# Appendix 5.7-A

# Preliminary Avian Risk Assessment

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# PRELIMINARY AVIAN RISK ASSESSMENT FOR THE CAPE WIND ENERGY PROJECT

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**and**

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**Executive Summary**

A preliminary avian risk assessment was conducted for the Cape Wind Energy Project (CWEP), proposed for a 28 square-mile area at Horseshoe Shoal in Nantucket Sound, Massachusetts. The project area is approximately 4.1 miles from the nearest point of Cape Cod, approximately 5.5 miles from Martha's Vineyard, and approximately 11 miles from Nantucket Island. The project will supply up to 420 megawatts of emission free energy generated by about 170 turbines. The turbines will be arrayed in matrix (approximately 560 m x 880 m). Each turbine will consist of a tower 80 m (261 feet) in height on which rotors of about 50 m (163 feet) will be mounted; for an overall height ASL (above sea level) of about 424 feet. Turbines will have Coast Guard and Federal Aviation Administration obstruction lighting. This project may be the first officially proposed offshore wind power project in North America.

The risk assessment reported herein consists of a review of the literature on the impacts of wind turbines on birds in Europe and North America; a review of what is known (literature and personal knowledge) about avian abundance and use in Nantucket Sound; and examination of known or suspected avian risk factors at the CWEP . Gaps in information regarding birds that use the Horseshoe Shoal area and about offshore wind turbines were identified. From these pieces of information, an overall assessment of risk is made, along with recommendations for further research where information about avian abundance and use is lacking.

The wind power literature includes studies from more than 10 states in the United States, Canada, and several countries in Europe. The results of these studies demonstrate relatively few avian collisions with wind turbines, especially when compared to other human-induced collision sources (communication towers, windows, transmission lines, and automobiles). At all sites in the United States, with the exception of the Altamont Pass in California where large numbers of raptors collide with wind turbines, avian fatalities have not proved to be significant. In Canada and Europe the same is true, although greater fatality rates have been reported at coastal facilities in the Netherlands and a site in southern Spain. None of these impacts has been deemed significant from a population perspective. Birds generally avoid wind turbines and some, including some seaducks will not approach within 100-200 m of wind turbines in offshore situations. This has not been suggested to have significant ecological impact to these species.

A review of avian abundance and use of Horseshoe Shoal shows that relatively few birds use the site. Most terrestrial species are absent, including hawks and songbirds, although night migrating songbirds and shorebirds will pass over the site at times. Use of the Shoal and nearby waters by gulls, terns, seabirds, and seaducks is likely, although information about their presence and behavior at those times is lacking. It is also important to note that the temporal window during which most species that frequent Horseshoe Shoal is short and virtually no birds use the site on a year-round basis. Assessed risk based on avian abundance and use patterns appears to be low to nil for most species, and, perhaps, low to moderate for the few species that use Horseshoe Shoal more often. It is also important to note that information about avian abundance and use of Horseshoe Shoal is limited for many species.

Overall, the likelihood of significant risk to birds from the CWEP is likely to be low. This preliminary assessment is based primarily on the fact that, compared to locations on shore or immediately adjacent to shore, relatively few birds use the Horseshoe Shoal and those that do so are present for relatively short periods of time. Gaps in our knowledge of avian use of Horseshoe Shoal were found, including use by terns (Roseate Tern – Federally Endangered and Common Tern – Massachusetts Species of Concern) and wintering waterbirds (seaducks [eider and scoter], loons, grebes, alcids, and gannets). Further studies of Horseshoe Shoal during the seasons when these species may be present were recommended to better assess risk to these birds.

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**Chapter 1. Introduction**

The late 1990s marked a period of rapid expansion of wind power development in the United States. Prior to 1995, there were few commercial wind turbine facilities outside of California. This changed dramatically in the last three years of the decade as facilities were constructed in at least 10 states and permits were either issued or applied for in another 5+ states. It is predicted (American Wind Energy Association) that there may be more than 15,000 commercial wind turbines operating in the United States by 2002.

With the growth of wind power, a concern for birds has become an issue at nearly all proposed wind power projects. The reason for this concern is the finding in the late 1980s and early 1990s that birds are killed at wind plants. The first such reports in the United States came from the Altamont Pass Wind Resource Area (APWRA), 40 miles east of San Francisco, California, where there were nearly 7,000 turbines spread over 150 $km^2$ (80 square miles; California Energy Commission 1989). Because this project was one of the first in the United States and was the largest in the world, the avian issue has become known among environmentalists, government agency staff, and those who oppose wind power projects.

The popular press has reinforced the mistaken perception that wind turbines kill birds en masse. For example, an article in the Wall Street Journal used the term "cuisinart" to describe turbines. However, rigorous and systematic studies done at sites throughout the United States, Canada, and Europe, have demonstrated that, to date, the numbers of fatalities at wind plants other than the Altamont have been small in comparison with other sources of collision mortality (Erickson et al. 2001) and they have not been suggested to impact bird populations. By rigorous and systematic we mean that the methods (duration of study, frequency of carcass searches, area of carcass searches, observer efficiency studies, and carcass scavenging studies) used at wind power sites have been accepted by various wildlife agencies and organizations as reliable means of determining numbers of fatalities. The lesson of the Altamont shows that there is a potential for risk to birds at wind plants and that careful siting of these plants, according to most experts, is paramount to avoiding or minimizing avian problems. Most fatality studies have been conducted in terrestrial situations and risk at offshore facilities has yet to be thoroughly investigated.

To evaluate potential risk to birds, preconstruction studies are invariably required or requested by regulatory agencies. These reports generally examine what is known or suspected about risk to birds at wind turbine facilities, mostly mortality, along with avian use of the proposed site. The term "use" in this case is meant to include diversity (number and type of species), abundance (numbers of individuals of various species that are present), and the behavior of birds when they are present on site. Once the information about known or suspected risk factors and overall use by birds has been gathered, it can be used to assess potential risks to birds at the site and to evaluate likely impacts to bird populations. This report is a preliminary assessment of risk for the proposed Cape Wind Energy Project (CWEP). The project is, to our knowledge, the first wind power project to seek permits for turbines in nearshore ocean waters of North America.

The sections that follow present: (i) a detailed summary of the literature on avian risk at wind turbines and known avian risk factors at wind power plants in North America and Europe; (ii) an overview of the avifauna that use the project area and what these birds are doing there; (iii) a preliminary summary of risk posed by the proposed project; and (iv) issues that need to be addressed to evaluate risk to birds at the CWEP. **Chapter 2** details what we know about avian fatalities and other impacts at both terrestrial and marine wind plants. The numbers of fatalities and ecological implications are summarized, as are the types of birds and non-lethal impacts. In addition, the behavior of birds in and around wind plants is examined as it relates to potential impacts. Notes on fatalities involving collisions and other impacts at communication towers and other tall structures are included as they pertain to wind turbine development. **Chapter 3** provides an overview of the types and species of birds that are known to frequent Nantucket Sound and adjacent waters of the Atlantic Ocean. Use of the area by birds is summarized to the extent that it is known. Greater detail is provided for endangered and threatened species, as well as rare species of the region. Major ornithological phenomena include nearby nesting by colonial waterbirds, foraging during the nesting season, migration through the area, stopover of migrants within the area, wintering in the area, and other miscellaneous behaviors and activity. In **Chapter 4**, presents an overview of potential risk to birds that use the CWEP area. This overview is based on what is presented in **Chapters 2** and **3**. From this risk assessment, major avian issues are identified along with recommendations as to how to better assess risk. The concluding section of this chapter details efforts to prevent or mitigate damage to birds. Thus, this document provides a starting point for conducting an in depth risk assessment at the CWEP.

**1.1. Description and Specifications of the Project Used for the Preliminary Risk Assessment**

The risk assessment that follows is for the CWEP area outlined in Figure 1. The project area is within about a 28 square mile area near the center of Nantucket Sound in the vicinity of Horseshoe Shoal. Turbines would be situated a minimum of about 4.1 miles from the shoreline of Cape Cod at Point Gammon. The shortest distance to other closest parts of Cape Cod are about 5.5 miles. The shortest distance to Martha's Vineyard would be about 5.5 miles, to Monomoy about 12.75 miles, and to Nantucket about 11 miles. A total of up to about 420 megawatts of emission-free electrical power is proposed. The power would be provided by up to 170 wind turbines (6.1 turbines per square mile). Each would have a nameplate capacity of about 2.7 megawatts.

Each turbine will be located atop a tubular structure embedded in a stationary position in the ocean floor. Turbines will be in a roughly rectangular grid approximately 560 m x 880 m. The proposed turbines' tower height is 80 m (261 feet) above the sea surface and the rotors are 50 m (163 feet) in length so that the swept area will be 100 m (326 feet) in diameter or 30 to 130 m (98-424 feet) above sea level (Figure 2). Each rotor would turn at about 20 rpm (or less) and tip speed would be about 89.2 m/sec (200 mph). Lighting specifications of the turbines has not been determined, although navigation lighting for watercraft has been requested by the Coast Guard and aircraft safety lighting has been requested by FAA. Changes in these specifications may result in the need for changes in the conclusions of this preliminary risk assessment. (It should be noted that turbines of this size and output have rarely been deployed commercially, so the specifications given are provisional estimates of those that will be in the final project design.)

Figure 1**.** Map showing project boundaries and tentative turbine layout of Cape Wind Energy Project on the Horseshoe Shoal of Nantucket Sound, Massachusetts. In addition, the location of Horseshoe Shoals is shown along with principal locations mentioned in the text. Map prepared by ESS.

