

**Preconstruction Studies of Abundance and Behavior of the Federally  
Endangered Brown Pelican, Roseate Tern, and Other Birds at the  
WindMar RE Project, Guayanilla, Puerto Rico**

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Prepared for WindMar RE Project  
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## Executive Summary

An avian use study was conducted at the WindMar RE wind power project site near Guayanilla, Puerto Rico, to determine the abundance and behavior of federally endangered Brown Pelicans and Roseate Terns, as well as more common species such as Magnificent Frigatebird, Turkey Vulture, and several other species. The study was conducted to determine whether or not these species might be at risk of colliding with turbines proposed for the site and if so, the potential degree of risk.

Observations were made from two observation points located on high ground on Cerro Toro at the base of the Punta Verraco peninsula (Cerro Toro observation site) and near the center of the Punta Verraco peninsula (Punta Verraco observation site). Observation periods were 1.5 hours in length, during which all birds and their behavior were recorded. For each bird, the height above the ground (in relation to turbine rotor height) and location near or over the peninsula were recorded. For the latter, the peninsula was divided into sectors corresponding to the area where turbines would be located and several other areas where there would be no turbines. An effort was made to observe during a wide range of daylight hours in order to insure that a representative time sample was gathered. Weather conditions were recorded, but they did not vary much during the study period (e.g., winds were always from SE-E).

A total of forty-eight (48) 1.5 hour observation periods (31 observation periods at the Punta Verraco site and 17 at the Cerro Toro site) were logged between May 16 and June 10, 2003. This represents a total of 69.5 hours: 45.5 at Punta Verraco and 24.0 at Cerro Toro.

A total of 1,021 observations were logged (14.7 bird observations per hour) of which Brown Pelican, Magnificent Frigatebird, and Turkey Vulture accounted for 32.3%, 45.8%, and 15.4% of observations respectively, or a large majority (93.5%) of all observations. A total of 13 species was observed. Three diurnal raptors were observed, once each. Roseate Terns were not observed during the study. Sandwich and Royal terns did not fly over land during the study period.

Use patterns were examined in detail for the three most numerous species. Brown Pelican and Magnificent Frigatebird were found to fly regularly over and seaward of the steep cliffs along the south shore of the Punta Verraco peninsula. To a far lesser extent, they were seen over the peninsula where turbines would be located. Thus, few pelicans and almost no frigatebirds actually crossed the peninsula between the Caribbean Sea and Guayanilla Bay. From the Cerro Toro and Punta Verraco observation sites, about 8.0% and 2.9%, respectively, of pelicans flew in the sectors where turbines would be located and at heights that coincide with turbine rotors. The percentages of frigatebirds that flew in this zone of potential risk were similar. On the other hand, Turkey Vultures flew almost exclusively over land and much more often within the zone of potential risk, i.e., 26.8% of the time from the Cerro Toro observation site, and 9.2% of the time from the Punta Verraco observation site. Small percentages of the other species were noted flying in this zone.

The limited amount of flying time spent by pelicans and other birds in areas where turbines rotors would be located suggests relatively low risk of collision to these birds. The demonstrated low risk of avian collisions at wind plants in the United States and Europe support this contention for pelicans and other birds. Despite the greater amount of time spent in the area where turbine rotors would be located, risk to Turkey Vultures is likely to be very low because the species occurs in many wind turbine areas and does not seem to be susceptible to colliding with turbines. Overall, collision fatalities are not likely to be biologically significant to any of the species that were observed at the WindMar RE site.

## Introduction

A Phase I Avian Risk Assessment was conducted for the WindMar RE Project, near Guayanilla, Puerto Rico, in late 2002 and early 2003. Although that assessment and the weight of evidence from previous studies of impacts to birds at wind power facilities suggest that risk to birds is likely to be low, it was determined that preconstruction studies were needed to examine the status, abundance, and use of several federally endangered species, including the Brown Pelican and Roseate Tern, within the boundaries of the proposed wind power project. A letter from U.S. Fish and Wildlife Service (FWS) dated April 23, 2003, also emphasized that such a study was needed and went on to say that other species – namely, Turkey Vulture, Red-tailed Hawk, Magnificent Frigatebird, Sandwich Tern, and Royal Tern – should be included in the study. Such information is desired to prevent and mitigate potential impacts of the project on birds.

Brown Pelican is not known to nest within several miles of the project site (the closest nesting site is Montalva Bay near La Parguera), but it does forage and roost along the coastline from Punta Verraco to Punta Ventana at the project site. It also roosts and forages in Guayanilla Bay and crosses Punta Verraco and possibly Cerro Toro as it flies between the Caribbean and Guayanilla Bay. Roseate Terns do not nest on the site, but they have been recorded nesting occasionally on small islets within a mile or two of the project site. They could conceivably fly over the project site, but there are no records of this happening, despite dozens of site visits by biologists working on projects at the project site. The behavior of pelican and Roseate Tern as they cross or fly over the proposed wind power project site is of interest from the perspective of determining potential risk.

When drafted in mid May 2003, the protocol used for this study was mailed to Dr. Jorge Saliva of the Boqueron office of FWS for review. Dr. Saliva is an expert on Roseate Terns and wrote the recovery plan for the Service (Saliva 1993). He is also the lead contact for any inquiries on the Brown Pelican. Dr. Saliva's comments on the protocol were received in an e-mail of August 13, 2003. We respond to them in this report.

## Study Area and Methods

The following survey protocols were designed to be used in spring 2003 to determine the status and use of Brown Pelican and Roseate Tern and other species at the WindMar RE project site. The other species were Turkey Vulture, Red-tailed Hawk, Magnificent Frigatebird, Royal Tern, and Sandwich Terns. They were emphasized in a letter from FWS to WindMar dated April 23, 2003, and signed by Carlos Diaz. The following protocols and methods were developed from the literature, interviews with experts, comments received from FWS, and the National Wind Coordinating Committee guidance document authored by Anderson et al. (1999).

