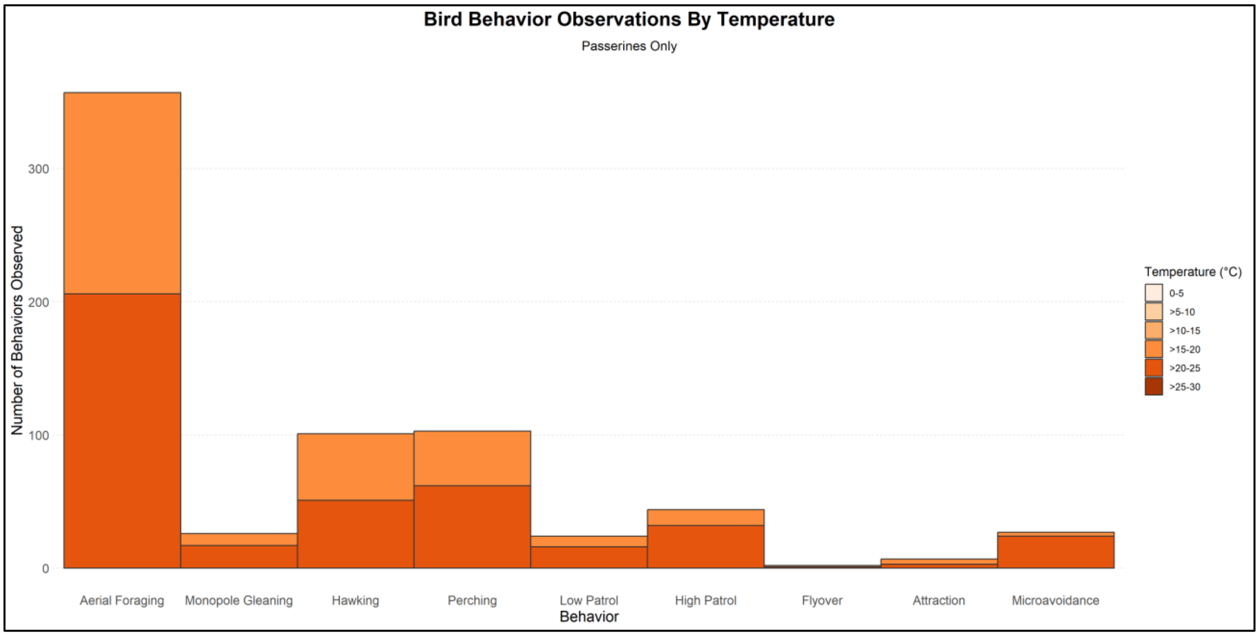


Figure 33. Passerine behavior associated with temperature during the spring, fall, and winter monitoring periods.

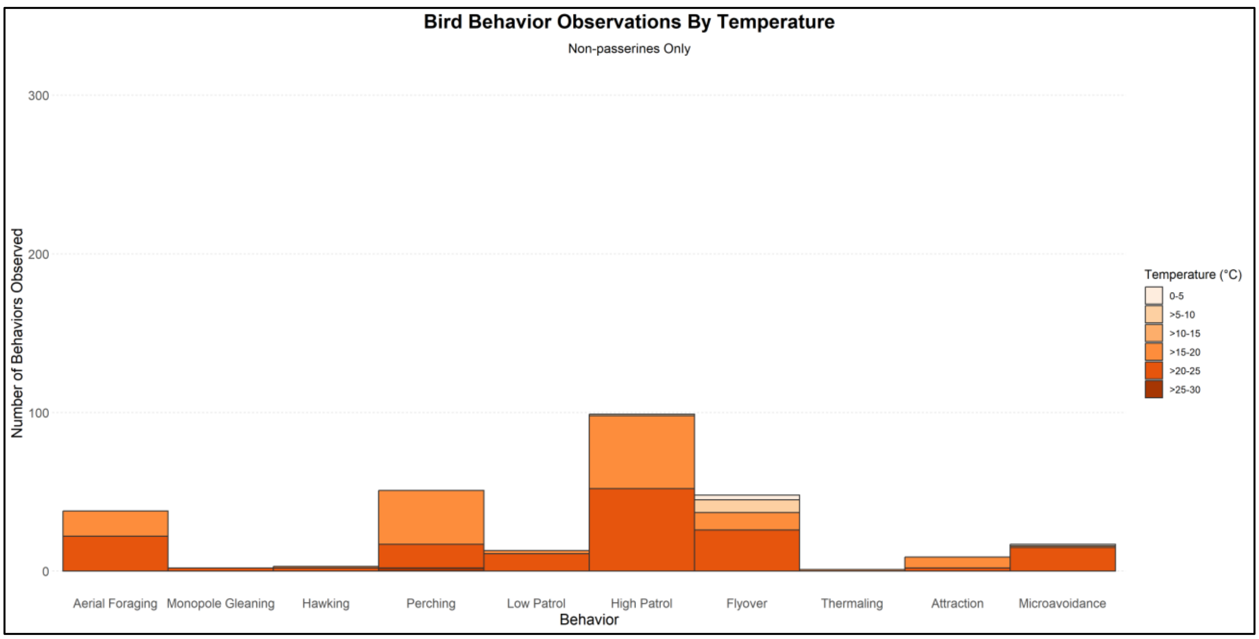


Figure 34. Non-passerine behavior associated with temperature during the spring, fall, and winter monitoring periods.

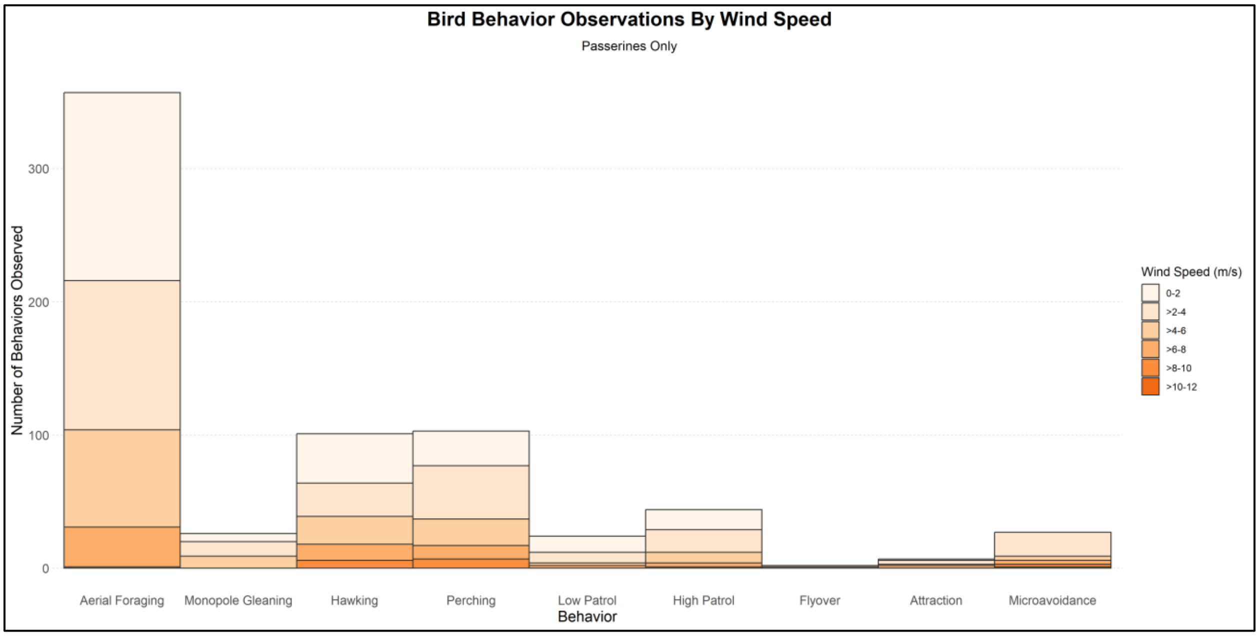


Figure 35. **Passerine behavior associated with wind speed during the spring, fall, and winter monitoring periods.**

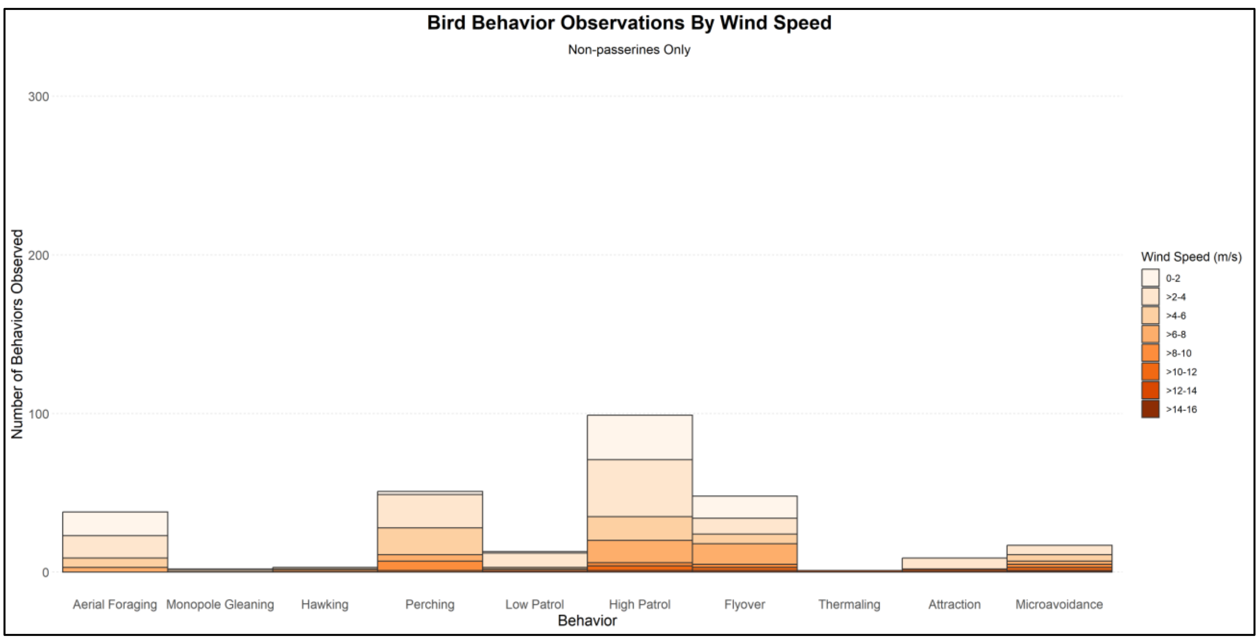


Figure 36. **Non-passerine behavior associated with wind speed during the spring, fall, and winter monitoring periods.**

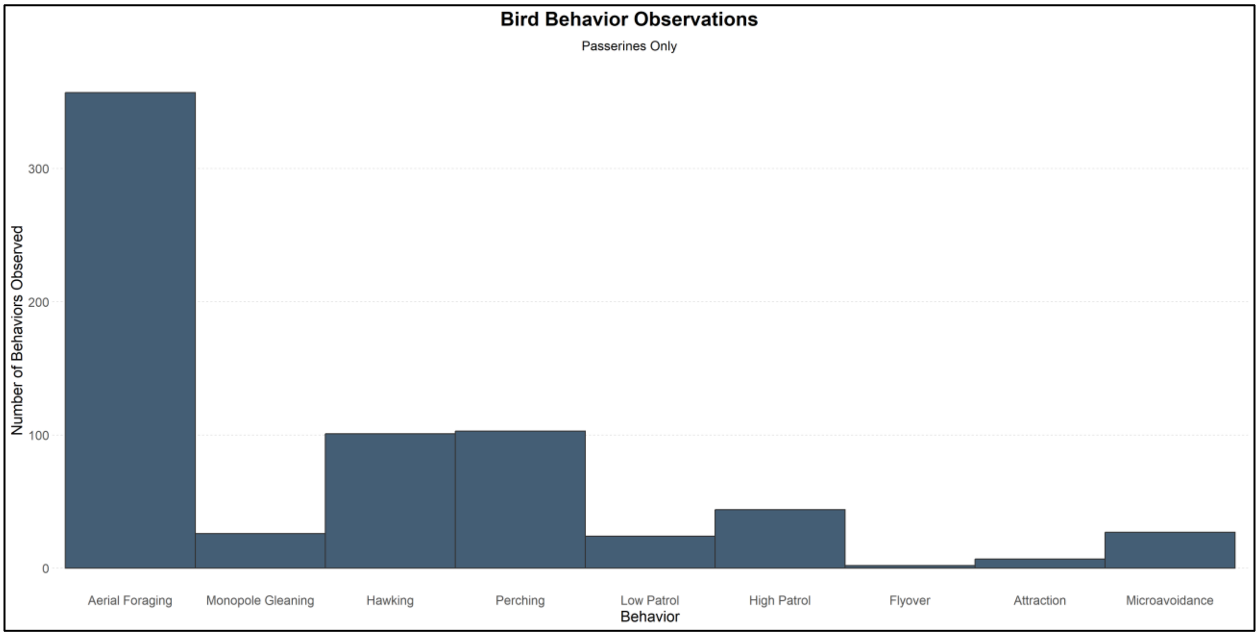


Figure 37. Passerine behavior observed during the spring, fall, and winter monitoring periods.

Figure 38. Peregrine Falcon patrolling at the turbine. The blades were not moving.

Figure 39. An Osprey coming to perch on the turbine platform.

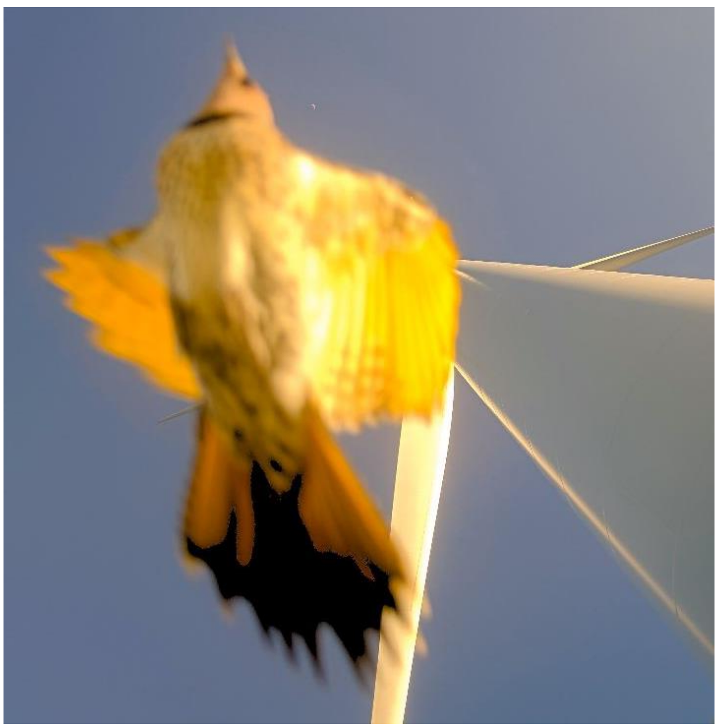


Figure 40. Northern Flicker coming to perch on the turbine platform.

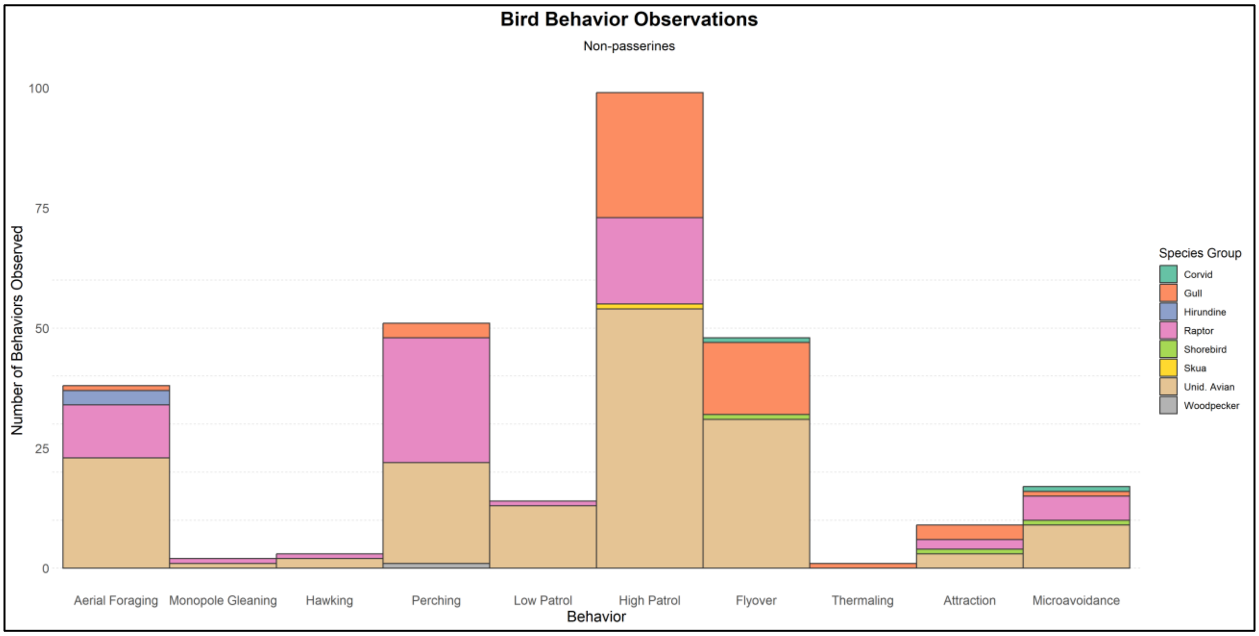


Figure 41. Behavior by all other bird species groups except passerines during the spring, fall, and winter monitoring periods.

4.0 Discussion

4.1 Wildlife Data

Bird activity in the offshore survey area is relatively low during the spring monitoring period (April 1 to June 15, 2021) with only 9 birds being detected between the two ATOM systems. Winter (January 15 to March 15, 2022) activity was also minimal with only 5 birds detected. Fall (August 15 to October 31, 2021) had the highest activity with 1,011 bird detections and 521 bat detections. This fall activity mostly represents southbound migration from breeding grounds to wintering grounds.

Sensor comparisons underscore the importance of a multi-sensor system for maximizing detections and species identifications (Robinson Willmott and Forcey 2014; Robinson Willmott et al. 2015). Nearly all bat species identifications were possible because of acoustic sensors, with only 7 bat detections identified to species from the video. Acoustic sensors detected 79% of all bat detections but only 3% of bird detections. Video sensors found 96% of bird detections but only 21% of bat detections. Video was also critical for species identifications of birds that were not vocalizing. Acoustic sensors alone would have only detected 4 bird groups while video sensors would have captured 8 groups. Combined sensors captured 9 bird groups.

Bat activity was highest when temperatures were between 22°C and 23°C and was lower above and below that range (Figure 11) suggesting that bats prefer moderate temperatures and likely use temperature as a cue for migration (Pettit and O'Keefe 2017). Higher bat activity during northerly winds during the fall was expected as these winds are favorable to southbound fall migration (Mabee et al. 2005). A decline in bat activity above wind speeds of 6 m/s and a further decline above 10 m/s (Figure 13) was expected given that bats are typically more active when wind speeds are low (e.g., Hayes et al. 2019). This is significant because the cut-in speed for the turbines at the CVOW Pilot Project is between 3 and 5 m/s, which suggests that most bat activity could occur when the blades are not spinning. Less bat activity when blades are spinning could reduce the likelihood of collisions.