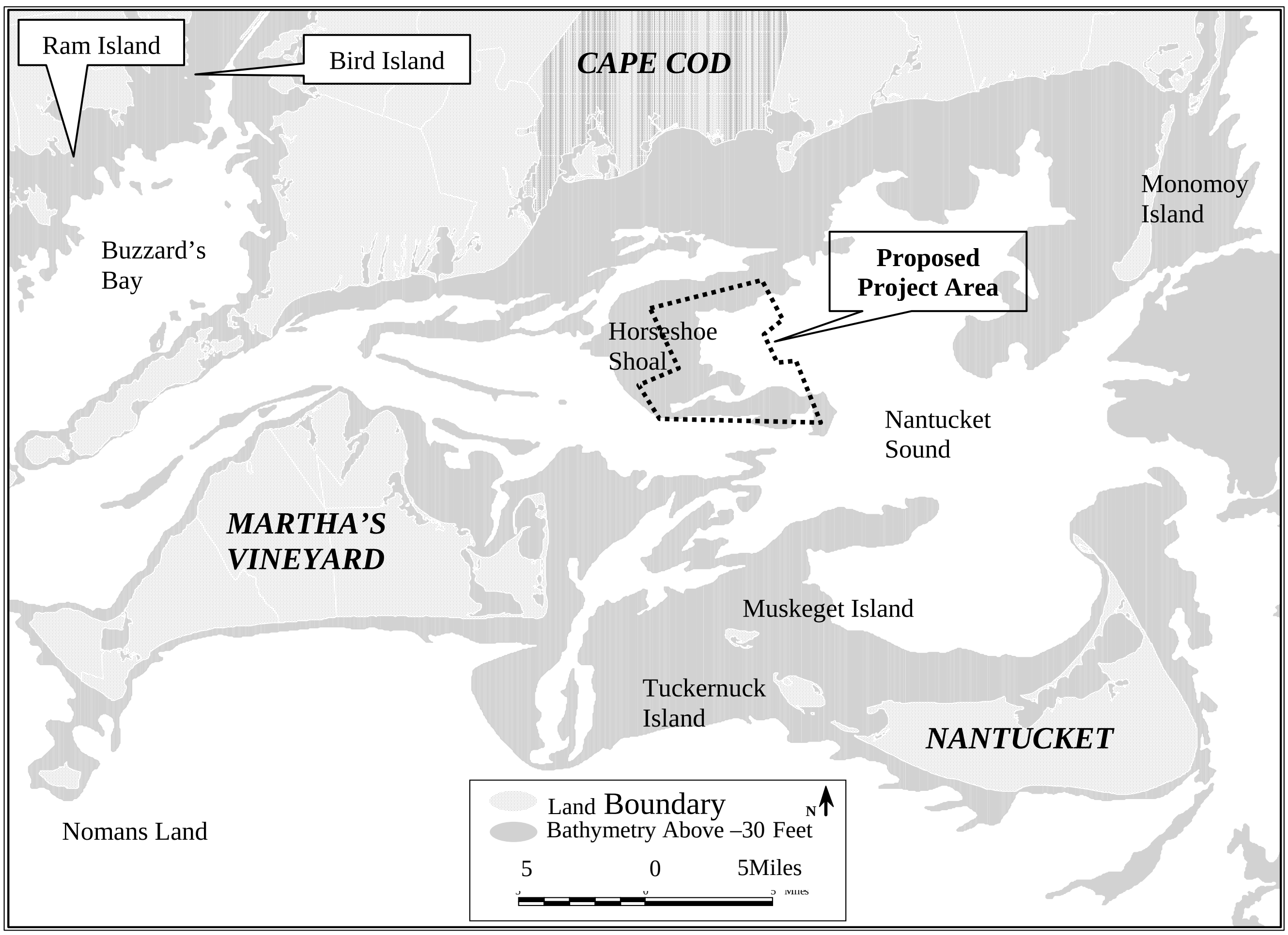
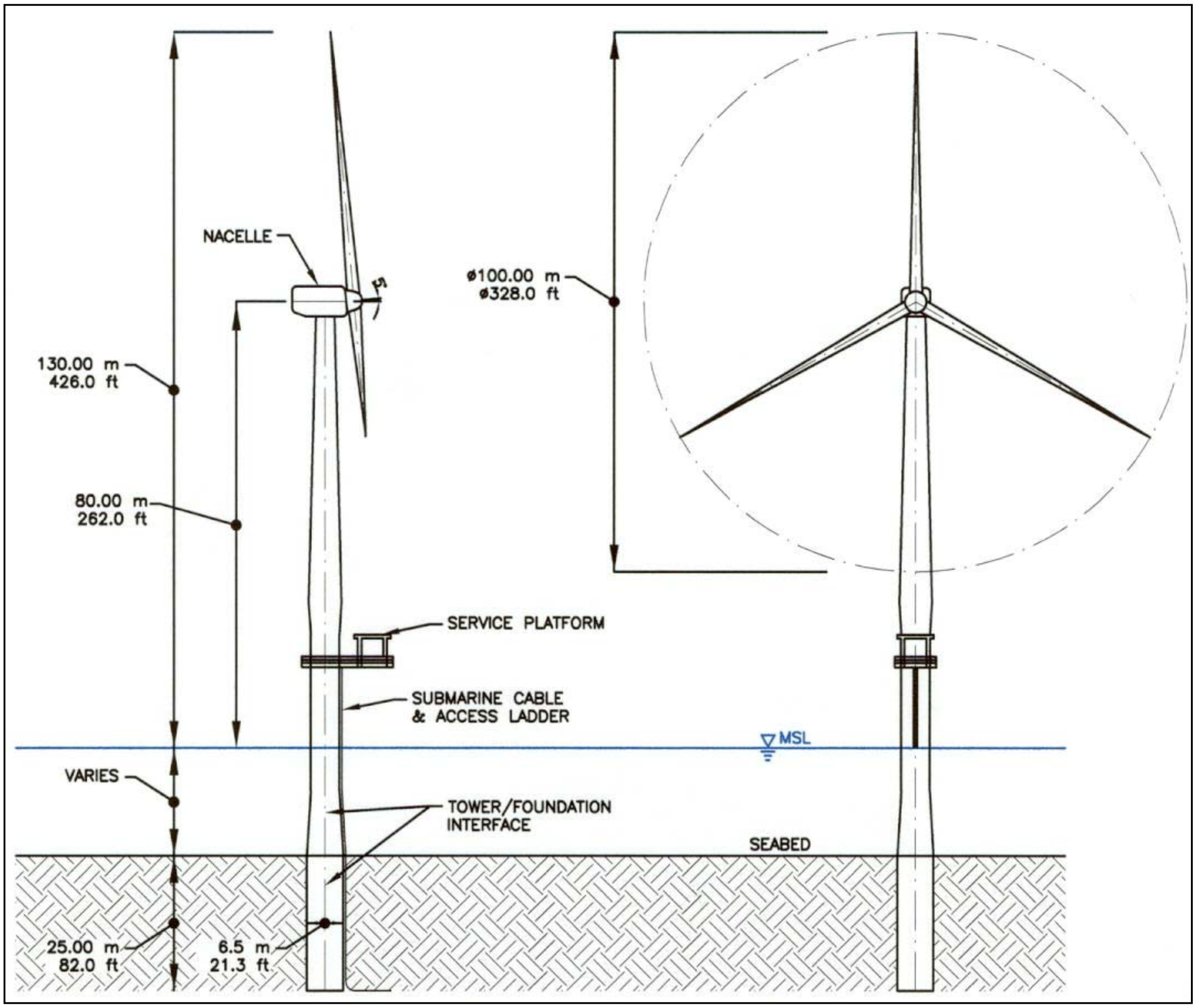


Figure 2. Schematic diagram of a modern wind turbine showing the tower, rotors, rotor-swept-area, and other technical aspects mentioned in the text for the types of turbines that are planned for the Cape Wind Energy Project, Massachusetts. Prepared by ESS.



## Chapter 2. Review of Avian Risk at Wind Plants in North America and Europe

Since the late 1980s studies of avian impacts at wind turbine facilities have been conducted at more than two-dozen locations, in at least five countries in Europe, at least 10 states in the United States and one location in Canada (one project). There has been no review of the European literature and only two recent reviews of the North American literature (www.currykerlinger.com, Erickson et al. 2001). With a very few exceptions, most studies have been onshore, so most of our knowledge is limited to terrestrial situations. The situations at which avian issues have been studied range from small wind power projects involving only two or three turbines, to large deployments involving thousands of turbines. Habitats in which these studies have been conducted include tilled agricultural fields, grazing land, desert, forest, lowland near the sea, jetties along the sea, in lakes adjacent to the sea, and short distances offshore. The few offshore, nearshore, or shoreline studies have been located at small wind plants in the United Kingdom, Denmark, and the Netherlands. The turbines involved have primarily been modern turbines of moderate electrical output (300-500 kilowatts each), each placed on a tubular tower. In addition, these turbines have been relatively few in number, ranging from about 9 to 25 turbines.

Three types of impacts to birds have been documented at wind turbine facilities ranging from ephemeral and not significant, to long-lasting and potentially significant impacts. (By significant, we mean impacts that have caused a decline in the population of a species.) These include:

- Displacement and disturbance during plant construction and habitat alteration
- Long-term displacement and disturbance resulting from the presence of turbines and other infrastructure on site
- Fatalities resulting from collision with moving turbine rotors

(Small numbers of birds have been electrocuted at wind power facilities, but these problems have been virtually eliminated because transmission lines are located underground within most modern wind plants and this issue will not be considered further.)

Studies in Europe focus more toward long-term disturbance and displacement as opposed to the primary focus on mortality of studies conducted in the United States. The reason for this disparity is likely to be based on the laws protecting birds. The Migratory Bird Treaty Act (MBTA) is cited in the United States and that law is based entirely on direct killing of birds, so that fatalities are viewed as a violation with prosecution a possible outcome. In Europe, the lack of open space compared to the United States may explain why disturbance and displacement are important factors. Habitat loss is viewed more seriously there. Although a wind plant may not occupy a large footprint within a farm or forest, the turbines may displace birds within short distances, thereby effectively eliminating or degrading the habitat for those species.

### 2.1. Displacement and Disturbance During Plant Construction

Displacement and disturbance to birds is evident as soon as ground-breaking occurs for construction of a wind power facility. Activity associated with arrival of equipment, road construction, land alteration, erection of turbines, and initial maintenance simply drives some birds out of the immediate area and some stay away until the project is on-line.

The construction activity at offshore windplants can also be considerable. Boats come and go, barges are moored for weeks or months, cranes are operating, and people are present. Similarly, the ocean bottom is disturbed and sediment is released into the water, much like with a dredging or clamming operation. Because so few offshore plants have been constructed, we know little about the process at such plants. Disturbance during the construction phase of most wind power projects is considered ephemeral, lasting several months to more than a year. To our knowledge, no studies of this type of disturbance have been conducted, primarily because this disturbance is short-lived. It should also be noted that unlike onshore wind power facilities, nesting birds are not likely to be disturbed by most offshore facilities (then nest onshore) and some construction activity may actually attract birds from great distances in a similar fashion to fisheries activities (clamming, long-lining, etc.).

### 2.2.1. Displacement and Disturbance from Infrastructure and Habitat Alteration

With the construction of a wind power facility comes a change in the landscape and, therefore, suitability of habitat to the birds that inhabit the area. Although the actual infrastructure present covers only a small percentage of the land's surface on most sites, the presence of tall structures with moving rotors has been demonstrated to disturb and displace some species of birds. The turbines, roads, and other infrastructure occupy as little as 1-2% of the land (or water) surface, depending upon the size of the area in which they are deployed. The results of published and unpublished studies are summarized in Appendix I.

A large variation in responses has been reported among the studies that have been conducted in terrestrial habitats. They range from avoidance to complete habituation, depending on the habitat in which a project is situated and the types of birds concerned. Results have not always been consistent and it is likely that habituation changes the response of individual birds to the presence of wind turbines, such that transient migrants may be affected in different ways than residents.

**2.2.2. Raptors and Soaring Birds**. Species that habituate rapidly include some raptors, although there are published and anecdotal accounts of raptors avoiding turbine areas. Richard Curry (former chair of the Kenetech Avian Task Force) reports complete avoidance by a naïve Red-tailed Hawk trained for falconry. Within a few days the bird flew closer to the turbines. That Red-tailed Hawks, Golden Eagles, kestrels and other raptors habituate to turbines is evident from reports of birds perching on the latticework, ladders, and work platforms on turbines in the Altamont or soaring close to them (Kerlinger and Curry unpublished, Orloff and Flannery 1992, 1996. Many raptors in the Altamont fly within a few feet of operating turbines (Kerlinger personal observations) and Griffon Vultures in Tarifa soar within 20-30 feet of operating turbines (Kerlinger personal observations). Ravens and Barn Owls, and some other species seem to habituate rapidly to turbines as is evident from their nesting within the nacelles of turbines in the APWRA.

At least one European study reported that Red Kite, Peregrine Falcon, Kestrel, Common Buzzard, and ravens in Wales are reluctant to occupy habitat close to turbines. However, because a feeding area for Red Kites was established nearby, these birds, as well as the buzzards and ravens may have simply been lured away (Lowther 2000). Migrating hawks that had undoubtedly never seen a wind turbine before seemed to avoid flying near 11 new turbines erected on hilltops in Vermont (Kerlinger 1997, 2000)

**2.2.3. <u>Songbirds, Shorebirds, and Night Migrants</u>**. Some songbirds (White-throated Sparrow, Blackpoll, etc.) in forested habitats seemed to habituate to newly erected turbines in Vermont, whereas others (Swainson's Thrush) did not (Kerlinger 1997, 2000). Whether the thrush's shift away from the turbines resulted from the forest canopy being opened for the turbines or from the presence of the turbines themselves is not known.

Studies of displacement of grassland and open-land birds in both the United States and Europe have had mixed results. Studies of grassland birds nesting in prairie-like habitats in southwestern Minnesota (Leddy et al. 2000) showed that fewer Eastern Meadowlarks and some other ground nesters were present close to turbines vs. farther away (~200-300 feet of the turbines). In the APWRA of California, meadowlarks, Horned Larks, and Loggerhead Shrikes perch on turbine tower latticework and fly amongst the turbines without any reluctance (Kerlinger, personal observations). The turbines have been in place there for 15-20 years and the birds seem to have habituated. There may be decreased use close to the turbines such that the effect is statistical rather than absolute. Long-term habituation studies are indicated.

European studies have also examined grassland and farmland birds in both nesting and feeding situations. As in the U. S., results were varied (Appendix I). Lapwings were investigated in Germany and found to avoid close proximity (~100 m) to turbines (Ihde and Vauk-Hentzelt 1999). However, other studies of this species, as well as Golden Plover, Skylark, Meadow Pipit, and some other species (songbirds and shorebirds) did not show displacement (Ihde and Vauk-Hentzelt 1999). These studies have shown small reductions in numbers of some resting and nesting grassland birds near turbines.

**2.2.4**. **<u>Waterfowl and Waterbirds</u>**. Studies of waterbirds at several locations in Europe have also shown varied results. At Blyth Harbour, where 9 modern turbines were constructed on a sea wall/jetty, species like Purple Sandpipers and Sanderlings were not impacted by the turbines and continued to feed on the jetty (Still et al. 2000). Cormorants, gulls, and eiders did not seem to avoid the turbine area at Blyth. In the Oosterbierum Wind Park in the Netherlands, in low-lying lands near the shore, disturbance to shorebirds and waterfowl was minimal (Winkelman 1995). In the Netherlands diving ducks avoided the areas within 300 m of new turbines and in another study showed avoidance behavior at a distance of about 100 m . These same ducks were reluctant to fly between turbines spaced by about 200 m (Winkelman 1995). Eiders studied at a 10 turbine off-shore wind power facility in the Kattegat of Denmark were reluctant to feed within 100 m of turbines. This avoidance was not deemed to be significant by the authors of the study and may have been a result of changing food availability (Guillemette et al.1998).

