Section III. Potential Effects of Wind Turbines on Birds, Bats and Marine Organisms in New Jersey's Coastal Zone

Wind turbines have the potential to impact breeding, wintering and migrating birds and bats. Appropriate siting of wind turbines depends upon many factors. Among the factors that determine the potential impact of wind turbines are the height of the turbine, the rotor swept area of the turbine, and the flight behavior of the birds and bats found in the area. The rotor swept area of a wind turbine is the area of the circle delineated by the tips of the blades of the wind turbine for a horizontal axis wind turbine, and the area determined by multiplying the rotor radius times the rotor height times 3.14 for a vertical axis wind turbine. The behaviors and flight altitudes of birds and bats are variable. For example, birds in migration tend to fly at higher altitudes than breeding birds that are nesting or foraging within and among suitable habitats. However, the altitude of migratory flight varies depending on weather conditions, visibility, navigation mode (celestial vs. geographic), taxonomic group (diurnal vs. nocturnal migration), age (juvenile vs. adults), and time constraints on migration associated with breeding vs. non-breeding period (frequency and duration of stops to rest and refuel).

Because of the variables involved, the placement of identical turbines in two different locations can lead to dramatically different impacts even though the size of the blades, the height of the structure and all other construction details are the same. In addition, the placement of two different turbines in the identical location can lead to dramatically different impacts depending on the height, rotor swept area, and design.

Another factor that can influence the potential impacts of wind turbines, where birds and bats are in the altitudinal range of the turbine, is the visibility of the turbine. While wind turbines are colored to maximize visibility for airplanes (white turbine against darker background of the earth, vegetation, water) and to minimize visual impacts to the human view-shed, white turbines are not necessarily highly visible to birds that approach them from a variety of directions (for example, white turbine against bright or hazy sky, or a white clouded sky). Even in good visibility conditions "motion smear" or "motion blur" can cause turbine blades, particularly the fast-moving end of the blade, to become transparent to the bird. Paradoxically, the "invisibility" of blade tips occurs at greater distances from larger turbines and worsens as a bird moves closer to the turbine. Moreover, the slim profile of blades in the lateral plane (looking side-on, parallel to the blade axis) and motion smear, make fast-moving tips of rotor blades invisible to birds approaching from side-on (Hodos, 2003).

Impacts can additionally vary based upon seasonal considerations. Migrating birds make landfall ("stopovers") daily to rest and refuel. Therefore, when stopping over, landbird and shorebird migrants fly at low altitudes over land and coastal waters to utilize foraging and roosting habitats in a manner similar to breeding birds. The duration of migration flight and stopover vary seasonally and by species. Migration is characterized by a time-stressed spring migration (April through May) where large numbers of birds move en masse to breeding areas and a less time-stressed fall migration (mid-July through November) where smaller flocks of birds move through New Jersey coastal areas over a longer period of time, stopping more frequently and for longer durations. In the spring and fall there is a propensity for some taxonomic groups to concentrate in large numbers because of food resources (e.g., spring migratory shorebirds feeding on horseshoe crab eggs) or at geographic barriers (concentrations of migrant songbirds and raptors along the Atlantic coast and in the Cape May Peninsula) (Niles et al., 2008, McCann et al., 1993). Stopover duration in spring and fall can range from one to several days up to several weeks.

Impacts can also vary between migratory and resident populations, as well as the relationship of the location of the wind turbines to nesting and foraging areas. Siting of wind turbines is a concern for breeding and wintering birds since there is a greater potential for interactions with the turbines over a longer timeframe than with migrating birds. Breeding and wintering species are likely to be more familiar with their home range area, have learned where hazards and obstacles are located, and may be better able to avoid them. However, unintended consequences can arise from poorly sited or managed (from the perspective of wildlife) turbines. For example, in the case of Altamont, California, the wind turbine area became an attractive nuisance for raptors because short-grass management increased the density of mammalian prey, and lattice towers provided hunting perches (Smallwood et al., 2001, Orlof & Flannery, 1992). Accordingly, the number of actual interactions between raptors and the wind turbines proved to be greater than anticipated. Various species of breeding grouse may avoid nesting in areas near structures like turbines, thus eliminating otherwise suitable habitat for these species (Manville, 2004). Multiple species of terns have been shown to be susceptible to collisions with turbines when they are sited between their breeding and foraging areas (Everaert and Stienen, 2007). Analogous instances could occur if turbines are located in areas of high use by a given species (its breeding- or winter range), or if vegetative management (on land) or turbine monopoles (in water) create habitat for their prey base (attractive nuisance). Cumulatively, as the number and size of wind turbines increase along the coast, the greater the potential for habitat loss and habitat avoidance.