Passerine and non-passerine activity was mostly restricted between 19°C and 22°C and was much less at both higher and lower temperatures outside this range (Figure 16). Temperature is known to be influential on bird migration (Haest et al. 2019), thus it is notable that birds prefer this narrow temperature range. The association of birds with northerly wind was expected given these winds are favorable to the southbound migration in the fall (Krietsch et al. 2020; Loring et al. 2020). The small amount of passerine activity when wind speed is >5 m/s is notable due to the cut-in speed being 3–5 m/s for the turbines at the CVOW Pilot Project. Less bird activity when blades are spinning could reduce the likelihood of collisions. Non-passerine activity also declined above 4 m/s though the decline was not as extreme as with passerines (Figure 21).

Lighting is likely a factor for insect (Wakefield et al. 2018) and bird (Kerlinger et al. 2010) attractions especially at night. At each turbine, there are three walkway lights, three navigation lights, and one spotlight over the door. The walkway lights and spotlight must be manually turned on and off and remain off unless personnel are on the platform. The navigation lights are amber LEDs with a photosensor. They automatically turn off and on depending on how much light the sensor receives. They are not set to any time schedule, and while they are typically on overnight, they could also come on during storm conditions or heavy fog due to low light conditions (Adam Cross, SGRE, personal communication). Many insects including *Spodoptera* moths are migratory (Nagoshi et al. 2012) and this likely explains their occurrence offshore along with other butterflies and dragonflies (Wikelski et al. 2006).

Most (73%) bird activity occurred when turbine blades were not spinning; however, it is unknown whether this was a result of the lack of blade motion or because of lower wind speeds that occur when blades are stationary. Most (56%) bat detections were recorded while the blades were spinning; however, it is not known if this was attraction to the moving objects or a willingness to forage at the higher wind speeds when the blades would normally be spinning. Aerial foraging was the most observed behavior for passerines and bats with perching being the second most common for birds (Figure 27, Figure 29). High patrol was the most common behavior for non-passerines (Figure 30). These behaviors have implications for collision risk because bats and birds are often distracted while chasing prey (aerial foraging) or looking for prey (high patrol) and may be less aware of the presence of the blades (Smallwood and Bell 2020). However most aerial foraging occurs when the blades are not moving so an increase in collision risk could be minimal. Microavoidance behaviors were observed 69 times in 9 bird and 2 bat species. Microavoidance reflects last-second action taken to avoid the turbine blades while in proximity to the blade surface (Cook et al. 2018). Microavoidance prevents a collision with the blade and is an essential behavior for reducing collision mortality. All bird behaviors were more common across higher temperatures (Figure **33**, Figure 34) and lower wind speeds (Figure 35, Figure 36) suggesting that these weather variables do not influence specific behaviors but do influence overall activity.

4.2 Challenges

Notable challenges occurred during the first year of monitoring. During the spring, there was a system short that caused 3 weeks of lost data on ATOM 2. During the winter, a satellite modem was damaged by water intrusion that prevented remote repair of a disk storage issue on ATOM 1, causing 15 days of lost data on this system. Minor issues such as software bugs could be fixed remotely via the satellite modem. Other periods of downtime were small and could mostly be attributed to power outages at the turbine (Appendix A). While hardware issues cannot be repaired remotely, the software issues that arose during operation underscore the importance of having a system that can be updated, maintained, and repaired from a remote location.

While there was remote accessibility via the satellite modem, the speed of the connection and data transfer limits precluded us from using the connection to remotely transfer video data. Use of the internet connection at the turbine was also not an option due to security concerns. Given these restrictions, data retrieval was done manually by traveling to each ATOM system via boat approximately once a month. While this increased the labor required to operate the systems successfully, this schedule did ensure minimal data loss.

One issue limiting detections from the video data is the restricted viewshed of the blades when obscured by the monopole and the view of only one side of the turbine. The number of targets missed because of this issue is not known. Placement of additional systems around the monopole is restricted by access and safety concerns, which limits available space. In addition, while the visible-light camera is useful during the day to augment detections from the thermal camera, it is of limited use at night. While artificial lighting does occur on the turbines, it does not provide sufficient lighting to assist with species identifications. The artificial lights are amber LEDs with a photosensor. They automatically turn on in low light conditions (i.e., at night, during storm conditions, or in heavy fog).

During the spring, fall, and winter monitoring periods, acoustic detectors found 31 bird detections occurred across 14 species and 412 bat detections occurred across 3 species. Despite these detections, the offshore environment is challenging for acoustic detections, with many conditions that can mask detections of birds including operational turbine noise. High wind, turbine operations, or water-saturated microphones can cause excessive noise that can preclude detection of birds or bats (Figure 42).

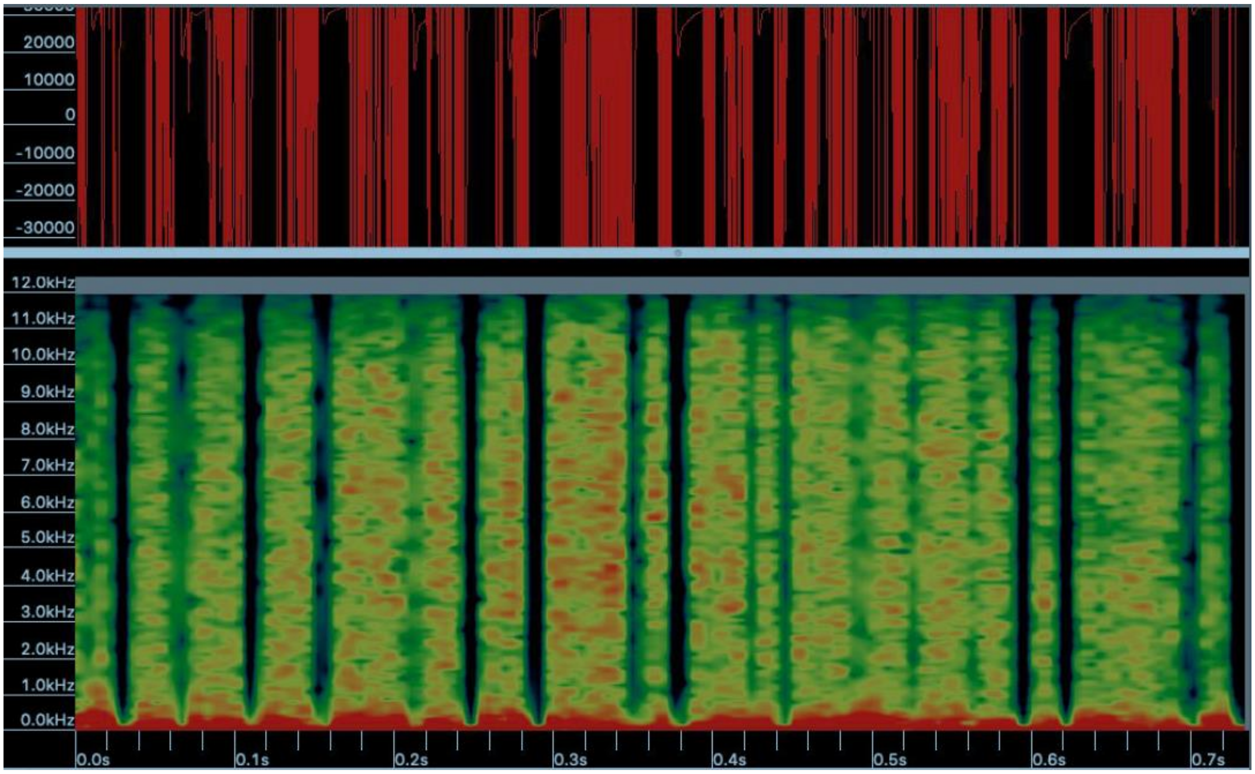


Figure 42. Example time signal (red, top) and spectrogram (bottom) of signal with high DC offset and high noise.

The Motus setup at each ATOM consisted of a Lotek SRX 800 receiver and two omnidirectional whip antennas. This antenna setup was chosen due to safety concerns with larger antennas. While a full calibration survey was not done with this setup, anecdotal detections of tags occurred out to 1.25 miles from the receiver. This system was also not capable of detecting the newer 434-Mhz tags. There are also known issues with this Motus setup generating false positive detections in the offshore environment; although, this issue can be addressed during the postprocessing of detections on the motus.org website. Given these limitations of the Motus system used in the first year, Dominion Energy has upgraded both Motus systems to use the dual band 434-Mhz receivers and Yagi antennas in the second and third years of monitoring. These upgrades will allow detection of a greater number of tags and longer detection range from the turbines. Data detected from these systems will be provided in a future report.

4.3 Recommendations

For the second and third years of the study, improvements have been made in two key areas to improve the reliability of the system:

1. upgrade of the disk storage on the system to a full solid-state drive (SSD) array, and
2. continued improvements to our AI algorithm to be able to distinguish bats, birds, and insects with a high degree of accuracy.

Upgrading to SSDs improves disk reliability by eliminating moving parts more likely to break over time. Improving the AI algorithm to distinguish bats, birds, and insects will improve analysis speed, reducing the need for manual review. More effort can be expended on bird and bat identifications and less on reviewing insect targets. Improvements in these areas will make the ATOM system a more reliable and efficient postconstruction monitoring solution.

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Appendices

Appendix A. ATOM System Uptime During the First Year of Operation

Date	A1IR	A1HD	A2IR	A2HD	Comment
4/1/2021	100	100	100	59	
4/2/2021	23	26	100	59	
4/3/2021	0	18	100	59	
4/4/2021	96	96	100	59	
4/5/2021	100	100	100	59	
4/6/2021	100	100	100	59	
4/7/2021	100	100	100	36	
4/8/2021	100	100	100	0	
4/9/2021	100	100	100	0	
4/10/2021	100	100	100	0	
4/11/2021	100	100	99	89	
4/12/2021	94	94	93	94	
4/13/2021	100	100	100	100	
4/14/2021	100	100	41	41	A2 maint
4/15/2021	88	88	0	0	A1 maint
4/16/2021	100	100	26	26	
4/17/2021	100	100	100	100	
4/18/2021	100	100	100	100	
4/19/2021	100	100	100	100	
4/20/2021	100	100	33	33	
4/21/2021	100	100	0	0	A2 no power
4/22/2021	100	100	0	0	A2 no power
4/23/2021	100	100	0	0	A2 no power
4/24/2021	100	100	0	0	A2 no power
4/25/2021	100	100	0	0	A2 no power
4/26/2021	100	100	0	0	A2 no power
4/27/2021	100	100	0	0	A2 no power
4/28/2021	100	100	0	0	A2 no power
4/29/2021	100	100	0	0	A2 no power
4/30/2021	100	100	0	0	A2 no power
5/1/2021	100	100	0	0	A2 no power
5/2/2021	100	100	0	0	A2 no power
5/3/2021	100	100	0	0	A2 no power
5/4/2021	100	100	0	0	A2 no power

Date	A1IR	A1HD	A2IR	A2HD	Comment
5/5/2021	100	100	0	0	A2 no power
5/6/2021	100	100	0	0	A2 no power
5/7/2021	100	100	0	0	A2 no power
5/8/2021	100	100	0	0	A2 no power
5/9/2021	100	100	0	0	A2 no power
5/10/2021	100	100	0	0	A2 no power
5/11/2021	56	56	0	0	A1 maint,A2 no power
5/12/2021	100	100	54	53	A2 maint
5/13/2021	100	100	96	96	A2 maint
5/14/2021	100	100	100	100	
5/15/2021	100	100	100	100	
5/16/2021	100	100	100	100	
5/17/2021	100	100	100	100	
5/18/2021	100	100	100	100	
5/19/2021	100	100	100	99	
5/20/2021	100	100	100	100	
5/21/2021	100	100	100	100	
5/22/2021	100	100	100	99	
5/23/2021	100	100	100	100	
5/24/2021	100	100	100	100	
5/25/2021	100	100	100	100	
5/26/2021	100	100	100	100	
5/27/2021	100	100	100	100	
5/28/2021	100	100	100	100	
5/29/2021	12	100	100	100	A1:video off, no sat modem
5/30/2021	0	100	100	100	A1:video off, no sat modem
5/31/2021	0	100	100	100	A1:video off, no sat modem
6/1/2021	42	100	100	100	A1:video off, no sat modem
6/2/2021	100	100	100	100	
6/3/2021	100	100	100	100	
6/4/2021	100	100	100	99	
6/5/2021	100	100	100	100	
6/6/2021	100	100	100	100	
6/7/2021	100	100	100	100	
6/8/2021	100	100	100	100	
6/9/2021	100	100	100	100	
6/10/2021	100	100	100	100	
6/11/2021	100	100	100	100	
6/12/2021	100	100	100	100	

Date	A1IR	A1HD	A2IR	A2HD	Comment
6/13/2021	100	100	100	100	
6/14/2021	100	100	100	100	
6/15/2021	100	100	100	100	
8/15/2021	100	100	100	100	
8/16/2021	100	100	100	100	
8/17/2021	100	100	100	100	
8/18/2021	49	47	100	100	
8/19/2021	100	100	100	100	
8/20/2021	99	100	100	100	A2 Martin visit, some corrupt files
8/21/2021	100	100	100	100	
8/22/2021	100	100	100	100	
8/23/2021	100	100	100	100	
8/24/2021	100	100	100	100	
8/25/2021	100	99	100	100	some corrupt files
8/26/2021	100	100	100	100	
8/27/2021	99	100	100	100	some corrupt files
8/28/2021	99	99	100	100	some corrupt files
8/29/2021	99	100	100	100	some corrupt files
8/30/2021	57	57	89	89	A1 & A2 turbine pwr out 1.5 hours
8/31/2021	100	100	100	100	
9/1/2021	100	100	100	100	
9/2/2021	100	100	100	100	
9/3/2021	100	100	100	100	
9/4/2021	100	100	100	100	
9/5/2021	100	100	100	100	
9/6/2021	48	48	48	48	A1&A2 turbine pwr out 12hrs
9/7/2021	100	100	100	100	
9/8/2021	100	100	100	100	
9/9/2021	100	100	100	100	
9/10/2021	100	100	100	100	
9/11/2021	100	100	100	100	
9/12/2021	100	100	100	100	atom down 13:26-15:26
9/13/2021	100	100	100	100	
9/14/2021	100	100	61	58	A2 data retrieval, HD camera replace
9/15/2021	100	100	100	100	A1 data retrieval, A2 Lotek repair
9/16/2021	100	100	100	100	
9/17/2021	99	100	100	100	
9/18/2021	100	100	100	100	
9/19/2021	100	100	100	100	

Date	A1IR	A1HD	A2IR	A2HD	Comment
9/20/2021	99	100	100	100	
9/21/2021	100	100	100	100	
9/22/2021	100	99	100	100	
9/23/2021	100	100	100	100	
9/24/2021	100	100	100	100	
9/25/2021	100	100	100	100	
9/26/2021	100	100	100	100	
9/27/2021	100	100	100	100	
9/28/2021	100	100	100	100	
9/29/2021	100	100	100	100	
9/30/2021	100	100	100	100	
10/1/2021	99	100	100	100	
10/2/2021	100	99	100	100	
10/3/2021	100	100	100	100	
10/4/2021	100	100	100	100	
10/5/2021	87	87	100	100	A1 turbine power out 3 hours
10/6/2021	100	100	90	90	A2 turbine power out 2.2 hours
10/7/2021	100	100	100	100	
10/8/2021	100	100	100	100	
10/9/2021	100	100	100	100	
10/10/2021	100	100	100	100	
10/11/2021	100	100	100	100	
10/12/2021	100	100	100	100	
10/13/2021	100	100	100	100	
10/14/2021	100	100	100	100	
10/15/2021	100	100	100	100	
10/16/2021	100	99	100	100	
10/17/2021	100	100	100	100	
10/18/2021	30	31	31	31	A1&A2 turbine pwr out starting 9:23:27 EDT
10/19/2021	0	0	0	0	A1&A2 turbine pwr out
10/20/2021	0	0	0	0	A1&A2 turbine pwr out
10/21/2021	37	37	37	37	A1&A2 turbine pwr out until 15:02 EDT
10/22/2021	100	100	100	100	
10/23/2021	100	100	100	100	
10/24/2021	100	100	100	100	
10/25/2021	100	100	100	100	
10/26/2021	100	100	100	100	
10/27/2021	100	100	100	100	

Date	A1IR	A1HD	A2IR	A2HD	Comment
10/28/2021	100	100	100	100	
10/29/2021	100	100	100	100	
10/30/2021	100	100	100	100	
10/31/2021	100	100	100	100	
1/15/2022	72	97	100	100	
1/16/2022	99	99	100	100	
1/17/2022	98	99	100	100	
1/18/2022	91	98	100	100	
1/19/2022	99	99	100	100	
1/20/2022	95	95	100	100	Chris trip to A1
1/21/2022	100	100	100	100	
1/22/2022	100	100	100	100	
1/23/2022	100	100	100	100	
1/24/2022	100	100	100	100	
1/25/2022	100	100	99	99	
1/26/2022	33	33	100	100	A1 data not saved
1/27/2022	0	0	100	100	A1 data not saved
1/28/2022	0	0	100	100	A1 data not saved
1/29/2022	0	0	100	100	A1 data not saved
1/30/2022	0	0	100	100	A1 data not saved
1/31/2022	0	0	100	100	A1 data not saved
2/1/2022	0	0	100	100	A1 data not saved
2/2/2022	0	0	100	100	A1 data not saved
2/3/2022	0	0	100	100	A1 data not saved
2/4/2022	0	0	100	100	A1 data not saved
2/5/2022	0	0	100	100	A1 data not saved
2/6/2022	0	0	100	100	A1 data not saved
2/7/2022	0	0	100	100	A1 data not saved
2/8/2022	0	0	100	100	A1 data not saved
2/9/2022	33	33	82	82	data retrieval A1 and A2
2/10/2022	100	100	1	2	
2/11/2022	100	100	27	23	
2/12/2022	100	100	100	100	
2/13/2022	100	100	100	100	
2/14/2022	100	100	100	100	
2/15/2022	100	100	100	100	
2/16/2022	100	100	100	99	
2/17/2022	100	100	100	100	
2/18/2022	100	100	99	98	

Date	A1IR	A1HD	A2IR	A2HD	Comment
2/19/2022	100	100	100	98	
2/20/2022	100	100	100	100	
2/21/2022	100	100	100	100	
2/22/2022	100	100	97	96	
2/23/2022	100	100	99	99	
2/24/2022	100	100	100	100	
2/25/2022	100	100	100	100	
2/26/2022	100	100	100	100	
2/27/2022	100	100	100	100	
2/28/2022	100	100	99	100	
3/1/2022	100	100	87	97	
3/2/2022	100	100	100	100	
3/3/2022	100	100	100	99	
3/4/2022	100	100	100	99	
3/5/2022	100	100	100	100	
3/6/2022	100	100	100	100	
3/7/2022	100	100	98	99	
3/8/2022	100	100	100	97	
3/9/2022	100	100	100	100	
3/10/2022	100	100	100	100	
3/11/2022	98	99	99	100	
3/12/2022	94	95	100	99	
3/13/2022	100	100	100	99	
3/14/2022	100	100	98	99	
3/15/2022	100	100	100	99	

Appendix B. Calibration

Video Calibration

Prior to testing, we reviewed the body size and wingspan for 75 bird species likely or known to occur in the offshore environment. Bird species were reviewed from the following families: goose, swan, duck, loon, grebe, fulmar, petrel, shearwater, storm-petrel, booby, gannet, cormorant, pelican, Ardeidae, raptor, shorebird, phalarope, skua, auk, gull, tern, sterna tern, and passerines. We binned the body size and wingspans using the natural breaks classification to generate 5 average bird size categories to represent 5 average categories of birds (Table B-1).