Surveys for these species entailed conducting behavioral observations at varying times of day (between sunrise and sunset) from an elevated location on Punta Verraco and another elevated location on Cerro Toro. No observations were made at Punta Ventana because there is unlikely to be flight activity by Brown Pelicans or terns over land there, because there is no reason for these birds to fly inland at that location to cross to Guayanilla Bay, which is much farther to the east.

Observations were made by two observers, one situated on the high point on Punta Verraco, the other located on the high point on Cerro Toro (Figure 1). The locations were chosen during a site visit on April 27, 2003 and both afford excellent views of these two areas as well as the surrounding airspace. From these locations, the airspace where all turbines would be located on Punta Verraco and Cerro Toro could be observed.

Observations were made during 90-minute observation periods (180 minutes when both sites were combined). The time of day of the observation periods included early morning (0700-0900), midday (1100-1400) and afternoon (1600-1800) hours so that daily activity patterns could be determined. Three surveys per week were conducted so that observations were made during early morning, midday, and afternoon. Surveys were conducted for a period of 8-12 weeks (May through July) such that a total of 17 to 31 observation periods at each site were conducted.

The two observers scanned the horizon in all directions using both naked eye and binoculars to locate birds. Songbirds and other small forest dwelling birds that did not fly more than about 30 feet above the canopy were not counted. Information for each individual bird or flock was noted on a data sheet (see Appendix I). The data recorded and how they were collected are provided in Table 1.

Data were logged into an Excel spreadsheet for analysis. This final report summarizes the findings and provides an estimate of risk to the species that were observed within the study area.

**Table 1.** Summary of instructions given to observers for taking data and completing the data sheets at the Cerro Toro and Punta Verraco observation points, WindMar RE wind power project, Guayanilla, Puerto Rico, spring 2003.

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Obs/Site – name or initials of observer and name of observation site (Punta Verraco or Cerro Toro)

Date – date of observation period

TimeStart – time observation period was initiated (e.g. 06:00, 11:25, 06:45, etc.)

WindSp/Dir – estimate of wind speed in miles per hour (can be bracketed – 5-10 mph) and direction in one of 8 cardinal compass directions

Cloud% - percentage of the sky covered by clouds (and note the thickness)

Precip – note if there is any light rain (if there is heavy rain surveys should not be done or they should be halted until the rain lessens to conditions where observations can commence again)

Temp – note temperature (bracket if necessary – 80-85 degrees, 83-88 degrees, etc.)

ObsNumb – provide a number for each observation starting at #1 and numbering sequentially on each day. Start at #1 at the beginning of each observation period.

Species – use a 4 letter abbreviation for each species (BRPE = Brown Pelican, ROTTE = Roseate Tern, FRIG = Frigatebird, RTHA = Red-tailed Hawk, AMKE = American Kestrel, TUVU = Turkey Vulture, KING = kingbird etc.). If the observer sees other species, a four-letter abbreviation should be provided, along with a note stating what that species is in the Notes column. Thereafter, the same abbreviation must be used for that species.

Numb – number of individuals

Dir – direction of flight in one of the 8 cardinal directions. If a bird turns, provide the second and third directions. If there are more than 3 directions, the observer need only provide the first 3. For example, NE would indicate a bird was flying to the northeast. NE-NW would indicate a bird was flying at first to the northeast and then to the northwest.

Height – height should be given as L = low (below 100 feet above the ground over which the bird is flying), M = medium (100-400 feet above the ground, the height of the turbine rotor), and H = high (greater than 400 feet above the ground). If a bird changes height please indicate as LM (low to medium) or ML (medium to low) or LMH (low to medium to high), etc.

Sector – The sectors are different for Cerro Toro and Punta Verraco. For Cerro Toro, the locations of birds should be noted as shown in Figure 1. Sector D includes the flat area between

Table 1 continued.

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the beach and the steep slopes of Punta Verraco and Cerro Toro. For Punta Verraco, the locations of birds should be noted as shown in Figure 1 as well. For Punta Verraco, the sectors to the west of the observation site are A1, B1, and C1. From the observation point to the meteorology tower, the sectors are noted A2, B2, and C2. East of the meteorology tower, the sectors are A3, B3, and C3.

Notes – provide information about the flight patterns and other behaviors of each bird if necessary. For example, if a bird flies back and forth several times, note that in this column.

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## **Results and Discussion**

### Summary of Observations

Prior to the gathering of data, observations were made at both the Punta Verraco and Cerro Toro observation points on April 28 and April 29, 2003. These observation periods were irregular in length and were done to test the usefulness of the two observation locations and to design the data collection methods to be used during this study. These observations were basically incidental to the actual collection of data and may be considered a pilot study.

The data used in this report and risk assessment were collected on 13 different days at the Punta Verraco observation site and 11 days at the Cerro Toro site (see Table 2 and Appendix II). Observations were made on 13 days during the study period, which extended from May 16 through June 10, 2003. Forty-eight separate 1.5-hour observation periods were accrued during the study period: 31 at the Punta Verraco observation site and 17 at the Cerro Toro observation site. A grand total of 69.5 hours of observations were made at Punta Verraco and Cerro Toro combined, with nearly two-thirds of the observations (45.5 hours – 65.5%) coming from the Punta Verraco observation site.

### Species Observed – Abundance and Relative Use

During the two-month study, a total of twelve (12) species were identified as flying well above the canopy in the areas covered by the Punta Verraco and Cerro Toro observation points (Table 3). A thirteenth species, likely a Peregrine Falcon, was also observed. The description of a large falcon suggests that the bird observed was a Peregrine because this species is the only large falcon known from Puerto Rico (Raefaele 1989). The most common species were Magnificent Frigatebird and Brown Pelican, which together accounted for more than three-quarters (78.1%) of all observations. Turkey Vultures accounted for an additional 15.4% of all observations (Table 4). This means that the other 10 species accounted for only 6.5% of observations. Five species were represented in the data set by only a single observation and three species were represented by 2 to 10 observations (Table 4). Thus, the abundance and use of the site and adjacent areas varied dramatically among species with a predominant amount of use being by frigatebirds, pelicans, and vultures. The percentages of the species observed at the Cerro Toro and Punta Verraco observation points were similar and varied only slightly. Roseate Terns were not observed during the study, nor have they been observed at other times by biologists working at the WindMar RE site.