A wide range of factors influencing the potential impact of wind turbines has similarly been found to apply to bats. To date, nearly all studies of bat mortality associated with wind energy development have cited a dominance of migratory, foliage- and tree-roosting lasiurine species killed by turbines (Arnett et al. 2007). In addition, it has been reported that the highest bat fatalities at wind energy facilities occur during late summer and early fall (Johnson 2005, Kunz et al. 2007) corresponding to the period of post-breeding southward migration for hoary, silver-haired and eastern red bats (Bogan et al. 1996, Koehler and Barclay 2000). Several studies have reported that bat migratory passage rates are higher during evenings with low wind speed (Arnett 2005, Reynolds 2006). Buchler (1980) reported that juvenile bats have reduced abilities to echolocate and fly and are therefore more susceptible to collisions than adults.

Bats appear to engage in more exploratory behaviors with wind turbines than birds. Horne et al. (2006) conducted a study of the behavioral responses of bats to operating wind turbines in West Virginia and reported that bats actively investigated both moving and stationary turbine blades. They also observed that bats landed upon and investigated turbine blades and monopoles suggesting that they may be attracted to wind turbines themselves possibly because they view these tall structures, standing in open areas, as potential roost trees or habitat where mates can be located (Kunz et al., 2007, Cryan, 2008). In addition to the potential for collisions with turbines, recent research has suggested that bats may also be susceptible to barotrauma, where tissue damage to their air-containing structures leads to death. Barotrauma occurs when the bats enter the air space around the turbine and experience a rapid decrease in air pressure. (Baerwald et al., 2008).

Reported altitudes of migrating bats are within the rotor-swept height of many new generation turbines. Some groups of bats have been reported to migrate at altitudes greatly exceeding 100 meters (Altringham 1996). Allen (1939) reported that bats observed migrating during daylight hours over Washington D.C. flew at heights between 46 and 140 meters (between 151 and 459 feet) above the ground. It has also been reported that many species of bats rely on linear features (rivers and coastlines) in the landscape while migrating (Strelkov 1969, Humphrey and Cope 1976, Timm 1989). This could direct migrating bats over wind energy facilities in the coastal region in higher-than-average numbers.

Although there is not extensive data on migrating bats in the coastal region of New Jersey, several species have been known to roost on buildings and other structures during the fall migration. Specifically, bats have been reported to roost on several casinos and other manmade structures in Atlantic City, New Jersey (Annette Scherer, personal communication, June 22, 2009).

Similarly, birds may be impacted by wind turbines located in tidal waters. The Cape Wind Energy Project Final Environmental Impact Statement, dated January 2009, prepared by the U.S. Department of the Interior Minerals Management Service (OCS Publication No. 2008-040) identifies potential impacts to include those associated with vessel traffic and oil spills, displacement of birds, as well as the risk of collision with the turbines and the barrier that wind turbines present to traveling birds. The impact would depend in part on the species, its behavior and use of the site, and the location and size of the turbines.

Other marine organisms, including marine mammals and sea turtles, may also be affected by the construction and operation of wind turbines. The impacts in marine waters are not well understood. From January 2008 through December 2009, the Department conducted Ecological Baseline studies to begin to address the distribution and abundance of species offshore and potential ecological impacts of offshore wind turbines. The Department gathered data on the abundance and distribution of birds, marine mammals and sea turtles in an area that reaches 20 nautical miles offshore, between Seaside Park and Stone Harbor (approximately 1,300 square nautical miles). Details on the study and reports can be found at http://www.nj.gov/dep/dsr/ocean-wind.