Table B-1. Dimensions of Targets

Target	Body Length (cm)	Wingspan (cm)
1	12.3	17.1
2	20.8	46.6
3	39.5	80.5
4	58.7	109.0
5	99.6	163.0

For each target size, we fabricated two foam targets to be carried underneath an operating drone. For each of the five bird target sizes, two physical models were made: wings entirely extended, and wings partially folded in to simulate diving or other movements where wings are not fully extended (Figure B-1). Each target was painted black to increase infrared (IR) visibility for the ATOM system and to simulate body heat from a bird or bat.

ATOM testing was conducted along the apron of a local grass airstrip. Due to the 400-ft altitude restriction of unmanned aircraft system (UAS) flights enforced by the Federal Aviation Administration (FAA), an overhead pass of the drone was performed at 400 ft above the ATOM system. This was done to ensure comparability with subsequent drone flights where the ATOM system would be tilted so that longer distances could be tested between ATOM and the drone. Following this 400-ft test flight, the ATOM system was tilted to an angle of 22 degrees (Figure B-2). This allowed testing to use the hypotenuse distance to approximate the vertical distance from the ATOM system while still accommodating the 400-ft FAA restriction. Twenty-two degrees was chosen to allow 1,000 ft of hypotenuse distance. This is farther than the maximum distance from the turbine platform to the top of the rotor swept area (187 m, 613 ft).

During testing, the ATOM system was powered up and operated normally while the physical bird models were attached to the drone and flown at varying distances from the ATOM system. The test drone recorded its GPS position at 0.2-s intervals. The drone and ATOM clocks were synchronized, and each GPS position reading was paired with the temporally nearest IR video frame. For each set of GPS coordinates, a distance (d) was computed relative to the ATOM system (Figure B-3). This distance is equivalent to the altitude above the ATOM system for a conventional vertically oriented ATOM system. Distance d is calculated by converting the GPS latitude (λ) and altitude (α) to Cartesian coordinates y and z relative to the ATOM system. A constant of 111,132 m per degree of latitude is used for this conversion. The GPS longitude can be ignored because the system is aligned along a north–south axis.

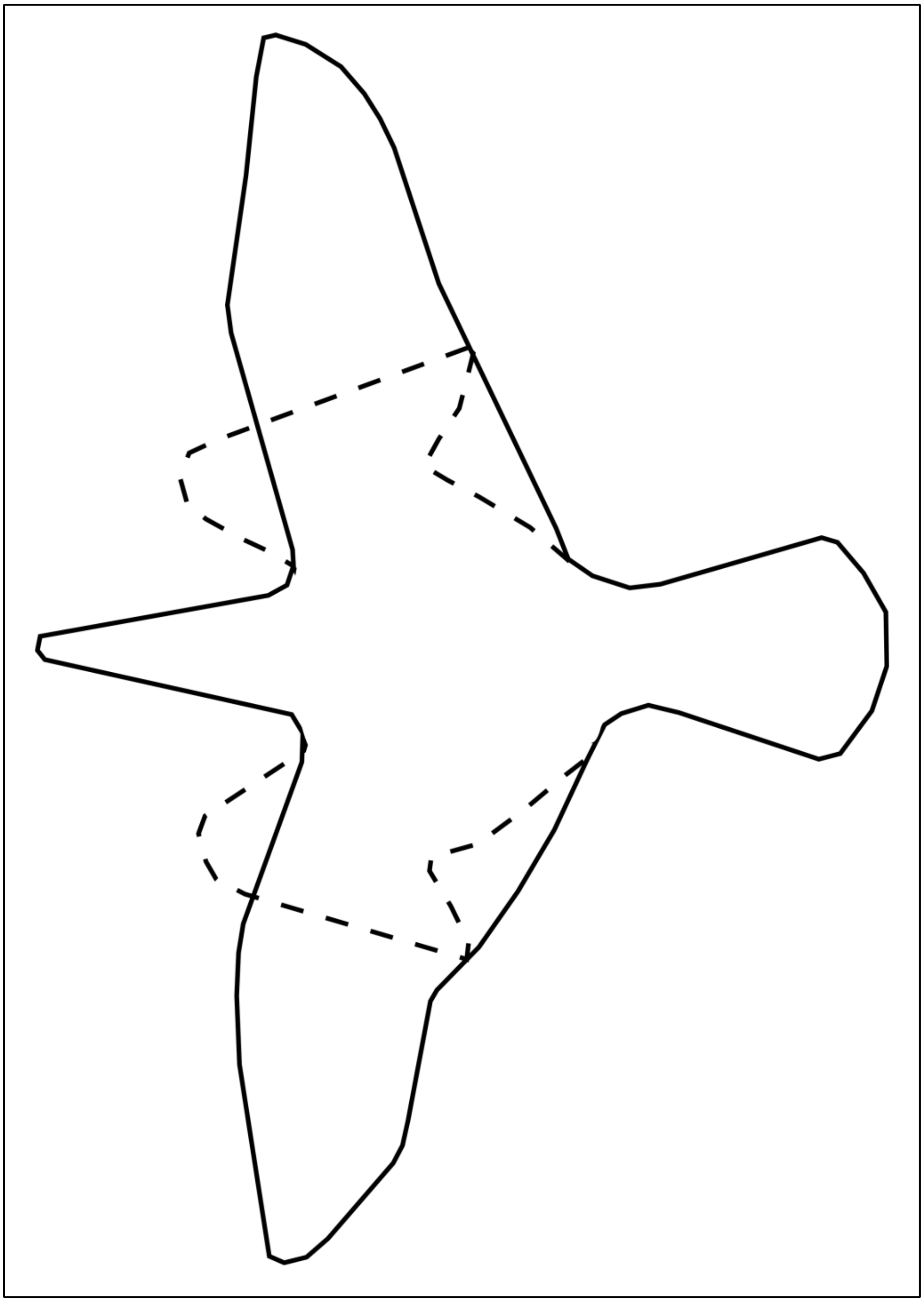


Figure B-1. Profile outlines of largest target.
Dotted lines show wings retracted; solid lines show wings extended.

Figure B-2. ATOM system tilted to 22 degrees to accommodate longer distance testing otherwise restricted by the FAA 400-ft drone flight height restriction.

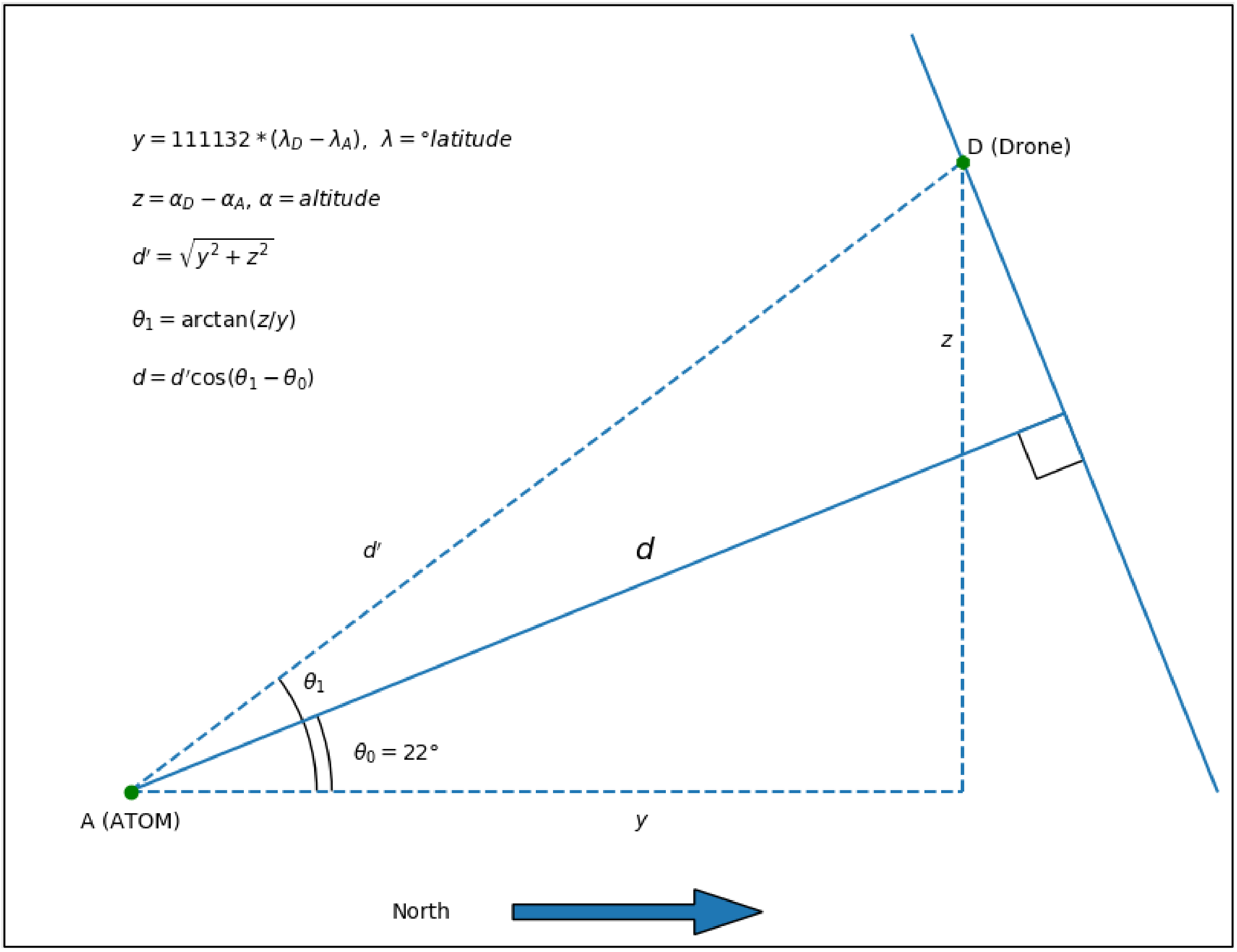


Figure B-3. Calculation of drone “altitude” (straight-line distance) relative to tilted ATOM system.

The first and last one second of each flight were used to establish the GPS position of the ATOM system and quantify the error of the GPS data. During the first and last second, the drone was known to be approximately 10 m due North of the ATOM system. The standard deviation of these 50 coordinate sets was 5.0 m, and their median was used to establish the position of the ATOM for all subsequent calculations.

The ATOM system tracks objects in each of its two IR cameras independently. An object tracked in only one IR camera is categorized as tracked, and these tracks were used to establish the detectability limits of the ATOM system. An object tracked in both IR cameras simultaneously is categorized as both tracked and stereo tracked. Stereo tracking permits flight height calculations of an object. These stereo tracks were used to establish the accuracy of the ATOM flight height calculations. Five test flights were conducted with various flight patterns. For each flight, the ATOM track data was compared to the drone GPS data to determine the maximum range at which the ATOM could track the drone and the accuracy of the ATOM flight height calculations.

For time periods when the drone was stereo tracked, *d* determined by the GPS position was compared to the flight height as determined by the ATOM system *(h)* based on the relative position of the drone in each IR camera.

After the completion of the tests, the test data were processed to extract tracks. The extracted tracks were then reviewed to separate drone tracks from bird, insect, and artifact tracks detected during the tests. Over the duration of the test approximately 300 bird and insect tracks were recorded in addition to the drone tracks.

To test the ability of the ATOM system to detect smaller targets that would mimic the size of a bat or small bird, we used a tennis ball as a surrogate object. For these tests we set up the ATOM system in the same way as the drone tests and tossed a tennis ball into the air at set distances from the system. Tosses were recorded at 1.5-m (5-ft) intervals from 7.6 m to 30.5 m (25 ft to 100 ft). For each trial, we recorded the time when the ball was thrown and the known horizontal distance from the system. The horizontal distance from the system and the angle of the ATOM system above ground allowed us to calculate the straight-line distance from the system.

Acoustic Calibration

Detection range of acoustic microphones is highly variable depending on the environmental conditions, ambient noise, sound volume, and sound frequency. For example, a 20-kHz sound at 20°C with 50% relative humidity can be detected from 5 m to 63 m depending on volume (Wildlife Acoustics 2014), but this does not include the highly noisy offshore environment, turbine noise, and varying weather conditions. Because it is not possible to consider all possible conditions that would affect the acoustic detection range at the turbine, we present the example above as an approximate detection range.

Motus Calibration

During each visit to the Motus system we used a test tag to validate the Motus system was working properly. The test tag was detected out to a range of 1.25 miles. A full calibration survey using methods outline by the US Fish and Wildlife Service (USFWS) will be done on an upgraded Motus system in 2022–2023.

Detection Range

Efforts to establish the detection range of the system were complicated by a lower than anticipated rate of object tracking. Due to the slow speed of the drone relative to a typical bird/bat in flight and motion of the drone directly toward or away from the cameras, the automated tracking system only detected the presence of the drone 22.4% of the time across all 5 flights. However, the maximum tracked ranges of 262.9–292.8 m achieved during flights 2, 3, and 4 are consistent with the point at which the drone becomes imperceptible in the recorded video. Further testing would be needed to establish a maximum plausible detection range, but the 280 m achieved for the drone alone during flight 4 (with no target attached) can be considered the reasonable limit at which an object of the size of the drone will be detected (Table B-2).

The area of the drone as detected by the ATOM system is approximately 3,800 cm^2 as determined from track data at the beginning of flight 5 prior to the attachment of the target bird cutout. For other size objects, the maximum detection range D_{MAX} will be proportional to the cross-sectional area of the object A. That is:

$$D_{MAX} \propto \sqrt{A} \qquad \text{Equation 1}$$

Using the drone detection distance of 280 m for a hypothetical object 1,000 cm^2 in area, this would suggest a detection range of 144 m.

Table B-2. ATOM Detection Ranges for Five Flights
Variability in detection ranges can be due to the flight tracks, angle of the flights, object velocity, and environmental factors

Flight	Attached Bird Model	Max *d* tracked (m)	Max *d* (m)	Flight duration (s)	% Tracked
1	None	65.3	110.1	177	10.0
2	Target 1, extended	262.9	314.2	636	21.2
3	Target 4, retracted	292.8	316.9	702	32.3
4	None	280.6	537.7	514	7.7
5	Target 2, retracted	134.6	134.9	289	34.4
Total		292.8	537.7	4635	22.4

Flight: the flight number
Attached Bird Model: the bird model, if any, suspended from the drone during the specified flight
Max *d* tracked: the maximum GPS distance (*d)* at which the drone was tracked by the ATOM system
Max *d*: the maximum GPS distance (*d)* recorded during the flight
Flight duration: the length of the flight
% Tracked: the percentage of the flight that was tracked by the ATOM system

Further tests of the ATOM system were performed by tossing a tennis ball into the air at set distances from the system, which was set up as it was for the drone tests. During these tests the tennis ball was tracked by the system up to a maximum distance of 24.4 m. Beyond that distance the tennis ball was not tracked and was not clearly visible in the recorded IR video. Given the 35-cm^2 cross section area of a standard tennis ball and the previously discussed relationship between maximum detection range and cross-sectional area (Equation 1), this result implies a detection range of 130 m for a hypothetical object 1,000 cm^2 in area, which is similar to the 144 m estimate calculated from the drone detection distance.

The ATOM system calculates flight heights (*h)* for all stereo-tracked objects to assist in assessing the risk from wind turbine blades. For these tests, *h* values computed by the ATOM system do not represent altitude due to the non-standard orientation of the ATOM system. To establish the accuracy of the ATOM flight height values we have compared them to an equivalent GPS distance *d* (Figure B-4; Table B-3). The accuracy of *h* values decreases with distance from the ATOM system due to the nature of stereo range finding. This can be seen in Figure B-5, which charts the standard deviation of $d - h$ binned by *d*, as well as in Figure B-6 to Figure B-9, which plot *d* and *h* versus time for each of the 5 test flights.

For distances of less than 100 m, the standard deviation of $d - h$ is less than the standard deviation of *d* alone (8.0 m, n=50) at the beginning of each flight. This suggests that *h* (height estimated by ATOM*)* is at least as accurate as the GPS data for flight heights under 100 m. Beyond 100 m the flight height data becomes less accurate (Figure B-6 to Figure B-9).

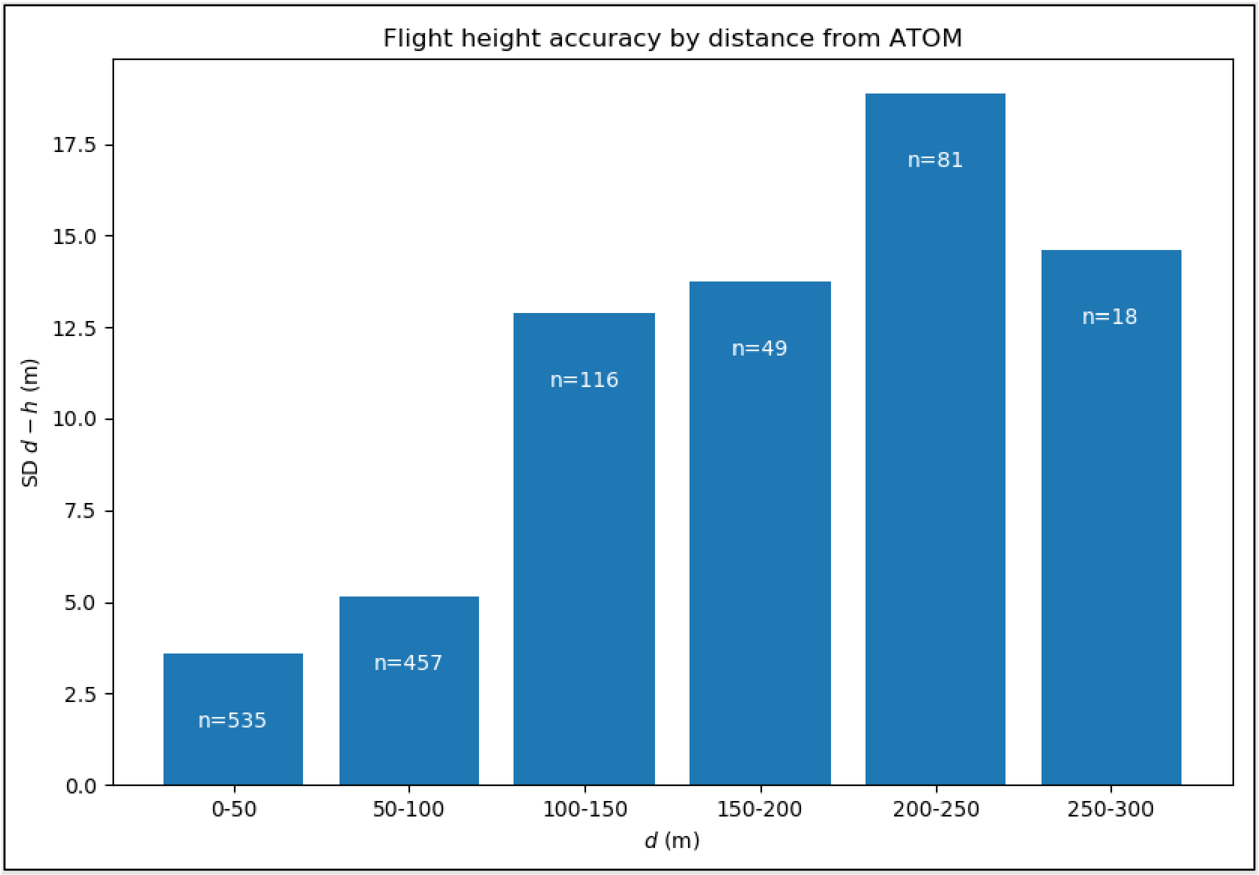


Figure B-4. Comparison of ATOM-calculated flight height to equivalent GPS flight height values binned by distance from ATOM system.

d represents the flight height calculated by the GPS (x-axis); SD *d-h* represents the difference in standard deviation of the flight height calculated by ATOM from the height recorded by the GPS unit (y-axis). n is the number of stereo-tracked video frames in each distance bin.