The numbers of bird observations per hour averaged 14.7 when both Cerro Toro and Punta Verraco observations are pooled (Table 4). The Punta Verraco site had a slightly higher rate per hour (15.0) than did the Cerro Toro site (14.3), but the difference is minor. The numbers of bird observations per hour at the two observation points varied from a minimum of less than 0.1 bird observations per hour for many of the species to 6.7 for frigatebirds and 4.7 for pelicans. The numbers of bird observations per hour is an important statistic because it provides an indication of relative use by different species and a measurement of how many times these birds entered or flew adjacent to the project site.

**Table 2.** Summary of observation periods, hours, total number of observations (all species), and number of observations for pelican and frigatebird at from the observation sites at Punta Verraco (V) and Cerro Toro (T), Windmar RE project, Guayanilla Bay, Puerto Rico, 2003.

Date	Location	Hours	Total Number of Observations	Pelicans	Frigatebirds
5/16/03	V	3.00	30	3	20
5/17/03	V	3.00	36	10	20
5/18/03	V	3.00	49	16	26
5/24/03	V	1.50	29	8	18
5/25/03	V	3.00	57	17	32
5/29/03	V	1.50	15	10	4
5/30/03	V	1.50	12	10	2
5/31/03	V	4.50	67	10	34
6/1/03	V	3.00	26	2	16
6/14/03	V	6.00	133	45	82
6/15/03	V	6.00	114	30	77
6/16/03	V	4.50	60	26	34
6/17/03	V	5.00	53	19	30
Total 13 days		45.50	681	206	395
		Birds per Hour = 15.00			
5/16/03	T	1.50	12	3	0
5/17/03	T	3.00	31	9	2
5/18/03	T	1.50	29	11	3
5/24/03	T	1.50	24	12	7
5/25/03	T	1.50	40	6	26
5/29/03	T	1.50	13	9	2
5/30/03	T	3.00	60	12	7
5/31/03	T	4.50	50	19	11
6/1/03	T	1.50	23	8	5
6/9/03	T	1.50	11	6	3
6/10/03	T	3.00	47	27	8
Total 11 days		24.00	340	122	74
		Birds per Hour = 14.25			
Total 15 days		69.50 Hours	1,021	328	469
		48 Observation Periods, Birds per Hour = 14.72			

**Table 3.** Overview of flight behavior of species observed at the Cerro Toro and Punta Verraco observation locations during behavioral observations at the WindMar RE wind power project, Guayanilla, Puerto Rico, in spring 2003. The descriptions that follow are a synopsis of the quantitative evaluations. (R = rare – fewer than 3 observations at both sites; U = uncommon – fewer than 40 observations at both sites; C = Common – greater than 100 observations at both sites).

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American Kestrel (U)	Flight over land at low to moderate altitudes (meandering flight)
Brown Booby (R)	Flight only over the sea at low altitudes
Brown Pelican (C)	Most flight over the sea and portion of land nearest the sea at a variety of altitudes including small proportion of time in turbine areas at rotor height
Caribbean Martin (U)	Too few observed to characterize, but most flight is likely to be along sea cliffs than in the wind turbine area
Falcon sp. (R)	Too few observed to characterize
Gray Kingbird (R)	Too few observed to characterize (they are common in the area but rarely fly high above the tree canopy)
Magnificent Frigatebird (C)	Most flight over sea and portion of land nearest the sea at a variety of altitudes including small proportion of time at turbine rotor height
Osprey (R)	Too few observed to characterize
Royal Tern (U)	Flight only at low altitudes over the sea
Red-tailed Hawk (R)	Too few observed to characterize
Sandwich Tern (U)	Flight only at low altitudes over the sea
Tricolored Heron (R)	Too few observed to characterize
Turkey Vulture (C)	Low to moderate wandering flight over land, at times within turbine rotor height

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**Table 4.** Summary of species, number of observations, percentage of observations with regard to total observations, and number of observations per hour (in parentheses) from the Punta Verraco and Cerro Toro observation sites of the WindMar Re Wind Power Project, Guayanilla, Puerto Rico, 2003.

Species	Cerro Toro	Punta Verraco	Total
<u>More Common Species</u>			
Brown Pelican	125 – 36.5% (5.2/h)	207 – 30.4% (4.5/h)	330 - 32.3% (4.7/h)
Magnificent Frigatebird	74 – 21.6% (3.1/h)	395 – 58.0% (8.7/h)	469 - 45.8% (6.7/h)
Turkey Vulture	82 – 24.0% (3.4/h)	76 – 11.2% (1.7/h)	158 - 15.4% (2.3/h)
<u>Less Common Species</u>			
American Kestrel	6 – 1.8% (0.3/h)	0 – 0.0% (0.0/h)	6 - 0.6% (0.1/h)
Brown Booby	2 – 0.1% (0.1/h)	0 – 0.0% (0.0/h)	2 - 0.2% (0.0/h)
Caribbean Martin	8 – 2.3% (0.3/h)	0 – 0.0% (0.0/h)	8 – 0.8% (0.1/h)
Falcon sp.*	0 – 0.0% (0.0/h)	1 – 0.1% (0.0/h)	1 - 0.1% (0.0/h)
Gray Kingbird	0 – 0.0% (0.0/h)	1 – 0.0% (0.0/h)	1 - 0.1% (0.0/h)
Osprey	0 – 0.0% (0.0/h)	1 – 0.1% (0.0/h)	1 - 0.1% (0.0/h)
Royal Tern	36 – 10.5% (1.5/h)	0 – 0.0% (0.0/h)	36 - 3.5% (0.5/h)
Red-tailed Hawk	1 – 0.3% (0.1/h)	0 – 0.0% (0.0/h)	1 – 0.1% (0.0/h)
Sandwich Tern	10 – 2.9% (0.4/h)	0 – 0.0% (0.0/h)	10 – 1.0% (0.1/h)
Tri-colored Heron	1 – 0.3% (0.1/h)	0 – 0.0% (0.0/h)	1 - 0.1% (0.0/h)
<b>Total</b>	<b>342 (14.3/h)</b>	<b>681 (15.0/h)</b>	<b>1023 (14.7/h)</b>

\* Peregrine Falcon is likely the species observed as this is the only large falcon that is known from Puerto Rico.

