Avian Ship-based Survey Final Post-Construction Monitoring Report

Block Island Wind Farm, Rhode Island

Stantec

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November 25, 2020

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Block Island Wind Farm (BIWF; Project), owned by Deepwater Wind Block Island, LLC (Deepwater Wind), is located approximately 4.8 kilometers (km; 3 miles [mi]) southeast of the coast of Block Island, Rhode Island (Figure 1-1). Block Island is an approximately 27.0 square km (10.4 square mi) island located approximately 14.9 km (9.3 mi) south of the Rhode Island mainland and 21.9 km (13.6 mi) northeast of the tip of Long Island, New York. The 30-megawatt (MW) BIWF consists of five Haliade 150 6-MW wind turbine generators (WTGs) and a submarine inter-array cable and export cable, which connects the BIWF to a substation on Block Island. The BIWF began commercial operations in December 2016. The maximum rotor-swept height of the BIWF WTGs is 180 meters (m; 591 feet) above water level.

Post-construction avian and bat surveys were required as a condition of the United States Army Corps of Engineers and the Rhode Island Coastal Resources Management Council permits issued for construction of the Project, as outlined in the Project's Construction and Post-Construction Avian and Bat Monitoring Plan (Revised April 2015; Tetra Tech 2015). Deepwater Wind contracted Stantec Consulting Services Inc. (Stantec) to conduct a series of post-construction bird and bat surveys during the first and third years of project operation, in 2017 and 2019 (Y1 and Y3 Operations), including ship-based avian surveys.

This report summarizes methods and results of the two years of post-construction ship-based avian surveys designed to 1) document species composition (diversity), distribution, and density of birds in and adjacent to the BIWF, and 2) assess how the BIWF may affect these same metrics when compared to similar pre-construction phase surveys. The report also includes a reanalysis of pre-construction ship-based avian survey (2009–2010, 2011) results to derive identical metrics from three distinct phases (pre-construction, Y1, and Y3 Operations). Surveys followed similar methods during each period, using transect-based visual observations to enable statistically valid analysis of whether bird diversity, distribution, density, and flight height differed before and after construction of the BIWF.

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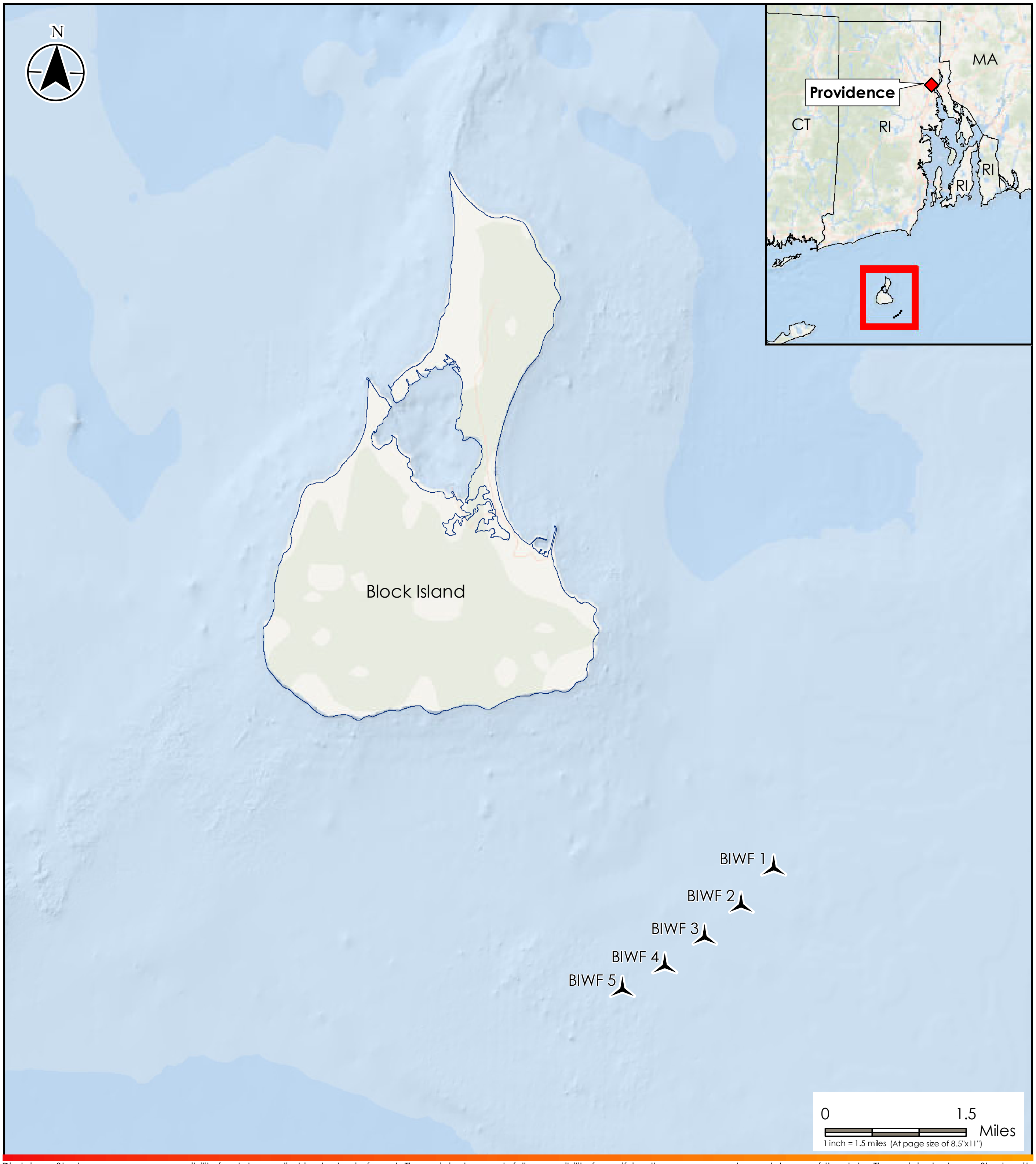

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Legend

⅄ BIWF Turbine Location

Client/Project

Deepwater Wind Block Island, LLC
Block Island Wind Farm
Block Island, Rhode Island

Figure No.

1-1

Title

Block Island
Wind Farm (BIWF)

6/22/2020

2.0 METHODS

2.1 FIELD SURVEY

Methods for the Y1 and Y3 Operations ship-based avian surveys were developed to be comparable to pre-construction methods as outlined in the BIWF Construction and Post-Construction Avian and Bat Monitoring Plan (Tetra Tech 2015). The pre-construction methods were based on standard distance sampling techniques (Thomas et al. 2006, as cited by Tetra Tech 2015).

Each survey followed a pair of double saw tooth pattern transects established and sampled during pre-construction surveys, Transect 1 (Point A–B) and Transect 2 (Point C–D) (Figure 2-1). Both transects included 25 segments, each of which was approximately 0.6–0.9 mi (0.96–1.5 km) in length, for a total transect length of approximately 16–18 mi (25–28 km). Segments 1 through 6 and 17 through 25 were considered outside the turbine area and Segments 7 through 16 were considered inside the turbine area.[1] The transects extended approximately 9 km (5.6 mi) west of Turbine 5 and approximately 6 km north of Turbine 1.

Stantec conducted 12 rounds of surveys per year during Y1 and Y3 Operations, each of which included a separate survey of the each of the transect pairs described above. During each survey, a pair of avian biologists (one primary observer and one data recorder) completed the paired transect surveys approximately 12 hours apart (e.g., Transect 1 in the afternoon, Transect 2 the following morning)[2]. Surveys occurred at intervals of approximately one visit per month, targeting days when sea conditions were suitable for survey (sea states 1–4 according to the World Meteorological Organization scale).

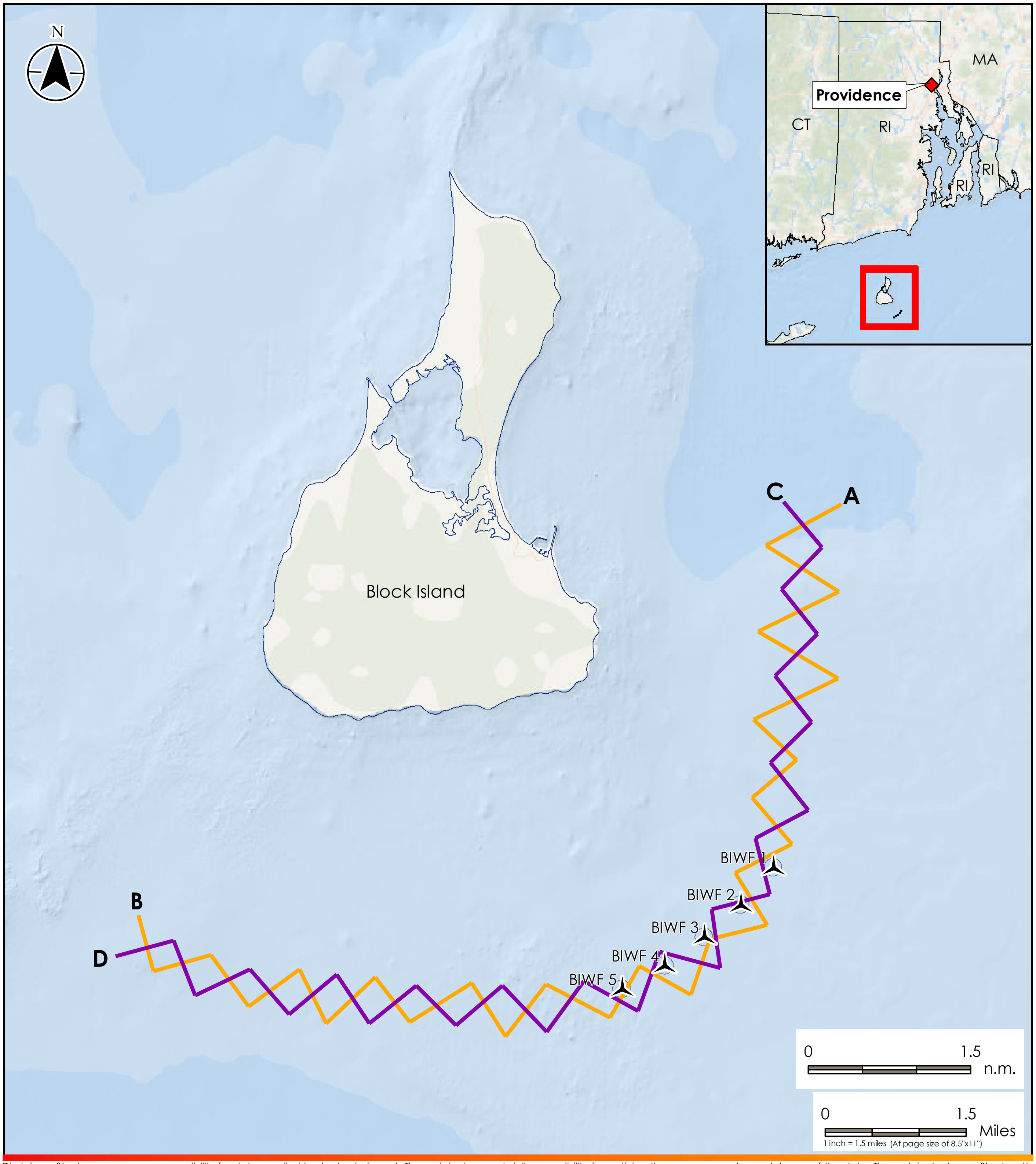
Surveys in Y1 and Y3 Operations were conducted from the F/V Lindsey E, based out of Block Island Harbor, and captained by Mike Ernst. The boat traveled at a constant survey speed of approximately 8 knots (14.8 km/hour). Observers used laser range finders to calibrate their estimates of bird distances on offshore structures such as buoys or the WTGs. Consistent with pre-construction surveys, all birds observed within 300 m in front and to the side of the vessel were recorded (birds observed behind the ship were not recorded). Though not stated in the pre-construction report, this distance was presumably selected because it is the approximate extent at which seabirds can readily be detected, and setting a maximum observation distance also serves to minimize the chances of double counting birds.