Table B-3. Selected Test Result Statistics Aggregated by Flight Number

Flight	Attached Bird Model	% Stereo tracked	Location Samples	Mean distance delta (m)	Distance delta SD (m)
1	None	7.0	62	-3.0	1.7
2	Target 1, extended	13.1	416	-4.3	2.9
3	Target 4, retracted	8.9	313	16.7	28.2
4	None	3.5	90	2.3	0.7
5	Target 2, retracted	26.0	375	-5.7	10.1
Total		10.8	1256	1.1	10.2

Flight: the flight number
Attached Bird Model: the bird model, if any, suspended from the drone during the specified flight
% Stereo Tracked: the percentage of the flight tracked by both ATOM IR cameras and for which distance calculations are available
Location samples: the number of GPS coordinates for which ATOM flight height data was available
Mean distance delta: The mean of (*d* - *h*) for data points that were stereo tracked
Distance delta SD: The standard deviation of the distance delta (see Mean distance delta)

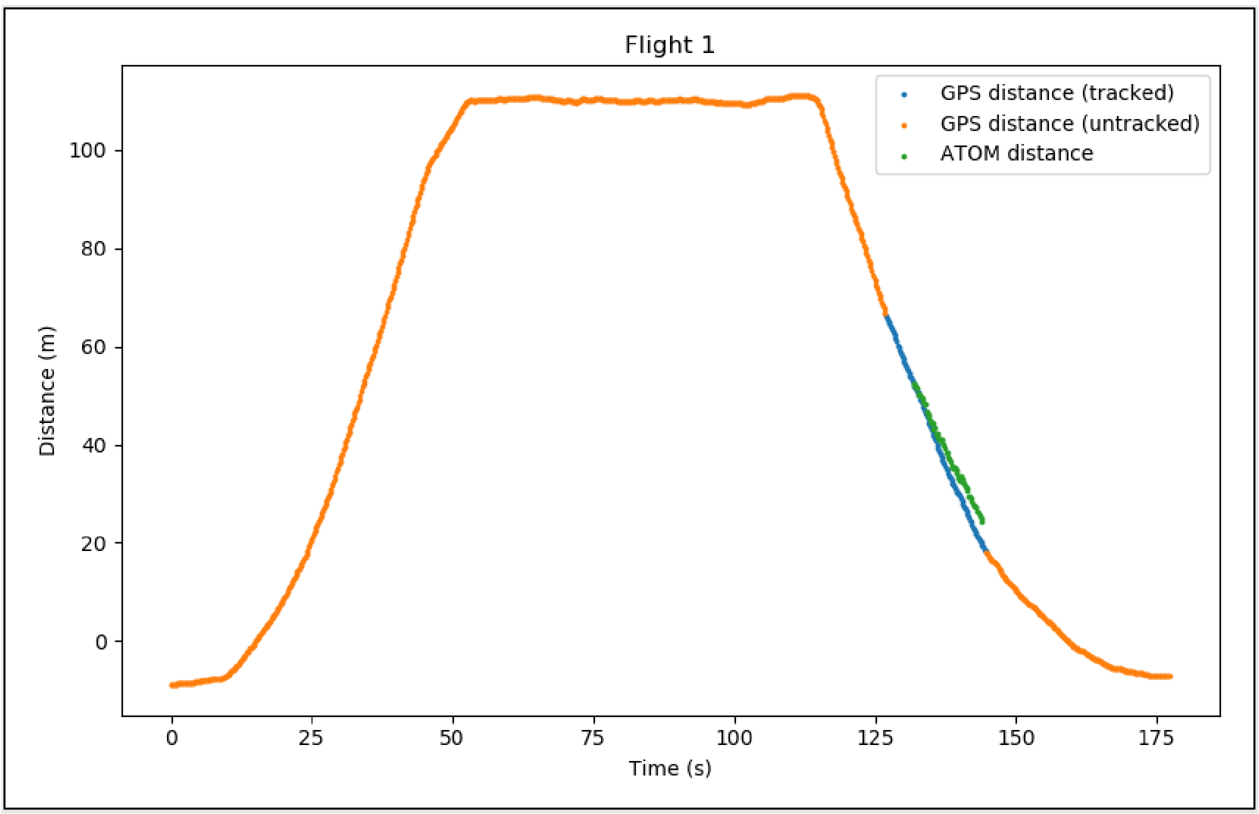


Figure B-5. Difference between *d* and *h* values from the GPS and ATOM system respectively during the duration of flight 1 as defined on the x-axis.

The presence of blue and green dots indicates stereo tracking and the closer the blue and green dots are together, the more accurate the ATOM system distance estimate. No ATOM estimates were available when the targets were untracked (orange points) or when tracked with one camera only (blue dots without green dots).

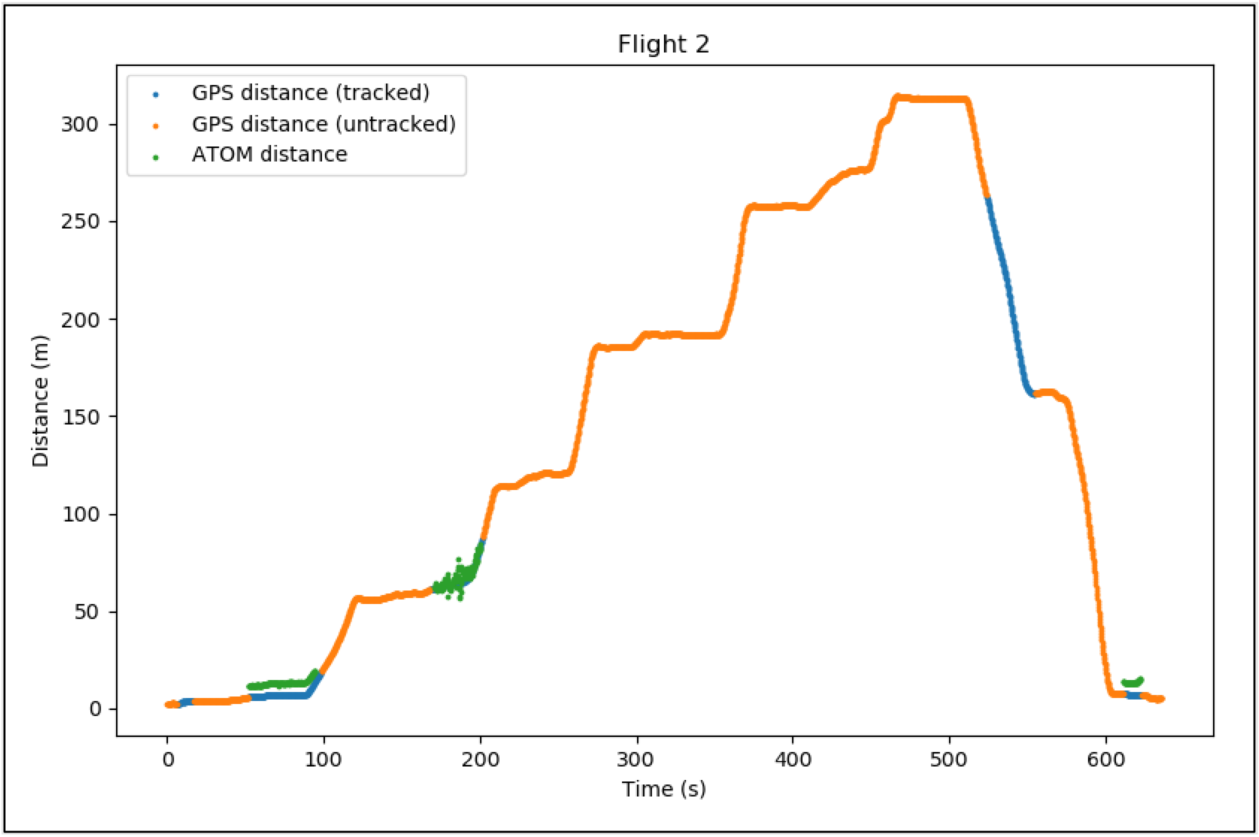


Figure B-6. Difference between *d* and *h* values from the GPS and ATOM system respectively during the duration of flight 2 as defined on the x-axis.

The presence of blue and green dots indicates stereo tracking and the closer the blue and green dots are together, the more accurate the ATOM system distance estimate. No ATOM estimates were available when the targets were untracked (orange points) or when tracked with one camera only (blue dots without green dots).

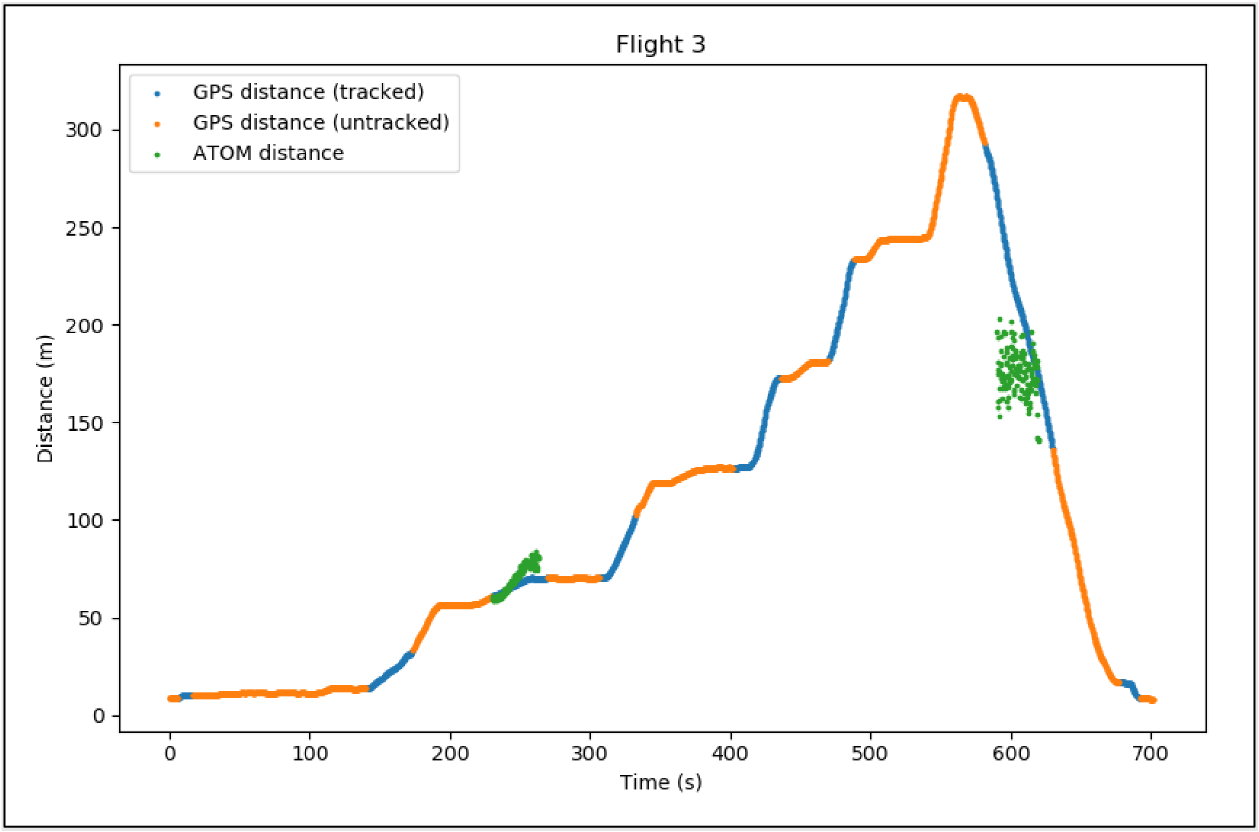


Figure B-7. Difference between *d* and *h* values from the GPS and ATOM system respectively during the duration of flight 3 as defined on the x-axis.

The presence of blue and green dots indicates stereo tracking and the closer the blue and green dots are together, the more accurate the ATOM system distance estimate. No ATOM estimates were available when the targets were untracked (orange points) or when tracked with one camera only (blue dots without green dots).

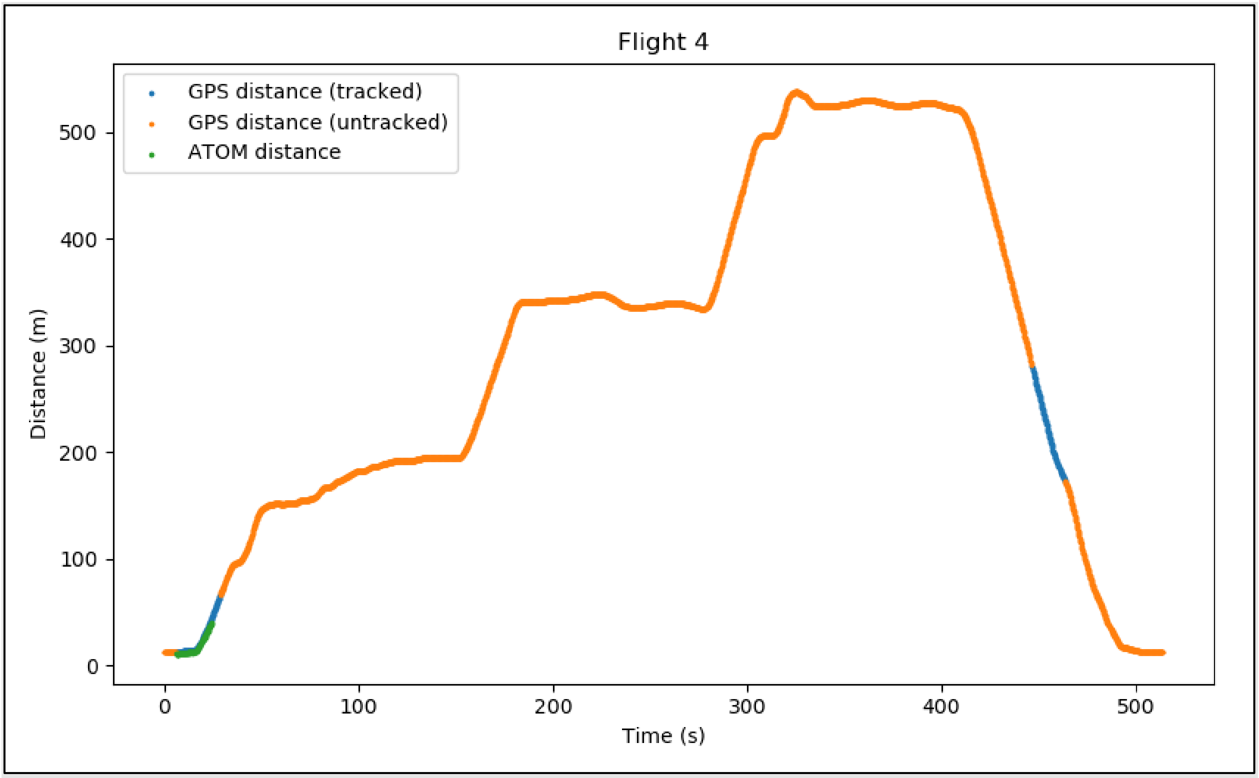


Figure B-8. Difference between *d* and *h* values from the GPS and ATOM system respectively during the duration of flight 4 as defined on the x-axis.

The presence of blue and green dots indicates stereo tracking and the closer the blue and green dots are together, the more accurate the ATOM system distance estimate. No ATOM estimates were available when the targets were untracked (orange points) or when tracked with one camera only (blue dots without green dots).

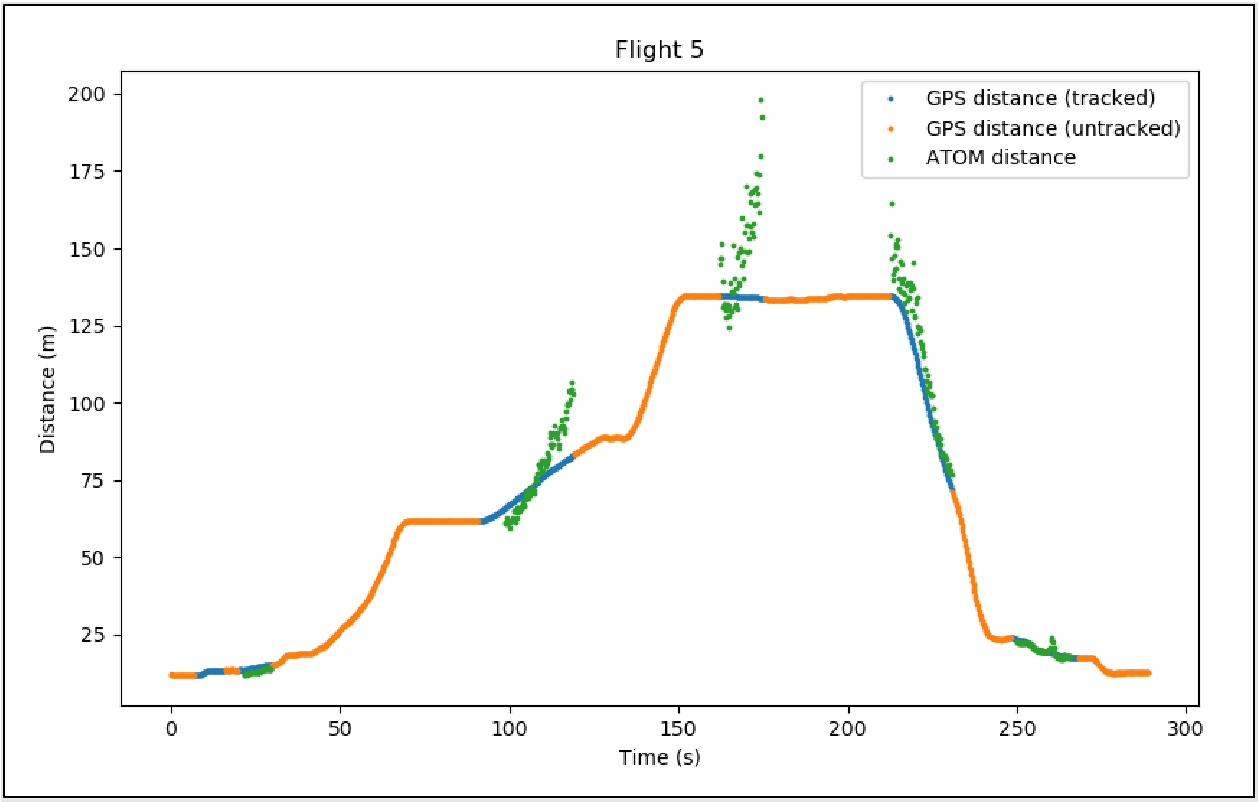


Figure B-9. Difference between *d* and *h* values from the GPS and ATOM system respectively during the duration of flight 5 as defined on the x-axis.