From the studies that have been conducted, there are no simple conclusions about whether wind turbines disturb and displace birds. Some species avoid the area near wind turbines in some cases but not in others. The diversity of findings suggests that a key question has yet to be investigated. That question is whether species that are susceptible to displacement and disturbance will eventually habituate to the turbines. Habituation studies should be conducted more than 2 or 3 years following the construction of a wind plant rather than immediately after completion.

### 2.3.1. Fatality Resulting from Collisions with Rotors

Fatality resulting from collisions with wind turbine rotors has been studied extensively in both the United States and Europe. There are at least 19,000 commercial sized wind turbines now operating in Europe (Appendix I) and there may be as many as 15,000 operating in the United States by the end of 2001. Virtually all of what is known comes from terrestrial wind power facilities, although a few studies have been conducted at coastal and offshore wind power facilities.

At most terrestrial wind plants, the numbers of fatalities have been low overall. Erickson et al. (2001) recently reviewed the published and unpublished literature from the United States. They concluded that the number of fatalities attributable to wind turbines in the United States may average about 1-2 birds per turbine per year. The studies that are available from about a dozen sites in about 10 states range from no birds found at a given wind plant to hundreds of birds found at a facility over several years (Appendix I). Small wind power sites often report no fatalities despite rigorous and systematic search efforts. Erickson et al.'s estimates of 1-2 fatalities per turbine per year included carcasses removed by scavengers and carcasses overlooked by those searching for them. Scavenging and observer efficiency are an integral part of studies that detect fatalities at wind plants and are done routinely at studies of larger wind plants (Erickson et al. 2001).

**2.3.2. <u>Raptors and Soaring Birds</u>**. In North America the species of birds killed varied among and within studies. Although it is believed that raptors are more susceptible to colliding with wind turbines than other birds, this has only been demonstrated for the APWRA of California (Howell and DiDonato 1991, Orloff and Flannery 1992, 1995) and to a lesser extent in the Tehachapi Mountains of California (Anderson et al. 2000). The numbers of fatalities reported at the former site includes several hundred Golden Eagles, Red-tailed Hawks, and American Kestrels, along with small numbers of other species. The APWRA is believed to be an anomaly, a function of the very large, year round population of raptors combined with an enormous number of old style turbines. No other group of birds seems to be disproportionately susceptible. Outside of California, fewer than five raptor fatalities have been reported in North America despite studies in many states (Appendix I).

In Europe, fatalities of raptors have been limited largely to the Tarifa wind power project area in southern Spain. Kestrels and Griffon Vultures were the most common fatalities with 0.34 medium-sized (the size of kestrels) bird fatalities per turbine per year (Marti Montes and Barrios Jaque 1995). The numbers were considered "unacceptably high, and far higher than indicated in any other European studies" (Lowther 1998), but these fatalities also included collisions with power lines. Another study at Tarifa reported only two raptor fatalities (Janss 1998) at 66 wind turbines or 0.03 bird fatalities per turbine per year. Another study reports fatality rates from Tarifa of 0.05 to 0.45 birds per turbine per year (Barrios and Aguilar 1995).

**2.3.3. <u>Songbirds and Night Migrants</u>**. Songbirds are the most common species involved in collisions with wind turbines at all other terrestrial wind power sites, but the numbers have been small. Some of these songbirds collide with turbines during nocturnal migration. Fewer than about 100 night migrating song and other birds have been reported from all the locations in the United States listed in Appendix I.

The European literature reveals little in the way of fatalities of night migrating songbirds, except from coastal wind farms in the Netherlands. It is likely that the birds involved in collisions reported by Winkelman (1994) were a variety of birds, including some songbirds and some waterbirds/shorebirds (see next section).

The tendency of night migrating birds to collide with communication towers has led some to suggest that turbines have the potential to impact these species (minutes of the National Wind Coordinating Committee Avian Subcommittee December 2000 meeting in Seattle, WA). The rationale for this view is that several million night migrating birds (mostly songbirds) collide with the communication towers each year (Kerlinger 2000, U. S. Fish & Wildlife Service website) and that, in comparison, wind turbines kill very few of these birds. That few night migrating birds have been found beneath wind turbines is because these towers are shorter than communication towers that kill birds and they do not have guy wires. Literature reviews of communication tower collisions reveal that high risk factors include a combination of tower height in excess of 500 feet, the presence of guy wires, and the presence of FAA required obstruction lighting on the towers (Trapp 1998, Kerlinger 2000, Avery et al. 1980, U. S. Fish and Wildlife Service Guidelines for Communication Towers 2000). Virtually no large-scale mortality events involving dozens or hundreds of birds have been documented at towers less than 500 feet in height (without flood lights), even with standard FAA lighting and guy wires. Towers less than 500 feet in height without guy wires have been infrequently documented to kill night migrating or other types of birds.

Wind turbines are less than 500 feet in height and do not have guy wires, which explains why so few night migrating song or other birds have been reported by the studies listed in Appendix I.

**2.3.4**. **<u>Waterfowl and Waterbirds</u>**. Clearly, the turbines in the low-lying areas of the Netherlands adjacent to the Wadden Sea experience a greater number of fatalities than turbines in upland situations (Winkelman 1995). The reason seems to be that there are large numbers of migrants, including waterfowl, shorebirds, and some songbirds, that move around these areas. These movements do not seem to be strictly migratory flight, but are likely to include low altitude flight among feeding locations (Winkelman 1995). Rate of fatalities reported by

Winkelman (1995) were 0.04-0.14 birds per turbine per day. From this some biologists suspect that turbines in coastal areas may present greater risk of collision because the resident birds are augmented by transient migrants, and all make frequent low-level feeding flights.

Fatalities of birds at wind turbines located in the water or offshore have seldom been documented because there are only a few places in the world where these situations now exist. Such facilities exist in the U.K. and Denmark. In the Netherlands, turbines are located in a "lake" that hosted large numbers of migrating and wintering diving ducks near the Wadden Sea. About five-dozen fatalities, mostly diving ducks, were reported from the 25 turbines in that lake (Winkelman 1995). Small numbers of fatalities were noted at 9 turbines located on a jetty at Blyth Harbor, consisting primarily of eiders (Lowther 2000). No information on fatalities is available from the offshore turbines at Tuno Knob (Tulp et al. 1999) or elsewhere within Denmark. The amount of information on fatalities at terrestrial sites is fairly well documented, but for offshore facilities the information is limited, at best.

### **2.3.5**. **Overall Numbers of Fatalities and Impacts on Populations**

Recent estimates of overall avian fatalities at wind turbines have ranged from fewer than one bird fatality per turbine per year to slightly greater than two bird fatalities per turbine per year in the United States. Erickson et al (2001) estimated slightly less than two birds per turbine per year (excluding pigeons, starlings, and House Sparrows) and arrived at a projection of 28,000 birds per year from the 15,000 turbines that are scheduled to be operating in the United States at the end of 2001. Curry & Kerlinger and other consultants who have conducted fatality surveys at wind power facilities feel this estimate is reasonable. These estimates are based on the actual numbers of carcasses found at about a dozen sites across the United States, as well as determinations of observer efficiency and carcass scavenging. Small birds often disappear more quickly than larger birds and are not as visible to searchers. Larger birds, the size of Red-tailed Hawks and eagles, are almost never missed during searches and tend to remain on the ground for several weeks or months. In the case of eagles and other large birds, carcasses are detectable for many months and in some cases for more than a year. Thus, the counts of fatalities of large birds are accurate and are likely to reflect the actual numbers of birds killed.

Estimates on total numbers of fatalities from European turbines are not readily available. Fatality studies have been conducted, but only those from the low lying areas of the Netherlands and from Tarifa in Spain have been suggested to be more than a few birds. No suggestion of population impacts have been reported from those locations.

The fact that fatalities of birds reported from wind plants usually include a taxonomically diverse array of species is important in evaluating the potential for turbines to impact populations. At least 50 species have been involved in collisions with turbines. At most wind plants, except the Altamont Wind Resource Area of California, fatality numbers for any given species are extremely small. For example, at the Ponnequin wind energy site, the largest number of fatalities for a species is about four individuals (Horned Larks).

A comparison of the numbers of birds estimated to be killed by wind turbines with other sources of human induced mortality in the United States is of heuristic value and relevant to evaluating the potential impacts caused by wind turbines. These statistics are included to provide perspective on the numbers of fatalities caused by wind turbines and other human induced fatalities. As can be seen in Appendix I, the numbers of fatalities for wind turbines are orders of magnitude smaller than for other human mortality sources. The fact that activities such as state and federally regulated hunting, which accounts for 120 million birds killed per year, does not impact populations of any species (for which millions or hundreds of thousands of some individual species are shot) strongly suggests that the numbers of birds killed by wind turbines are not likely to cause population declines for many species. This is particularly the case for r-selected species, including waterfowl, songbirds, shorebirds, and some others that have high reproductive output and nest over a large geographic area. For k-selected species - with low reproductive output and limited geographic ranges - fatalities resulting from collisions with wind turbines could potentially impact populations. Whether population impacts will potentially result from collisions with turbines is dependent upon species-specific characteristics and must be considered on a species by species basis.

To date, there has been no suggestion that wind turbines impact populations of any species because the numbers of fatalities identified are small. There is one possible exception, the case of Golden Eagles in the APWRA. From three-four years of research conducted by Grainger Hunt, a population model suggests a possible small decline in the breeding population of this species near the project site. However, the empirical data does not agree with the theoretical evidence and other ecological factors may confound the situation for Golden Eagles. The fact that immature Golden Eagles are not currently nesting, suggests that there has not been a population decline. These factors include loss of tens of thousands of acres of habitat in recent years in the areas surrounding and within the wind turbine areas (reservoirs, housing and industrial developments, landfills, roads, etc.). Ironically, these habitat losses have made the turbine farms important habitat for Golden Eagles. Overall, the number of fatalities reported at wind plants has been small, especially when compared to other sources of human induced mortality (summarized in Appendix I).

Although wind turbines kill very few birds, all towers have a bad reputation because of the occasional fatalities of migrants at tall communication towers. Unlike communication towers, wind turbines have not been found to impact large numbers of night migrating song and other birds. With communication towers, studies have shown that a large majority of night migrating birds are killed at towers in excess of 400-500 feet (152 m; Trapp 1998 – report to the US Fish and Wildlife Service; Kerlinger – report to US Fish and Wildlife Service – reports available on the Service's Office of Migratory Bird Management web page – http//www.fws.gov/r9mbmo). No mass mortality events of night migrating or other birds have been found at communication towers less than about 500 feet in height or at wind turbines because these towers do not seem to project high enough into the night sky to impact anything other than very small numbers of migrants and turbines do not have guy wires.

**Table 2.1**. Summary of human sources of direct avian mortality in the United States. The numbers provided are generally accepted by the environmental community (conservation organizations and government wildlife agencies). BPY = birds per year killed by the source indicated. The number of fatalities does not include habitat impacted or expected impacts as a result of these activities. For example, there are no impacts calculated as a result of climate change resulting from the burning of fossil fuel or habitat change resulting from acid precipitation. The American Bird Conservancy, National Audubon, and US EPA have provided models that predict habitat change and subsequent population impacts on birds in North America.

| Source of Mortality | Numbers Estimated (BPY) | Attribution/Reference |
|---|---|---|
| Glass Windows | 100 million to 1 billion | D. Klem, Muhlenberg College |
| House and Feral Cats | 100-200+ million<br>(perhaps 1 billion?) | National Audubon Society |
| Hunting | 120 million | U. S. Fish and Wildlife, Gill 1995 |
| Pesticides | 67 million | Smithsonian Migratory Bird Center |
| Automobiles and Trucks | 60+ million | U. S. Fish and Wildlife |
| Mowing of Hay | millions? | Suspected – smaller numbers known |
| Communication Towers | 4-5+ million | U. S. Fish and Wildlife |
| Oil & Gas Extraction | 1-2 million | U. S. Fish and Wildlife |
| Stock Tank Drownings | 1 million? | Suspected – smaller numbers known |
| Commercial Fishing | 1 million? | Suspected – smaller numbers known |
| Coal Strip Mining | millions (suspected) | Documented habitat elimination |
| Wind Turbines | low thousands<br>28,000 | Curry & Kerlinger estimates*<br>Erickson et al. 2001** |

*Estimates made using known fatalities at U. S. wind plants with the number of turbines known to be operating as of 2001 at about 11,000 currently.
**Estimate for 2001 for the U. S. based on same information as Curry & Kerlinger estimate extrapolated to 15,000 turbines on-line by the end of 2001.