[1]Reports summarizing pre-construction (TetraTech and Detect 2012) and Y1 Operations avian surveys (Stantec 2018) considered segments 7, 15, and 16 to be outside the turbine area, although these segments were recategorized as within turbine areas for this final report to include a 1-nautical-mile buffer around the turbines consistent with the Bureau of Ocean Energy Management avian survey guidelines (BOEM 2017), and because potential changes in avian behavior (e.g., avoidance) may occur at greater distances from immediate turbine areas.
[2] The two transects sampled per visit were surveyed during separate days in most cases, although weather and sea conditions occasionally required morning and afternoon surveys to occur during the same day, with as long of a pause period as possible between the two surveys to reduce the opportunity to double count the same birds.

Data were recorded on a handheld tablet equipped with a global positioning system. Birds detected were identified to species level, when possible. Number of individuals (or estimates of individual numbers in the case of large flocks) were also recorded.

For each bird or flock of birds, the observer estimated the distance from ship to the bird(s) (to the nearest 10 m), azimuth of the observed bird(s) from the boat, general direction of flight, flight height category (<10 m, 10–25 m, 26–125 m, 126–200 m, and >200 m), and behavior (flying or sitting on the water). Additional applicable notes (e.g., secondary behaviors, following vessel, turbine interaction) were also recorded.

Detailed weather observations including sea state, air temperature, water temperature, wind speed, and wind direction were recorded at generally 30-minute intervals during the survey as feasible (recording bird observations was prioritized).



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Prepared by GAC on 2016-12-09
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Legend

BIWF Turbine Location

Ship-based Bird Survey Transect

Transect 1

Transect 2

Client/Project

Deepwater Wind, LLC
Block Island Wind Farm
Block Island, Rhode Island

Figure No.

2-1

Title

Ship-based Avian Survey Transects

6/22/2020

2.2 DATA ANALYSIS

Stantec summarized results of avian count data from pre-construction and post-construction phases to generate equivalent metrics of avian diversity, distribution, and density, as described below[3]. To enable comparison of pre-construction and post-construction results, Stantec compiled a single dataset of 'raw' data for all survey years, formatting data so that species groups, transects, survey segments, and segment group assignments were consistent among all survey periods. Stantec compiled and processed using R software (R Core Team 2016), excluding observations marked as double-counts from analyses and also excluding unidentified species groups from calculations of species richness and analyses of diversity. Stantec calculated identical metrics and summary statistics for each survey period (pre-construction, and Y1 and Y3 Operations) to enable statistical comparison of results across periods. We summarized data from Y1 and Y3 Operations separately to assess inter-annual variation in spatial and seasonal distribution of birds, but also aggregated post-construction data for certain tests to determine whether patterns differed between pre-construction and post-construction phases as well as between the three distinct survey periods.

2.2.1 Abundance, Encounter Rates, and Species Richness

To compare bird abundance and encounter rates before and during Project operation, we summarized the total numbers of birds (abundance) observed per species and the number of birds observed per species per survey transect (encounter rates) during each survey period. We also calculated and compared encounter rates for segments inside and outside the turbine area during each phase. We calculated the number of species observed (species richness) per survey period and transect to look for seasonal and spatial patterns in diversity before and during Project operation. Survey effort inside and outside the turbine area varied (more segments were located outside the turbine area), and we generated species accumulation curves (i.e., collector curves) using the R package "Vegan" (Oksanen et al. 2017) to visually represent diversity as a function of survey effort during each phase. We excluded unidentified species categories (e.g., unidentified loon) when calculating species richness. We treated Transects 1 and 2 as independent samples when calculating encounter rates and generating species accumulation curves. We compared overall encounter rates inside (segments 7–16) versus outside (segments 1–6 and 17–25) the turbine area using non-parametric Mann-Whitney-U tests, analyzing encounter rates calculated per month within each survey period (pre-construction, and Y1 and Y3 Operations) and for combined post-construction periods.

2.2.2 Density

We estimated density (birds/km^2) per species, segment, and segment group using R package "Distance" (Miller 2017). Perpendicular distance of birds to the transect (binned at intervals of <50 m, 50–100 m, 101–200 m, 201–300 m and >300 m) was estimated in the field during pre-construction surveys (Tetra Tech and DeTect 2012) and calculated using GIS during post-construction surveys based on estimates of

[3] Pre-construction survey data were reanalyzed to enable direct comparison with results of surveys during Y1 and Y3 Operations; therefore, pre-construction summary metrics in this report do not necessarily match that provided in the pre-construction report by TetraTech and Detect (2012).

distance and azimuth[4] from the ship recorded in the field. Midpoints of perpendicular distance bins were calculated as distance measurements, the number of birds counted per observation were entered as the cluster size, and each survey transect was considered an independent sample. Birds beyond 300 m perpendicular distance from the transect and birds that were determined to be following the survey vessel were omitted from distance analysis. Density estimates for various subsets of data (e.g., species, segment, or segment group) were based on the same detection function, selected from among available models based on lowest Akaike Information Criterion score. The detection function used for all density estimates used a hazard-rate key function with cosine adjustment term, or order 2, and a distance range of 0 to 300 m.

To test whether density of birds was affected by presence/operation of the BIWF, we used non-parametric Kruskall-Wallis tests to compare the density calculated for each species within each segment group (segments 1–6, 7–16, and 17–25), analyzing data separately for each survey period (pre-construction, and Y1 and Y3 Operations) and for combined post-construction periods. For each period, we calculated a single density estimate for each species in each segment group per month, considering months as independent samples. To account for variation in seasonal presence among species, we also performed a second round of Kruskall-Wallis tests for each species using the subset of data from which months with zero observations were removed. To visualize variation in density among segment groups, we also plotted density estimates for each species and segment group using box and whisker plots.

2.2.3 Flight Heights

We calculated the midpoint of each flight height bin estimated in the field (<10 m, 10–25 m, 26–125 m, 126–200 m, >200 m), using 300 m as the midpoint for the highest flight height bin, and calculated the mean midpoint value per species, segment group, and month, weighted by the number of birds counted during each observation. We compared flight heights per segment group and period using visual comparison of box plots of monthly mean height estimates for each species. Birds sitting on the water were excluded from the flight height analyses. When presented, standard errors around means were calculated from 5,000 bootstrapped samples generated using the R package “boot” (Canty and Ripley 2017).

3.0 RESULTS

3.1 SURVEY EFFORT

Stantec conducted 12 rounds of surveys (each consisting of two transects) during Y1 and Y3 Operations, occurring between January and December 2017 and again between February 2019 and January 2020 (Table 3-1). Pre-construction effort included 17 rounds of surveys conducted between July 2009 and September 2011. Surveys occurred approximately monthly, although prolonged adverse sea conditions prevented surveys in October 2017 resulting in two rounds of surveys in November 2017.

[4] In cases where azimuth data were missing, 90-degree azimuth from the transect were assumed.

Table 3-1. Survey effort for ship-based avian surveys during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at Block Island Wind Farm.

Phase	Survey	Transect 1 (Point A–B)	Transect 2 (Point C–D)
Pre-construction	Survey 1	7/16/2009	7/22/2009
	Survey 2	7/31/2009	8/12/2009
	Survey 3	8/18/2009	9/8/2009
	Survey 4	9/15/2009	9/24/2009
	Survey 5	10/1/2009	10/14/2009
	Survey 6	11/9/2009	11/18/2009
	Survey 7	11/19/2009	11/21/2009
	Survey 8	12/7/2009	12/15/2009
	Survey 9	1/14/2010	2/2/2010
	Survey 10	2/3/2010	3/2/2010
	Survey 11	3/19/2010	3/20/2010
	Survey 12	4/7/2010	4/14/2010
	Survey 13	4/21/2010	5/11/2010
	Survey 14	5/26/2010	6/9/2010
	Survey 15	6/24/2010	NA
	Survey 16	8/31/2011	9/20/2011
	Survey 17	9/21/2011	9/21/2011
Y1 Operations	Survey 1	1/30/2017	1/30/2017
	Survey 2	2/21/2017	2/22/2017
	Survey 3	3/30/2017	3/31/2017
	Survey 4	4/18/2017	4/18/2017
	Survey 5	5/23/2017	5/23/2017
	Survey 6	6/27/2017	6/27/2017
	Survey 7	7/18/2017	7/19/2017
	Survey 8	8/15/2017	8/14/2017
	Survey 9	9/14/2017	9/13/2017
	Survey 10*	11/12/2017	11/12/2017
	Survey 11	11/24/2017	11/24/2017
	Survey 12	12/4/2017	12/3/2017

Phase	Survey	Transect 1 (Point A–B)	Transect 2 (Point C–D)
Y3 Operations	Survey 1	2/23/2019	2/22/2019
	Survey 2	3/27/2019	3/28/2019
	Survey 3	4/30/2019	4/29/2019
	Survey 4	5/27/2019	5/27/2019
	Survey 5	6/24/2019	6/25/2019
	Survey 6	7/25/2019	7/24/2019
	Survey 7	8/29/2019	8/29/2019
	Survey 8	9/25/2019	9/25/2019
	Survey 9	10/15/2019	10/14/2019
	Survey 10	11/5/2019	11/4/2019
	Survey 11	12/18/2019	12/12/2019
	Survey 12	1/14/2020	1/14/2020

* No surveys occurred in October 2017 due to prolonged adverse weather and sea conditions; therefore, two rounds of surveys occurred in November 2017.

3.2 ABUNDANCE, SPECIES RICHNESS, AND ENCOUNTER RATES

We observed 3,732 birds representing 21 species (not including unidentified species groups) during Y1 Operations surveys and 1,858 birds representing 28 species during Y3 Operations surveys. Pre-construction surveys documented 6,957 birds representing 32 species (Table 3-2). Sea ducks were the most abundant species group during pre-construction and Y1 Operations and gulls were most abundant during Y3 Operations.

Species richness ranged from 5 to 15 species per month during Y1 and Y3 Operations; most species were observed in December and January during Y1 and Y3 Operations, and December through February during pre-construction surveys (Figure 3-1). Species richness was generally lower among segments within the turbine area compared to adjacent surveyed areas during Y1 and Y3 Operations, whereas species richness was more similar inside and outside the turbine area during pre-construction surveys (Figure 3-2). Species richness collector curves indicated lower overall species richness inside versus outside the turbine area during each period, although this was partially attributable to fewer survey segments inside the turbine area (Figure 3-3). The species accumulation curves increased more slowly, however, for segments inside versus outside the turbine area during Y1 and Y3 Operations. This was not the case pre-construction, indicating that diversity was lower inside the turbine area only during the post-construction survey periods. Overall species richness was also lower during each post-construction survey period compared to pre-construction.

Combining all species (and including unidentified birds), the encounter rate was 217.4 birds per survey during pre-construction surveys, 155.5 birds per survey in Y1 Operations[5] and 77.42 birds per survey in

[5] Note that this report corrects an error in Stantec's interim report on Y1 Operations (Stantec 2018), which incorrectly reported an overall encounter rate of 116.6.

Y3 Operations (Table 3-2). Mean overall encounter rates among months were lower post-construction (mean 35.8 birds per survey combining Y1 and Y3 Operations) than pre-construction (mean = 77.2 birds per survey) according to a Welch's t-test (t (52.606) = -2.597, p = 0.01). Overall decreases in encounter rates were driven largely by decreases in certain species groups including sea ducks, gannets, and loons, although encounter rates of individual species fluctuated between survey periods (Table 3-2). Encounter rates for all bird species groups varied substantially among months during each survey period, although with the exception of a spike in shearwater observations in summer 2017, tended to be higher during mid-winter and late fall (Figure 3-4). Overall encounter rates appeared to be slightly lower for segments inside versus outside the turbine area during Y1 and Y3 Operations (Figure 3-5), although this pattern was not statistically significant during Y1 Operations (W = 78, p = 0.10) or Y3 Operations (W = 104, p = 0.18). Combining Y1 and Y3 Operations periods, encounter rates were significantly lower in the turbine area post-construction (W = 356, p = 0.03). During pre-construction surveys, encounter rates varied substantially among segments, but differences between segments inside and outside the turbine area were not statistically significant (Figure 3-5).