The presence of blue and green dots indicates stereo tracking and the closer the blue and green dots are together, the more accurate the ATOM system distance estimate. No ATOM estimates were available when the targets were untracked (orange points) or when tracked with one camera only (blue dots without green dots).

Flight 2, target A attached

Flight 3, target B attached

Flight 5, target C attached

Appendix C. Acoustic Calls Identified During the Fall Monitoring Period at ATOM 1 and ATOM 2

Location	Species	Scientific Name	Family	ATOM	Date	Time	ID Confidence
A1L	Upland Sandpiper	*Bartramia longicauda*	Scolopacidae	ATOM 1	09/06/21	10:00:31 PM	High
A1L	Upland Sandpiper	*Bartramia longicauda*	Scolopacidae	ATOM 1	09/07/21	03:32:44 AM	High
A1R	Upland Sandpiper	*Bartramia longicauda*	Scolopacidae	ATOM 1	09/30/21	11:33:48 AM	Low
A1L	Spotted Sandpiper	*Actitis macularius*	Scolopacidae	ATOM 1	08/15/21	12:45:14 AM	High
A1L	Spotted Sandpiper	*Actitis macularius*	Scolopacidae	ATOM 1	08/15/21	12:45:23 AM	High
A2L	Solitary Sandpiper	*Tringa solitaria*	Scolopacidae	ATOM 2	08/28/21	11:22:27 PM	High
A1R	Herring Gull	*Larus smithsonianus*	Laridae	ATOM 1	09/15/21	07:46:56 AM	High
A1L	Royal Tern	*Thalasseus maximus*	Laridae	ATOM 1	08/31/21	01:51:17 AM	Medium
A2L	American Robin	*Turdus migratorius*	Turdidae	ATOM 2	08/15/21	08:10:35 AM	Medium
A2L	American Robin	*Turdus migratorius*	Turdidae	ATOM 2	08/15/21	10:02:28 AM	Medium
A2L	Northern Waterthrush	*Parkesia noveboracensis*	Parulidae	ATOM 2	10/23/21	10:51:22 AM	Low
A1R	Black-and-white Warbler	*Mniotilta varia*	Parulidae	ATOM 1	10/13/21	10:40:07 PM	Low
A1R	Black-and-white Warbler	*Mniotilta varia*	Parulidae	ATOM 1	10/15/21	02:08:57 PM	Low
A2L	American Redstart	*Setophaga ruticilla*	Parulidae	ATOM 2	08/28/21	09:42:30 PM	Low
A1R	Northern Parula	*Setophaga americana*	Parulidae	ATOM 1	10/14/21	01:55:05 AM	Low
A1R	Northern Parula	*Setophaga americana*	Parulidae	ATOM 1	10/15/21	04:15:50 PM	Low
A2L	Magnolia Warbler	*Setophaga magnolia*	Parulidae	ATOM 2	09/06/21	11:38:40 PM	Low
A1R	Bay-breasted Warbler	*Setophaga castanea*	Parulidae	ATOM 1	08/21/21	11:08:09 PM	High
A2L	Bay-breasted Warbler	*Setophaga castanea*	Parulidae	ATOM 2	09/30/21	09:36:03 PM	Low
A2R	Palm Warbler	*Setophaga palmarum*	Parulidae	ATOM 2	09/03/21	02:34:39 PM	High
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	08:02:22 AM	Medium
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	08:10:47 AM	Medium
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	09:44:52 AM	Medium
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	10:03:08 AM	Medium
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	10:05:03 AM	Medium

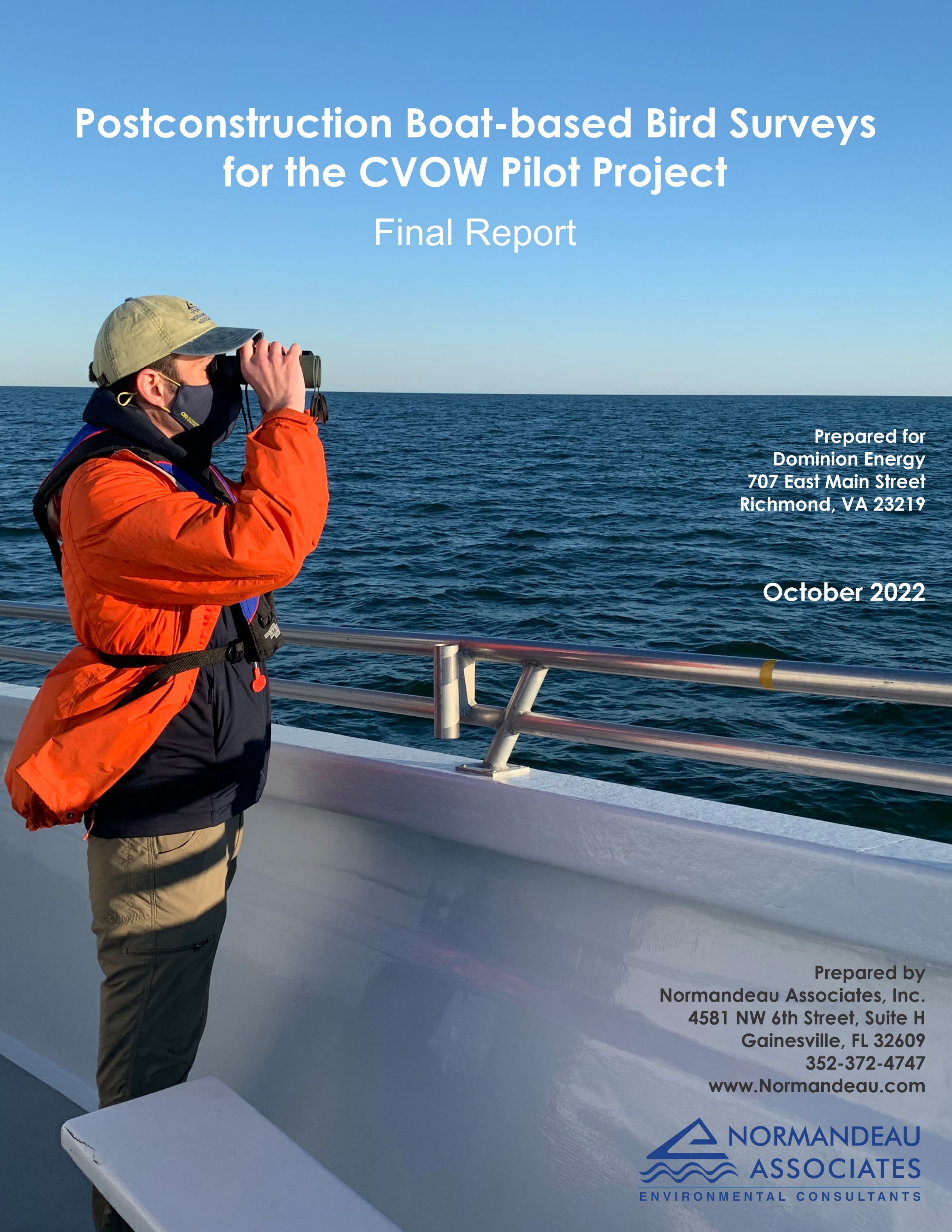
Location	Species	Scientific Name	Family	ATOM	Date	Time	ID Confidence
A2L	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	01:35:14 PM	Medium
A2R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	08:01:47 AM	High
A2R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	08:10:56 AM	High
A2R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	08:11:05 AM	High
A2R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	10:01:32 AM	High
A2R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 2	08/15/21	10:04:40 AM	High
A1R	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinalidae	ATOM 1	09/30/21	06:26:34 PM	Low

Appendix B

Boat Based Surveys Final Report

Postconstruction Boat-based Bird Surveys for the CVOW Pilot Project

Final Report



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Postconstruction Boat-based Bird Surveys for the CVOW Pilot Project

Final Report

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Acronyms and Abbreviations

AIC	Akaike information criterion
BOEM	Bureau of Ocean Energy Management
CVOW Pilot Project	Coastal Virginia Offshore Wind Pilot Project
Dominion	Dominion Energy
km	Kilometers
mi	Statute miles
MW	Megawatt
nm	Nautical miles

1 Introduction and Overview

Dominion Energy (Dominion) is the designated operator for the Coastal Virginia Offshore Wind Pilot Project (CVOW Pilot) research lease (OCS-A-0497). The project is a 12-megawatt (MW), two-turbine offshore wind demonstration project approximately 24 nautical miles (nm) (27 statute miles [mi], 43 kilometers [km]) offshore of Virginia Beach, Virginia. The research lease is located adjacent to and on the west side of the Dominion commercial lease (OCS-A-0483).

To support development of the CVOW Pilot Project, one year of pre-construction boat-based surveys were conducted between May 2013 and April 2014 (Tetra Tech 2014). The purpose of the surveys was to record information on birds that may be foraging, transiting, or migrating through the Survey Area (Figure 1).

As part of a bird and bat postconstruction monitoring plan (Tetra Tech and Normandeau 2020), Dominion proposed one year of post-construction boat-based surveys in 2021 using the pre-construction survey methodology and designed to record information on foraging, transiting, or migrating birds. These six surveys were to determine if there were any post-construction changes in bird abundance. One survey was to be conducted during each of these periods:

- Jan 1–Jan 30
- Mar 15–Apr 15
- Jun 1–Jun 30
- Jul 15–Aug 15
- Sep 15–Oct 15
- Nov 15–Dec 15

Specific objectives of the offshore bird studies in the Survey Area were to:

- Determine the species composition of the bird community
- Assess the use by rare, threatened, and endangered species
- Identify the preconstruction and postconstruction spatial and temporal distribution patterns of birds
- Estimate the preconstruction and postconstruction relative abundance of birds
- Quantify, if possible, any changes in the spatial distribution and abundance of birds following construction of the turbines
- Gather information on the behavior of birds (e.g., foraging, sitting on the water, following vessels)
- Estimate flight height of birds

Pre-construction surveys consisted of 13 monthly boat-based avian surveys within the CVOW Survey Area (Figure 1, Table 1). Two surveys were conducted in both May 2013 and February 2014. No pre-construction surveys were conducted during November (Table 1). Post-construction surveys occurred in January, March, June, August, September, and November 2021 (Table 1).

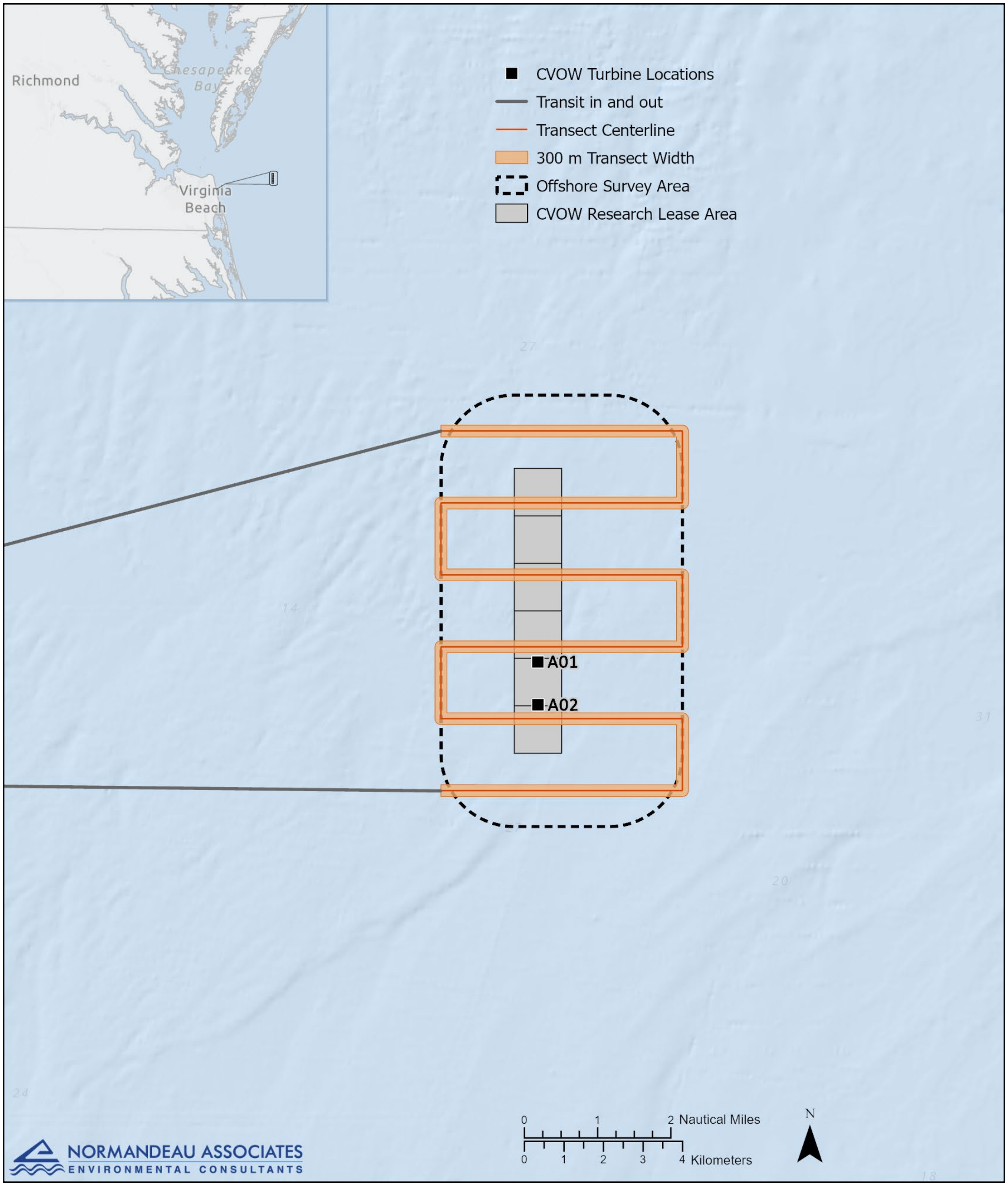

Figure 1. Boat-based survey transects and turbine locations in the CVOW Pilot Project Survey Area.

Table 1. Dates of Boat-based Surveys

Survey Dates	
Preconstruction	**Postconstruction**
05-14-2013	01-24-2021
05-22-2013	03-30-2021
06-17-2013	06-02-2021
07-08-2013	08-05-2021
08-13-2013	09-30-2021
09-10-2013	11-17-2021
10-02-2013	
12-19-2013	
01-09-2014	
02-07-2014	
02-22-2014	
03-11-2014	
04-03-2014	

2 Methods

2.1 Data Collection

Post-construction boat-based surveys followed a strip transect pattern through the Survey Area with a 1-nm (1.9-km) buffer using the same approach as the pre-construction surveys (Tetra Tech 2014; Figure 1). For the January survey, we use a charter vessel 30 feet in length; all other surveys used a charter vessel 75 feet in length. Separation between transects is 4,987 ft (1.52 km), minimizing double counting (Figure 1). In addition, incidental data were collected during transit to and from the Survey Area along a pre-established route. Surveys were conducted on days when sea conditions were appropriate (i.e., conditions of <Beaufort 4). Detailed weather observations were recorded using handheld anemometers at the start and end of each survey. Observers recorded wind speed, wind direction, air temperature, relative humidity, and sea state on standardized data sheets (Table 2).

Table 2. Maximum Beaufort Conditions Encountered during Post-construction Surveys

Survey	Max Beaufort Scale	Wind Speed	Wave Height
January	2	4–6 knots (1.6–3.3 m/s)	1–2 ft (0.3–0.6 m)
March	2	4–6 knots (1.6–3.3 m/s)	1–2 ft (0.3–0.6 m)
June	1	1–3 knots (0.5–1.5 m/s)	0–1 ft (0–0.3 m)
August	3	7–10 knots (3.4–5.5 m/s)	2–4 ft (0.6–1.2 m)
September	1	1–3 knots (0.5–1.5 m/s)	0–1 ft (0–0.3 m)
November	2	4–6 knots (1.6–3.3 m/s)	1–2 ft (0.3–0.6 m)

During each survey, the vessel traveled at a constant speed of 10 knots (18.5 km/hour). Surveys began at or after sunrise and continued until the full transect was complete. Two qualified biologists conducted the surveys; the primary observer recorded all birds that fell within a moving "box" that measured 984 ft (300 m) ahead and 984 ft (300 m) perpendicular on both sides of the ship. The primary observer was assisted by a data recorder observer so they could focus on identifying birds. All individual birds detected during the surveys were identified to species level, when possible. Behavioral information on all birds was recorded including feeding, sitting on water, direct flight, and diving. For birds sitting on the water (and for birds in flight, when possible), the observer estimated a perpendicular distance from the ship to the bird. Before each survey, observers were given rangefinders to visually calibrate estimated bird distances using a fixed point (e.g., a buoy at a variety of distances) (BOEM 2020).

2.2 Distance Analysis Method and Density Calculations

To effectively compare bird activity between survey year and season within the Survey Area, we used the R package "Distance" (Miller et al. 2019) to generate a detection function by pooling all avian species and surveys. Pre-construction surveys completed by Tetra Tech (Tetra Tech 2014) followed a protocol whereby bird distances were collected in binned distances of (0–25 m, 25–50 m, 50–100 m, 100–200 m, and 200–300 m). Because exact distances were not available from the pre-construction data, we binned the 2021 Normandeau collected data into the same bin structure. Using the entire data set, we evaluated several candidate detection functions using Akaike information criterion (AIC) and chose a half-normal detection function with survey type (pre-construction Tetra Tech surveys vs post-construction Normandeau surveys) coefficients to generate different detection probabilities. The detection probabilities were used to generate separate abundance estimates for each monthly/seasonal survey by correcting the number of observed individuals by accounting for those birds unobserved within the covered area out to 300 m from the survey ship. Then the estimated number of birds observed were extrapolated to the whole Survey Area by applying a correction factor of 2.34, which reflects the size difference between the area covered by the survey and the overall size of the Survey Area and buffer. To investigate temporal effects, we considered each survey as a stratum in our analysis to generate separate density estimates for each survey. We divided the boat survey route into 11 discrete but connected transects to gain a better understanding of spatial variance. Four observations lacked distance data and were omitted from the distance analysis.

2.3 Behavior and Flight Height

To quantify the proportion of individuals in flight compared to those sitting on the water within the Survey Area, birds were considered in flight if their flight height was greater than 0 m above sea level. For birds observed in flight directly or nearly directly overhead, vertical flight elevation was measured with rangefinders. When the rangefinder did not reliably reflect off the bird in flight, which occurs mostly when birds fly low over the water below the height of the boat (approximately 30 ft [9.1 m]), flight heights were estimated based on rangefinder calibrations. No error data were collected on flight height estimates. The raw flight height information provided in Appendix A is the only place in this report containing the incidental data collected during transit to and from the Survey Area.

To compare the difference in flight heights between pre- and post-construction surveys, we considered observation events rather than individuals to control for single observation events.