Because individual birds were certainly counted more than once, the total number of individual birds present is likely much lower than the total number of observations, particularly for the commonly observed species. For example, the hundreds of pelican observations were likely from about five to ten individuals. A maximum of about one-half dozen of these birds were visible at one time. For those species that were observed one or a few times, the actual numbers of individuals in the area are likely to be closer to the number observed.

### Behavior and Use Patterns

When behavioral observations of all species are combined for both the Cerro Toro and Punta Verraco observation sites, several patterns emerge. More than one-half (51.8%) of all birds (Figure 2) were observed flying at less than 100 feet above the substrate (treetops, rocky outcroppings, bare ground, and water). About 17% were observed flying higher than about 400 feet and the remaining 30% were within the 100 to 400 foot high range, which is the same as that of the wind turbine rotors.

The distribution of birds over the landscape, however, was more highly skewed (Figure 3). About three-quarters (76.3%) of all observations at both Cerro Toro and Punta Verraco occurred within the A sector, the sector that includes the Caribbean Sea and the adjoining land that is to the east of where wind turbines would be constructed (Figure 1). Only slightly more than one sixth of all observations (17.5%) were of birds flying over the area where wind turbines would be constructed.

When we examine the observations of birds flying over Sector B (where turbines would be) and look at the different heights, we see that only about one bird in 20 (6.25%) flew at the height of rotors (100-400 feet). A slightly higher percentage (8.6%) flew at altitudes below the rotor height and fewer (2.6%) flew above the rotor height (Figure 4).

Flight direction varied among species, although there were some common patterns. Most interesting is that there were few observations of birds flying along a north to south axis (or south to north), i.e., birds flying perpendicular to or crossing the Punta Verraco peninsula (Figure 5). For a majority of birds observed at the Punta Verraco observation site, flight direction was decidedly east to west. Nearly two-thirds (61.8%) of observations were of birds traveling east to west or west to east, parallel to the peninsula, whereas only 2.5% of observations were of birds traveling on a north to south or south to north track and about one-third (35.7%) were birds traveling northeast, southeast, northwest, or southwest (Figure 5). At the Cerro Toro observation site, the percentage of birds flying east to west or west to east was 56.7%, whereas birds flying diagonal to the axis of the peninsula (northeast, northwest, southeast, southwest) was 33.0%, and only 6.7% flew to the north or south.

In most of the species observed, there were too few observations to determine flight patterns. On the other hand, for frigatebirds, pelicans, and vultures, which accounted for more than 90% of all observations, distinct patterns were evident. At Punta Verraco, 60.8% of frigatebirds flew toward the east and another 31.4% flew toward the northeast. At Cerro Toro, the percentage that flew east to west or west to east was lower, at 45.9%. Only one bird was observed to fly on a north to south axis, which amounts to only 1.4% of observations of this

species at Cerro Toro. Frigatebirds flying to the northeast at Cerro Toro accounted for 43% of the observations at that site. Overall, very few frigatebirds crossed the peninsula and only 7 of 469 (1.5%) total observations (Cerro Toro and Punta Verraco combined) were of birds flying north to south or south to north.

Pelicans at Cerro Toro and Punta Verraco both showed a distinct tendency to fly parallel to Punta Verraco, as was the case for frigatebirds. More than one-half (56.7%) of pelican observations at Cerro Toro were of birds flying east to west or west to east, but only 6.7% of the observations were of birds flying north to south or south to north. Another 33.0% of pelicans at Cerro Toro flew on a northeast to southwest axis (percentages do not sum to 100% because a few observations did not include this information). At Punta Verraco, the pattern was similar with nearly two-thirds of pelicans flying east to west or west to east and only 3.4% flying north or south. Northeast and southwest were the next most common flight directions, together accounting for 35.7% of pelicans (Figure 5). These observations strongly suggest that pelicans and frigatebirds use the updrafts along the southern shore of Punta Verraco as a means of flying along the coast while possibly watching for food over the Caribbean. Several birds were observed fishing, so this is likely the case.

Turkey Vultures were less directional in their flight directions, although they too were seen frequently flying along an east to west axis. A total of slightly less than one-half (46.3%) of all vulture observations were along this axis. Birds flying north to south were infrequently observed and only 7% were seen doing this. Thus, the pattern for this bird was somewhat similar, although not as marked. It is likely that pelicans, frigatebirds, and vultures all rely on similar updrafts for energy efficient transport, which is why their flight direction patterns were similar.

Individual patterns, to some degree mirrored that of the general patterns for all species although there were some distinct differences. For Tricolored Herons, the large falcon, Osprey, and Gray Kingbird, there were too few individuals for patterns to be detected, and few of these birds flew over the areas where turbines would be constructed. The small numbers of terns, both Royal and Sandwich, as well as Brown Booby, were all observed flying over the sea (Sector A), well away from the portion of the project site where turbines would be located. For these birds, height above the ground did not matter, although all of those birds flew within the low height category – below the height of the rotors.

For the three species for which the largest numbers of observations were made, frigatebirds, pelicans, and vultures, the percentage of observations within Sector B varied between 90.5% for vultures to 10.4% for pelicans as observed from the Cerro Toro site (Table 5). Observations from Punta Verraco site showed percentages in Sector B ranged between 51.3% for vultures and 4.8% for pelicans (Table 5). Frigatebirds were found more frequently overland and over Sector B than were pelicans, but far less frequently than were vultures (Table 5).