**2.3.6**. **Suspected or Known Factors Associated With Collision Risk.**

Several factors that may increase or contribute to risk of birds colliding with wind turbine rotors have been either demonstrated or suspected. Unfortunately, these risks have not been rigorously studied in an experimental or field trial format. Thus, for each factor the null hypothesis remains to be tested at situations other than where the risk was demonstrated originally.

The factors are as follows:

- Avian Use/Species Specific Behavior - Flight and Foraging Behavior –
  The most important risk factor for any wind power site is thought to be use. By use we mean the numbers of birds, types of species, seasonal duration of their presence, and their behavior when present at a site. Where risk from collision has been demonstrated, there have always been large aggregations of birds and high use of the site. Species that collide with wind turbines do so when hunting or regularly flying close to turbines, and it seems that the greater the use, the greater the probability of birds colliding with turbines. These include raptors, waterfowl, and, perhaps shorebirds and songbirds (both during daytime flight at nesting areas and during night migration), although in most settings few collisions occur. Other species, including gulls, ravens, crows, turkey vultures, and some others fly all day long (exhibiting high use) in some wind parks but seem to collide very rarely with turbines and in some wind parks do not collide with turbines at all.

- Turbine Design and Specifications
  - Height – turbine height has not been demonstrated as a risk factor in collisions although shorter 60-foot towers may be more dangerous to raptors. Communication towers taller than 500 feet are more risky to night migrating birds than those less than this height. Also turbine rotors that come close to the ground may be risky to very low flying birds. This factor is dependent on the species of birds that use an area and how they use the turbine area.
  - Tower Structure – Lattice vs Tubular (perchability) – tubular towers that do not have perch sites for raptors and other birds are thought to present less risk than towers on which perching is possible. Perching is believed to be both a direct and indirect risk to birds like raptors that use lattice type towers as perch sites. The direct risk is through collision while attempting to perch or take off from a turbine that is operating. The indirect risk is likely to be through habituation. Turbines that permit perching allow birds to spend time in very close proximity to turbines, thereby promoting habituation. They are then more likely to approach operating turbines and collide with rotors. Perching on the nacelles of larger turbines may be possible, but this does not (perhaps very rarely) seem to occur at modern wind plants.
  - Turbine Spacing – the highest fatality rates of raptors have been found at turbines in the APWRA with spacing of 80-100 feet (rotor to rotor distance is only 30-40 feet) – wider spacing may result in fewer fatalities. It is believed that as raptors fly between these turbines while hunting ground squirrels, they sometimes collide with rotors.

Wider spacing of turbines is likely to pose less risk. The relationship between spacing and collisions has not been tested thoroughly, but the rationale for this statement is similar to fishing nets with small mesh catching a greater number of fish. Turbines with closer spacing may simply have less open space for birds to fly between them. This relationship has yet to be empirically tested and there is no data for waterbirds or waterfowl.

- Rotor RPM and Tip Speed – larger, slower rotating turbines seem to be no more risky on a rotor-swept-area basis than smaller and faster rotating turbines, but only one empirical (Howell 1994) study and one theoretical (Tucker 1995) study have been done. Hodos (2000) has reported that tip speed is what matters most, although larger rotors may be more visible than smaller rotors that travel at the same speed. These hypotheses need more testing, although at the modern wind plants with turbines that rotate at slower speeds, fatalities numbers have been generally small.
- Lighting – towers without FAA lighting are less likely to be involved in collisions of night migrating song and other birds because it is the lights that attract birds to towers (Avery et al. 1980, U. S. Fish and Wildlife Service 2000.). White strobes are believed to be less attractive than red incandescent lights (U. S. Fish and Wildlife Service 2000, S. Gauthreaux, 1999 address to the Communication Tower Working Group), but this has not been demonstrated in a completely controlled situation.

➢ Numbers of Turbines and Density – The shear number of turbines in places like the APWRA and their density are likely to be a risk factor. In the APWRA there are now 5,400 turbines, down from a maximum of 7,000 in about 1990. The density there is 67.5 turbines (obstacles) per square mile. This high risk site is quite different from sites like the wind projects at Ponnequin where there are slightly more than 20 per square mile or in Pennsylvania where there are about 4 to 8 per square mile. It is likely that risk increases with density of obstructions.

➢ Topography – steep hills (with short turbines) – In the APWRA fatalities of Golden Eagles and Red-tailed Hawks are two to three times more likely to occur at end of row turbines that are situated on steep hills or canyon walls or at turbines that are in the middle of strings that are at the bottom of a canyon or steep valley – notch or dip in a ridge (Kerlinger and Curry in prep.). This factor was so well documented that it has been incorporated in the Alameda and Contra Costa county, California, recommended practices for siting new or repowered wind turbines. Keeping turbines on level ground in the APRWA, and perhaps other sites, is likely to reduce risk of collision. In marine environments, the surface is flat, except for waves and the sea bottom, so this relationship may not apply. However, shorelines and islands often concentrate both land and seabirds into flight lines within restricted areas, thereby increasing risk of collision.

➢ Visibility – Visibility has been demonstrated to be an important risk factor for predicting collisions at lit communication towers (Avery et al. 1980). On nights with poor visibility (fog, rain, snow, or low cloud cover, night migrating song and other birds are attracted to communication tower lights and often collide with the guy wires. At unlit turbines, the risk of collision may be greater at night or at dawn or dusk because moving rotors may not be detectable. Fog and other conditions that make seeing towers difficult have been associated with fatalities at terrestrial communication tower sites (Trapp 1998). Eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman 1995) and at offshore towers at Tuno Knob in Denmark (Tulp et al. 1999). It is not known how poor visibility caused by rain or fog would impact waterbirds in marine environments, although their movements are more limited at such times.

### 2.4. Summary

Two types of impacts to birds have been studied and documented at wind power facilities in North America and Europe during a little more than a decade of study. Displacement of birds resulting from disturbance associated with the presence of turbines has been demonstrated among several species of birds in both terrestrial (grassland, low-lying agricultural land, farm fields, and forest) and marine habitats. At a few sites, birds are reluctant to forage or nest in the immediate vicinity of or beneath turbines. In as many studies, this type of disturbance has not been demonstrated or has been shown to be minimal. Birds are not excluded from large areas by turbines, although localized effects are evident. In at least one or two cases, birds seem to have habituated to turbines so that this impact is minimal. The key question regarding this type of impact is whether birds habituate to the presence of turbines over many years. Studies in marine habitats have been extremely limited.

Fatalities resulting from collisions with turbines have been studied at more than a dozen sites in several countries. The number of collisions reported from different wind plants has usually been small, involving several species. In perhaps three locations, a moderate level of fatality has been documented. In Spain, dozens of resident vultures have collided with turbines at a large wind plant in Tarifa. In the Netherlands, shorebirds, waterfowl, and songbirds collide with wind turbines in small numbers in low-lying areas along the sea where use by these species is great. In the APWRA significant fatality levels among raptors have been reported.

Small numbers of fatalities are likely to occur at all turbine installations, although nowhere in North American or Europe have these impacts been judged to be significant or to cause population problems or impact rare or threatened species. The numbers of fatalities at wind turbines are insignificant in relation to other human-induced sources.

## Chapter 3. Birds in the Project Area

The project area is located on Horseshoe Shoal in the middle of Nantucket Sound (Fig. 1). The shores of the Sound are quite well known ornithologically, but there is little information available about the site itself. The Sound is traversed by huge numbers of migrating landbirds, some of which travel to or from the mainland or islands adjacent, and it is visited for differing durations by a diversity of waterbirds. These include year round residents, summer residents, winter residents, and transient migrants that may stay for varying lengths of time. Some species fall into more than one of these categories.

This chapter will anticipate some of the topics addressed in greater detail in **Chapter 4** by giving more attention to those groups of birds likely to be affected by the wind turbines. In practice, that means those that feed in the project area and may be affected by disturbance or habitat change, and those that fly through the area at rotor-height (30-130 m, see **1.1** above) and are thereby at risk of collision. A general conclusion about flight patterns and heights is that the requisite information is not available for Nantucket Sound, where no heights have been measured. Broad generalizations for flying seabirds and other waterbirds are: that heights are much greater over land than water, by night than by day, and when migrating than when feeding. The descriptions are provided below principally to identify topics of concern. The following terms are used to identify characteristic flight in relation to rotor-height: **Very low** – generally < 30 m asl (above sea level), thus below the rotors; **Low** – frequently 40–150 m asl, thus at some risk of collision; **High** – usually >150m, thus not at risk of collision. Some species may fly in any or all of these height bands. Use of these terms is very tentative: when flying at night, or in bad visibility, or when confused (by the presence of lights or obstructions), the birds may behave differently:

Available information on bird numbers is limited: much of what follows is based on interpretation of shore-based observations because there have been no systematic surveys that included the project area. For winter birds, there are several Christmas Bird Counts nearby, but these are land-based and count only birds visible from shore, so they do not extend to the project area. The important exceptions are roosting flights of seaducks. Aerial counts include midwinter waterfowl surveys conducted annually by the Massachusetts Division of Fisheries and Wildlife (MassWildlife) and the U.S. Fish and Wildlife Service (USFWS). These follow the shoreline and record inshore species: they do not cover even as far offshore as 3 miles. However, for species that **do** feed in the project area these numbers indicate the potential for large concentrations. Both these aerial surveys inevitably miss some of the large concentrations of seaducks: the annual totals show large variations but no trends (G. Haas, USFWS, pers. comm.). For present purposes the maxima are used. For summer birds, all the colonial nesters were counted in 1984 and in 1994-5. Nesting terns are counted every year (by diverse persons, with numbers assembled by MassWildlife). The transient visitors and staging migrants have not been reliably enumerated. For nesting birds, the numbers refer to those using the area while nesting nearby.

In the following preliminary discussion of bird use, the many species of birds are combined into a few groups with similar attributes in relation to their use of the area. These groupings are not primarily based on biological taxonomy, but combine birds that move and feed in similar ways.

### 3.1 Major Groups of Birds that use the Sound

Oceanic/pelagic seabirds. In summer, large numbers of non-breeding shearwaters (principally 3 species) and stormpetrels (chiefly Wilson's) visit the northwest Atlantic, but relatively few enter Nantucket Sound (most June – August). Most fly very low. Numbers are very variable: usually they are more abundant further offshore, but they occasionally come close inshore. Their daily presence within the Sound: often hundreds, rarely thousands. In winter, Northern Gannets are abundant over the continental shelf, but rarely enter the Sound in large numbers. Occasionally they are abundant near the south coast of Nantucket and other islands during migration (e.g. 1500+, Muskeget, May 1981; 15,000+, Monomoy, with many in the Sound, on 20 Nov 73). These birds may dive from rotor-height.

Cormorants. Two species occur: the Double-crested *Phalacrocorax auritus* principally in summer (April-October), the Great *P. carbo* in winter (October-April). Both are pursuit divers and feed on fish, usually in shallow coastal waters. Most flights are very low but migrants fly higher. (Height not recorded). Both species will readily perch/roost on any suitable site and will take advantage of all such opportunities presented by turbines or any associated structures. At present very few D-c Cormorants nest near the project area but hundreds (mostly non-breeders) are present at Monomoy, and numbers increase in late summer with post-breeding dispersal and then migration: thousands are present for unknown stays (Sep-Oct). Most of the cormorants that nest abundantly in northern New England and the Maritimes migrate along the coast, but much of this movement occurs to the west of the project area, and the numbers that occur within the project area and flying at rotor height are not known.

Seaducks. These abundant migrants and winter residents may be one of the most significant unknowns for the Cape Wind Energy Project. Very large numbers of Common Eiders and Long-tailed Ducks (Oldsquaws) are resident (Oct-May) with smaller numbers of the 3 Scoters (*Melanitta spp.)* that are more numerous as transients during migration (Oct-Nov, Mar-May). Wintering scoters are generally reported <2 km from shore, while Eiders and Long-tailed Ducks use offshore shoals (Veit and Peterson 1993, Goudie et al. 2000, Savard et al. 1998, Brown and Frederickson 1997). There are no adequate data on their numbers and distribution in the area: some are present in large "rafts", numbering thousands of birds, close to shore, while others may be found anywhere in the Sound. In summer, immature Eiders are present in moderate numbers (100), near the islands, also an occasional Scoter. All 5 species are divers and feed on the bottom, principally taking molluscs and crustaceans. Eiders concentrate at patches where prey is available in high concentrations in shallow water (Guillemette et al 1993). The location of such patches changes from year to year. Diets in the project area are not known. Most feeding is in water < 20m deep, but Long-tailed ducks can dive much deeper than this (to >60m): near Nantucket they have been found to eat amphipods (R.Veit, pers. comm.).