2.4 Flight Direction

For analysis of flight direction, we selected species encountered within the Survey Area with five or more observations of directional flight; species observed flying in multiple directions are not included in the flight direction section. Definitive flight direction was recorded as north (N), northeast (NE), northwest (NW), south (S), southeast (SE), southwest (SW), east (E), west (W), and variable. For individuals flying back and forth or in circles where flight directions were not definitive, no flight direction was recorded. All data were recorded with the SeaScribe app for mobile devices.

3 Results

3.1 Encounters and Patterns

During pre-construction surveys, observers documented 24 avian species ($\bar{x}$ = 5.38, SE = 0.56 species/survey), and during post-construction surveys, observers documented 17 avian species ($\bar{x}$ = 4.0, SE = 0.93 species/survey) (Table 3). Considering pre- and post-construction surveys, Northern Gannet (*Morus bassanus*) was the most observed species (n = 1,300, 75%), followed by Common Loon (*Gavia immer* [n = 72, 4.16%]), Razorbill (*Alca torda* [n = 60, 3.47%]), Great Black-backed Gull (*Larus marinus* [n = 47, 2.72%]), and Dovekie (*Alle alle* [n = 44, 2.54%]) (Table 4). The greatest difference in individuals encountered between pre- and post-construction surveys was Northern Gannet with 1,219 (82% of total) observed during pre-construction surveys and 81 (33% of total) observed during post-construction surveys (Table 4). However, the disparity is driven by a single pre-construction survey on February 7, 2014, when 1,166 Northern Gannet were mostly observed in nine groups ranging in cluster sizes between 20 and 350 individuals (Table 4). Otherwise, species composition and counts were similar between pre- and post-construction surveys. No rare, threatened, or endangered species were encountered from either federal or state listings.

Pre-construction surveys resulted in an average of 114.0 ± 93.2 birds/survey (mean ± SE). Omitting the early February pre-construction survey, which accounted for 82.8% of observations (n = 1,231, of which 1,166 were Northern Gannet), resulted in an average of 21.2 ± 5.96 birds/survey. Post-construction surveys resulted in an average of 40.2 ± 20.1 birds/survey. Encounter rates (number of individuals observed ÷ total survey line length) per survey were similar between pre- and post-construction surveys. Including the early February pre-construction survey, pre-construction surveys had a mean survey encounter rate of 2.56 ± 2.09 birds/survey. When omitting the February pre-construction survey, the pre-construction encounter rate was 0.47 ± 0.13 birds/survey, and the postconstruction encounter rate was 0.90 ± 0.45 birds/survey. Seasonal patterns were similar between pre- and postconstruction surveys. Overall, the four preconstruction winter surveys (Jan, early-Feb, late-Feb, Mar) accounted for 91.4% of observations (n = 1,358), and the two postconstruction winter surveys accounted for 77.0% of observations (n = 189) (Table 4).

Table 3. List of Species or Species Groups Encountered Within the Survey Area

Common Name	Scientific Name	Pre-survey Presence	Post-survey Presence
Barn Swallow	*Hirundo rustica*		x
Black Scoter	*Melanitta americana*	x	
Bonaparte's Gull	*Chroicocephalus philadelphia*	x	x
Common Grackle	*Quiscalus quiscula*	x	
Common Loon	*Gavia immer*	x	x
Common Tern	*Sterna hirundo*		x
Cory's Shearwater	*Calonectris diomedea*	x	
Dovekie	*Alle alle*	x	x
Gray Catbird	*Dumetella carolinensis*		x
Great Black-backed Gull	*Larus marinus*	x	x
Great Blue Heron	*Ardea herodias*		x
Great Egret	*Ardea alba*		x
Herring Gull	*Larus argentatus*	x	x
Laughing Gull	*Leucophaeus atricilla*	x	x
Lesser Black-backed Gull	*Larus fuscus*	x	
Northern Fulmar	*Fulmarus glacialis*	x	
Northern Gannet	*Morus bassanus*	x	x
Palm Warbler	*Setophaga palmarum*		x
Purple Martin	*Progne subis*	x	
Razorbill	*Alca torda*	x	x
Red Phalarope	*Phalaropus fulicarius*	x	
Red-necked Phalarope	*Phalaropus lobatus*	x	
Red-throated Loon	*Gavia stellata*	x	x
Ring-billed Gull	*Larus delawarensis*	x	x
Royal Tern	*Thalasseus maximus*	x	
Sanderling	*Calidris alba*	x	
Song Sparrow	*Melospiza melodia*	x	
Sooty Shearwater	*Ardenna grisea*	x	
Surf Scoter	*Melanitta perspicillata*	x	
Wilson's Storm-Petrel	*Oceanites oceanicus*	x	x

Table 4. Pre-contruction Raw Counts of Species Observed in the Survey Area per Survey

Species	Jan	Feb	Feb	Mar	Apr	May	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	% of Total
Surf Scoter	0	0	1	0	0	0	0	0	0	0	0	0	-	0	1	0.07
Black Scoter	0	0	0	0	25	0	0	0	0	0	0	0	-	0	25	1.68
Red-throated Loon	2	4	0	2	1	1	1	0	0	0	0	0	-	0	11	0.74
Common Loon	14	1	1	0	4	5	2	0	0	0	0	0	-	0	27	1.82
Northern Fulmar	0	2	0	0	0	0	0	0	0	0	0	0	-	0	2	0.13
Cory's Shearwater	0	0	0	0	0	0	0	0	0	0	0	1	-	0	1	0.07
Sooty Shearwater	0	0	0	0	0	1	0	0	0	0	0	0	-	0	1	0.07
Wilson's Storm-Petrel	0	0	0	0	0	0	3	2	0	0	0	0	-	0	5	0.34
Northern Gannet	6	1,166	14	21	10	0	0	0	0	0	0	0	-	2	1,219	82.09
Sanderling	0	0	0	0	0	3	0	0	0	0	0	0	-	0	3	0.20
Red-necked Phalarope	0	0	0	0	0	0	0	0	0	0	13	0	-	0	13	0.88
Red Phalarope	0	0	0	0	0	0	0	0	0	0	1	0	-	0	1	0.07
Dovekie	0	0	1	0	0	0	0	0	0	0	0	0	-	0	1	0.07
Razorbill	31	4	9	1	0	0	0	0	0	0	0	0	-	0	45	3.03
Bonaparte's Gull	18	0	0	0	1	0	0	0	0	0	0	0	-	2	21	1.41
Laughing Gull	0	0	0	0	0	0	2	1	5	4	3	2	-	0	17	1.14
Ring-billed Gull	1	0	0	0	0	0	0	0	0	0	0	1	-	0	2	0.13
Herring Gull	0	24	0	0	5	0	0	0	0	0	0	0	-	1	30	2.02
Lesser Black-backed Gull	0	1	0	0	0	0	0	0	0	0	0	0	-	0	1	0.07
Great Black-backed Gull	1	29	1	1	0	0	0	0	0	0	0	2	-	0	34	2.29
Royal Tern	0	0	0	0	0	0	0	0	3	0	0	0	-	0	3	0.20
Purple Martin	0	0	0	0	0	0	0	0	0	20	0	0	-	0	20	1.35
Song Sparrow	0	0	0	1	0	0	0	0	0	0	0	0	-	0	1	0.07
Common Grackle	0	0	0	1	0	0	0	0	0	0	0	0	-	0	1	0.07
TOTAL	**73**	**1,231**	**27**	**27**	**46**	**10**	**8**	**3**	**8**	**24**	**17**	**6**	**-**	**5**	**1,485**	**100.0**

Table 5. Post-contruction Raw Counts of Species Observed in the Survey Area per Survey

Species	Jan	Feb	Feb	Mar	Apr	May	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	% of Total
Red-throated Loon	0	-	-	0	-	-	-	0	-	0	0	-	1	-	1	0.41
Common Loon	0	-	-	45	-	-	-	0	-	0	0	-	0	-	45	18.37
Wilson's Storm-petrel	0	-	-	0	-	-	-	0	-	9	2	-	0	-	11	4.49
Northern Gannet	58	-	-	9	-	-	-	0	-	0	0	-	14	-	81	33.06
Great Blue Heron	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
Great Egret	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
Dovekie	43	-	-	0	-	-	-	0	-	0	0	-	0	-	43	17.55
Razorbill	15	-	-	0	-	-	-	0	-	0	0	-	0	-	15	6.12
Bonaparte's Gull	3	-	-	0	-	-	-	0	-	0	0	-	0	-	3	1.22
Laughing Gull	0	-	-	1	-	-	-	0	-	0	0	-	0	-	1	0.41
Ring-billed Gull	0	-	-	0	-	-	-	0	-	0	0	-	2	-	2	0.82
Herring Gull	6	-	-	2	-	-	-	0	-	0	4	-	8	-	20	8.16
Great Black-backed Gull	7	-	-	0	-	-	-	0	-	0	0	-	6	-	13	5.31
Common Tern	0	-	-	0	-	-	-	0	-	3	0	-	0	-	3	1.22
Barn Swallow	0	-	-	0	-	-	-	0	-	1	0	-	0	-	1	0.41
Gray Catbird	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
Palm Warbler	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
Unidentified Passerine	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
Unknown	0	-	-	0	-	-	-	0	-	0	1	-	0	-	1	0.41
TOTAL	**132**	-	-	**57**	-	-	-	**0**	-	**13**	**12**	-	**31**	-	**245**	**100.0**

3.2 Densities

Winter (Jan–Mar) represented the greatest density estimates for pre- and post-construction surveys with the early February pre-construction survey having the greatest estimated Survey Area density of 53.2 ± 20.2 birds/km^2 followed by the post-construction January survey (31.5 ± 7.0 birds/km^2) and the March survey (13.3 ± 6.2 birds/km^2) (Figure 2, Table 5). Spring (Apr–Jun) had the lowest overall density estimates with a maximum density of 1.9 ± 0.9 birds/km^2 during pre-construction surveys and a density of 0.0 birds/km^2 during the single spring (Jun) post-construction survey (Figure 2, Table 5).

Across all surveys, bird cluster size (number of individuals observed together) was expected to be 3.01 birds/cluster. Considering estimated cluster size per survey, pre-construction surveys had a greater expected cluster size (average 3.2 ± 1.6 birds/cluster/survey) compared to post-construction surveys (average 1.7 ± 0.5 birds/cluster/survey). The early February survey during pre-construction monitoring had the greatest expected cluster size with 22.3 birds/cluster/survey, and all other surveys had an expected cluster size of less than 4 birds/cluster/survey (Figure 3).

3.3 Behavior and Flight Height

There were no observed spatial patterns in flight heights within the Survey Area (Figure 4). Of 245 birds observed during post-construction surveys, 50.2% were in flight (n = 123) (Table 6). The greatest number of flying birds occurred during the January survey (n = 62) (Table 6, Appendix A) with Northern Gannet accounting for 43.1% of birds in flight (n = 53) (Table 7). The greatest proportion of birds observed in flight were observed during the August survey (100.0%) (Table 6). Flight heights (n = 123) ranged from 1 to 200 m above sea level (unknown bird species); however, of all flying birds, 98.3% (n = 121) were observed at heights less than 30 m (Figure 5, Table 7, Appendix A). Considering all six post-construction surveys, mean flight height was 12.3 m above sea level and the overall median flight height was 10 m (Table 6, Figure 5). Pre-construction survey flight heights were reported in flight-height bands. After similarly binning post-construction flight heights into flight-height bands, there was little difference between pre- and post-construction flight heights within the Survey Area (Figure 6). Appendix A presents flight height information for each individual bird encountered. The CVOW Pilot swept zone (RSZ) is between 33 and 189 meters above sea level. There were 123 in-flight observations during the post-construction surveys, 121 observations were below the RSZ, 1 observation above the RSZ and 1 observation within the RSZ. This represents 98% of all in flight observations within the lease area were at or below 30 meters.

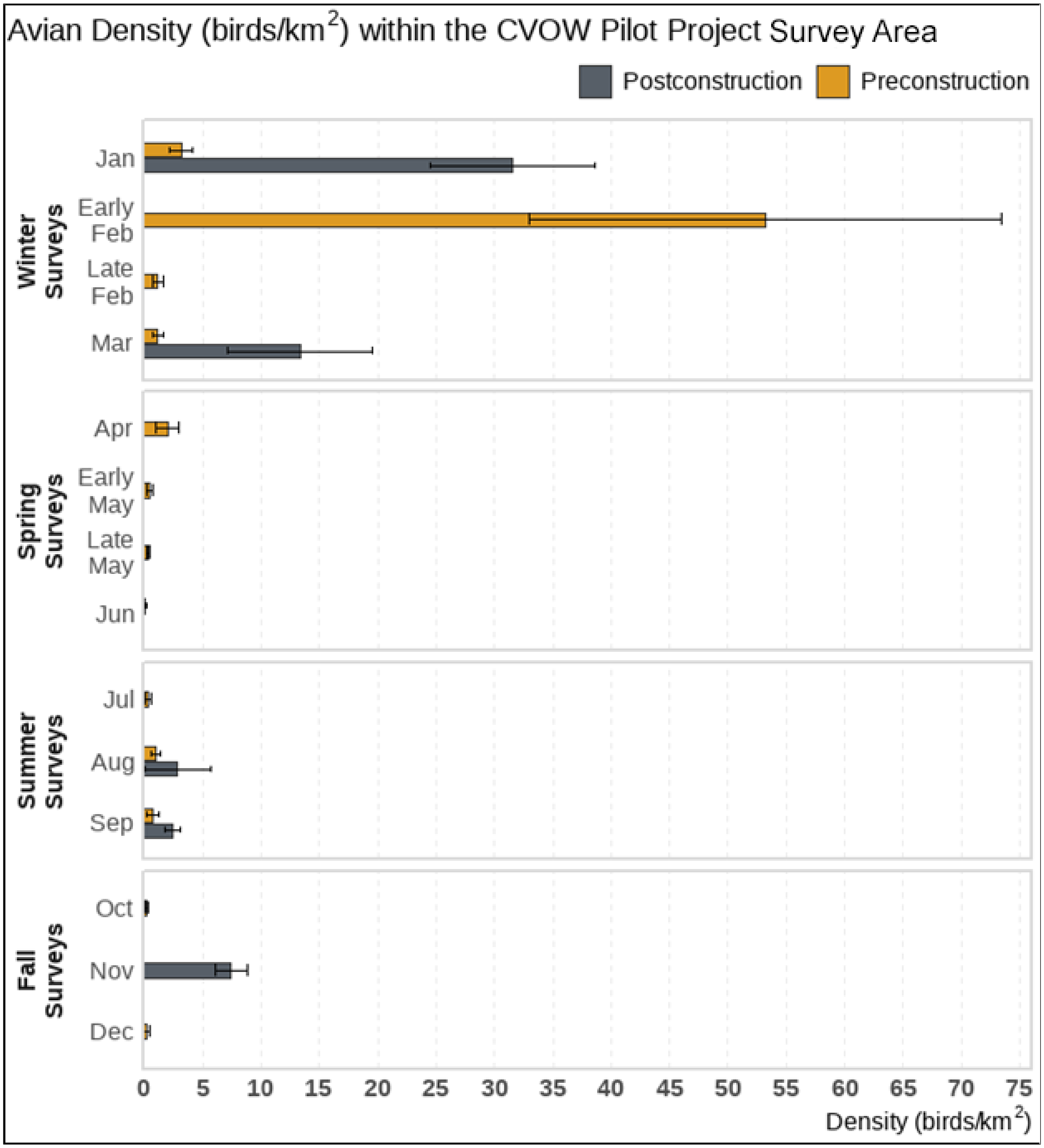

Figure 2. Seasonal density estimates (mean birds/km^2 and SE) from boat-based distance sampling surveys.

Table 5. Distance Analysis Results for Boat-based Surveys Showing Estimated Survey Area Abundance and Density (birds/km²)

The number of observed birds were first corrected to the number of expected birds using the average detection probability (p) derived from the distance analysis. Four observations lacked distance data and were omitted from the distance analysis.

Type	Survey	Survey Area (km²)	Survey Effort (km²)	Detection Probability (p)	Observed Individuals	Estimated Survey Area Abundance (birds/survey)	SE	Estimated Survey Area Density (birds/km²)	SE
Post	January	62.6	26.7	0.15	132	1,972.4	442.3	31.5	7.0
Post	March	62.6	26.7	0.15	56	836.7	388.3	13.3	6.2
Post	June	62.6	26.7	0.15	0	0.0	0.0	0.0	0.0
Post	August	62.6	26.7	0.15	12	179.3	173.7	2.8	2.7
Post	September	62.6	26.7	0.15	10	149.4	40.6	2.3	0.6
Post	November	62.6	26.7	0.15	31	463.2	86.0	7.3	1.3
Pre	January	62.6	26.7	0.86	73	197.5	64.6	3.1	1.0
Pre	Early February	62.6	26.7	0.86	1,231	3,330.6	1,268.6	53.2	20.2
Pre	Late February	62.6	26.7	0.86	27	73.0	30.4	1.1	0.4
Pre	March	62.6	26.7	0.86	27	73.0	26.8	1.1	0.4
Pre	April	62.6	26.7	0.86	46	124.4	59.1	1.9	0.9
Pre	Early May	62.6	26.7	0.86	10	27.0	15.8	0.4	0.2
Pre	Late May	62.6	26.7	0.86	8	21.6	8.3	0.3	0.1
Pre	June	62.6	26.7	0.86	3	8.1	3.6	0.1	0.05
Pre	July	62.6	26.7	0.86	8	21.6	14.0	0.3	0.2
Pre	August	62.6	26.7	0.865	24	64.9	25.3	1.0	0.4
Pre	September	62.6	26.7	0.865	17	45.9	29.9	0.7	0.4
Pre	October	62.6	26.7	0.865	6	16.2	7.3	0.2	0.1
Pre	December	62.6	26.7	0.865	5	13.5	13.1	0.21	0.2

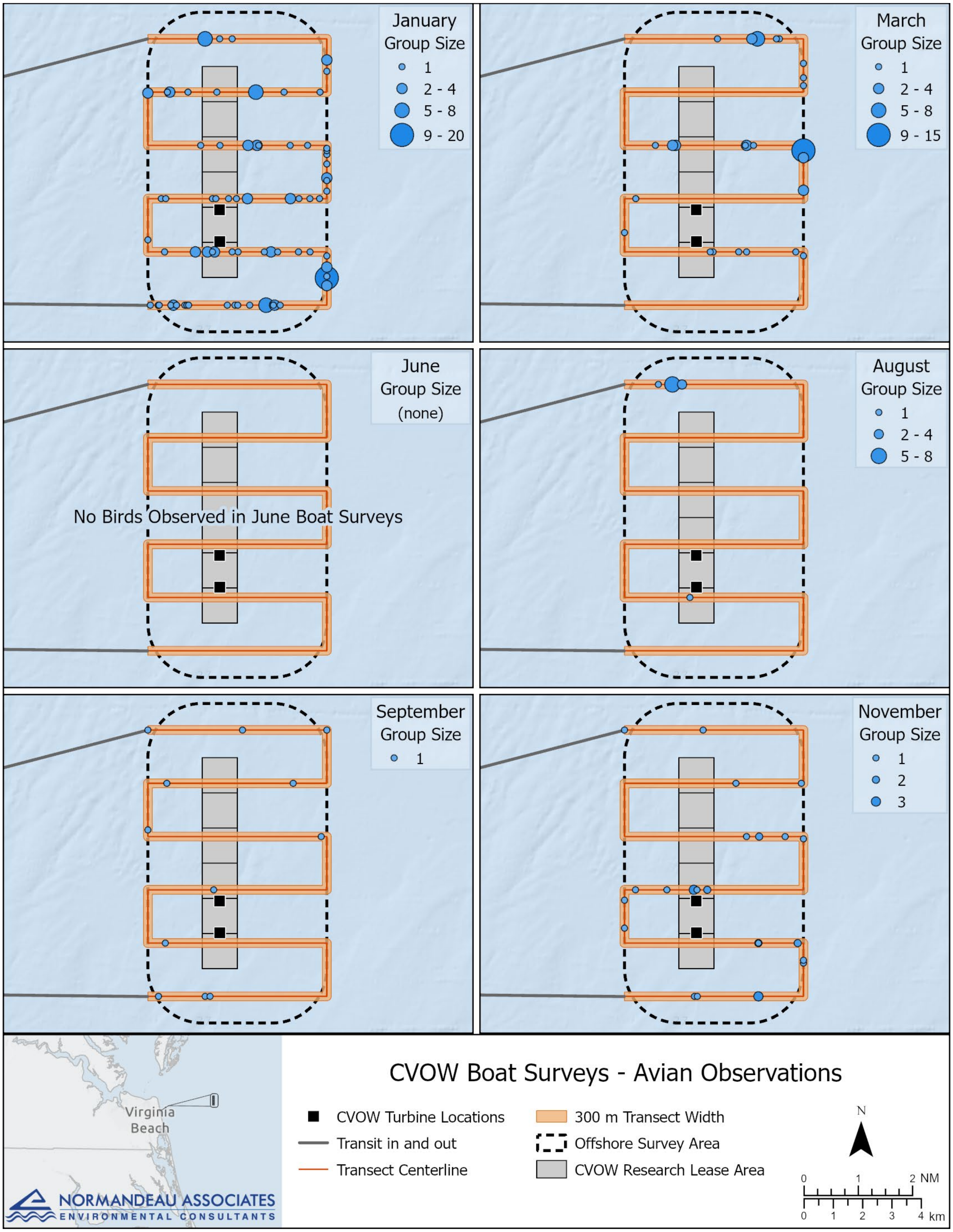

Figure 3. Distribution and abundance of bird observations during post-construction boat-based surveys.