With respect to height of these species within Sector B, from Cerro Toro, between one-third and one-half of pelicans and frigatebirds, respectively, flew within height class M (the height of rotors), whereas slightly more than one-quarter of all vultures flew within this height

range (Table 5). From Punta Verraco, about one-third of pelican and frigatebird observations were within the M height class, whereas only 13.2% of vultures flew within this height class (Table 5).

When examining the numbers of pelicans, frigatebirds, and vultures that flew within height class M while within Sector B, the height range and location of where turbines would be constructed, vultures were most likely to be in this height and sector, whereas frigatebirds and pelicans were less likely to be in this height and sector. Observations from Cerro Toro showed that about one-quarter of all vultures flew within in Sector B at Height M (B&M, see Table 5), whereas less 8% of pelicans and 12.2% of frigatebirds flew within B&M. There were fewer observations from the Punta Verraco observation site of birds flying within B&M, although Turkey Vultures were more than three times more likely to fly in B&M than were the other two species. Nevertheless, percentages were small for vultures, pelicans, and frigatebirds within B&M, being 9.2%, 2.9%, and 1.8% respectively.

### Discussion of Study Period and Methods

The study period used for assessing presence of birds at the WindMar project site, and risk to those birds, included the nesting season when Roseate Terns, Brown Pelicans, and other local nesting birds are most likely to be present. These are the species for which there is greatest concern. But, year-round measurements at the site show that wind direction and speed do not vary greatly during the year – the wind blows consistently from the east to southeast, the same direction as during the study period. This being the case, we believe that the results of this study strongly indicate what bird use can be expected during other seasons.

In commenting on the protocol for this study, Dr. Jorge Saliva, a FWS endangered species specialist based in the Boquerón, Puerto Rico, office, pointed out that weather conditions and habitat characteristics may influence bird activity patterns. However, measurements show that wind direction and wind strength vary little over the year, and data we have consulted show little variation in water temperature. Therefore, although we will continue to observe bird activity patterns in other months of the year, we believe the data set analyzed in this study strongly reflects the year-round bird use at the WindMar site.

### **Assessment of Risk**

Assessing collision risk to bird species present at any proposed wind power site cannot be precisely done because no methods have been validated as reliable predictors of risk. The reason is that the numbers of fatalities at almost all wind power projects have been small and not biologically significant (Erickson et al. 2001). Despite the fact that there are currently recommended research methods (USFWS 2003, Anderson et al. 1999), there has not been a study that has shown that any of these methods can predict risk accurately.

Authorities agree, however, that risk of collision at wind energy projects is species and site specific (Anderson 1998). Raptors have been shown to be most susceptible to collision (Erickson et al. 2001), other birds less so. Similar findings have emerged from studies of collisions with tall communication towers, where songbirds have been shown to collide more

often than do shorebirds or waterfowl (Shire et al. 2000). To assess risk to individual species, authors like Anderson et al. (1999) suggest conducting behavioral studies like the one we have done here for the WindMar RE site. Part of risk is believed to be bird abundance at a site. Another part is bird behavior at that site. Taken together, abundance and behavior constitute the “use” of a particular site, and determining use patterns can give an indication of risk. Nevertheless, the only way to validate this risk is through post-construction mortality studies.

At the WindMar site, thirteen species of birds were observed during the April through June behavioral observation period. For seven species fewer than eight observations were made, some of which could have been of the same individual. For these species (Brown Booby, Red-tailed Hawk, Falcon sp., Gray Kingbird, Osprey, Tricolored Heron, and Caribbean Martin) risk is likely to be low or nonexistent. With respect to Brown Booby, Osprey, and Tricolored Heron, none were observed within the area where turbines would be located, so no individuals could have been at risk. It is not known if individuals of any of these species pass through the site in greater numbers within the turbine area at other times during the year, but given the steady annual wind regime, this seems unlikely. For other species, such as Royal and Sandwich terns, risk is also likely to be nonexistent because none were observed flying over land, and the birds observed were hundreds of meters from where turbines would be constructed.

With respect to Roseate Terns, a federally listed species, significant efforts were made to detect this species. Regular examination of the island that is situated off Punta Verraco in the Caribbean Sea did not yield any observations of this species, nor did the regular behavioral observations conducted at Punta Verraco and Cerro Toro. Furthermore, regular visits of the site during the past five years by several trained biologists (Orlando Garrido, John Guarnaccia, Alfonso Silva, and others) have not revealed the presence of this species. If it visits the area, it does so very infrequently and is not likely to fly over land where turbines would be located, like its congeners, the Sandwich and Royal Terns. Risk of collision to this species is, therefore, nonexistent.

Turkey Vultures were the species that were most likely to spend time within the wind turbine area and flying at rotor height. (American Kestrels also flew “frequently” within this zone, but this is based on six observations, not 158 for the vulture.) The fact that nearly one-sixth of all observations of vultures were within the rotor-swept height-zone suggests that these birds could be at risk. However, based on studies conducted in the Altamont Pass Wind Resource Area of California (Orloff and Flannery 1992, 1996) and other projects (Erickson et al. 2002), it has been demonstrated that this species is not likely to collide with wind turbines, even with use estimates comparable or higher than the WindMar site. Turkey Vultures have been recorded flying amongst the turbines for hours without colliding (personal observations), and only on very rare occasions have these birds have been found dead under the 5,400 wind turbines in the Altamont. Therefore, the assessed risk for this bird species, which spends the most time of any in the rotor zone at the WindMar site, is estimated as low to none.