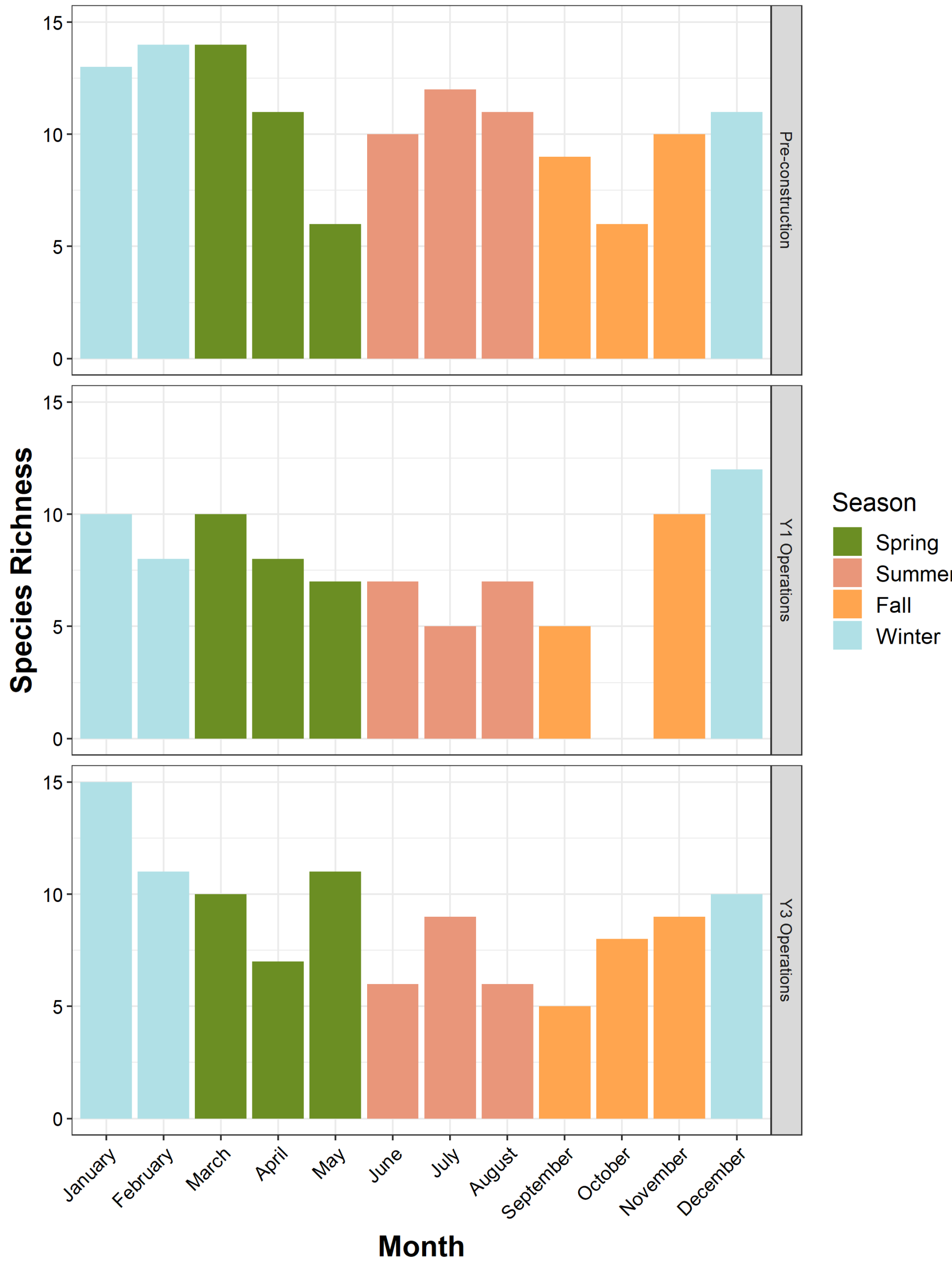

Figure 3-1. Species richness by season and month during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

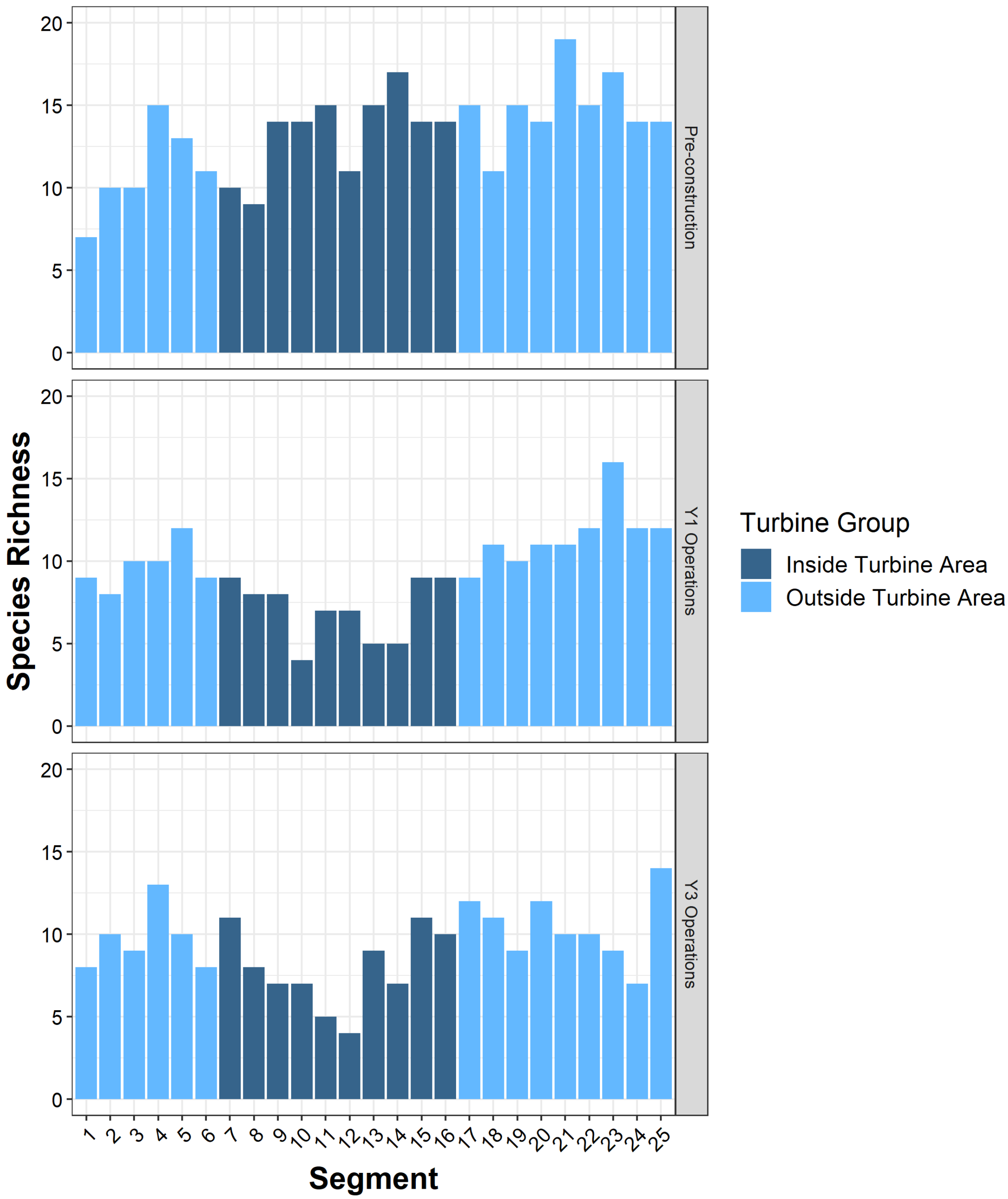

Figure 3-2. Species richness by transect segment during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

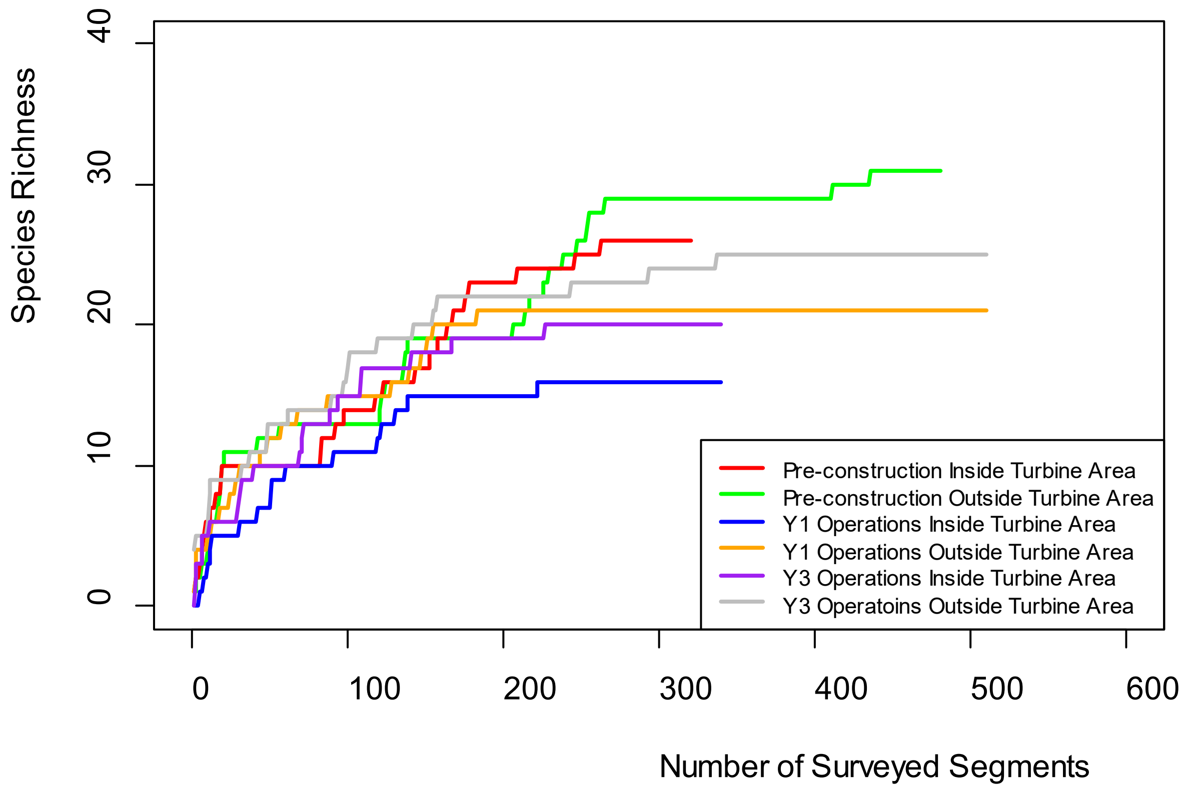

Figure 3-3. Species collector curves for segments inside and outside of turbine area during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

Table 3-2. Number of birds observed and encounter rate (birds observed per survey) by species during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