The overall goal of the study is to provide spatial and temporal data on species utilizing New Jersey offshore waters to assist in determining potential areas for wind power development. The study is intended to address the following questions:

1. What are the abundance, distribution, flight behavior (i.e., height and regular pathways), and utilization (for example, feeding, breeding) of bird species in the Study Area?

2. What are the abundance, utilization (for example, feeding), and distribution of marine mammals in the Study Area?

3. What are the abundance, utilization (for example, feeding), and distribution of sea turtles in the Study Area?

4. What are the abundance, utilization, and distribution of other marine biota (for example, fish, shellfish) in the Study Area?

5. What is the distribution of other existing natural resources, including, but not limited to, shoals and sand?

6. Using predictive modeling, mapping, and environmental assessment methodologies, what portions of the Study Area are more or less suitable for energy power facilities based on potential ecological impacts?

Three primary field surveys (avian, marine mammal and sea turtle) were conducted through this 24-month study. All wind power impacts data in the United States have been collected in terrestrial systems. Using methods utilized in European studies of offshore wind power, the baseline study assessed the spatial and temporal distribution of avian species (including migratory and resident species), marine mammals and sea turtles, and marine fish and shellfish off the coast of New Jersey, throughout the year. The Ecological Baseline Study final report released in July 2010, includes maps identifying the relative environmental sensitivity of different locations within the Study Area, as well as maps identifying temporal and spatial use of the baseline area for birds, marine mammals and various ocean uses.

Although the impacts are not well understood, it is known that marine mammals are sensitive to noise and vibrations (Cape Wind EIS). Marine mammals, particularly whales, and sea turtles are vulnerable to vessel strikes. The potential for such vessel strikes would increase during construction and servicing of offshore wind turbines. A Danish study of two offshore wind farms found that after two years, the abundance of porpoises had not returned to pre-construction densities at one of the two locations (DONG Energy et al. 2006). There are no existing offshore wind farms in the United States.

The Department appreciates that many other sources can impact bird populations more than wind turbines; partially because these sources outnumber wind turbines in New Jersey's landscape (e.g. the number of buildings or cats versus turbines). While birds may be attracted to and perch on communication towers or buildings, for example, there is a minimal risk of injury when the bird approaches to perch or alights from the structure. In contrast, when a bird is attracted to perch on a tower associated with a wind turbine, it is put into immediate danger of contact, either in approaching the tower or alighting from it, with the spinning rotor blades. The presence of structures throughout the landscape highlights the importance of being aware and controlling for impacts from new sources since many of the species populations are already under so much pressure due to other anthropogenic factors.

Department’s Large Scale Wind Turbine Siting Map

As demonstrated above, wind turbines may cause unacceptable levels of mortality to birds and bats in some locations particularly as they increase in size. Accordingly, the Department has carefully evaluated the land in the coastal zone and prepared a map that identifies specific areas on land where larger wind turbines, those 200 feet in height or taller or having a cumulative rotor swept area of greater than 4,000 square feet are unacceptable due to the operational impacts of the turbines on birds. These areas are identified on the Department’s Large Scale Wind Turbine Siting Map that is available for download on the Department's interactive mapping website at www.nj.gov/dep/gis. This map was produced in an effort to minimize the impacts of wind turbine operation to birds. Under the CZM rules, no portion of such wind turbine(s) including blades, towers and site disturbance can be located in or over these areas. Areas identified on the Large Scale Wind Turbine Siting Map are those areas where the Department currently has wildlife data to make the determination that a wind turbine (or turbines) 200 feet in height or taller, or with a cumulative rotor swept area of greater than 4,000 square feet on a site, would pose a significant and unacceptable risk to birds. Details on the methodology and justification used to map these areas can be found in the Large Scale Wind Turbine Siting Map report on the Department's website at www.state.nj.us/dep/landuse. (See Appendix A)