Brown Pelicans and Magnificent Frigatebirds were the two species most often observed in this study. Together, they accounted for 78.1% of all observations at Punta Verraco and Cerro Toro. It appears, however, that risk to these birds is low because they seldom fly within the turbine area at the height range of the rotors. Instead, most fly over the sea or along the steep

cliffs adjacent to the sea, using updrafts from prevailing easterlies to soar and look for fish. There were, however, small numbers of observations of birds crossing the peninsula in the rotor zone. For Brown Pelican, the percentage of all observations in the rotor zone was 8.0% from Cerro Toro and 2.9% from Punta Verraco. For the Frigatebird, the corresponding values were 12.2% and 1.8%. Because, in cross-section, the actual area swept by rotors is 28% of Sector B, the percentage of pelicans and frigatebirds that would actually be within the potential zone of risk would be much less, 2.2% and 0.8% respectively. These percentages can be driven down significantly further when one takes into account that birds do recognize wind turbines as obstacles and regularly avoid flying into them. For these reasons, the number of fatalities that are likely per year is expected to be minimal.

Studies at other wind power facilities show that use by many species occurs without significant numbers of collisions. For example, use by Turkey Vultures and other raptors at sites in Minnesota, Oregon-Washington, and Wyoming range between about 0.4 and 1.5 birds per hour (Erickson et al. 2002) entirely within the turbine area. For comparison, Turkey Vulture use at the WindMar site (i.e., birds flying in Zone B among the turbines, regardless of height, but not necessarily entirely within the turbine area) measured 1.6 birds per hour. Each of the above projects, however, has more than 100 turbines, yet mortality of raptors, including vultures, ranged between 0.000 and 0.053 birds per turbine per year. Interestingly, no Turkey Vultures have been recorded dead at these sites. This strongly suggests that this soaring bird is much more adept than buteo hawks at seeing and avoiding turbines.

Magnificent Frigatebird use in the proposed WindMar turbine field (Zone B) is 0.4 birds per hour, which is significantly below the 0.4 and 1.5 range for raptors quoted above. Since this bird is a superb flier and does not forage over land (i.e., it will not be distracted by foraging when within the turbine field), we predict that it is unlikely to collide with the 19 turbines on the Punta Verraco peninsula. Nevertheless, there are no published studies of Magnificent Frigatebird use and mortality at wind energy projects. The closest examples would be two projects in Curacao, which have not been systematically studied. Frigatebird mortality has not been noted there (Roy Kolader, personal communication via John Guarnaccia), however.

The Caribbean Brown Pelican (*Pelecanus occidentalis occidentalis*) is a special case, because it is federally listed and, unlike the Roseate Tern, it has been recorded regularly in the airspace of the proposed WindMar turbine field on the Punta Verraco peninsula. Pelicans predominantly use wind deflected up the cliffs at Punta Verraco and Cerro Toro to power their flight in an easterly and northeasterly direction. 64% of all pelicans observed were traveling on an east-west axis. 32% traveled on a northeast-southwest axis. Only 4% (0.2 bird observations hour) crossed the peninsula directly on a north-south axis on their way between the Caribbean and Guayanilla Bay. The average number of pelicans per observation crossing the peninsula directly was 1.6 birds. While the intent of these crossing flights may be to reach foraging areas, pelicans do not forage over land. Therefore, unlike raptors, they would not be distracted by foraging when within the airspace of the wind farm and would likely pay close attention to the wind turbines and avoid them.

Pelican use of the airspace in the proposed WindMar turbine field is relatively low (0.3 birds per hour) when compared with studies of raptors at sites with more than 100 turbines

(range of 0.4 to 1.5 birds per hour, from Erickson et al. 2002). As stated above, mortality rates for raptors, which appear to be particularly susceptible to turbine collisions, range widely, from 0.000 to 0.053 mortalities per turbine per year at sites with over 100 turbines. Since pelican use of the WindMar turbine airspace is lower than raptors studied at other sites, and since pelicans, as noted above, are more likely to avoid turbines than raptors, the mortality rate for pelicans is likely to be much lower.

Pelicans observed in the WindMar rotor zone itself (Zone B at Height M) was 0.2 bird observations per hour, which is lower than the 0.3 bird observations per hour quoted above because some birds flew above and below that rotor swept area. Since the rotor swept area in cross-section is only 28% of total area (nineteen 80-m diameter rotors distributed along the 3.4-km dogleg spanning the crown of Cerro Toro to the tip Punta Verraco), the number of birds in the rotor zone decreases to 0.06 observations per hour. In a twelve-hour day, therefore, there would be 0.72 observations of pelicans transiting airspace that will be occupied by spinning rotors. Our data indicate that most of these observations would be of single birds. Because it has been demonstrated that birds recognize wind turbines as obstacles and regularly avoid flying into them, it is highly likely that collision mortality for pelicans will be low to none.

The number of individual pelicans using the WindMar site appears to be low, possibly only six individual birds on a daily basis, with numbers occasionally swelling to 20 to 40 individual birds (Alfonso Silva and Antonio Perez-Asso, personal communication). Therefore, few pelicans will be exposed to the WindMar project once it is constructed.

While these arguments support a risk assessment of low to none (not biologically significant) for the Brown Pelican, there have been no studies of Brown Pelican interactions with coastal wind energy projects. Brown Pelicans do occur in Curacao, where two wind projects have been constructed, but neither project has been studied systematically. Nevertheless, anecdotal information suggests that pelicans avoid these wind farms (Roy Kolader, personal communication).

In conclusion, risk of colliding with wind turbines for most species of birds that frequent the WindMar project area at Punta Verraco is relatively low or nonexistent. Abundance of most species that were observed was low, or the species simply did not fly over land in the area where turbines were located. Three species frequently flew over or adjacent to Punta Verraco, Brown Pelican, Magnificent Frigatebird, and Turkey Vulture, such that they could be exposed to collision with the turbine rotors. However, very few of these birds flew in the areas where turbines would be located at the heights of the rotors. For this reason, risk to these species is likely to be low and not biologically significant.