Species	Pre-construction (2009–2010, 2011)		Y1 Operations (2017)		Y3 Operations (2019)	
	Total birds observed (n)	Encounter Rate (birds per survey)	Total birds observed (n)	Encounter Rate (birds per survey)	Total birds observed (n)	Encounter Rate (birds per survey)
Loons	**578**	**18.06**	**132**	**5.50**	**167**	**6.96**
Red-throated Loon	26	0.81	14	0.58	57	2.38
Common Loon	552	17.25	116	4.83	104	4.33
Unidentified Loon			2	0.08	6	0.25
Grebes					**5**	**0.21**
Red-necked grebe					5	0.21
Shearwaters	**206**	**6.44**	**1,005**	**41.88**	**12**	**0.5**
Cory's Shearwater	29	0.91	213	8.875	4	0.17
Greater Shearwater	98	3.06	176	7.33		
Manx Shearwater	18	0.56			1	0.04
Audubon's Shearwater	9	0.28				
Sooty Shearwater	29	0.91	4	0.17	6	0.25
Unidentified Shearwater	23	0.72	612	25.5	1	0.047
Storm Petrels	**114**	**3.56**	**127**	**5.29**	**16**	**0.67**
Wilson's Storm-petrel	102	3.19	127	5.29	16	0.67
Unidentified Storm-petrel	12	0.38				
Gannet	**866**	**27.06**	**183**	**7.63**	**334**	**13.92**
Northern Gannet	866	27.06	183	7.63	334	13.92
Cormorants	**93**	**2.91**	**4**	**0.17**	**91**	**3.79**
Great Cormorant	14	0.48	4	0.17	16	0.67
Double-crested Cormorant	35	1.09			75	3.13
Unidentified Cormorant	44	1.38				
Sea Ducks	**2,644**	**82.63**	**1,722**	**71.75**	**177**	**7.38**
Common Eider	215	6.72	103	4.29	49	2.04
Long-tailed Duck	6	0.19	7	0.29	2	0.08
Surf Scoter	28	0.88	12	0.50	8	0.33
Black Scoter	947	29.59	1,265	52.71	55	2.29
White-winged Scoter	693	21.66	330	13.75	57	2.38
Unidentified Scoter	382	11.94	2	0.08		
Unidentified Duck	353	11.03			6	0.25
Red-breasted Merganser	20	0.63	3	0.125		
Raptors					**1**	**0.04**
Merlin					1	0.04
Shorebirds	**13**	**0.41**			**2**	**0.08**
Ruddy Turnstone					2	0.08
Sanderling	5	0.16				
Unidentified Shorebird	8	0.25				
Jaegers			**1**	**0.04**		
Unidentified Jaeger			1	0.04		
Gulls	**1,847**	**57.72**	**540**	**22.50**	**586**	**24.42**
Bonaparte's Gull	6	0.19	2	0.08		
Laughing Gull	15	0.47			15	0.63
Ring-billed Gull	17	0.53				
Herring Gull	491	15.34	329	13.71	384	16.00
Great Black-backed Gull	476	14.88	201	8.38	174	7.25
Black-legged Kittiwake	14	0.44			8	0.33
Unidentified Gull	828	25.88	8	0.33	5	0.21
Terns	**102**	**3.19**	**6**	**0.25**	**77**	**3.21**
Common Tern	65	2.03	6	0.25	75	3.13
Forster's Tern	1	0.03				
Least Tern	1	0.03				
Unidentified Tern	35	1.09			2	0.08
Alcids	**459**	**14.34**	**9**	**0.38**	**371**	**0.20**
Common Murre			1	0.04	4	0.17
Thick-billed Murre	10	0.31				
Razorbill	257	8.03	6	0.25	349	14.54
Unidentified Murre	82	2.56	2	0.08		
Dovekie	20	0.63			1	0.04
Black Guillemot	2	0.06			1	0.04
Unidentified Alcid	88	2.75			16	0.67
Passerines	**7**	**0.22**	**2**	**0.08**	**6**	**0.25**
Bank Swallow	2	0.06				
Barn Swallow			2	0.08	4	0.17
Unidentified Swallow	5	0.16				
Yellow-rumped Warbler					2	0.08
Unidentified	**28**	**0.88**	**1**	**0.04**	**13**	**0.54**
Unidentified Bird	28	0.88	1	0.04	13	0.54
All Species	**6,957**	**217.4**	**3,732**	**155.5**	**1,858**	**77.42**

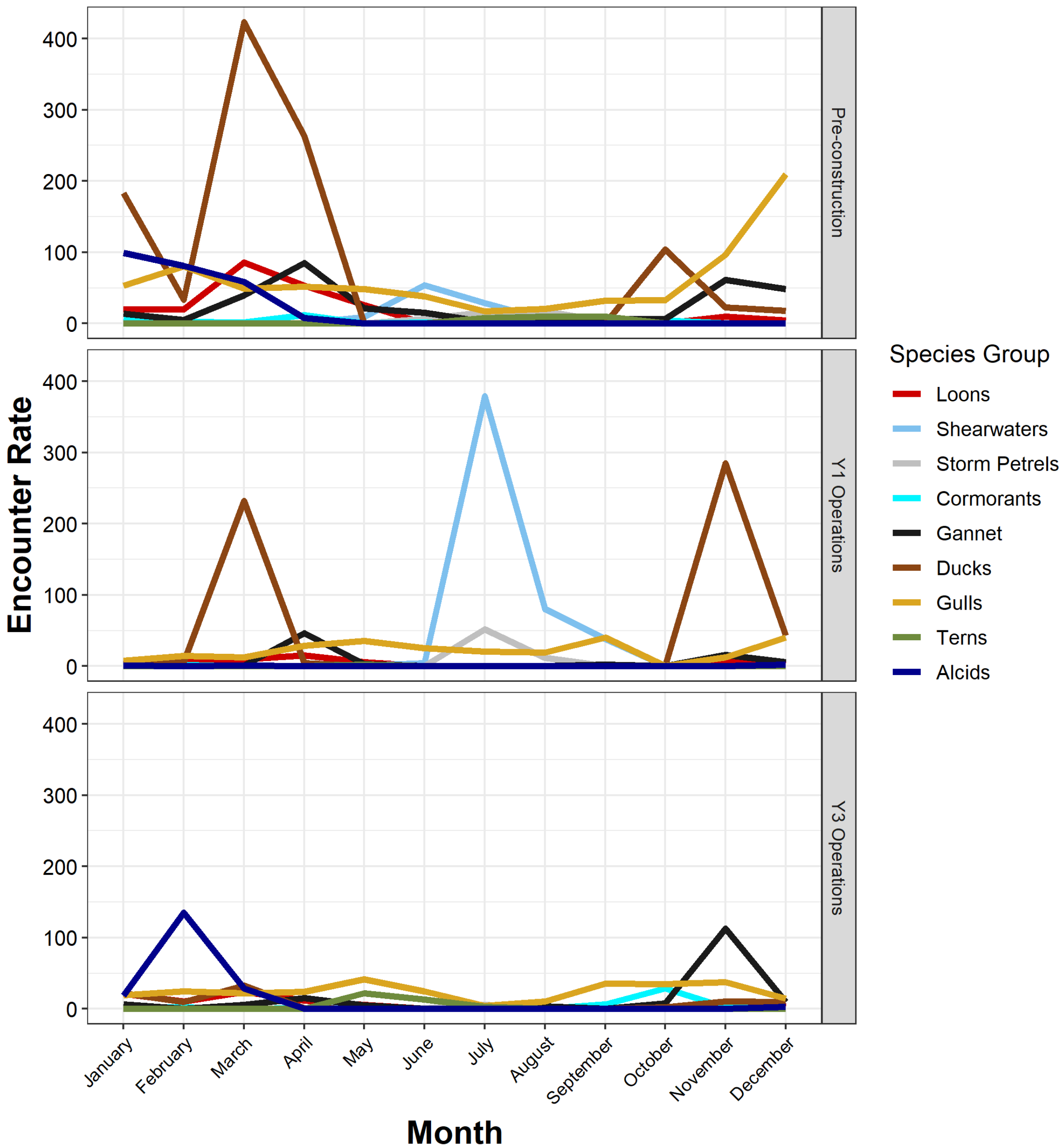

Figure 3-4. Encounter rates per species group per month during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

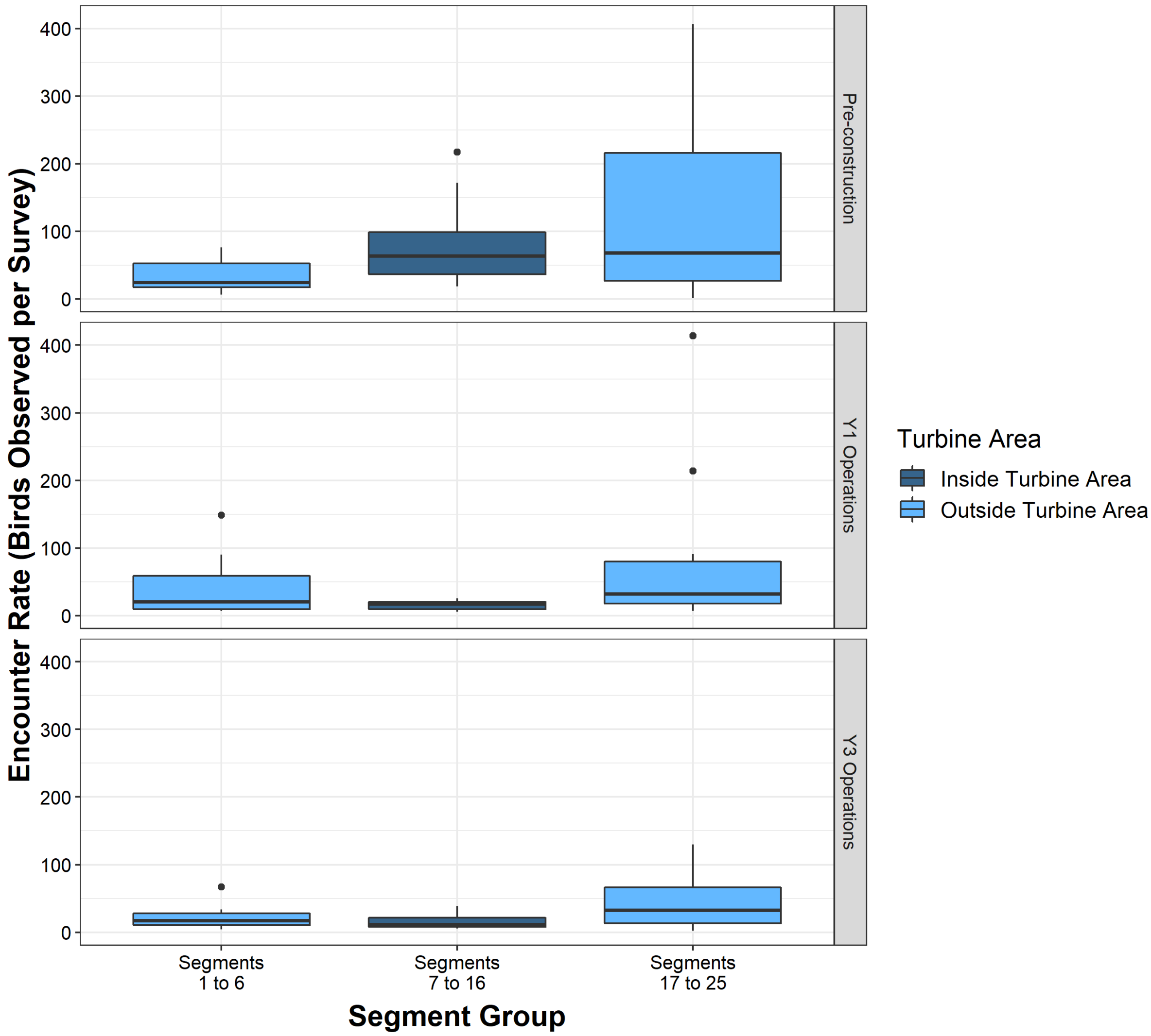

Figure 3-5. Encounter rates by segment group during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

3.3 DENSITY

Overall density for all species and all segments combined was 24.42 birds/km^2 in Y1 Operations and 12.18 birds/km^2 in Y3 Operations, compared with 34.22 birds/km^2 during pre-construction surveys. Mean overall bird density among surveys was lower post-construction (mean 31.3 birds/km^2 combining Y1 and Y3 Operations) than pre-construction (mean = 13.3 birds/km^2) according to a Welch's t-test (t (83.287) = -3.08, p = 0.003). Densities were generally aligned with abundances of birds reported in Table 3-2 for individual species, with most species occurring at densities of less than 0.5 birds/km^2 (Table 3-3). Species with the greatest density (and abundance) included black scoter (*Melanitta nigra*) and white-winged scoter (*Melanitta fusca*) during the pre-construction and Y1 Operations survey periods. Black scoter and white-winged scoter densities were lower during the Y3 operations survey period. Northern gannets (*Sula bassanus*) and herring gulls (*Larus argentatus*) occurred at consistently high densities compared to other species during each survey period. Bird density varied seasonally, following similar patterns to encounter rates, with certain species groups having higher density during winter months, and others more prevalent during summer (Figure 3-6).