The numbers in Table 3.1 are notably high and inconsistent, reflecting the difficulties in counting seaducks alluded to earlier, as well as annual fluctuations. The area is recognized as a major wintering area for Common Eider (Krohn et al. 1992) and for Long-tailed Duck (G. Robertson, pers. com.) but total populations of these species are not well-established and the origins of those in Nantucket Sound are not known. For the Common Eider, Goudie et al. (2000) mention 600,000 – 750,000 individuals for the whole of North America, and for the western Atlantic population in the mid 1980s, Krohn et al. (1992) estimated 350,000. Annual hunting harvests of Common Eiders and Long-tailed Duck in the Atlantic Flyway are about 20,000 and 10,000+ birds per year, respectively (U. S. Fish & Wildlife Service statistic).

Preferred feeding areas shift unpredictably (in both short- and long-term: days to years) and include coastal ponds as well as any water < 20 m deep and sometimes to 60m. It is very likely that individuals return year after year to the same places (Robertson and Cooke 1999), although there are no data for the project area. Tidal flows carry the birds away from preferred feeding spots so that diurnal feeding flights, to return to such spots, are frequent. Recent work in Denmark has shown that nocturnal flights also occur and are more frequent on moonlit nights (Tulp et al. 1999). These flights typically occur at very low altitudes (<30m) but have not been examined in detail. The distribution of feeding ducks in and near the project area is not well known.

**Table 3.1.** Indicative numbers of Seaducks and other species in Nantucket Sound and adjacent shallow seas in **W**inter or on **M**igration. (Daily maxima)

| **Species** | **Principal Season** | **Veit & Petersen[1] (1993)** | **MDFW Midwinter[2]** | **CBC[3]** |
|---|---|---|---|---|
| Common Eider *Somateria mollissima* | W | 500,000 | 150,000 | 15,000 |
| Scoters *Melanitta spp.* | MW | 30,000 | 30,000 | 2,000 |
| Long-tailed Duck *Clangula hyemalis* | W | 180,000 | 4,000 | 250,000 |
| Loons *Gavia spp.* | MW | 300 | - | |
| Grebes | MW | (300) | - | |
| Alcids | W | 1500 | | |

[1]Summaries of reported observations from miscellaneous sources.
[2]Shores of Nantucket Sound and Islands: Nantucket, Martha's Vineyard and Monomoy.
[3] Christmas Bird Counts at Nantucket, Tuckernuck and Cape Cod.

Roosting movements that involve many thousands of birds in near-darkness each evening and morning are known for Long-tailed Ducks; these birds fly in huge flocks between feeding areas on the Shoals southeast of Nantucket and nocturnal roosts in the Sound (Davis 1997). Locations of feeding and roosting areas vary and flights are typically at rather low altitudes (20 – 200m), occasionally at wave-top height, but may include large changes in height (R.Veit, S. Perkins) and have not been quantified. Eiders and scoters may make similar roosting movements but on a smaller scale; these have not been identified. In all cases, some movements occur at night but their extent is unknown. The numbers of Long-tailed Ducks counted while flying to roost are much greater than those seen or estimated to be present during aerial surveys.

Migratory movements of these ducks involve coastal flights, many at low or very low elevations (0 - 60 m), and overland flights at high elevations (>300m). Many of these flights are seen by day, but some are nocturnal. A Danish study showed that <10% of migrating eiders were at >50 m (Kahlert et al. 2000); however, Spring departures of scoters from Nantucket Sound in late afternoon and into the night were described by Mackay (1891), as usually occurring above 200m. In s. Finland, migrating scoters and Long-tailed Ducks studied by radar flew above 500 m overland, and above 100m over the Baltic Sea (Bergman and Donner 1964). From Cape May, NJ, most migrating scoters are reported <2 miles from shore and flying less than about 20-30m above the water. Off Manomet, on the west side of Cape Cod Bay, most of the large flights of migrating scoters fly low; however, the movements in the project area have not been described.

Eiders nest along the coast to North and East (with a handful also in Buzzards Bay), while scoters nest inland (in the tundra and taiga) to North and West. Migrants arriving in the project area include not only those in the midst of low-level coastal flights but also those that have arrived overland. Wintering Eiders are most numerous from Cape Cod northwards, while Scoters are more numerous to the south (to the mid-Atlantic states and as far as the Gulf of Mexico). Migrating Scoters are numerous in Fall and Spring. In Fall, most fly near the mainland, cross the Cape at its base, and may not fly through the project area. In Spring, however, they reach the Cape and Islands on a broad front and the duration of stopovers in the project area is not known.

<u>Other divers – including loons, mergansers, grebes, alcids.</u> Red-breasted Mergansers, along with loons, grebes, and alcids (puffins and auks) are migrants and winter residents. They feed principally on fish and other moving prey. They often fly very low, but sometimes low (in the height-range of the rotors). Numbers resident in the project area are likely to be in the high hundreds, with alcids occasionally much higher (transient thousands, usually outside the Sound). Migrant loons (April-May, October) number in the thousands, but many of these fly to the west of the project area.

<u>Geese and non-sea ducks.</u> Large numbers of geese and ducks are present in the coastal wetlands, estuaries and bays, principally in winter (Oct-Apr), but do not visit the project area except in transit. These species include Geese (Canada, Brant), Bay ducks (eg. Goldeneye, Scaup) and freshwater ducks (eg. Hooded Merganser, and various dabblers).

<u>Gulls and Terns.</u> Both groups nest adjacent to the project area, feed within it, and travel to concentration points along the shores. Most feeding is near-shore and from the surface, but they may concentrate anywhere over the shoals. The locations are not predictable, except over short periods. Most flying occurs below 30m asl, but this has not been investigated systematically. Some nocturnal migration (of terns) entails initial climbing to altitudes of 1000 m, or more.

Terns are summer residents: almost 20,000 pairs of four species nest in Massachusetts, the majority near the project area (Blodget 2001, n.d.). All are species of concern, but particularly the >2000 pairs of the Endangered Roseate Tern (see Endangered and Threatened Species, below, for more information). Few individuals of these species are present outside the period May – mid September. During the nesting season most terns feed close to shore and there are no reports of large numbers in the project area. However, a large post-breeding, pre-migration staging area is located at South Beach/North Monomoy, near the northeastern corner of the Sound (Trull et al. 1999). At this site very large numbers of terns (more than ten thousand) gather (August - September), often spending nights there and dispersing widely to feed. Some cross the project area and may rest by day at several points along the shores of the Sound. All these birds are thought to return to South Beach each night; many arrive around nightfall at elevations of around 80m asl, possibly having crossed the project area. Foraging range is typically 5 km, ranging to 30 km. This gathering includes Roseate Terns from as far away as Maine and New York, and Cape Cod and the Islands appear to be the major staging area for much of the New England population.

Gulls are numerous year-round: about 65,000 nest in Massachusetts. In 1994-95 there were, south of Boston Harbor, about 11,000 pairs of Herring Gulls (decreasing), and a similar number of Great Black-backed Gulls (increasing) (Blodget and Livingston 1996). Laughing gulls (a summer visitor) have increased to 1100 pairs (Blodget 2001). Additional migrants arrive in Fall, some travel on and some stay, but the present annual numerical fluctuations are not well known. Many individuals feed along the shore, or inland. Others feed at sea, or follow fishing boats. These individuals are active in the project area. Numbers cited include 140,000 for outer Cape Cod and Nantucket (January 1982) and 25,000 nesting on Monomoy in 1995.

<u>Shorebirds.</u> For large numbers of shorebirds, (40,000 daily summed maxima), the wide expanses of inter-tidal flats at Monomoy form an important migratory staging area in fall (July – September); smaller numbers occur there in spring (May-June) and elsewhere in the area. These include birds such as Semi-palmated Sandpipers, Oystercatchers, and Red Knots: 20 species are regularly reported from the area and a total of 41 species have been seen at least once. The site is recognized as of "Regional Importance" in the Western Hemisphere Shorebird Reserve Network (Corven, pers. comm., 2001)). These birds feed intensively and are unlikely to travel frequently through the project area. Migration occurs at night and at high altitudes. The threatened Piping Plover nests on beaches adjacent to the project area: it is discussed with other listed species in section 3.2.

<u>Wading birds.</u> Herons, egrets and ibises nest in relatively small numbers on the Cape and Islands and winter further south. Migrants often fly very low, but sometimes low by day but few cross the project area (perhaps hundreds per year during migration).

Raptors. Numerous hawks, falcons and relatives frequently follow shorelines in the course of their migrations and can be readily seen by day, flying at low altitudes (Kerlinger 1989). Most species stay with the land, some (Peregrine Falcon, Merlin, Osprey, and Northern Harrier) readily cross wide water gaps and thus may traverse the project area. Other species may make short crossings, <5km, in suitable weather conditions (Kerlinger 1989, Kerlinger et al. 1983).

Fall migration does occur on Cape Cod in small numbers (hundreds to perhaps a thousand or more individuals) at places like Wellfleet (Heintzelman 1986). Subsequent movements of these birds are not known: most of them probably head westwards along the Cape to the mainland, but others may fly south along Monomoy and on to Nantucket and Martha's Vineyard. Up to 50 Peregrine/day have been observed on Martha's Vineyard during autumn migration (V. Laux, pers. comm.). However, very few of these birds will have passed through the project area. Ospreys feed on fish and are known to feed 5 km out over open water, but the majority of their feeding occurs <2 km from shore.

Passerines and other landbirds. Every spring and fall the Sound is traversed by huge numbers (millions) of migrating landbirds; that is, songbirds and other species. Most of them are in the midst of long distance nocturnal flights at high altitude, some have been drifted offshore by winds. The small numbers flying at low elevations include the few diurnal migrants (for example, swallows), those for which these lands are their final destination and the much larger numbers of transients, pausing onshore in the course of longer travels. Some of these are re-orienting and flying back to shore in the early morning following offshore drift at night. Most of the migration occurs on only a few days each year (perhaps 10 to 20) and crosses the Sound on a broad front.

### 3.2 Endangered and Threatened Species

Bird species of particular conservation concern are those listed by Federal or State actions as Endangered, Threatened or of Special Concern. The State listings refer to the status of the breeding populations within the Commonwealth of Massachusetts which may involve different individuals than those in the project area. For Massachusetts, these species are summarized in 321 CMR, and those likely to occur in the project area are shown in Table 3.2. This Table includes 3 Federally listed and 12 State-listed species. (The State list includes the 3 Federally-listed species and one recently de-listed, the Peregrine Falcon). The State List includes a further 16 species that would not be expected in the project area. These comprise 8 passerines, 5 water/marsh birds, 1 sandpiper, and 2 owls.

Table 3.2. Listed Species[a] in the Project Area

| **Species** | | **Conservation Status[b]** | | **Presence[c]** |
|---|---|---|---|---|
| Common Loon | *Gavia immer* | SC | | SWM |
| Leach's Storm-petrel | *Oceanodroma leucorhoa* | E | | S |
| Bald Eagle | *Haliaeetus leucocephalus* | E | **US: T** | W |
| Northern Harrier | *Circus cyaneus* | T | | M |
| Sharp-shinned Hawk | *Accipiter striatus* | SC | | M |
| Peregrine Falcon | *Falco peregrinus* | E | | M |
| Piping Plover | *Charadrius melodus* | T | **US: T** | SM |
| Roseate Tern | *Sterna dougallii* | E | **US: E** | SM |
| Common Tern | *Sterna hirundo* | SC | | SM |
| Arctic Tern | *Sterna paradisaea* | SC | | SM |
| Least Tern | *Sterna antillarum* | SC | | SM |
| Short-eared Owl | *Asio flammeus* | E | | S |

[a]This list includes all bird species in Mass 321 CMR that occur in the project area.
[b]MA status: E=endangered, T=threatened, SC= special concern.
US status: US E = endangered, US T = threatened.
[c]Presence: S = Summer (May-Sep), W = Winter (Dec-Mar), M = Migration

Additional information about the listed species follows: conservation status is that given in 321 CMR. Presence identifies the pattern of seasonal occurrence in the project area.