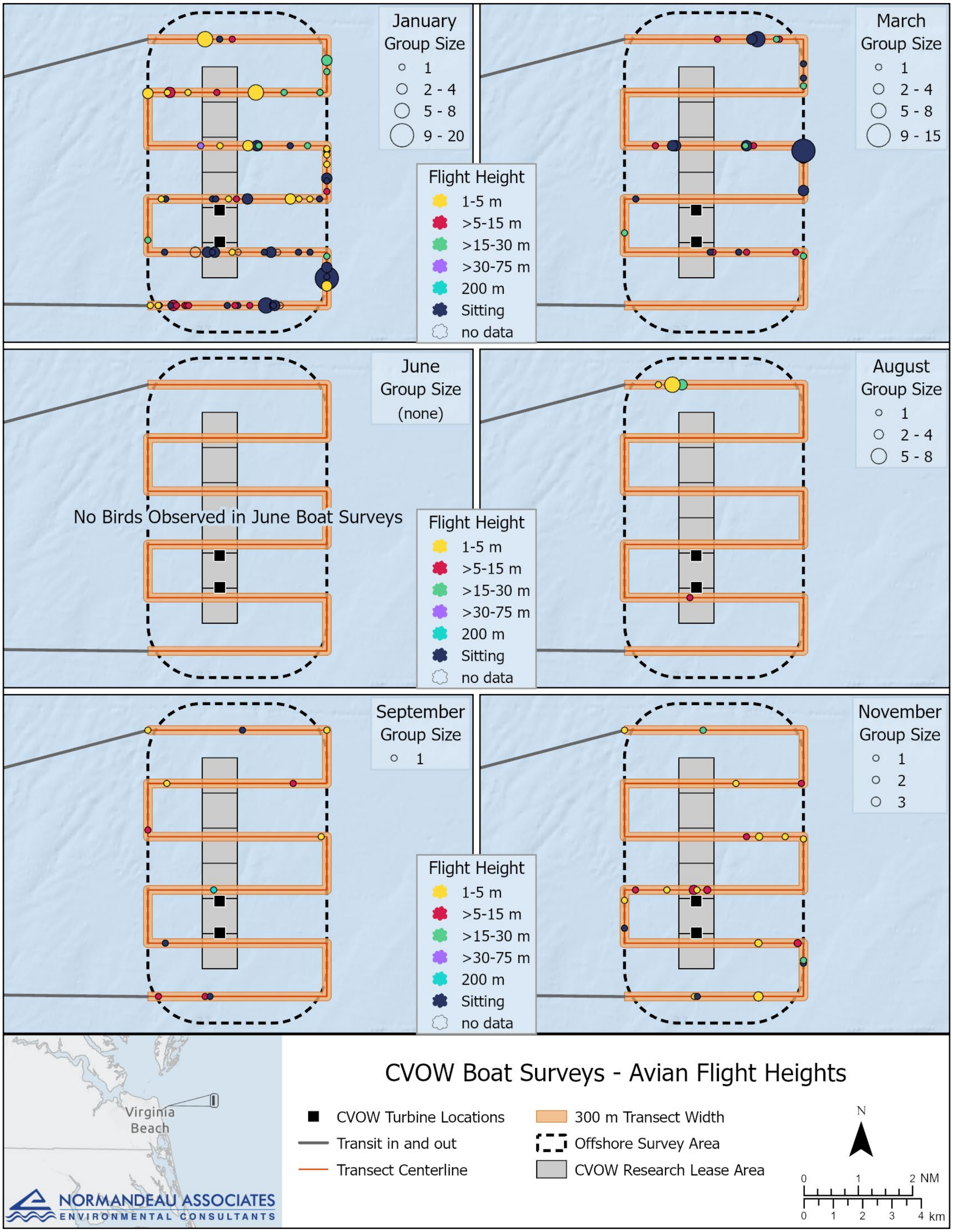

Figure 4. Spatial distribution of birds observed in flight during post-construction surveys.

Table 6. Summary of Birds in Flight vs Sitting during Post-construction Surveys

Survey	Total Birds Observed	Total Birds in Flight	Proportion Birds in Flight	Mean Flight Height (m)	Median Flight Height (m)
January	132	62	46.9%	11.1	9.0
March	57	12	21.0%	15.5	15.0
June	0	0	0.0%	0.0	0.0
August	13	13	100.0%	10.5	5.5
September	12	9	75.0%	6.2	2.0
November	31	27	87.0%	27.1	8.0
Total	**245**	**123**	**50.2%**	**12.3**	**10.0**

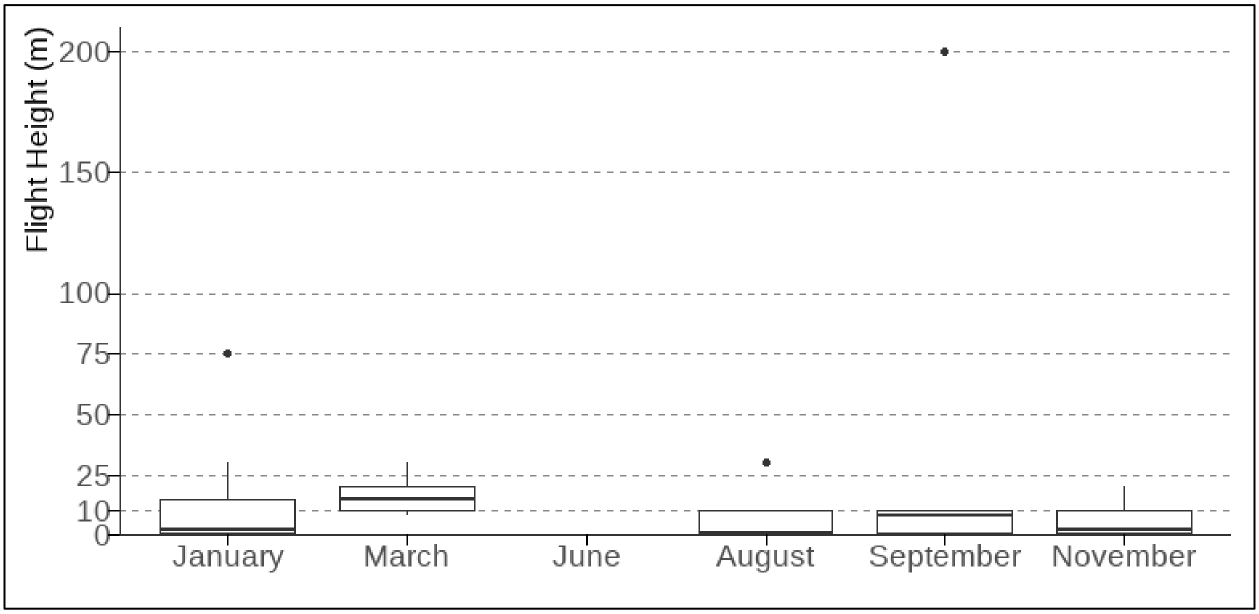

Figure 5. Boxplot distribution of flight heights during post-construction surveys. Dark horizontal lines represent the median flight height value for each survey.

Table 7. Number of Individuals and Minimum, Maximum, Mean, and Median Flight Heights Encountered during Post-construction Surveys

Common Name	No. Individuals	Min	Max	Mean	Median	Standard Error Mean
Common Loon	1	10	10	10.00	10	NA
Wilson's Storm-petrel	11	1	1	1.00	1	0.00
Northern Gannet	53	1	30	10.57	10	1.34
Great Blue Heron	1	10	10	10.00	10	NA
Great Egret	1	5	5	5.00	5	NA
Dovekie	8	1	2	1.13	1	0.13
Razorbill	11	1	2	1.27	1	0.14
Bonaparte's Gull	3	3	10	7.67	10	2.33
Laughing Gull	1	8	8	8.00	8	NA
Ring-billed Gull	2	10	10	10.00	10	0.00

Common Name	No. Individuals	Min	Max	Mean	Median	Standard Error Mean
Herring Gull	16	1	75	12.38	10	4.38
Great Black-backed Gull	9	1	30	12.89	10	4.11
Common Tern	3	30	30	30.00	30	0.00
Barn Swallow	1	10	10	10.00	10	NA
Unidentified Passerine	1	1	1	1.00	1	NA
unknown	1	200	200	200.00	200	NA

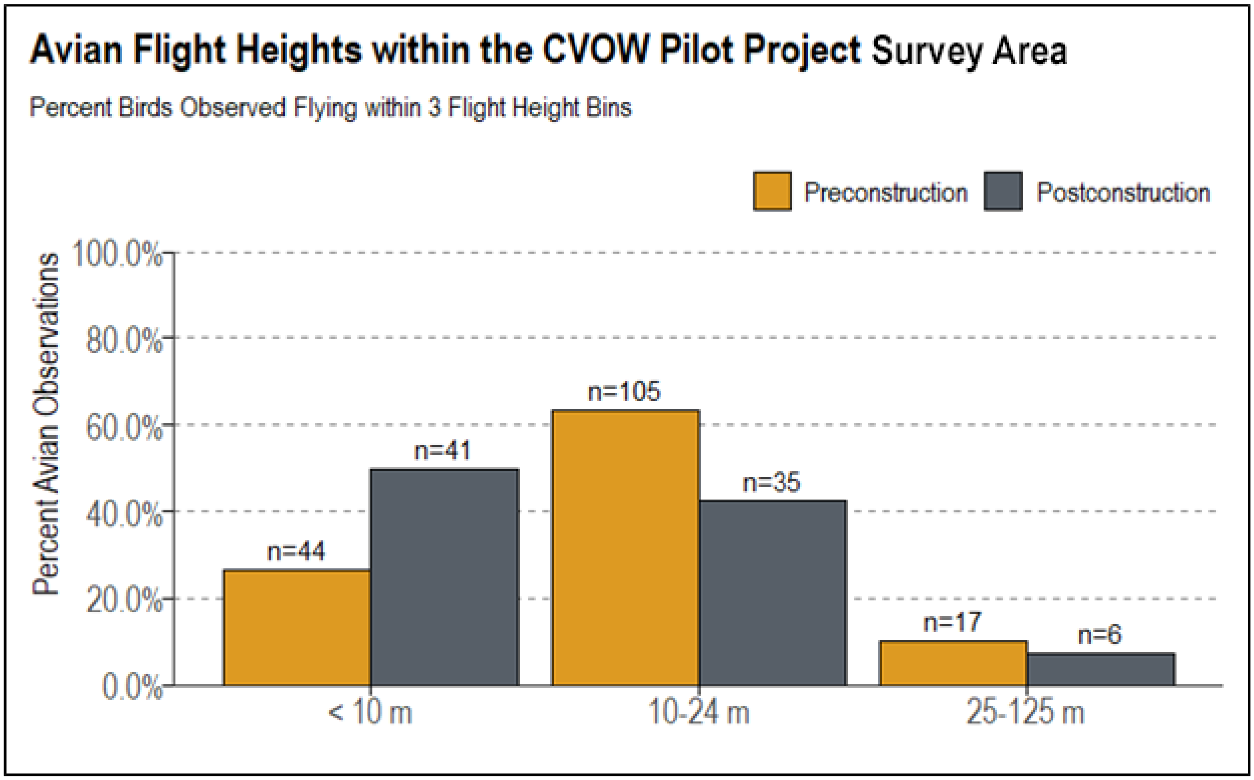

Figure 6. Pre-construction and post-construction flight heights within the CVOW Survey Area.

3.4 Flight Direction

Within the Survey Area, only four species had five or more observations in flight where flight direction was directional and not omnidirectional: Northern Gannet, Dovekie, Razorbill, and Herring Gull (*Larus argentatus*). Of the 81 Northern Gannets observed during 2021 (Table 4), 65% (n = 53) were flying (Table 7) with 49% (n = 26) having directional flight, 65% (n = 17) of which were flying in a north-south direction and the remaining 17% (n = 9) flying east or west (Figure 7). Of the 43 Dovekie observed (Table 4), 19% (n = 8) were flying (Table 7) with 87.5% (n = 7) of those flying directionally, 71% (n = 5) of which were flying to the east (Figure 8). Of the 15 Razorbill observed during 2021 (Table 4), 73% (n = 11) were observed flying (Table 7), all of which had directional flight with 64% (n = 7) traveling to the west (Figure 9). Of the 20 Herring Gulls observed (Table 4), 80% (n = 16) were in flight (Table 7) with 44% (n = 7) traveling in directional flight (Figure 10) and 56% (n = 9) showing no directional flight.

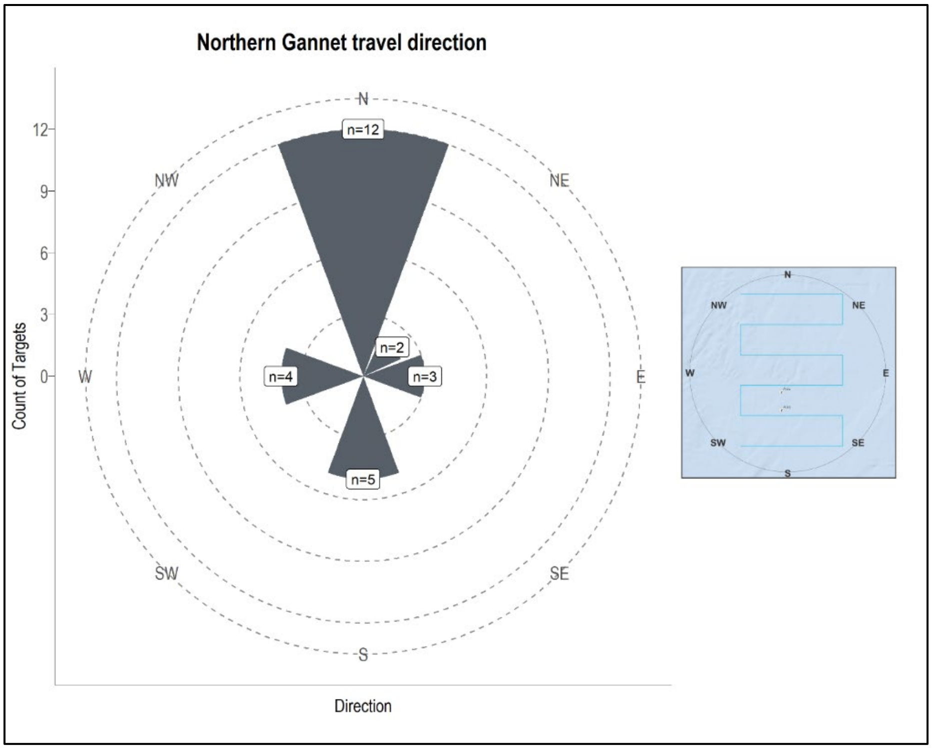

Figure 7. **Frequency of Northern Gannet flight directions within the Survey Area during post-construction surveys.**

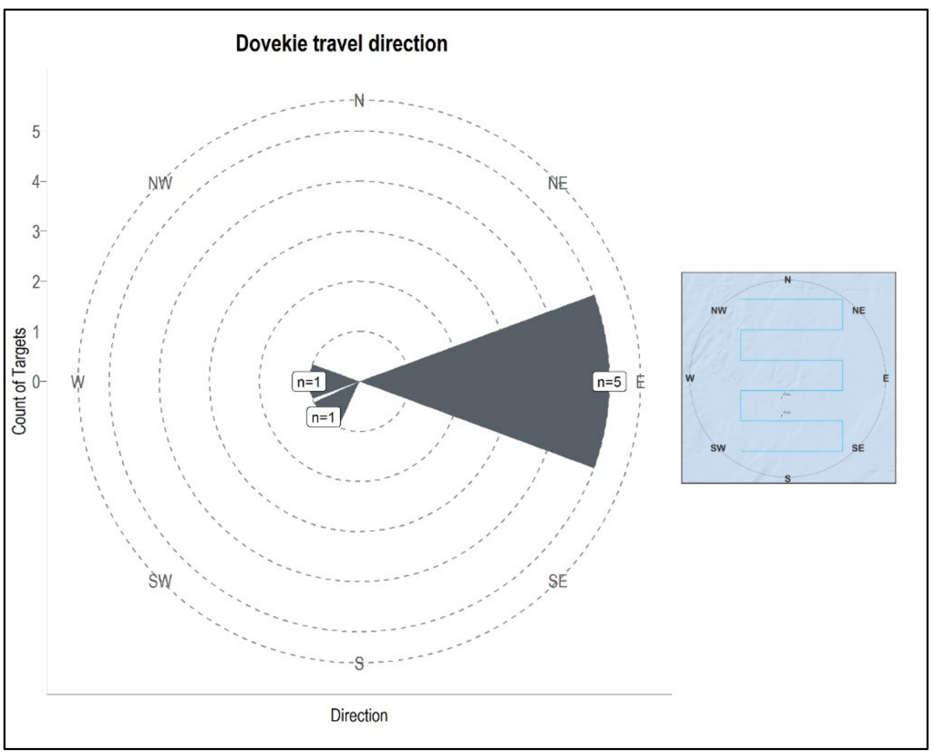

Figure 8. **Frequency of Dovekie flight directions within the Survey Area during post-construction surveys.**

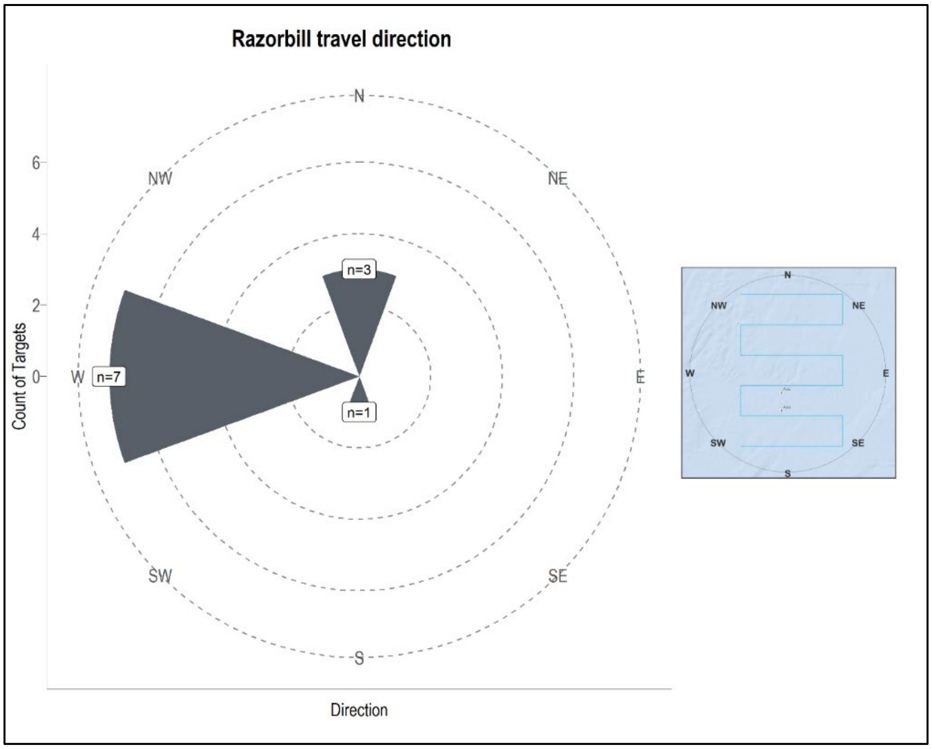

Figure 9. Frequency of Razorbill flight directions within the Survey Area during post-construction surveys.