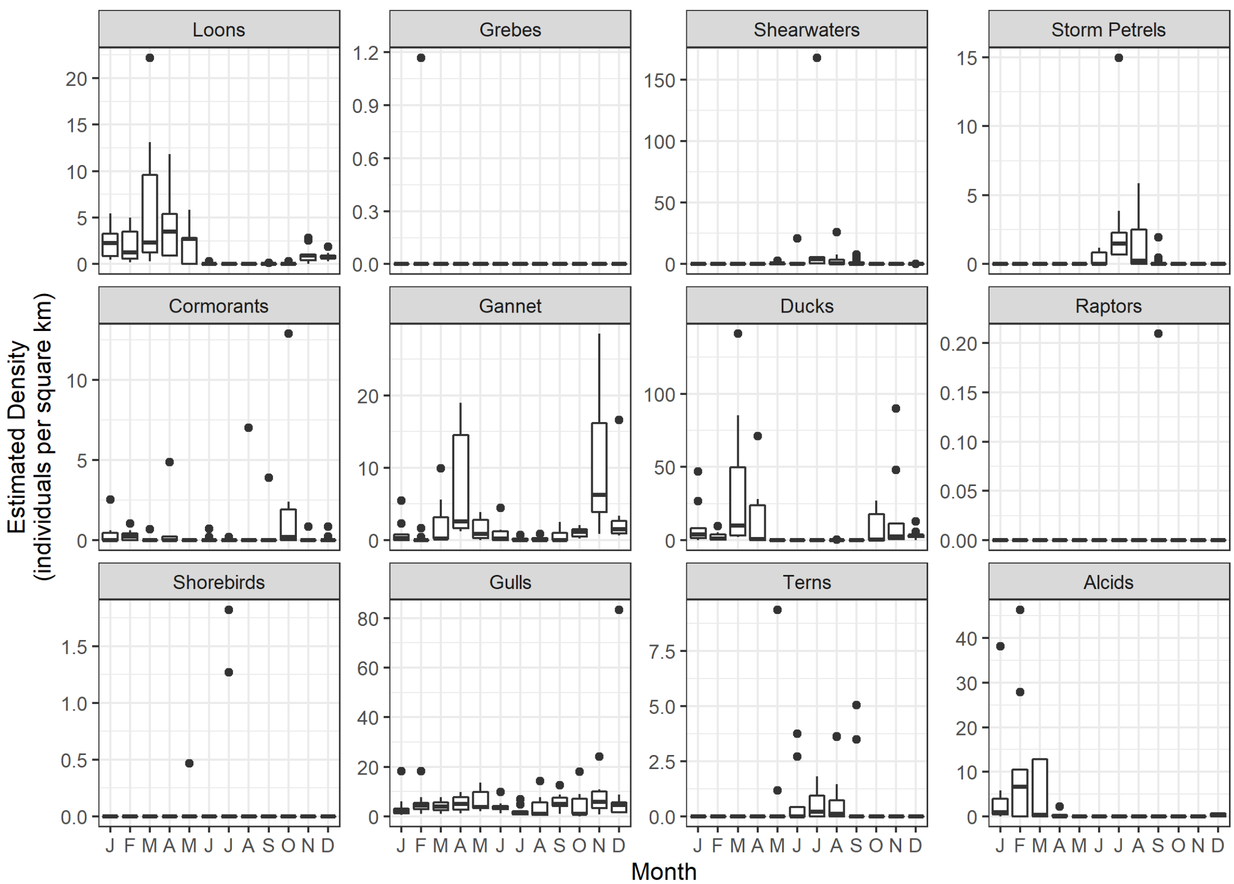

Figure 3-6. Estimated density by month per species group, aggregating results among segment areas and survey phases at the Block Island Wind Farm

Overall density of birds varied among segments and segment groups during each survey period, and were slightly lower inside versus outside the turbine area during Y1 and Y3 Operations (Figure 3-7; Figure 3-8), although these differences were not statistically different based on non-parametric Kruskall-Wallis tests treating density estimates calculated for each segment group from each survey as independent. Similarly, although density estimates appeared to differ among segment areas for certain species groups, none of these differences were significant (Figure 3-9). This was the case whether analyses included months with zero observations (months that, ecologically, the species would not be expected to occur in the area) or were limited to months with activity for each species group. Similarly, overall densities did not vary significantly inside versus outside the turbine area when data from both post-construction survey periods were combined.

Table 3-3. Density (birds/km2) by species during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm.

Species	Pre-construction (2009–2010, 2011)	Y1 Operations (2017)	Y3 Operations (2019)
	Estimated Density (95% CI)	Estimated Density (95% CI)	Estimated Density (95% CI)
Loons	**2.84 (1.61–5.02)**	**0.91 (0.62–1.33)**	**1.14 (0.34–0.62)**
Red-throated Loon	0.14 (0.05–0.37)	0.10 (0.05–0.21)	0.40 (0.24–0.13)
Common Loon	2.71 (1.50–4.91)	0.80 (0.53–1.20)	0.70 (0.18–0.42)
Unidentified Loon		0.01 (0.00–0.07)	0.04 (0.04–0.01)
Grebes			**0.03 (0.03–0.01)**
Red-necked grebe			0.03 (0.03–0.01)
Shearwaters	**1.00 (0.36–2.81)**	**6.92 (1.74–27.49)**	**0.08 (0.04–0.03)**
Cory's Shearwater	0.14 (0.05–0.39)	1.36 (0.47–3.94)	0.03 (0.02–0.01)
Greater Shearwater	0.49 (0.12–2.01)	1.09 (0.25–4.67)	
Manx Shearwater	0.10 (0.02–0.45)		0.01 (0.01–0.00)
Audubon's Shearwater	0.04 (0.01–0.18)		
Sooty Shearwater	0.14 (0.05–0.41)	0.03 (0.01–0.09)	0.04 (0.03–0.01)
Unidentified Shearwater	0.12 (0.05–0.28)	4.31 (0.78–23.86)	0.01 (0.01–0.00)
Storm Petrels	**0.57 (0.27–1.22)**	**0.63 (0.20–1.98)**	**0.11 (0.06–0.03)**
Wilson's Storm-petrel	0.51 (0.24–1.09)	0.63 (0.20–1.98)	0.11 (0.06–0.03)
Unidentified Storm-petrel	0.06 (0.02–0.20)		
Gannet	**4.28 (2.55–7.19)**	**1.21 (0.46–3.16)**	**2.14 (1.22–0.72)**
Northern Gannet	4.28 (2.55–7.19)	1.21 (0.46–3.16)	2.14 (1.22–0.72)
Cormorants	**0.47 (0.18–1.20)**	**0.03 (0.01–0.08)**	**0.61 (0.37–0.19)**
Great Cormorant	0.07 (0.03–0.17)	0.03 (0.01–0.08)	0.11 (0.04–0.05)
Double-crested Cormorant	0.18 (0.04–0.84)		0.48 (0.36–0.12)
Unidentified Cormorant	0.23 (0.05–0.97)		
Sea Ducks	**12.90 (6.73–24.74)**	**11.94 (3.96–35.99)**	**1.10 (0.32–0.61)**
Common Eider	1.12 (0.48–2.62)	0.71 (0.24–2.05)	0.34 (0.19–0.12)
Long-tailed Duck	0.03 (0.01–0.10)	0.05 (0.01–0.16)	0.01 (0.01–0.00)
Surf Scoter	0.14 (0.05–0.37)	0.08 (0.03–0.21)	0.06 (0.03–0.02)
Black Scoter	4.62 (1.91–11.17)	8.77 (2.90–26.55)	0.31 (0.15–0.12)
White-winged Scoter	3.36 (1.08–10.41)	2.22 (0.52–9.39)	0.40 (0.14–0.20)
Unidentified Scoter	1.83 (0.74–4.55)	0.01 (0.00–0.07)	
Unidentified Duck	1.71 (0.57–5.14)		0.04 (0.03–0.01)
Red-breasted Merganser	0.10 (0.03–0.32)	0.02 (0.01–0.08)	
Raptors			**0.01 (0.01–0.00)**
Merlin			0.01 (0.01–0.00)
Shorebirds	**0.06 (0.01–0.34)**		**0.01 (0.01–0.00)**
Ruddy Turnstone			0.01 (0.01–0.00)
Sanderling	0.02 (0.00–0.13)		
Unidentified Shorebird	0.04 (0.01–0.21)		

Species	Pre-construction (2009–2010, 2011)	Y1 Operations (2017)	Y3 Operations (2019)
	Estimated Density (95% CI)	Estimated Density (95% CI)	Estimated Density (95% CI)
Jaegers			
Unidentified Jaeger	NA	NA	NA
Gulls	**8.56 (5.41–13.54)**	**3.29 (2.46–4.40)**	**3.79 (0.48–2.92)**
Bonaparte's Gull	0.03 (0.01–0.13)	0.01 (0.00–0.07)	
Laughing Gull	0.07 (0.02–0.21)		0.09 (0.04–0.03)
Ring-billed Gull	0.08 (0.02–0.33)		
Herring Gull	2.02 (1.41–2.89)	2.03 (1.33–3.08)	2.49 (0.38–1.81)
Great Black-backed Gull	2.13 (1.57–2.90)	1.18 (0.77–1.83)	1.12 (0.21–0.77)
Black-legged Kittiwake	0.07 (0.02–0.20)		0.05 (0.03–0.02)
Unidentified Gull	4.12 (1.86–9.08)	0.05 (0.01–0.28)	0.03 (0.03–0.01)
Terns	**0.51 (0.16–1.59)**	**0.04 (0.01–0.13)**	**0.52 (0.31–0.17)**
Common Tern	0.33 (0.11–0.96)	0.04 (0.01–0.13)	0.50 (0.31–0.16)
Forster’s Tern	0.00 (0.00–0.03)		
Least Tern	0.00 (0.00–0.03)		
Unidentified Tern	0.17 (0.05–0.63)		0.01 (0.01–0.00)
Alcids	**2.22 (0.83–5.95)**	**0.06 (0.02–0.17)**	**2.60 (1.37–0.93)**
Common Murre		0.01 (0.00–0.04)	0.03 (0.02–0.01)
Thick-billed Murre	0.05 (0.01–0.26)		
Razorbill	1.24 (0.37–4.14)	0.04 (0.01–0.15)	2.46 (1.34–0.86)
Unidentified Murre	0.39 (0.08–1.89)	0.01 (0.00–0.05)	
Dovekie	0.10 (0.03–0.35)		0.01 (0.01–0.00)
Black Guillemot	0.01 (0.00–0.05)		0.01 (0.01–0.00)
Unidentified Alcid	0.43 (0.09–2.04)		0.11 (0.07–0.04)
Passerines	**0.03 (0.01–0.09)**	**0.01 (0.00–0.08)**	**0.04 (0.02–0.01)**
Bank Swallow	0.01 (0.00–0.05)		
Barn Swallow		0.01 (0.00–0.08)	0.03 (0.02–0.01)
Unidentified Swallow	0.02 (0.01–0.06)		
Yellow-rumped Warbler			0.01 (0.01–0.00)
Unidentified	**0.13 (0.04–0.42)**	**0.01 (0.00–0.04)**	**0.09 (0.07–0.02)**
Unidentified Bird	0.13 (0.04–0.42)	0.01 (0.00–0.04)	0.09 (0.07–0.02)
All Species	**34.22 (24.01–48.78)**	**24.42 (12.55–47.52)**	**12.18 (8.56–17.33)**