<u>Common Loon.</u> This widely distributed and abundant but declining breeder in northern lakes reaches its southern limit in Massachusetts, where it is rare. Populations of Common Loons are reported to be imperiled by numerous factors, including disturbance of nesting areas, declines in lake productivity, mortality from fishing lures and weights made of lead, and contamination with other toxic metals. These fish-eating divers are present in the Sound throughout the year, with larger numbers in winter (Oct-Apr) and during migration seasons. Summering birds are principally immature pre-breeders. They occur singly or in small parties. Daily movements have not been described. Migratory flights have not been well-characterized in the project area: off the coast of New Jersey they fly low, overland they fly very high.

<u>Leach's Storm-petrel.</u> This abundant species is on the Massachusetts list by reason of a very small, declining colony in Buzzards Bay at the very edge of the species' range (large numbers nest in Maine and the Maritimes). These individuals probably feed far offshore and may pass through the project area, flying very low.

<u>Raptors.</u> The four listed diurnal raptors may occur in the project area during migration (see preceding section for general description of movements.). Bald Eagles are rarely reported from the Cape or from Nantucket, suggesting that they rarely cross the project area. The Peregrine Falcon is the species most likely to be seen in the project area. A few migrating Sharp-shinned Hawks and Northern Harriers are likely to cross from Monomoy to Nantucket in autumn, and even fewer to fly in this corridor in spring (Kerlinger et al. 1983). Most of the individuals involved in these crossings are likely to be from northern populations and therefore not from those listed by the Commonwealth.

<u>Piping Plover.</u> This federally **threatened** beach-nesting shorebird is found along the terrestrial peripheries of the Sound from April to October. In 2000, almost 500 pairs nested in Massachusetts, a third of these were on shorelines near the project area (Mostello and Melvin 2001). These birds feed entirely on the shore; while nesting, they are confined to the vicinity of their nests. More extensive pre- and post-season movements entail occasional crossings of the project area but these are infrequent and not well characterized. The current prohibition on color banding this species means that the question of movements between sites cannot be readily addressed.

<u>Roseate Tern.</u> This species is listed as federally **endangered** because of declines in numbers and from being vulnerable when concentrated in the small number of nesting colonies (USFWS 1989). A large fraction of the northwest Atlantic population nests in Massachusetts (1628 of 3980 pairs in 1997, USFWS 1998) most in Buzzards Bay (west of the project area). A few pairs nest at sites adjacent to the project area (only 6 in 2000). The birds nesting in Buzzards Bay feed in the western end of Nantucket Sound but have not been reported from the project area (Heinemann 1992). However, it is likely that the entire population passes through the Sound at some point each year. In spring, pre-breeders feed near Nantucket and then fly to nesting colonies in Buzzard's Bay. Most such flights would not pass through the project area. Banded individuals from as far away as Maine and Long Island, New York have been identified at the large pre-migratory staging areas on Monomoy and Nantucket in late summer. This geographic range includes > 95% of the regional population and the mixed flocks of staging terns numbers > 10,000 individuals (Trull et al. 1999). During this time, the adults and their still-dependent young forage at sea. Much of their time is spent close to shore, outside the project area, but unknown numbers feed throughout the project area and may travel through it between diurnal loafing areas and nocturnal roosting sites on the different islands. (See preceding section, under Gulls and Terns).

<u>Other Terns.</u> The other 3 tern species – Common, Arctic, and Least – are of Special Concern in Massachusetts especially because they nest at vulnerable sites and require vigilant management if they are to survive and prosper. On Cape Cod, the Arctic Tern is at the southernmost extremity of its breeding range: numbers breeding in Massachusetts were down to 8 pairs in

2000 (Blodget 2001). The other two species are holding their own. Most of the Arctic Terns seen in the area are young pre-breeders, from large northern populations.

Short-eared Owl. The few pairs of this species remaining in Massachusetts are present as summer residents and nest on Nantucket, Tuckernuck, and possibly Muskeget. They may possibly travel through the project area during migration.

### 3.3 Types of Use: Patterns of Movement

The patterns of bird movements in the likely vicinity of wind turbines in Nantucket Sound fall into several classes that, in conjunction with weather conditions, influence the potential for collisions in the project area. These classes are not mutually exclusive. The following lines summarize information for the separate groups presented above and may differ substantially from the behavior of birds near terrestrial wind turbines.

Effects of weather. Every pattern of movement summarized below is affected by weather, particularly in relation to collision risk. Birds fly faster (airspeed) into headwinds, but may be at greater risk in tailwinds when both height and groundspeed are greater. Poor visibility (fog or storm) increases risk. Storms have major effects on bird use of the area. They bring in offshore species, sometimes in very large numbers, and they alter bird behavior. For example, shearwaters that generally fly below rotor height soar higher in strong winds. Flight activity may be reduced when visibility is poor, especially at night.

Daily Feeding Movements. The majority of birds flying through the project area at low or very low altitudes are seeking food: some are visiting familiar locations such as mussel beds or fish refuges, others are exploring opportunistically. Birds scanning visually for prey may be at greater risk of collision than bottom feeders because their attention is focused on the water below. Such factors are thought to explain the mortality of Golden Eagles in the APWRA of California and they might apply particularly to plunge divers such as terns and gannets. However, there are no relevant data.

Nightly Roosting Flights. These typically occur around sundown (and again in the morning) and may involve large flocks under conditions of poor visibility. They have been noted for post-breeding terns, and wintering seaducks, and may be more widespread. The heights have not been measured.

Seasonal Migrations. The majority of migration is thought to occur at night and at high elevations. Birds depart under clear conditions and climb rapidly to altitudes of hundreds or thousands of meters where they are not at risk of collision. Some groups migrate by day (e.g. raptors, loons) while other travel by day or by night (e.g. seaducks).

Movement at Night. The frequency of low-level movements at night by any of the bird groups is unknown for the project area. Near Danish windfarms in winter both Common Eider and scoter were recorded flying frequently at night (Tulp et al. 1999), with more movements on moonlit nights.

## Chapter 4. Preliminary Assessment of Risk at the Cape Wind Energy Project and Identification of Risk Factors and High Risk Species

The best, and perhaps only, means of assessing potential risk to birds at proposed wind power project sites, is to compare the avifauna and risk factors present at a proposed project site with operating wind plants for which the magnitude of risk has been established. By comparing the species that are present (numbers of individuals and seasonal presence) and their behavior at a proposed site with sites that have been previously developed and for which risk has been determined, an informed assessment can be made as to the overall risk to birds that can be anticipated at a new project. This comparison can be done by using empirical and theoretical information that is available. In the case of most wind power plants this is a somewhat routine process because there is now a robust and growing body of information about risks to birds at wind power facilities. These facilities have been primarily in terrestrial situations in North America and Europe.

For the Cape Wind Energy Project the traditional means of assessing risk is somewhat problematic because there is little information available about risk to birds at offshore or marine wind power projects. There are currently very few wind turbines in marine environments and those that do exist are relatively new or unstudied. Those studies were reviewed in **Chapter 2**. Despite the paucity of information about marine projects, a rough estimation of risk can be made. The risk assessment that follows is based on what we know about risk in terrestrial and marine wind power projects. This method of assessing risk is valid for many of the species, although for many others it is a rough approximation and additional information from new studies will be necessary. Some of the same risk factors that have been found onshore apply to offshore situations, especially where primarily land-based species are in question.

The risk assessment that follows is divided into (i) displacement/disturbance during the construction process; (ii) displacement/disturbance from infrastructure during plant operation (post-construction); and (iii) fatality resulting from collisions with towers and rotors. For each of these types of risks we consider the various groups of birds summarized in Chapter 3 and make various determinations including significance of the impact. By “significant” we mean an impact that is likely to put a population of the species at risk of decline. By “not significant” we mean an impact that is not likely to put a population of the species at risk of decline. Finally, we outline some of the steps needed to assess risk with a greater degree of certainty when and if such steps are indicated.

### 4.1 Displacement/Disturbance During the Construction Process

It is likely that some displacement of birds will result from the disturbance associated with human activity during the construction process at the Cape Wind Energy Project. Increased boat traffic, presence of equipment (cranes, barges, pilings, mooring platforms, etc.), human presence, and noise will result in displacing some birds from the immediate area in which the activity occurs, out to a distance of several hundred meters. The exact distance is unknown and will depend upon which activities are occurring and the familiarity of the birds. Some level of avoidance may persist in the absence of active work/movement. Spillage of materials such as oils, during the construction process may also deter birds from using an area or impact them more directly. This disturbance may last for several years during the Cape Wind Energy Project with boats, barges, and other activities being continuous during construction. We anticipate that feeding and resting activity at or within several hundred yards of the turbine sites will be reduced during the construction process. The types of birds that are less likely to feed at the construction sites include alcids, seaducks, loons, grebes, and some other diving birds, as well as some pelagic species.

Some other species, including terns, gulls, cormorants, and some others may feed within a few feet of the construction sites because these species habituate rapidly to human structures and forage near them on a regular basis. For species like migrating land birds disturbance is expected to be minimal and not significant because the birds are far above the construction process.

A second type of impact can be expected during the construction process. Birds are likely to be attracted to the downstream plume created during excavation and other activities that stir up the floor of the ocean and sound. Like dredging and other similar activities, these practices release organisms from the sea bottom and make them easy prey to fish and avian predators. In turn, the feeding fish attract fish eating birds. This type of impact may be considered beneficial.

Overall, the impact to feeding and resting birds in Nantucket Sound is likely to be minimal (not significant) because construction activities are ephemeral and likely to last only a few months at each turbine location. In any given location where a turbine or turbines are erected, impacts of this sort will last only during the construction period and the impact will occur in only a small portion of the total project area at any one time.

Risk of Impact: Minimal and Short-lived.

### 4.2. Disturbance/Displacement Resulting from Deployed Infrastructure – Post-Construction

After construction of the Nantucket project, or a portion of the project, the infrastructure remaining will include, for each turbine. a tubular tower (80 m [261feet] in height) with a work/landing platform near the water surface, a cable head, navigational lighting on or near the work platform, and three rotors (50 m [163 feet] in length) attached to a nacelle, on top of which may be FAA lighting. These will present a new and imposing structure to the surface of the sound and ocean. It is likely that some species of birds will avoid or refrain from activity near these structures. Avoidance may include not resting or feeding near the towers or migrating around them. The avoidance behavior, primarily minimum distance to which an animal will approach these structures, is likely to vary among species.

The European literature reports a variety of turbine avoidance behaviors by seaducks and some other species, ranging from no avoidance to not flying or feeding within hundreds of meters of the turbines. It is likely some seaducks, loons, grebes, alcids, pelagic birds, and some other species will not feed or rest within the area beneath or near the turbines. A study at Tuno Knob, in Denmark, reported effects on nocturnal flights of eiders out to 1,500 m from turbines (Tulp et al. 1999).

Because the turbines will be situated a minimum of 4.1+ miles from the main body of Cape Cod, more than 5.5 miles from Martha's Vineyard and more than 11 miles from the other islands, it is unlikely that any of the endangered or threatened species that are known to occur within or adjacent to the CWEP area (see Table 4.1 for a list) will be displaced from a significant portion of their feeding or resting areas. The terns on the list are not likely to spend much time foraging at these distances from their nesting sites on shore, but are more likely to feed there during the period between breeding and migration. Those that venture far from shore will have ample areas in which to forage, both within Nantucket Sound and in the Atlantic Ocean. The same applies to Common Loon. Leach's Storm-Petrel is present for only a short time each year and its normal foraging areas are out in the Atlantic Ocean, well away from the project area. We do not anticipate significant displacement, resulting from the presence of turbines, of any endangered or threatened species from foraging or resting areas.

The presence of novel objects can and does deter birds and other animals from entering into areas that would normally be available to them while foraging and migrating. Wind turbines erected off shore will be novel to birds flying over Nantucket Sound. Studies in Europe and in North America have demonstrated varying effects ranging from reduction of nesting activity near turbines, avoidance of turbines by foraging waterfowl, and complete habituation to towers by some raptors, shorebirds, and other birds. In some cases, birds have avoided flying between turbines, resulting in their flying around the last turbine spaced at 200 m in a string rather than flying between turbines (Winkelman 1994).