The Department's Division of Fish and Wildlife mapped areas on land of documented bird concentration and nesting for resident threatened and endangered bird species, as well as areas of documented bird concentration and stopover locations for migratory songbirds, migratory raptors, and migratory shorebirds. Regional areas of high migratory bird concentration, such as the lower Cape May Peninsula and the Delaware Bayshore, were identified on the map. The Department mapped the most southerly 20 km of the Cape May peninsula and portions of the Delaware Bayshore as an area of highly significant bird concentration for many groups of migrating birds (raptors, songbirds, and shorebirds). Direct bay-to-ocean flight paths for Red Knots and other shorebirds have been documented in this portion of the peninsula. The mapped area included all land within the lower Cape May peninsula and continued northward to a point that is roughly 3-km north of Cape May Courthouse. The Delaware Bayshore was also represented on this map and included all coastal wetlands (and all areas within 1 km of these wetlands) beginning at the lower 20-km boundary line and extending around the Delaware Bayshore to the northern side of the Cohansey River. These are areas where the Department has determined that the installation of wind turbine(s) 200 feet in height or taller, or having a cumulative rotor swept area greater than 4,000 square feet on a site, are unacceptable due to potential impacts on migratory and resident birds.

The Lower Cape May peninsula, Delaware Bay, and Delaware Bayshore support a diverse and abundant assemblage of wildlife and are collectively considered one of New Jersey's, and the Country's, most valuable natural resources. Aggregates of more than 500,000 shorebirds use the Bay each year during spring migration. These shorebirds make daily cross-bay and cross-peninsula flights at low altitude in search of food and roost areas. Each May-June, a large percentage of the entire western Hemisphere's population of Red Knots is located along the bay. Other shorebird species (Ruddy Turnstone, Sanderling, Semipalmated Sandpiper, Dunlin, Short-billed Dowitcher) are also present in high numbers at this time. In addition, thousands of waterfowl winter in Delaware Bay. Of particular note are American Black Ducks since New Jersey winters one-third of all black ducks in the eastern United States (with significant concentrations in Delaware Bay wetlands) and tens of thousands pass through during both spring and fall migrations. Finally, the Cape May region is home to one of the most celebrated raptor and songbird fall migrations in the world. These migrants become concentrated along the coast of the Delaware Bay and into the southern portion of the Cape May peninsula. The open water of Delaware Bay can create a temporary barrier to migrating birds, many of which are juveniles, causing them to "stopover" in these areas to rest and feed while awaiting favorable conditions for crossing.

The diversity and abundance of wildlife using the lower Cape May peninsula and Delaware Bayshore has lead to national and international recognition of these areas. For example, the Delaware Bay is designated as “Wetlands of International Importance” under the RAMSAR Convention (an intergovernmental treaty signed in 1971 and providing the framework for national action and international cooperation for the conservation and sustainable use of wetlands and their resources). See www.ramsar.org. Similarly, the Cape May peninsula is considered by many authorities to be one of the top birding destinations in the world.

The Department also included a number of other regions of high bird concentration in the Large Scale Wind Turbine Siting Map. These additional regions are smaller in area than the Cape May Peninsula or Delaware Bayshore, but contain such documented high concentrations of avian use that the Department believes that large wind turbine development within theses area would pose a significant risk to wildlife.

The species considered when delineating these regions were those documented to be at risk of colliding with wind turbines and/or those that exhibit flight patterns or behaviors that put them in collision risk. For example, Osprey forage at low altitudes and therefore often fly through what would be considered the “rotor swept zone” for both large and small turbines. Additionally, Osprey are one of species reported to have been struck and killed within the past three years at the Atlantic City wind facility. These factors combined led the Department to consider Osprey as a species that may be directly impacted by wind turbines. As such, occurrences of this species directly contributed to the mapping of regions in the Large Scale Wind Turbine Siting Map.

Biologists within the Department hand delineated the boundaries of the regions described below using GIS software and 2007 digital aerial photography. The Department included these regions or areas in the Large Scale Wind Turbine Siting Map because they contain habitats known to receive high use by those avian species considered to be susceptible to collisions with large wind turbines. Contained within these regions are areas of high nesting concentrations of colonial long-legged wading birds, Osprey, Bald Eagles, Peregrine Falcons, Black Skimmers, Least Terns, and Piping Plovers as well as significant foraging habitats and major migratory stopover habitats for waterfowl, songbirds, shorebirds, and raptors.