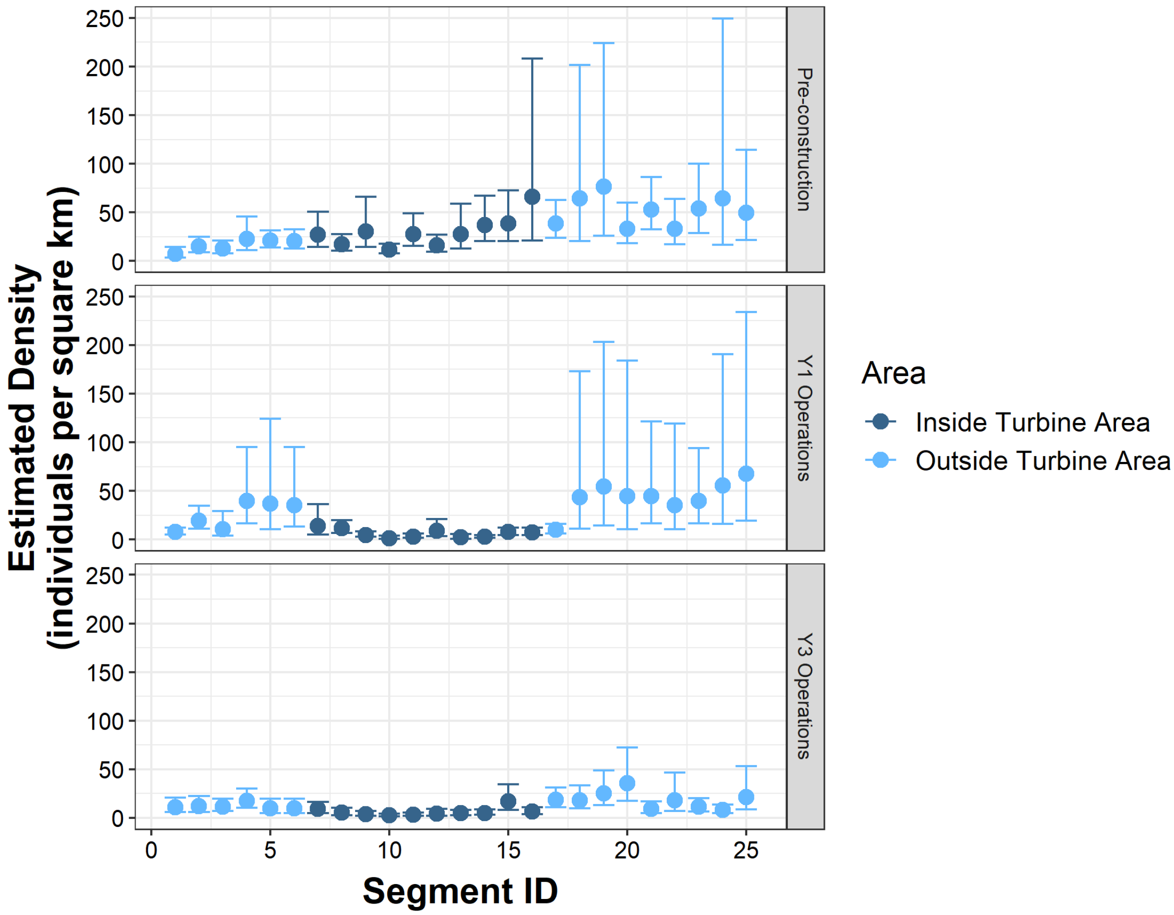

Figure 3-7. Density (combined species) per segment during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm. Error bars represent standard error.

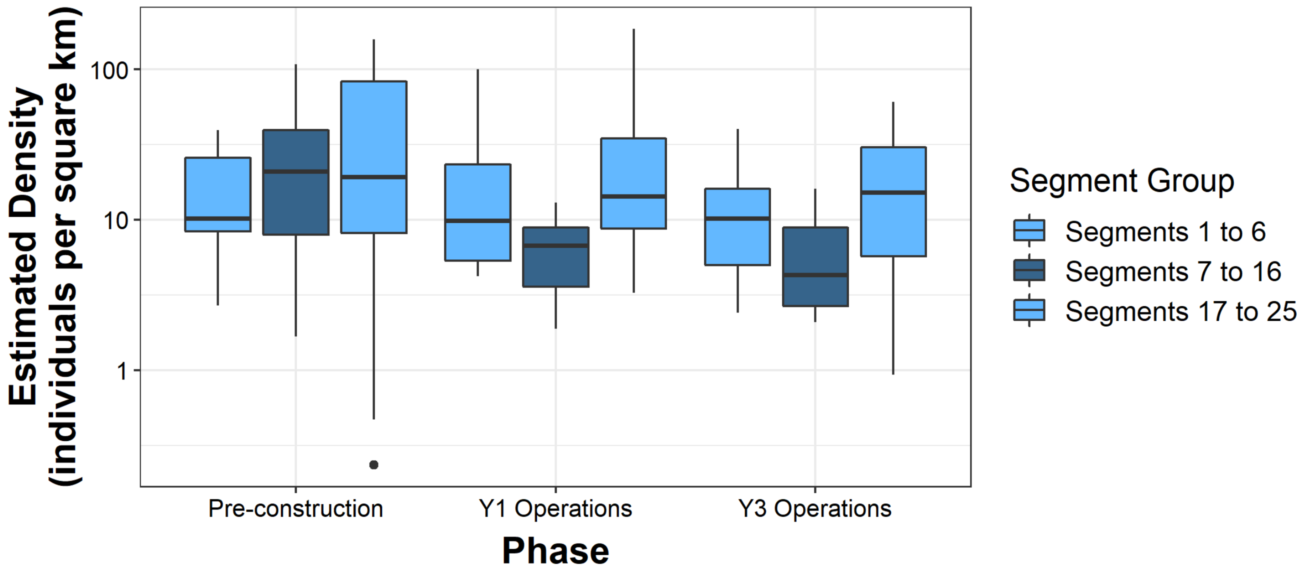

Figure 3-8. Density (combined species) per area during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm (plotted are the distributions of independent density estimates per area calculated from each independent survey transect, with boxes enclosing the upper and lower quartiles and error bars representing limits of 1.5*inter-quartile range).

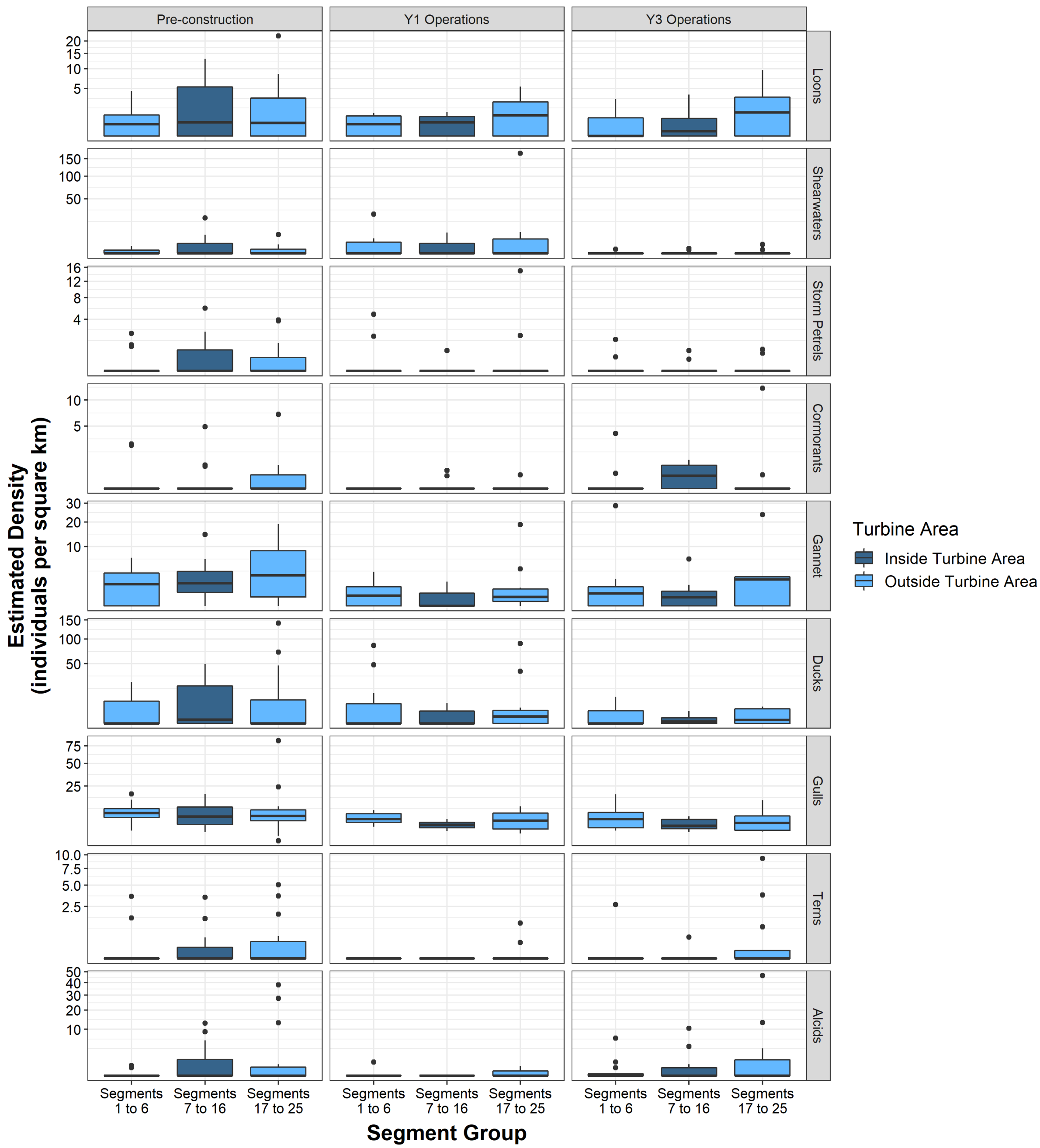

Figure 3-9. Avian density estimates for common species groups per area during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm (plotted are the distributions of independent monthly density estimates per area calculated per species group, with boxes enclosing the upper and lower quartiles and error bars representing limits of 1.5*inter-quartile range).

3.4 FLIGHT HEIGHTS

Flight heights were available for 4,016 birds identified to species during pre-construction surveys, 2,102 birds during Y1 Operations, and 1,208 birds during Y3 Operations ship-based avian surveys. Flight heights varied among species, with alcids observed exclusively in the <10-m height category versus northern gannets, red-throated loons, and certain gull species, which were more evenly distributed among height categories (Table 3-4). Overall, very few observations occurred in rotor-swept categories (26–125 m and 126–200 m), with approximately 5% of flights observed within these categories during both pre-construction and post-construction study periods (Figure 3-5). Species that were observed at heights within the rotor-swept zone primarily consisted of gulls but also included gannets, cormorants, and loons (Figure 3-5).

Uneven sample sizes and considerable variance among surveys, species, segments, and segment groups prevented robust statistical comparison of flight height inside and outside the turbine area, although flight heights appeared to be generally similar inside and outside the turbine area (Figure 3-10). Flight height also varied substantially among segments, but with no clear pattern of higher or lower flight heights within the turbine area (Figure 3-11).