**Table 5.** Summary of percentages of birds flying within the area where turbines would be located (Sector B), at the height of the turbine rotor (Height M), and birds flying within the area where turbines would be located and at rotor height (B&M) at the Cerro Toro and Punta Verraco observation areas of the WindMar RE wind power project, Guayanilla, Puerto Rico, in spring 2003. N/A indicates no birds of that species were observed from that observation site.

Species	Cerro Toro			Punta Verraco		
	Sector B	Height M	B&M	Sector B	Height M	B&M
More commonly observed species						
Brown Pelican	10.4%	32.8%	8.0%	4.8%	37.2%	2.9%
Magnificent Frigatebird	13.5%	47.3%	12.2%	5.1%	31.1%	1.8%
Turkey Vulture	90.2%	28.0%	26.8%	51.3%	13.2%	9.2%
Less commonly observed species						
American Kestrel	33.3%	16.7%	16.7%	N/A	N/A	N/A
Brown Booby	0.0%	0.0%	0.0%	N/A	N/A	N/A
Carribean Martin	0.0%	0.0%	0.0%	N/A	N/A	N/A
Falcon sp.*	N/A	N/A	N/A	0.0%	100.0%	0.0%
Gray Kingbird	N/A	N/A	N/A	100.0%	100.0%	100.0%
Osprey	N/A	N/A	N/A	0.0%	0.0%	0.0%
Royal Tern	0.0%	0.0%	0.0%	N/A	N/A	N/A
Red-tailed Hawk	100.0%	0.0%	0.0%	N/A	N/A	N/A
Sandwich Tern	0.0%	0.0%	0.0%	N/A	N/A	N/A
Tri-colored Heron	0.0%	0.0%	0.0%	N/A	N/A	N/A

**Table 6.** Assessment of risk to species observed at the Cerro Toro and Punta Verraco observation points at the WindMar RE wind power project, Guayanilla, Puerto Rico; None = no fatalities likely, Low Risk = very small numbers of fatalities may occur annually (1-2-individuals).

Species Observed	Assessed Risk	Basis
American Kestrel*	Low-None	Very few individuals in area
Brown Booby	None	Very few individuals and flight over ocean only
Brown Pelican	Low-None	Some flight over project area at turbine rotor height
Carribean Martin	Low	Very few individuals in area
Falcon sp.	Low-None	Very few individuals in area
Gray Kingbird	Low-None	Very few individuals fly at turbine rotor height
Magnificent Frigatebird	Low-None	Some flight over project area at turbine rotor height
Osprey	Low-None	Very few individuals in area
Royal Tern	None	Flight over ocean only
Red-tailed Hawk*	Low-None	Very few individuals in area
Sandwich Tern	None	Flight over ocean only
Tri-colored Heron	Low-None	Very few individuals in area
Turkey Vulture*	Low-None	Literature suggests species is not collision susceptible

\* Individuals of these species have collided with wind turbine rotors according to literature.

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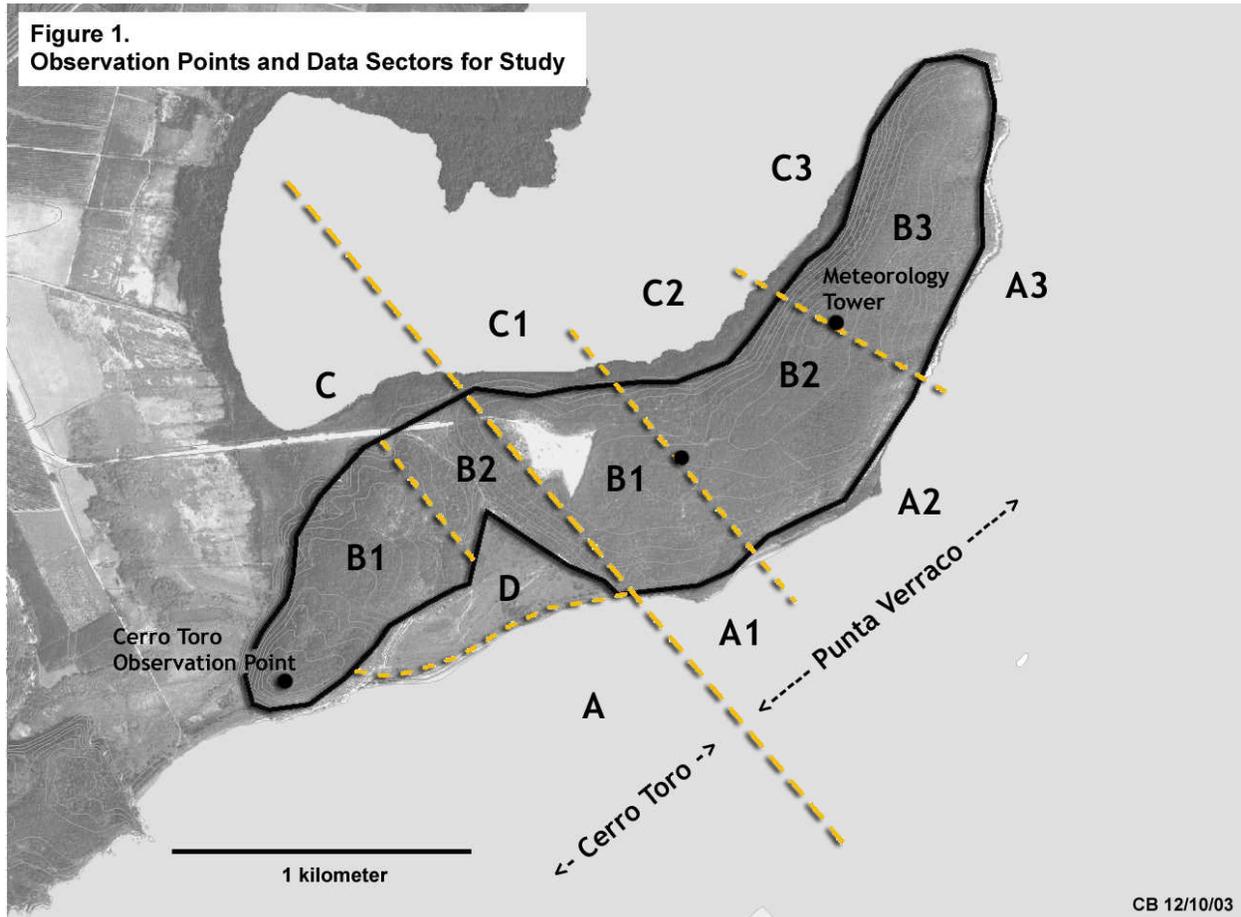
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**Figure 1.** Map showing location of the two observation points at Punta Verraco (dot adjacent to B1) and Cerro Toro used for the assessment of risk to pelicans, terns, and other birds at the WindMar RE wind power project site, Guayanilla, Puerto Rico.