The hand-delineated regions of high avian use include: 1) Hereford Inlet and the back-bay areas west of Stone Harbor for concentrations of beach-nesting birds, nesting long-legged wading birds, Osprey and migratory shorebird concentrations; 2) Great Egg Harbor/Tuckahoe River for concentration of nesting Osprey, Bald Eagle wintering, and nesting Peregrine Falcons; 2) Little Egg/Brigantine Inlets, and Mullica River Region for high concentrations of wintering waterfowl, migratory shorebirds and songbirds, colonial nesting waterbirds, nesting Piping Plover and nesting Osprey; 3) Island Beach State Park and Sedge Islands Wildlife Management Area for high concentrations of migratory shorebirds, nesting Osprey, beach-nesting birds, nesting long-legged wading birds, wintering waterfowl and nesting Peregrine Falcons; 4) Gateway National Recreation Area - Sandy Hook Unit for high concentrations of Osprey, migratory songbirds and beach-nesting birds 5) Stow Creek and Mannington Meadows for high concentrations of nesting Bald Eagles; 6)

Maurice River for nesting Osprey and Bald Eagle concentrations; and 7) Palisade Mountains for concentration of nesting Peregrine Falcons.

Critical habitats and flight paths for individual endangered or threatened bird species were also represented on the Large Scale Wind Turbine Siting Map. Location information for these species was obtained from the Department's Oracle-based Biotics Database, which is a database used to track the locations of endangered and threatened species throughout New Jersey. Only those documented species occurrences known to be active contributed to the areas identified on the Department's Large Scale Wind Turbine Siting Map. Furthermore, similar to the criteria used when mapping the regions described above, only those avian species with a documented, or anticipated, risk of colliding with wind turbines were considered in this mapping. The species (and life history categories from the Biotics Database) included in the mapping were: Black Skimmers (nesting colony), Black-crowned Night-heron (nesting colony), Yellow-crowned Night-heron (nesting colony), Least Tern (nesting colony), Piping Plover (nesting area), and Red Knot (non-breeding sighting). Locations characterized as migratory shorebird concentration sites were also mapped.

To identify critical habitats and flight paths for these species, active species occurrence areas (points, lines, and polygons) were taken from the Department's Biotics Database. In all cases, the locations of the species occurrence areas (for those species listed above) were first buffered by distances specific to each species. This form of buffering allowed areas/habitats in close proximity to the species occurrence to be considered for final mapping. The Department recognizes that areas proximate to nesting sites or colonies of endangered or threatened species deserved special protection because adult birds make regular flights through these areas to forage, care for their chicks, and carry out courtship behaviors. Low altitude flights (at altitudes equivalent to rotor swept heights) are typical during the breeding season for the species considered in the Large Scale Wind Turbine Siting Map and these flight patterns increase their risk of collision with wind turbines. During the mapping process, biologists made every reasonable effort to remove unsuitable land-cover types from the buffer zone surrounding each species occurrences, provided that known flight paths remain within the mapped area. For example, nesting colonies of Least Terns that were documented to be active for a minimum of three years since 1995 were included in the mapping and were buffered by 400 meters. Within this 400-meter buffer, most urban areas were removed. However, if the Department had documented observations of flight paths for this species (e.g. movements from nesting areas to foraging areas), and those flight paths cross directly over urban areas, the urban areas were included in the mapping. Therefore, in some cases habitats that would typically be considered "unsuitable" for a particular species were including in the Large Scale Wind Turbine Siting Map because they fell within a known flight path for an endangered or threatened species. The following buffer distances were applied: 1) Black-crowned Night Heron (nesting colony) and Yellow-crowned Night Heron (nesting colony) – 300 meters; 2) Black Skimmer (nesting colony) and Least Tern (nesting colony) – 400 meters; and 3) Red Knot (non-breeding) and Shorebird Concentrations sites – 1000 meters. A detailed justification of buffer size and a species-by-species description of the hand selection/removal process of land-cover types can be found in the Department's Large Scale Wind Turbine Siting Map Report.