With respect to the CWEP area, ~ 170 large turbines are being proposed that are spaced by 800 m x 560 m in a rectangular grid. The area that will potentially be impacted is the cumulative area within which birds will not fly or forage. Assuming that some waterfowl such as Common Eiders and other birds do not approach within 100m of wind turbines as demonstrated in studies at Tuno Knob, Denmark, each of the turbines proposed for the Nantucket Sound project could, theoretically, exclude foraging birds from an area of about 0.0324 $km^2$ per turbine. Extrapolating to 170 turbines, this would mean that an area of roughly 5.3 km2 of the waters of Nantucket Sound (0.4% of the entire Sound) could potentially become unsuitable foraging habitat for some species. This is unlikely to incur a detrimental effect on wintering eider and other seaduck populations, unless the areas that are rendered unsuitable are preferred foraging areas. The actual area impacted could vary by species and over time.

It is possible, but unlikely that some birds will not enter the Nantucket turbine matrix. This is a worst-case scenario that would render a portion of the Sound unsuitable for those species. This result is unlikely because minimum spacing between turbines will be about 560 m (about 1,826 feet). The fact that songbirds and raptors routinely fly between turbines that are only 100 feet apart in older wind plants, strongly suggests that birds do habituate Also, at Tuno Knob and other locations, birds regularly approached within 100-200 m of operating turbines, again suggesting that turbines spaced at 560 m are not likely to present a barrier to migrating birds or birds flying to and from foraging areas. However, field studies of this spacing distance between turbines will resolve this issue, especially in light of the night studies of Tulp et al. (1999) who demonstrated that eiders responded to turbines at nearly 1,500 m.

It is likely that some habituation will occur as turbines are erected and go online. Many birds habituate readily to man-made objects, especially if humans are not present, although some species avoid all such objects. The European literature shows that at Blyth Harbour eiders and other birds did habituate to the turbines such that no impacts were realized. It is likely that these birds habituated to the presence of the turbines that were constructed on a jetty (Lowther 2000).

Because some species of seaducks readily feed on mussels and other invertebrates among the rocks of jetties and pilings of docks, it is possible that some birds may be attracted by the prospect of abundant invertebrates that will colonize the bases of the turbines (depending on the ferocity of wave action).

With respect to migration, habituation might not occur in the same fashion and it may not occur at all for some birds. Although adults may have come into contact with wind turbines during a previous migration (spring and autumn) or winter, birds of the year may not. In the case of flocking species, young birds may not be reluctant to approach turbines if adults in their flock fly or swim close to turbines. Thus, for some birds flying at within 100-200 m above the water, turbines may present a barrier, making birds fly around them. This is analogous to waterbirds avoiding flight over land. These birds simply follow coastlines or deviate around jetties and headlands.

We conclude that, although habituation may occur, systematic studies need to be conducted involving seaducks that use the waters within the area of the Cape Wind Energy Project.

### 4.3. Fatalities Resulting from Collision With Turbine Rotors

Although there is abundant information regarding the frequency of bird collisions with turbine rotors, most of the information that is available comes from terrestrial wind plants (see **Chapter 2**). The paucity of studies from marine environments makes it somewhat problematic to evaluate the risk of collision with turbines erected in nearshore and ocean waters. Studies done in terrestrial and marine environments have demonstrated that most flying birds detect and avoid turbine rotors. However, the fact that small numbers of birds do collide with turbines suggests that avoidance is not always successful.

To provide a preliminary assessment of collision risk at the Nantucket project, we examine known avian use of the Cape Wind Energy Project area in relation to what is known about avian collisions at both terrestrial and marine wind plants. We provide separate assessments for the different groups of birds. In **Chapter 2** we have provided information about which season(s) these birds are present, approximately how many individuals are present, what birds are doing within the project area, diel timing of activities, and generalities regarding height of flight and other behaviors. This is the information used to assess risk to these bird groups.

We consider duration of presence to be an important factor, especially when combined with behavior. If birds are present for only a small portion of the year, risk is likely to be lower than if birds are present for a larger portion of the year. Risk is also dependent upon how much of the time they are present within the turbine areas and their behavior while they are present, especially the height at which they fly and how they respond to turbines. For example, Piping Plovers are present from April through September, yet their risk is negligibly low because they will not be present in the turbine areas for long periods (or possibly at all). They simply pass through the Nantucket Sound area during migration. On the other hand, wintering seaducks such as Long-tailed Duck are present from November through March – about the same proportion of the year as the plovers, but for some individuals, much of their time may be spent in the turbine areas. Thus, risk to these species is judged to be potentially greater than for the plovers.

For each of the following groups of birds, we assign a risk assessment of low, moderate, or high that depends on the likelihood of birds colliding with turbines. For some groups or individual species we were not able to assess risk because information that could be used to assess risk was not available. In addition, we provide a first-cut estimate of whether the collisions that we anticipate will be significant or not significant from a population perspective. These estimates are first approximations and should be considered preliminary and subject to revision as more data are gathered.

**4.3.1. Oceanic/Pelagic Seabirds**. Gannets, storm-petrels, shearwaters, and other seabirds frequent the project area in varying numbers and times of the year, depending on species. For gannets, the risk period is primarily during migration as they pass through the area and to a lesser degree the winter months when fewer individuals are present. Storm-petrels, shearwaters, and other pelagic species fly into the area and may forage there, but their behavior is relatively unknown. Risk of collision for an individual bird is most likely to occur if birds feed in the area for several days or months. It is likely that birds actively migrating through the project area are likely to avoid flying close to turbines or within the rotor swept area. However, pelagic species like Leach's Storm-Petrel are known to be attracted by bright lights (Montevecchi et al. 2001, Pfand 1996), such as those on oil rigs, city parking lots and stadiums (mercury vapor lamps). At these times, they may fly close enough to the turbines to collide with the rotors.

Risk – Unknown, not likely to be significant, but further study is indicated.

**4.3.2. Gulls and Terns**. Very small number of gulls have been involved in collisions with wind turbines in California and Europe and the risk to these birds has never been reported to be high in published and unpublished studies. Gulls are present in the Cape Wind project area most of the year. They probably forage in the area, but more of their activity is within three miles of the shore than within the project area itself. Much of their flight occurs within the height of the rotor swept area. It is likely that if gulls habituate to the turbines (as they do with most other man-made structures), low to moderate numbers of fatalities may result. Risk to gulls, therefore is likely to be low and not significant.

Risk to terns is unknown. Because of the rare status of some of these birds and because they have never been studied near wind turbines, risk is difficult to assess. Further study needed to determine level of risk and significance of potential risk.

**4.3.3. Seaducks**. There is likely to be some degree of risk to these birds for three reasons: they are present during nearly one-half of the year, they are present in large numbers, and they make daily (sometimes nocturnal) movements to and from feeding areas within or near the project area and their distribution is strongly affected by storms. European studies have demonstrated collisions involving small numbers of eiders at turbines built along jetties and among diving ducks situated in saltwater lakes adjacent to the Wadden Sea (Winkelman 1995). Wind turbine facilities in North America located in Minnesota (Buffalo Ridge), Iowa (Clear Lake), Wisconsin, and California (Solano County and Altamont) are situated in areas that experience high use by waterfowl, mostly geese and dabbling ducks. At these sites, few individuals of these types of species have collided with turbines. Though these waterfowl are dabbling ducks and geese, rather than seaducks and divers, they are likely to have similar visual physiology and have similar abilities at detecting the presence of turbines. However, seaducks and divers are faster fliers and less maneuverable, so they may not be able to physically avoid turbines to the extent that dabblers can. This may place these birds at greater risk than dabblers.

Risk to seaducks is likely to be moderate, but not significant from a population perspective and insignificant when compared to the 20,000+ Common Eiders and 10,000+ Long-tailed Ducks harvested annually by hunters in the Eastern Flyway in 1999 (U. S. Fish & Wildlife annual harvest statistics). Risk to seaducks may be greater than for other groups of birds because of their presence for 5-6 months in winter. Further study is indicated, especially with respect to Long-tailed Duck and Common Eider winter movements.

**4.3.4. Cormorants**. Double-crested Cormorants have a limited window of seasonal presence within the project area that includes less than about one-half of the year. It is unlikely that large numbers of these birds will spend significant time foraging in the area of the turbines. Great Cormorants are present during a smaller window, mostly in winter. Both species frequently perch on large, man-made structures. Perching sites on the turbines may increase the risk of collision to these species by providing a means for the bird to frequent the area near the rotors. Elimination or minimization of perching on turbines will probably reduce risk of collision to these species.

Cormorant migration over water is mostly within daylight hours and frequently within the height of the rotor swept area. Individuals migrating through the project area will be within the project area for a short period of time.

Risk – Low, not significant.

**4.3.5. Other Divers – loons, grebes, alcids**. Alcids generally fly close to the sea surface, below the rotor height, but loons and grebes do fly within 100-200 feet of the water surface and their flights occur mostly in daylight. The few studies of migrating loons and grebes show that they usually do not fly above 100 feet above the waves (Clay Sutton, personal communication and P. Kerlinger unpublished data from observations of thousands of these birds along the New Jersey Shore at Cape May, NJ). Their presence is seasonally limited to less than about six months of the year, with many individuals simply passing through the area.

Because moderate numbers of these birds migrate through the project area and lesser numbers winter and forage within the project area, more information on height of flight and avoidance reactions to structures is needed. In addition, we do not know the extent to which, if any, these birds fly at night during migration.

Risk – Unknown, significance unknown. Further study needed.

**4.3.6. Shorebirds (Plovers, Sandpipers, and Allies).** Studies from the Netherlands – near the coast – have demonstrated that shorebirds can be at risk of colliding with wind turbines during migration stopovers. Collisions did not seem to be during active migration, but were instead associated with local flights between foraging and resting areas. This type of collision risk does not seem to be applicable to shorebirds over open water in migration or among birds moving across the Sound. There is likely to be little risk to the large numbers of night migrating shorebirds as their altitude usually is well above turbine height. Shorebirds making diurnal flights between Monomy and Nantucket or among other islands may fly within the height range of rotors at times, but these birds are likely to see the turbines and avoid them if flying during daylight. In addition, the amount of time that these birds spend in the area is restricted to about one-third of the year, limiting risk to this period.

Risk – Low, not significant. Further study – specifically height of flight at night – would be helpful for better assessing risk.

**4.3.7. Raptors**. The number of individual raptors and raptor species that are likely be present at more than 3 miles from shore and within the project area is very small. Their presence is most likely to occur during migration (April-May, September-October), which is only one-third of the year. Individual birds migrating through the area will usually fly through the area only one time per season or per year. The risk during other months is virtually nonexistent because these species simply will not be present except in rare instances. Raptors have been suggested to be more susceptible to colliding with wind turbines than other types of birds (Anderson Orloff and Flannery 1992, 1996) but only raptors engaged in active foraging and pursuit of prey have been impacted by wind turbines. An exception may be the Griffon Vultures at Tarifa that have collided with turbines as they soar on updrafts in close proximity to the turbines, but these birds may also have been hunting. Collisions are less likely offshore because few species of raptors forage over water, especially more than three miles from shore.

Ospreys and, to a far lesser extent, some falcons (Peregrine and Merlin) do forage over water, potentially increasing the time they spend in the Cape Wind project area. To date, no Osprey or Merlin has been reported to collide with a wind turbine, although a single Peregrine fatality has been reported from the APWRA. If the turbines have suitable perching sites, as is the case in the APWRA, raptors such as Peregrines, Ospreys, and some others may perch on them, thereby habituating them to turbines and possibly increasing the risk of collision. If turbines are devoid of perching structures, habituation is less likely because these birds will have no way of remaining close to the turbines. At least one study (Kerlinger 1999) has demonstrated that migrating raptors avoided turbines and did not fly close to them. It is likely that none of these individuals had ever seen a turbine previously. Raptors trained for falconry cowered when they were taken out of their cages within several hundred feet of a wind turbine (R. Curry, personal communication, Kenetech Corporation Avian Task Force).

Risk – Low, not significant

**4.3.8 Passerines and Other Landbirds**. Night migrating songbirds, for the most part, are likely to fly at altitudes well above the turbine rotors and are not at risk of collision. Those birds that are caught out over the ocean at dawn, often attempt to return to shore. These birds frequently fly at much lower altitudes (especially with head winds) and are likely to be within or below the rotor height. At this time some may be at risk, although with good visibility, these birds are likely to avoid the turbines.

It should be noted that songbirds are likely to be attracted to lights during poor visibility conditions (rain, fog, snow, low ceiling). Thus, equipping the turbines with lights, including bright lights on the landing platform, ship navigation beacons, and, or aircraft safety, lights will significantly increase the risk of collisions. Lighting is the primary factor in collision mortality at communication towers. Virtually all communication towers that kill large numbers of birds are greater than 500 feet in height and have guy wires (data presented in Trapp 1998, Kerlinger 2000). Ironically, it is implementation of a federal regulation that attracts the birds to their death. Unguyed towers of less than 500 feet without lighting pose virtually no threat to migrants. If there are no FAA aircraft warning lights or other lights on the turbines, they are unlikely to attract birds and risk to night migrants is likely to be negligible. Ship navigation lights, to our knowledge, have not been shown to attract birds.