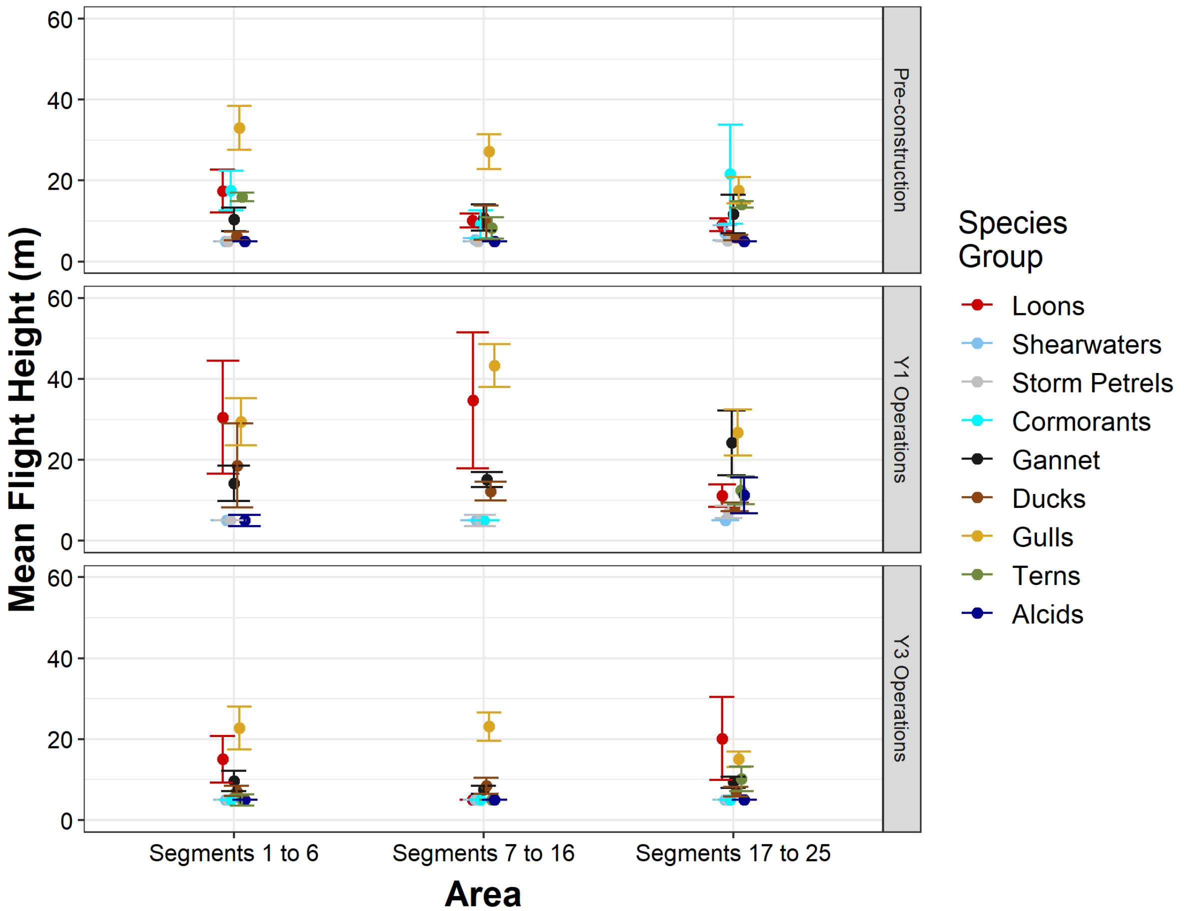

Figure 3-10. Flight heights by species and segment group during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at Block Island Wind Farm.

Table 3-4. Percentage of observations of flying birds by species and flight height category during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at Block Island Wind Farm.

Species	Total (n)	Pre-construction (2009–2010, 2011) Flight Height Category					Total (n)	Y1 Operations (2017) Flight Height Category					Total (n)	Y3 Operations (2019) Flight Height Category				
		<10m	10–25m	26–125m	126–200m	>200m		<10m	10–25m	26–125m	126–200m	>200m		<10m	10–25m	26–125m	126–200m	>200m
Loons																		
Common Loon	16	69%	31%	0%	0%	0%	14	43%	57%	0%	0%	0%	17	100%	0%	0%	0%	0%
Red-throated Loon	224	30%	67%	3%	0%	0%	21	67%	14%	19%	0%	0%	14	43%	43%	14%	0%	0%
Shearwaters																		
Cory's Shearwater	29	100%	0%	0%	0%	0%	134	100%	0%	0%	0%	0%	4	100%	0%	0%	0%	0%
Greater Shearwater	77	92%	8%	0%	0%	0%	65	97%	3%	0%	0%	0%						
Manx Shearwater	18	100%	0%	0%	0%	0%							1	100%	0%	0%	0%	0%
Audubon's Shearwater	16	100%	0%	0%	0%	0%												
Sooty Shearwater	29	100%	0%	0%	0%	0%	4	100%	0%	0%	0%	0%	1	100%	0%	0%	0%	0%
Storm-petrels																		
Wilson's Storm-petrel	102	99%	1%	0%	0%	0%	120	75%	25%	0%	0%	0%	16	100%	0%	0%	0%	0%
Gannet																		
Northern Gannet	799	78%	20%	1%	0%	0%	75	43%	48%	9%	0%	0%	237	59%	39%	2%	0%	0%
Cormorants																		
Great Cormorant	9	100%	0%	0%	0%	0%	2	100%	0%	0%	0%	0%	4	100%	0%	0%	0%	0%
Double-crested Cormorant	35	6%	9%	86%	0%	0%							71	100%	0%	0%	0%	0%
Sea Ducks																		
Common Eider	198	100%	0%	0%	0%	0%	78	72%	28%	0%	0%	0%	47	66%	34%	0%	0%	0%
Long-tailed Duck	6	83%	17%	0%	0%	0%	7	71%	29%	0%	0%	0%	2	100%	0%	0%	0%	0%
Surf Scoter	28	100%	0%	0%	0%	0%	12	50%	50%	0%	0%	0%	8	100%	0%	0%	0%	0%
Black Scoter	936	97%	3%	0%	0%	0%	1,064	61%	39%	0%	0%	0%	55	56%	44%	0%	0%	0%
White-winged Scoter	393	100%	0%	0%	0%	0%	76	66%	34%	0%	0%	0%	49	92%	8%	0%	0%	0%
Red-breasted Merganser	15	100%	0%	0%	0%	0%	3	100%	0%	0%	0%	0%						
Raptors																		
Merlin													1	100%	0%	0%	0%	0%
Shorebirds																		
Ruddy Turnstone													2	100%	0%	0%	0%	0%
Sanderling	5	100%	0%	0%	0%	0%												
Gulls																		
Bonaparte's Gull	1	100%	0%	0%	0%	0%	1	0%	100%	0%	0%	0%						
Laughing Gull	15	87%	0%	13%	0%	0%							12	42%	58%	0%	0%	0%
Ring-billed Gull	14	21%	36%	43%	0%	0%												
Herring Gull	428	36%	40%	23%	0%	0%	258	41%	37%	21%	0%	0%	308	34%	56%	8%	1%	0%
Great Black-backed Gull	395	42%	42%	16%	1%	0%	157	32%	38%	30%	0%	1%	124	48%	35%	16%	0%	0%
Black-legged Kittiwake	13	100%	0%	0%	0%	0%							8	50%	38%	13%	0%	0%
Terns																		
Common Tern	65	29%	68%	3%	0%	0%	5	40%	60%	0%	0%	0%	35	77%	23%	0%	0%	0%
Forster's Tern	1	100%	0%	0%	0%	0%												
Least Tern	1	0%	100%	0%	0%	0%												
Alcids																		
Thick-billed Murre	9	100%	0%	0%	0%	0%												
Razorbill	116	100%	0%	0%	0%	0%	4	100%	0%	0%	0%	0%	186	100%	0%	0%	0%	0%
Dovekie	20	100%	0%	0%	0%	0%												
Black Guillemot	1	100%	0%	0%	0%	0%												
Passerines																		
Bank Swallow	2	0%	100%	0%	0%	0%												
Barn Swallow							2	100%	0%	0%	0%	0%	4	100%	0%	0%	0%	0%
Yellow-rumped Warbler													2	100%	0%	0%	0%	0%
Overall	**4,016**	**76%**	**19%**	**5%**	**<1%**	**0%**	**2,102**	**61%**	**34%**	**5%**	**<1%**	**<1%**	**1,208**	**64%**	**31%**	**4%**	**<1%**	**0%**

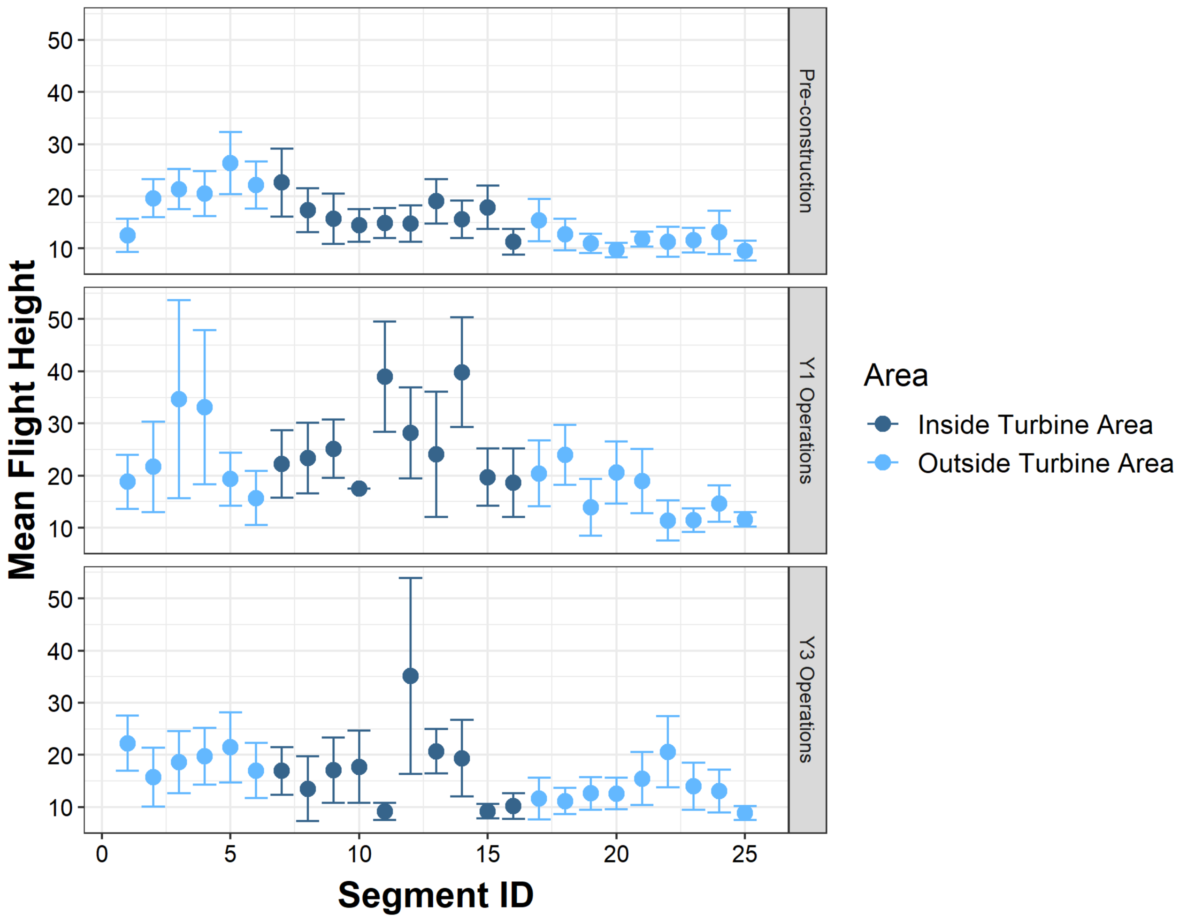

Figure 3-11. Mean flight height by segment during pre-construction (2009–2010, 2011), Y1 Operations (2017), and Y3 Operations (2019) periods at the Block Island Wind Farm. Error bars represent standard error.

4.0 DISCUSSION

Ship-based avian surveys at Block Island Wind Farm documented multiple metrics of bird diversity, abundance, and distribution during three distinct survey periods (pre-construction, Y1 Operations and Y3 Operations). Surveys followed a protocol developed before the Project was built and were designed to evaluate the potential effects of the BIWF on bird distribution and behavior.

Visual ship-based surveys allow for more accurate detection and identification of species that occur from the water's surface to heights above the rotor-swept zone compared to other available survey technology (aerial surveys). However, visual distance sampling surveys must be conducted during the day and during periods of decent weather (low wind speeds and low sea states). As such, these surveys can only describe the occurrence and behaviors of birds during daytime periods and periods with fair conditions.