The CZM rules contain provisions for changing the map. Revisions to the map may result in additional areas being mapped or areas that are currently mapped being removed. The procedure for revising the map includes public notice and an opportunity for public involvement in the revision process. First, the Department shall publish notice of its intent to revise the map in the New Jersey Register, including a description of the proposed revision and an explanation of why it is being proposed. The Department will also post the proposed revision of the map on its interactive mapping website at www.nj.gov/dep/gis and publish notice in a newspaper that is generally circulated within each county affected. This notice shall include relevant information related to the proposed revision, and an invitation for interested parties to provide comment to the Department for a period of 30 days. Upon consideration of the available information and public comments, if the Department concludes that revising the map is appropriate based on the potential risk to birds and bats associated with the operation of large scale wind turbines, the Department will revise the map as appropriate, publish a description of the revision in the New Jersey Register as well as in one newspaper of general circulation in the county. The Department will also post the revised map on the Department's interactive website.

Adaptive Management - Curtailment of Wind Turbine Operations

To address the operational impacts of wind turbines on birds and bats, the Department may require the curtailment of wind turbine operations during peak migration periods when migrating birds or bats would likely be flying at the height of the rotor swept area or be present at seasonally high densities throughout the entire air column. These periods occur in the both the spring (April through June) and fall (August through November). Curtailment will be limited to 360 hours per turbine in a calendar year. Wind turbines have a normal range of operations, which factors in among other things, wind speeds, temperatures and icing. The 360 hours would be counted as those times within the normal operational range of the turbine that limitations were in effect on operations. Potential curtailment measures include establishing a minimum wind speed that must be achieved prior to starting operations and shutting down operations during certain weather conditions or migratory events. Weather conditions that may necessitate curtailment include low wind speeds, low altitude cloud cover, strong storms, or approaching weather fronts favorable to bird or bat migration (such as northwest winds in the fall or southerly winds in the spring). Bats appear to be most susceptible to collisions during their peak fall migration (likely August – September) on nights of low wind conditions (Arnett et. al, 2008). Where bat mortality is of concern, an example of curtailment could be an increase to cut-in speed (an additional 2-3 meters per second) during periods of peak migration. The cut-in speed is the lowest speed at which electricity generated by the wind turbine would enter the power grid. This has already been shown to reduce bat fatalities between 50-87 percent (Arnett et. al, 2009, Baerwald et al. 2009, O. Behr, University of Erlangen, unpublished data). Curtailment for birds could occur during either spring (April-June) or fall migrations (August-November) and would likely be on days or nights with low altitude cloud cover (when birds fly lower and are more likely to be in the vicinity of the rotor swept area) or just ahead of a weather front that would result in a mass migration event (e.g. northwest winds during fall migration) (Richardson, 1998). For birds, an example of a curtailment would be a complete shutdown of the turbines until the visibility improved or the front passed. A pilot project is currently underway in Texas experimenting with "real-time" temporary shutdowns of turbines. Radar units at the site track the movement patterns of birds during peak migration periods from up to 4 miles away. This information is combined with weather data to automatically shutdown the turbines if collision risk appears to be imminent. If the pilot study proves that this technique is successful in reducing collisions it could also be applied in New Jersey (http://www.detect-inc.com/wind.html). The specific measures applicable will be developed by the Department using monitoring results and evaluating published and unpublished studies or data.

The Department believes that 360 hours of turbine curtailment during a year is conservative given that coastal New Jersey lies along the Atlantic Flyway, which is a major migration corridor for many species. The diversity of species using this corridor results in migrating species moving through New Jersey's airspace for as many as 9 months of the year (http://www.njaudubon.org/Research/records.html). Therefore, 360 hours of potential (not necessarily actual) curtailment represents only 5.5 percent of the migration period. In addition, as noted above, some curtailment could be accomplished through a change in cut-in speed, rather than a total shutdown. This would likely result in low monetary losses as the generators do not produce a lot of energy at low wind speeds.

Curtailment may not be required of each wind turbine facility and may not be required in each year or season. The Department will notify the permittee in writing when curtailment is required, beginning the first year that it is required for the permitted facility. Such notification will be made by March 15^{th} of the first year curtailment is required during the spring migration and by July 15^{th} of the first year curtailment is required during the fall migration. The 360 hours may be split between the spring and fall migrations. For example, if data indicates that raptors are of more concern in a particular region or facility, the Department may require that the hours of shut down be applied later in the fall migration rather than in the spring migration. This information shall also be made available on the Department's website.

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