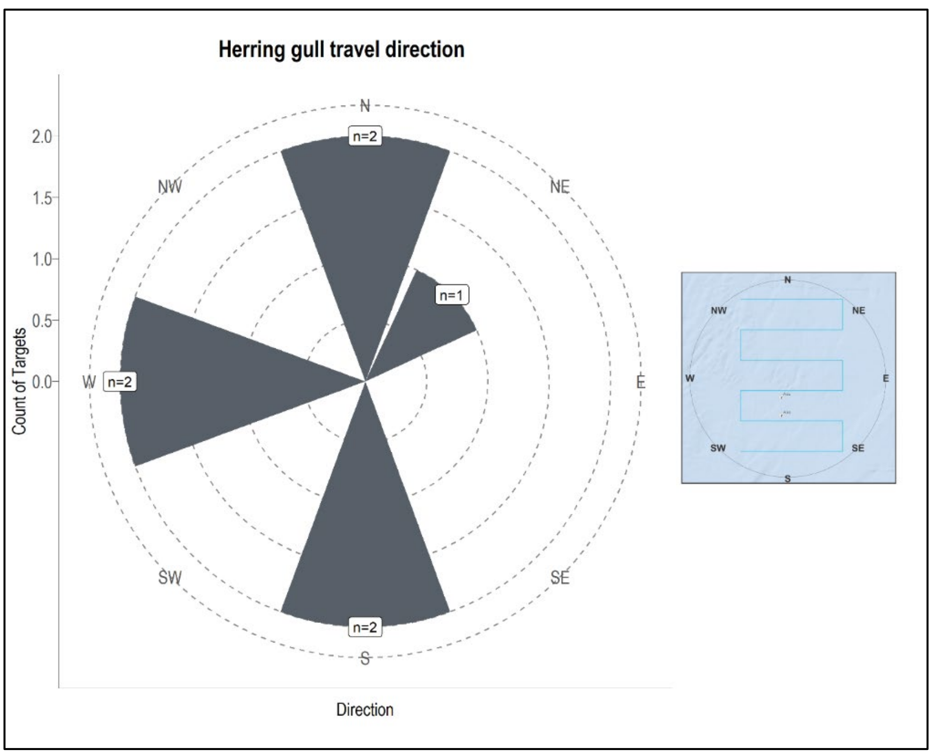

Figure 10. Frequency of Herring Gull flight directions in the Survey Area during post-construction surveys.

4 Discussion

During analysis of the post-construction surveys, the team was initially looking for patterns in behavior or distribution that could be compared with the results of the pre-construction surveys. Several factors affect the statistical power of the data:

- The pre-construction survey spanned a single year and contained 13 surveys. There is evidence that a single year of data cannot account for naturally occurring interannual variations in counts, particularly for seabirds that may quickly move to maximize foraging opportunities influenced by a variety of factors including tides and shifting temperatures and currents, underwater predators, and fishing bycatch discards (Camphuysen et al. 2004; Goyert et al. 2016). Additionally, there was a temporal separation of seven years between the one-year pre-construction study and the post-construction surveys, which spanned a single year and comprised only six surveys. The large temporal difference in surveys limits our ability to make meaningful conclusions about the influence of the CVOW Pilot Project turbines on bird species composition and abundance.
- As with all visual surveys, data have inherent observer biases. Observer biases include differences in accurately recording flight heights and/or distance from the survey vessel (Borkenhagen et al. 2018). Larger, whiter birds can be successfully identified at a greater distance than smaller, darker birds. For example, the postconstruction surveys encountered 43 Dovekie (post-construction survey median distance from boat 10 m) and 15 Razorbill (postconstruction median distance from boat 50 m). These two species need to be closer to the boat for successful identification than larger, whiter birds such as Northern Gannet, which had a higher encounter rate in the pre-construction surveys (n = 1,219) than in the post-construction surveys (n = 81) with the preconstruction median distance from the boat within the 101 m to 200 m distance bin. The presence of many larger birds in the pre-construction surveys shifted the mean detection distance further from the boat compared to the post-construction surveys.
- We recorded flight heights when birds were closest to the boat to get the most accurate flight height information. Species such as gannets and gulls are often attracted to vessels (Camphuysen et al. 2004), thus their flight behavior and associated flight heights are not representative of their natural undisturbed behavior.

Flight height information collected during these surveys adds to our general knowledge of bird flight heights, which might potentially be useful for collision risk assessments. During the pre-construction survey, flight heights were binned into flight-height bands whereas in the post-construction surveys they were given unique values. For the post-construction flight height in comparison to the RSZ, which reaches from 33 to 189 meters above sea level, 98% of all in flight observations within the lease area were flying outside the RSZ, 1 observation was within and 1 above the RSZ. When reviewing flight altitudes collected during the post-construction surveys, it is important to note that all flight height values were collected during the daytime and in the confined weather conditions of up to ≤Beaufort 3: wind speed of 3.4–5.5 m/s (7–10 knots) and wave height of 0.6 m–1.2 m (2 ft–4 ft).

Based on the data collected and the caveats above, there does not appear to be strong evidence of either attraction or displacement within the Survey Area. Birds were largely distributed uniformly within the survey transects (Figure 3). Additionally, the Survey Area had low-density occupation in general, and several surveys that recorded fewer than 10 individuals across the entire Survey Area.

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Appendix A: 2021 Flight Height Information

2021 Flight Height Information for Individuals Seen within the CVOW Survey Area

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Common Loon	1	10	March
Wilson's Storm-petrel	8	1	August
Wilson's Storm-petrel	1	1	August
Wilson's Storm-petrel	1	1	September
Wilson's Storm-petrel	1	1	September
Northern Gannet	1	1	January
Northern Gannet	1	1	January
Northern Gannet	4	1	January
Northern Gannet	1	1	January
Northern Gannet	7	1	January
Northern Gannet	1	3	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	15	January
Northern Gannet	1	15	January
Northern Gannet	1	15	January
Northern Gannet	2	15	January
Northern Gannet	1	15	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	25	January
Northern Gannet	4	30	January
Northern Gannet	1	8	March
Northern Gannet	1	10	March
Northern Gannet	1	10	March
Northern Gannet	1	15	March
Northern Gannet	1	15	March
Northern Gannet	1	20	March
Northern Gannet	1	20	March
Northern Gannet	1	20	March
Northern Gannet	1	30	March
Northern Gannet	2	1	November
Northern Gannet	1	1	November

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	1	3	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	2	15	November
Great Blue Heron	1	10	September
Great Egret	1	5	September
Dovekie	1	1	January
Dovekie	1	1	January
Dovekie	2	1	January
Dovekie	1	1	January
Dovekie	1	1	January
Dovekie	1	1	January
Dovekie	1	2	January
Razorbill	3	1	January
Razorbill	5	1	January
Razorbill	1	2	January
Razorbill	2	2	January
Bonaparte's Gull	1	3	January
Bonaparte's Gull	2	10	January
Laughing Gull	1	8	March
Ring-billed Gull	2	10	November
Herring Gull	1	8	January
Herring Gull	1	10	January
Herring Gull	1	10	January
Herring Gull	1	15	January
Herring Gull	1	75	January
Herring Gull	1	20	March
Herring Gull	3	1	November
Herring Gull	1	1	November
Herring Gull	3	10	November
Herring Gull	1	8	September
Herring Gull	1	8	September
Herring Gull	1	10	September
Great Black-backed Gull	1	2	January

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Great Black-backed Gull	1	30	January
Great Black-backed Gull	1	30	January
Great Black-backed Gull	2	1	November
Great Black-backed Gull	1	2	November
Great Black-backed Gull	1	10	November
Great Black-backed Gull	1	20	November
Great Black-backed Gull	1	20	November
Common Tern	3	30	August
Barn Swallow	1	10	August
Unidentified Passerine	1	1	September
unknown	1	200	September

2021 Flight Height Information for Individuals Seen in Transit To and From the CVOW Survey Area

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Canada Goose	13	75	September
Surf Scoter	1	2	November
Black Scoter	3	1	January
Black Scoter	3	2	January
Black Scoter	7	5	January
Black Scoter	1	5	January
Black Scoter	12	5	September
Unidentified Scoter	22	40	November
Unidentified Scoter	1	1	November
Hooded Merganser	4	30	January
Red-breasted Merganser	4	40	November
Red-breasted Merganser	7	100	November
Red-throated Loon	7	5	January
Red-throated Loon	3	10	January
Red-throated Loon	1	10	January
Red-throated Loon	1	10	January
Red-throated Loon	1	15	January
Red-throated Loon	3	15	January
Red-throated Loon	5	20	January
Red-throated Loon	1	20	January
Red-throated Loon	2	20	January
Red-throated Loon	2	20	January
Red-throated Loon	1	20	January

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Red-throated Loon	1	20	January
Red-throated Loon	2	35	January
Red-throated Loon	1	10	March
Red-throated Loon	1	20	March
Red-throated Loon	2	1	November
Red-throated Loon	2	1	November
Red-throated Loon	1	1	November
Common Loon	1	10	January
Common Loon	1	20	January
Unidentified Loon	1	10	January
Great Shearwater	1	10	January
Wilson's Storm-petrel	1	1	September
Northern Gannet	1	1	January
Northern Gannet	2	2	January
Northern Gannet	2	2	January
Northern Gannet	1	5	January
Northern Gannet	2	8	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	1	10	January
Northern Gannet	3	10	January
Northern Gannet	6	10	January
Northern Gannet	2	15	January
Northern Gannet	1	15	January
Northern Gannet	1	15	January
Northern Gannet	2	15	January
Northern Gannet	1	15	January
Northern Gannet	1	15	January
Northern Gannet	1	20	January
Northern Gannet	2	20	January
Northern Gannet	1	20	January

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Northern Gannet	2	20	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	20	January
Northern Gannet	1	25	January
Northern Gannet	1	25	January
Northern Gannet	1	30	January
Northern Gannet	1	30	January
Northern Gannet	1	30	January
Northern Gannet	1	30	January
Northern Gannet	1	30	January
Northern Gannet	1	30	January
Northern Gannet	2	30	January
Northern Gannet	6	30	January
Northern Gannet	1	40	January
Northern Gannet	1	40	January
Northern Gannet	200	50	January
Northern Gannet	1000	50	January
Northern Gannet	2	50	January
Northern Gannet	2	60	January
Northern Gannet	2	60	January
Northern Gannet	2	60	January
Northern Gannet	1	1	March
Northern Gannet	1	10	March
Northern Gannet	2	10	March
Northern Gannet	3	10	March
Northern Gannet	1	10	March
Northern Gannet	1	15	March
Northern Gannet	1	20	March
Northern Gannet	1	20	March
Northern Gannet	2	20	March
Northern Gannet	1	30	March
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	2	1	November
Northern Gannet	1	1	November
Northern Gannet	1	1	November

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Northern Gannet	2	1	November
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	1	1	November
Northern Gannet	1	2	November
Northern Gannet	1	2	November
Northern Gannet	1	3	November
Northern Gannet	1	4	November
Northern Gannet	2	4	November
Northern Gannet	1	5	November
Northern Gannet	1	5	November
Northern Gannet	10	5	November
Northern Gannet	1	8	November
Northern Gannet	2	8	November
Northern Gannet	1	8	November
Northern Gannet	4	8	November
Northern Gannet	30	9	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	2	10	November
Northern Gannet	4	10	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	2	10	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	2	10	November
Northern Gannet	1	10	November
Northern Gannet	1	10	November
Northern Gannet	3	10	November
Northern Gannet	1	12	November
Northern Gannet	1	15	November
Northern Gannet	1	15	November
Northern Gannet	1	15	November
Northern Gannet	1	15	November
Northern Gannet	2	15	November

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Northern Gannet	2	15	November
Northern Gannet	2	15	November
Northern Gannet	4	15	November
Northern Gannet	25	15	November
Northern Gannet	3	19	November
Northern Gannet	2	20	November
Northern Gannet	3	20	November
Northern Gannet	1	20	November
Northern Gannet	2	20	November
Northern Gannet	2	20	November
Northern Gannet	1	20	November
Northern Gannet	3	20	November
Northern Gannet	3	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	3	20	November
Northern Gannet	1	20	November
Northern Gannet	1	20	November
Northern Gannet	3	20	November
Northern Gannet	50	20	November
Northern Gannet	30	30	November
Northern Gannet	1	30	November
Northern Gannet	3	30	November
Northern Gannet	1	30	November
Northern Gannet	1	30	November
Northern Gannet	4	40	November
Northern Gannet	2	80	November
Double-crested Cormorant	1	10	January
Double-crested Cormorant	1	1	November
Double-crested Cormorant	12	3	November
Brown Pelican	1	1	September
Brown Pelican	1	1	September
Brown Pelican	1	1	September
Brown Pelican	2	1	September

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Brown Pelican	9	5	September
Great Blue Heron	1	10	September
Great Egret	1	1	September
Great Egret	1	15	September
Great Egret	3	30	September
Unidentified Jaeger	1	3	November
Dovekie	1	1	January
Dovekie	1	5	January
Dovekie	2	30	January
Razorbill	2	1	January
Razorbill	1	1	January
Razorbill	2	1	January
Razorbill	1	1	January
Razorbill	2	1	January
Razorbill	2	1	January
Razorbill	1	1	January
Razorbill	3	1	January
Razorbill	3	1	January
Razorbill	4	3	January
Razorbill	3	5	January
Razorbill	1	5	January
Razorbill	1	3	November
Bonaparte's Gull	3	3	January
Bonaparte's Gull	3	5	January
Bonaparte's Gull	1	10	January
Bonaparte's Gull	3	10	January
Bonaparte's Gull	1	10	January
Bonaparte's Gull	1	10	January
Bonaparte's Gull	2	15	January
Bonaparte's Gull	3	15	January
Bonaparte's Gull	1	15	January
Bonaparte's Gull	1	20	January
Bonaparte's Gull	2	25	January
Bonaparte's Gull	1	30	January
Bonaparte's Gull	1	10	March
Bonaparte's Gull	3	20	March
Bonaparte's Gull	4	1	November
Laughing Gull	1	5	March

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Laughing Gull	1	10	March
Laughing Gull	1	8	November
Laughing Gull	1	10	November
Laughing Gull	1		November
Ring-billed Gull	1	5	January
Ring-billed Gull	1	15	January
Ring-billed Gull	1	20	January
Ring-billed Gull	2	30	January
Ring-billed Gull	1	1	November
Ring-billed Gull	1	10	November
Ring-billed Gull	1	20	November
Herring Gull	1	5	January
Herring Gull	2	10	January
Herring Gull	1	10	January
Herring Gull	1	10	January
Herring Gull	1	10	January
Herring Gull	1	15	January
Herring Gull	1	20	January
Herring Gull	2	25	January
Herring Gull	2	25	January
Herring Gull	1	30	January
Herring Gull	3	60	January
Herring Gull	1	100	January
Herring Gull	1	1	March
Herring Gull	1	5	March
Herring Gull	1	8	March
Herring Gull	4	1	November
Herring Gull	1	1	November
Herring Gull	1	1	November
Herring Gull	1	2	November
Herring Gull	5	3	November
Herring Gull	1	7	November
Herring Gull	2	10	November
Herring Gull	1	10	November
Herring Gull	2	10	November
Herring Gull	1	10	November
Herring Gull	1	10	November
Herring Gull	6	12	November

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Herring Gull	1	20	November
Herring Gull	10	1	September
Herring Gull	5	1	September
Herring Gull	1	1	September
Herring Gull	3	2	September
Herring Gull	1	2	September
Herring Gull	1	3	September
Herring Gull	1	3	September
Herring Gull	1	4	September
Herring Gull	1	4	September
Herring Gull	1	4	September
Herring Gull	1	5	September
Herring Gull	1	5	September
Herring Gull	2	5	September
Herring Gull	1	5	September
Herring Gull	1	5	September
Herring Gull	2	8	September
Herring Gull	2	10	September
Herring Gull	1	10	September
Lesser Black-backed Gull	1	10	November
Great Black-backed Gull	1	10	January
Great Black-backed Gull	2	10	January
Great Black-backed Gull	1	15	January
Great Black-backed Gull	1	20	January
Great Black-backed Gull	1	50	January
Great Black-backed Gull	1	4	November
Great Black-backed Gull	2	5	November
Great Black-backed Gull	1	8	November
Great Black-backed Gull	1	8	November
Great Black-backed Gull	2	10	November
Great Black-backed Gull	1	10	November
Great Black-backed Gull	4	10	November
Great Black-backed Gull	1	10	November
Great Black-backed Gull	1	15	November
Great Black-backed Gull	1	20	November
Great Black-backed Gull	1	20	November
Great Black-backed Gull	2	30	November
Great Black-backed Gull	1	4	September

Common Name	Number of Individuals	Flight Height (m)	Survey Month 2021
Great Black-backed Gull	1	5	September
Great Black-backed Gull	1	8	September
Great Black-backed Gull	2	8	September
Unidentified Gull	2	30	January
Unidentified Gull	4	30	January
Unidentified Gull	1	50	January
Royal Tern	7	5	September
Royal Tern	1	6	September