Species that are active at night (diurnal migrants) and potential behaviors during fog and/or heavy rain cannot be sampled using these methods.

To enable statistical comparison of results from pre-construction surveys, conducted between 2009 and 2011, and those conducted in Y1 and Y3 Operations, Stantec compiled and reprocessed raw survey data from each survey period using common methods and metrics. Abundance, diversity, and species composition of birds varied seasonally and spatially in and near the Project during all survey periods. For all species combined and for all survey years combined, species richness was highest in mid-winter; encounter rates were highest in mid-winter/late fall; and density was highest in winter for some species groups and summer for others (dependent on the species' season of occurrence). Seabirds are highly mobile, with numerous factors affecting distribution and abundance on multiple temporal and spatial scales. Overall, birds were slightly less numerous and less densely distributed during the two post-construction survey periods compared to pre-construction surveys, although not all species or species groups followed this pattern. Encounter rates were significantly lower inside versus outside the turbine area during post-construction surveys when results from Y1 and Y3 Operations were combined, although there was substantial variation in encounter rates among months. Bird diversity was also slightly lower inside the turbine area than outside the turbine area during each post-construction survey period, though this was not the case pre-construction. Density of birds was also lower inside versus outside the turbine area during each post-construction survey period, although this pattern was not statistically significant overall or for any species group. Similarly, flight heights did not vary significantly before or after Project construction, or inside or outside the turbine area. The likely driving factor in flight heights observed were differences in behaviors among species groups and where those species groups occurred. That is to say, variation in timing and location of observations of species groups among segment locations reflected the flight heights observed at those locations. Overall, very few observations occurred in rotor-swept height categories (26–125 m and 126–200 m), with approximately 5% of flights within these categories during pre-construction and post-construction study periods. Species that were observed at heights within the rotor-swept zone primarily consisted of gulls but also included gannets, cormorants, and loons.

Displacement effects are complicated and can be difficult to track as the distribution and numbers of marine birds can be influenced by many potential factors which influence seasonal distribution of prey sources and ultimately the distribution of bird species, including weather (e.g., seasonally fluctuating surface water temperatures) and water depth. Notably, measured bird densities at BIWF tended to be higher and more variable within Segments 7–25 than in Segments 1–6 during pre-construction and post-construction, even though both of these segment groups were outside the turbine area, illustrating spatial variation that is unrelated to presence of the BIWF. Segments 7–25 were shallower than Segments 1–6, likely contributing to differences in food supply among areas, which in turn may have affected distribution and density of birds (Figure 4-1).

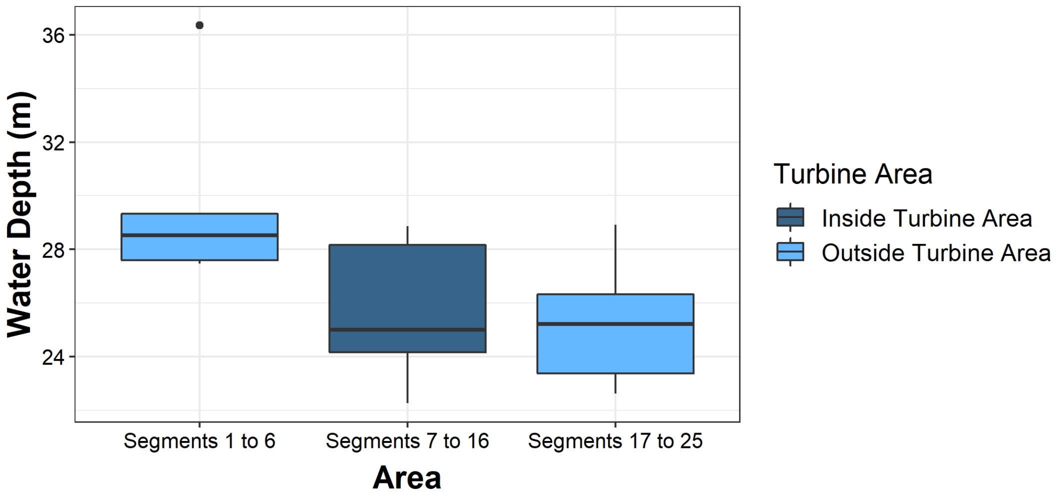

Figure 4-1. Distribution of mean water depths among segments in each area sampled at the Block Island Wind Farm during pre-construction and post-construction surveys.

In Europe, researchers documented displacement effects on birds due to the presence of offshore WTGs, particularly when blades were spinning; however, researchers also suggested that observed displacement and avoidance was also potentially attributable to an increase in boat traffic for the wind farm (Dierschke et al. 2016). Species groups such as gannets, loons, and alcids appear to be particularly vulnerable to displacement effects (Willmott et al. 2013), while gulls and cormorants show some attraction to offshore wind farms (Dierschke et al. 2016). Surveys at BIWF documented slight decreases in encounter rates and density inside versus outside the turbine area or pre- versus post-construction for these species, although differences were not significant. While some species of divers (e.g., loons) appeared to continually avoid WTGs at a project in the German North Sea, even 5 to 6 years after construction (Mendel et al. 2014), other species groups including alcids began to reoccur at other European offshore wind farms after several years of operation, possibly due to reef effect or other variations in food distribution and availability in vicinity of WTGs, or habituation (Dierschke et al. 2016).

Analysis of ship-based bird survey results from pre-construction and post-construction periods did not document pronounced or consistent significant shifts in bird distribution, abundance, or behavior. Instead, variance in metrics were similar inside and outside the turbine area during each survey period, and we did not detect effects that could be linked directly to presence and operation of the BIWF. This result does not necessarily mean that individual birds are not adjusting their behavior due to presence of WTGs but suggests that the WTGs are not influencing patterns in bird distribution on a large scale. We purposely combined data from adjacent survey segments when conducting statistical tests of metrics from inside the turbine areas and outside the turbine areas to avoid potential issues with pseudo replication (e.g., adjacent survey segments are not necessarily independent) and reduce the potential of detecting a statistically significant difference that was not accurate (type I error). Therefore, visual indications of differences in bird abundance or distribution from inside the turbine area compared to outside the turbine area, as observed and measured during the field surveys, do not represent a statistically-significant impact from the BIFW using the metrics calculated for our analyses. A per-segment analysis would likely show a significant effect but counts made along each segment cannot necessarily be assumed to be independent samples of each other based on the field sampling design that was used.

The BIWF is small (5 WTGs) relative to existing offshore wind farms in Europe where more pronounced displacement effects have been observed, and the Project's footprint may be too small to trigger behavioral avoidance that may occur at a larger facility with multiple strings of more WTGs. Our surveys may also have been unable to detect subtle changes in distribution and behavior of birds that could be resulting from operation of the BIWF as these surveys were designed to detect relatively large-scale effects, and the lack of such effects suggests that the BIWF WTGs may not be having a large influence on birds in and around the Project. Importantly, the scale at which potential displacement may occur may vary among species or as a factor of project or habitat characteristics, and surveys may not have been equally able to document such differences for all species groups.

The BIWF is located within 4.8 km (3 mi) of Block Island, which itself is within sight of the Rhode Island (14.9 km [9.3 mi]) and New York (21.9 km [13.6 mi]) shorelines. This is considerably closer to mainland areas than most European offshore wind farms that have been constructed and investigated. While outside the scope of this study, the visual proximity of the BIWF WTGs to land could potentially lessen any behavioral effects (e.g., avoidance) to those species such as loons and alcids that are known to be vulnerable. In other words, WTGs that are located further offshore may contrast more with the otherwise flat landscape offshore than WTGs in visual proximity to land. Similarly, Block Island Sound receives regular recreational and commercial boat traffic therefore birds that occur in proximity to BIWF may already be habituated to vessels and other visible infrastructure compared to birds occurring further offshore.

Species groups observed across segment groupings during pre-construction and post-construction were generally similar with observations of all species groups across each segment grouping, with the exception of terns which were not observed within the turbine area segments during post-construction surveys. Terns have demonstrated continued use of some offshore wind farms while also demonstrating avoidance behaviors at others (Krijgsveld 2014). Several factors may influence tern behavior in response to offshore wind developments, including a facility's location in relation to foraging habitats (Krijgsveld 2014).

There were several observations of note during post-construction surveys which suggest certain bird groups may be attracted to WTGs in the marine environment rather than be displaced by them. Double-crested cormorants (*Phalacrocorax auritus*) were observed on multiple occasions perching on the foundations of the BIWF WTGs during both Y1 and Y3 Operations (Table 4-1). Stantec avian biologists observed a peregrine falcon (*Falco peregrinus*) on October 14, 2019 chasing prey near Turbine B1 (the falcon was beyond 300 m from the survey vessel therefore the observation was documented incidentally). The observers saw the falcon capture an unknown avian prey species in air and then land with its prey on a crane attached to the WTG B1 platform. The falcon remained visible on the platform crane for several minutes (still present when observers left the area). These species were assumed to be attracted to the WTGs for perching opportunities and would otherwise have no natural perches offshore. Observations of birds flying or sitting on the water in proximity to turbines were relatively uncommon during post-construction surveys; however, species such as loon, shearwater, gannet, and gull were observed within 100 m of turbines (Table 4-1).

Table 4-1. Observations of birds within 100 m of turbines during 2017 and 2019 ship-based surveys.

Date/Time (EST) of Observation	Species	Number of Individuals	Behaviors
2/22/2017 15:10	great cormorant	1	sitting 25 m above water on turbine 5 foundation, turbine spinning
3/31/2017 11:17	common loon	1	sitting on water within 10 m turbine 1
3/31/2017 11:22	common loon	1	sitting on water within 30 m turbine 2 then dove as boat approached
9/14/2017 12:59	Cory's shearwater	4	sitting on water <100 m from turbine 4; fish breaking nearby. Then went to flight (<10 m, heading east)
2/22/2019 20:37	great cormorant	3	perched on lower sign of turbine 5 foundation
2/23/2019 16:11	northern gannet	1	NOGA approaching turbines, passed btw turbines 2 & 3 at 30 m above water
6/25/2019 10:52	double-crested cormorant	1	perched on turbine 2 foundation
7/24/2019 22:33	double-crested cormorant	1	perched on sign on turbine 2 foundation
10/14/2019 18:23	double-crested cormorant	1	perched on turbine 4 foundation
10/15/2019 (~13:00)	peregrine falcon	1	PEFA observed chasing unknown avian prey species near turbine 1. Took prey out of sky and landed with prey on crane attached to turbine 1 platform. PEFA remained visible on platform crane as survey vessel left area (4+ minutes)
11/4/2019 18:23	great cormorant	2	perched on turbine 2 foundation
11/5/2019 13:40	double-crested cormorant	1	perched on turbine 5 foundation
11/5/2019 13:43	great cormorant	1	perched on turbine 4 foundation
12/12/2019 17:10	great cormorant	1	sitting on turbine 4 foundation
12/18/2019 14:19	great cormorant	2	sitting on turbine 5 foundation
1/14/2020 15:46	great black-backed gull	1	GBBG flew south between WTGs 2 & 3 at rotor height
1/14/2020 15:56	great cormorant	1	perched on turbine 4 foundation
1/14/2020 16:00	great cormorant	2	perched on turbine 5 foundation

The importance of biologically-based year-to-year variation in species' prey availability (both spatially and temporally), climatic conditions, and other factors, as well as our ability to sample avian activity equally across all of those conditions must be recognized when interpreting these results. The naturally occurring seasonal variation in each species' occurrence and activity in the area is expected, and partially unpredictable, which further hinder our ability to capture statistical differences in our dataset. While additional years of avian use surveys may provide more data on which to compare pre- and post-construction use metrics it is uncertain if such a larger data set would allow for the identification of subtle differences in use for any one species or species group. Our analysis, however, does indicate that a very large, or notable, impact to avian presence near the BIWF does not appear to have occurred due to presence and continued operation of the Project.

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