**Appendix II.** Summary of dates, time, hours and weather during the avian risk surveys at the Cerro Toro (T) and Punta Verraco (V) observation points at the WindMar RE wind power project, Guayanilla, Puerto Rico, spring 2003.

Date	Location	Time	# of Hours	Wind Dir.	Speed	Temp	CC	Notes
5/16/03	T	12:30-2:00	1.50	SE	30	34	0	
5/16/03	V	7:30-9:00	1.50	E	20	30	5	
5/16/03	V	12:00-1:30	1.50		20	30	10	wind speed very variable (5-20 or more)
5/17/03	T	7:00-8:30	1.50	SE	5	28	0	no bird activity on the little island located 140 from here
5/17/03	V	7:00-8:30	1.50	SE	5-10	28	0	no Pelican or Frigate were observed between 7:41-8:30
5/17/03	T	12:30-2:00	1.50	SE	30	34	0	
5/17/03	V	12:30-2:00	1.50	SE	10-20	34	0	
5/18/03	T	7:00-9:30	1.50	SE	10	28	10	no bird activity on the little island SSE of this site
5/18/03	V	7:00-8:30	1.50	SE	5	34	20	CC 20 to 0 at 7:40 – wind speed variable 0-10
5/18/03	V	10:30-12:00	1.50	SE	15-20	36	40	CC 80% at 11:00 and 30% at 12:00
5/24/03	V	12:30-2:00	1.50	SE	20-25	42	0	
5/24/03	T	2:30-4:00	1.50	SE	20-30-40	40	20	
5/25/03	V	8:30-10:00	1.50	SE	10	35/37	30-10	
5/25/03	T	10:30-12:00	1.50	SE	20-32	36-40	5-0	
5/25/03	V	1:00-2:30	1.50	SE	15-20	36-39	0	
5/29/03	T	4:00-5:30	1.50		30	32	0	no bird activity at the small offshore island
5/29/03	V	4:00-5:30	1.50	SE	5-10	35	0	
5/30/03	T	7:00-8:30	1.50	SE	15	28	30	
5/30/03	T	12:10-1:40	1.50	SE	20	34	0	no seabird activity at the small island S of Punta

Verraco

Date	Location	Time	# of Hours	Wind Dir.	Speed	Temp	CC	Notes
5/30/03	V	3:00-4:30	1.50	SE	5-10	35	5	
5/31/03	V	7:00-8:30	1.50	SE	10	30	20-40	
5/31/03	T	7:30-9:00	1.50	SE	5	28	20	
5/31/03	T	12:00-1:30	1.50	SE	20	34	0	
5/31/03	V	12:00-1:30	1.50	SE	10	37	0	
5/31/03	T	4:00-5:30	1.50	SE	20	34	0	no seabird activity on small island S of peninsula
5/31/03	V	4:00-5:30	1.50	SE	10	34-29	0-10	
6/1/03	T	7:00-8:30	1.50	SE	5	28	0	no bird activity on small island S of peninsula
6/1/03	V	7:00-8:30	1.50	SE	0-5	27-32	0	
6/1/03	V	8:30-10:00	1.50	SE	0-5	32	0	
6/9/03	T	4:00-5:30	1.50	SE	30	32	50	very cloudy over land (100), almost clear sky over sea; no bird activity on small island S of peninsula
6/10/03	T	6:00-7:30	1.50	SE	5	28	5	no bird activity at small island S of Punta Verraco
6/10/03	T	4:00-5:30	1.50	SE	30	32	80	no bird activity on small island S of peninsula
6/14/03	V	9:00-10:30	1.50	SE	0-5	34	30-50	
6/14/03	V	10:30-12:00	1.50	SE	5-10	36	30	
6/14/03	V	12:00-1:30	1.50	SE	5-10	36	40	
6/14/03	V	1:30-3:00	1.50	SE	5-10	37-34	20-40	
6/15/03	V	7:00-8:30	1.50	SE	5	29-31	10-20	high activity of birds in C1,C2 fishing in same place In a.m., a lot of "Laviotas" in C1-C2

Date	Location	Time	# of Hours	Wind Dir.	Speed	Temp	CC	Notes
6/15/03	V	8:30-10:00	1.50	SE	5-10	31-33	20-30	cloud very variable – 20-30 70-40-70; no birds observed in C1-C2 at 9:30 a.m.
6/15/03	V	10:00-11:30	1.50	SE	5-10	33-36	70-50	cloud very variable- 70-50 20
6/15/03	V	11:30-1:00	1.50	SE	5-10	36	20-5	
6/16/03	V	2:30-4:00	1.50	SE	5	30	80	
6/16/03	V	4:00-5:30	1.50	SE	5	30	90	
6/16/03	V	5:30-7:00	1.50	SE	5-10	29	70	1 Pelican flying in front of Cerro Toro at 7:00
6/17/03	V	2:00-3:30	1.50	SE	5-10	32	70	
6/17/03	V	3:30-5:00	1.50	SE	5-10	31	60	
6/17/03	V	5:00-7:00	2.00	SE	5-10	30	50	

Total Hours	69.50
Cerro Toro	24.00
Punta Verraco	45.50