Few migrants are killed by onshore turbines that extend to nearly 300 feet above the ground, even when they are lit with FAA recommended aircraft safety lights (Appendix I).

Risk – Low to High, dependent upon lighting of towers, but not significant; presence of FAA or Coast Guard navigation lighting will increase risk from low to potentially high levels (high degree of uncertainty). Risk is unlikely to be as great as for guyed communication towers in excess of 500 feet in height that are located onshore.

### 4.4. Endangered, Threatened, and Other Listed Species

Of the three federally listed species that are known to frequent the project area (Table 4.1), only the Roseate Tern is likely to spend much time in the vicinity of the turbines. The other two species (Bald Eagle and Piping Plover) are likely to fly between Monomoy and Nantucket (or over some portion of the project area), but their flights are infrequent and mostly direct as neither is adapted for foraging over the open ocean. With respect to Massachusetts listed species, most will be occasional or rare visitors to the project area and, therefore, not at risk of colliding with the turbines (Table 4.1). Also see the text above and below for risk evaluation of these and ecologically similar species.

**Table 4.1**. Assessment of risk of collision to state and federal listed species[a] at the Nantucket Wind Power Project.

| Species | Use of the Area | Assessed Risk - Collision |
|---|---|---|
| Common Loon | Moderate/Low | Low?/NS-S? |
| Leach's Storm-petrel | Low | Low?-Negligible/NS? |
| Bald Eagle | Infrequent/Low | Negligible/NS |
| Northern Harrier | Infrequent/Low | Negligible/NS |
| Sharp-shinned Hawk | Very Infrequent | Negligible/NS |
| Peregrine Falcon | Moderate/Infrequent | Low/NS |
| Piping Plover | Moderate/Infrequent | Low-Negligible/NS |
| Roseate Tern | Moderate/High | Moderate??/NS-S? |
| Common Tern | Moderate/High | Moderate??/NS-S? |
| Arctic Tern | Moderate | Moderate??/NS-S? |
| Least Tern | Moderate/Infrequent | Low?/NS |
| Short-eared Owl | Low/Infrequent | Low/NS |

[a]This list includes all bird species in Mass 321 CMR that occur in the project area.
Neglible = no fatalities likely, Low – small numbers possible, NS – indicates not likely to be a significant risk to a species population.
S indicates significant disturbance possible and species may not use area near turbines.
? indicates the question is open and needs to be investigated because information is lacking.

### 4.5.1. Mitigation of Known or Suspected Risk Factors

There are currently few "best industry practices" for the design of turbines and wind power facilities for minimizing avian collisions with rotors. The reason is that fatalities have been deemed significant in only a few situations (perhaps only one location in North America). Furthermore, it is extremely difficult to test practices (if practices were standardized) at operating turbines because the rate of fatalities at single turbines is so low. For example, even where raptor collision rates are deemed to be highest in the APWRA, the rate is only about 0.03-0.07 birds per turbine per year (Howell 1997, Orloff and Flannery 1992, 1996). This means that, on average, only one raptor collision occurs at a given turbine every 30 years. Conducting studies with such a low rate of collision is only possible at wind plants where there are large numbers of turbines. This has made development of best industry practices difficult. At most sites, collisions are so infrequent that these practices are not necessary. Most importantly, turbines should not be situated in locations where there are high traffic rates of birds that are known to be susceptible to colliding with turbines or turbine-like structures.

**4.5.2. Turbine Tower Design**. It is believed that tubular towers are less risky than lattice towers because birds cannot land or perch on tubular towers. Because the Cape Wind project calls for tubular towers, that offer minimum opportunities for perching, these towers are not likely to present high risk. The work and landing platform (and possibly the nacelle), however, may provide perch sites for cormorants, gulls, terns, and other species. In May and June, any terns attracted to perching sites are likely to engage in high courtship flights (to 100 m) and other behavior that will bring them into the rotor swept area. It is recommended that the towers be constructed so as to provide no perching opportunities for birds. If this is not feasible, perching opportunities should be minimal. Elimination of perching will also eliminate potential maintenance and human safety problems created by bird feces that may accumulate on the towers.

**4.5.3 Lighting**. The lighting on communication towers, offshore oil platforms, buildings, parking lots, and other structures is known to attract birds. This attraction can contribute to collision risk. With respect to communication towers, the FAA/FCC lighting requirements are now recognized as being, perhaps, the most significant risk factor to migrating songbirds and, to a lesser extent, some other types of birds (Avery et al. 1980, Trapp 1998, Kerlinger 2000). With respect to wind turbines on land, FAA lighting is present on many towers greater than 200 feet in height. As was stated in **Chapter 2** above, few night migrants are impacted by wind turbines, presumably because turbines, to date, have extended to only about 300 feet AGL, below the altitude of most nocturnal migration. However, the Nantucket project towers will extend to 450 or 500 feet above the water and could potentially impact migrants if they are lit according to FAA guidelines.

With respect to aircraft safety lighting, the U. S. Fish & Wildlife Service recommends low intensity white strobe lights as opposed to red incandescent blinking lights because unpublished field studies indicate that this pattern is less attractive to night migrants (Gauthreaux unpublished study, US Fish & Wildlife Service guidelines to Ecological Services offices). It is also believed that lights with the longest possible off-cycle (time between blinks) are less attractive to night migrants than lights with shorter off-cycles. The Communication Tower Working Group is now soliciting investigations that will resolve the issue of safe lighting for communication towers. However, the FAA may not approve of white strobes for night obstruction marking. It is recommended that lighting not be used on the towers, but if it is required by FAA, lights should be those deemed safest by the Communication Tower Working Group and U. S. Fish & Wildlife Service. (There is current debate as to whether FAA is legally liable for avian fatalities under the MBTA. It also seems that this federal agency and several others are functionally exempt from MBTA enforcement.)

Standard ship navigation beacons have not been demonstrated to attract birds and, therefore not likely to increase risk. Bright spotlights (or mercury vapor lamps), as are used for worker safety, are likely to attract several types of birds, including pelagic species like storm-petrels (Montevecchi et al. 2001) that could then be at risk. We strongly recommend that bright lights are turned on only when needed for worker safety and at other times be turned off.

**4.5.4. Height of turbines (in relation to avian flight**). Because lighted towers in excess of 500 feet are known to attract migrating songbirds, we recommend that the turbines be kept below this height. We also recognize that many waterbirds (pelagic species and seaducks) fly close to the water, so we recommend that the turbine rotors do not come within about 100 feet of the ocean surface. The current specifications fall within this range and may be a compromise between these two height levels and the species of birds mentioned above.

**4.5.5. Tip Speed, Rotation Rate, Rotor Swept Area, and Visibility of Rotors.** Rotor speed and rotational rate vary among turbines. The recent trend in turbine design has been toward larger rotors with slower revolutions per minute. Table 4.2 provides a comparison of rotor length, rotation rate, tip speed, and perceived/documented risk for several types of turbines, including the turbines proposed The specifications of these turbines is estimated and needs to be confirmed before more realistic risk assessment is done. Table 4.2 shows that the rotor tip speed may be very fast for the turbines that are planned for use at the CWEP project.

**Table 4.2**. Comparison of rotor length, rotation rate, and tip speed of various turbines. For turbines with variable rotation rate or two speed rate, the higher value(s) were used.

| Model | Rotor Length | Rotation Rate | Tip Speed | Perceived/Documented Risk |
|---|---|---|---|---|
| Kenetech 56-100 | 28’ | 72 rpm | 144 mph | High |
| Micon 700 (or other) | 77’ and > | 22-24 rpm | ~121-140 mph | Low-Moderate |
| Proposed CWEP | ~163’ | ~20 rpm? (variable?) | ~200 mph? | Unknown |

Larger, slower-turning rotors, especially if they are variable speed or have two-speed gearing are recommended over faster turning and constant rotation rate rotors. Slower turning and larger turbine rotors are believed to present lower risk to birds. A theoretical study by Tucker (1996) demonstrated that the slower rotational rate of variable speed turbines and two-gear turbines is less risky to birds passively flying through the rotor swept area (flying in direct flight between the rotors) than turbines with smaller rotors and faster rotational rates. Empirical support for his theoretical predictions was presented by Howell (1997) who studied fatalities of raptors at large (500 kilowatt) Kenetech 33 kvs turbines and Kenetech 56-100 turbines, found that for raptors, the rate of fatality was proportional to the rotor swept area. This demonstrated, via lower fatality rate per rotor swept area, that the larger turbines were not more risky than smaller turbines per unit of energy produced. A recent analysis of a larger database for these species showed that the larger, slower-turning turbines in the APWRA had never experienced collisions with Golden Eagles, while the faster turning and smaller turbines adjacent to them had. It should also be noted that at the newer wind turbine sites where large machines, in the range of 0.7 to 1.5 megawatts, have been deployed, collisions have been small in number and not significant (see **Chapter 2**).

Birds can clearly see and recognize turbines, but they may not be able to see fast moving rotor tips. Risk is believed to be proportional to visibility of the rotor tip and at fast speeds a phenomenon called “tip smear” occurs. Research by McIsaac (pers. comm.) has demonstrated that birds like kestrels recognize turbines as distinct entities. Hodos (2000) at the University of Maryland, also using captive kestrels, demonstrated varying ability to detect rotors painted with different patterns. He found that the most visible pattern (as of spring 2001) was the painting of one rotor black and leaving the other two white. Kerlinger suggested painting only the distal one-third to one-half would provide the same visibility. Tests are now needed to determine if painting of the distal portion of a rotor on newer, larger turbines is appropriate to increase visibility and reduce the potential for collisions.

We recommend that rotation rate and, therefore, tip speed be kept as slow as possible on the CWEP turbines. We further recommend that the findings of Hodos be tested and that one of the three rotors on each turbine be painted (at least the distal one-half or one-third) to promote visibility in daytime conditions if tests reveal that this significantly increases the visibility of the turbine rotor.

**4.5.6. Audio Deterrents**. There has been little research done to determine whether birds can be deterred from flying near turbines or other structures. The Electric Power Research Institute has experimented with some noise making devices and Breco Buoys, which emit various types of noises, are used at oil platforms off the northern coast of Alaska to deter seaducks from flying too closely (Ted Swem, U. S. Fish & Wildlife Service, pers. comm.).

## 4.6. Conclusions and Recommendations

The seasonal presence of large numbers of individuals of several mostly common and a few rare species and their behavior within the project area, suggests a potential for risk at the CWEP site. Risk includes both displacement resulting from the presence of turbines and collisions resulting in fatalities. The risks associated with displacement are likely to be minimal and not significant because the project area accounts for a small percentage of the entire habitat available to these species. Moreover, many birds habituate to the presence of turbines, which further reduces the likelihood of significant displacement.

Risk of collision is more difficult to assess because little is known about the susceptibility of collision of several species that are known to feed and rest within the project area. For most species, the probability of large numbers of collisions is low because few individuals of these species are present within the project area or those that fly at altitudes that are well above the turbines or are not susceptible to colliding with them.

The four groups of birds that need further study that will result in a more complete assessment of risk include three species of terns, at least two species of seaducks, seabirds, and several species of diving birds.

- The presence of terns (Roseate, Common, and, perhaps, Arctic) and their behavior in the project area should be studied (before and after construction) during the nesting and post-nesting seasons (April-August).

- The daily and diel movements of hundreds of thousands of seaducks, primarily Common Eider and Long-tailed Ducks, within the project area during migration and winter suggests the potential for high risk and the need for further study (November-March).

- Little is known about the presence and movements of mostly pelagic seabirds (Northern Gannet, shearwaters, and storm-petrels) in the project area. A study that provides a more complete picture of the seasonal and numerical presence, as well as behavior of these species, will provide the information needed to better assess risk.

- Several species of diving birds (Common and Red-throated loons and alcids) are present in the project area during migration and winter. A study that provides information about numerical and geographic presence, as well as behavior, will provide the information needed to better assess risk.

We suggest the use of radar and, or direct visual observations (day and night) to determine the distribution and behavior of these species within Nantucket Sound and the adjacent waters of the Atlantic Ocean. In addition, we recommend that studies now being conducted at offshore wind projects in Denmark, United Kingdom, Germany, and the Netherlands, be monitored closely because those studies will provide critical information about some of the species listed above, as well as other species. These studies will provide information about collision and displacement risk for some of the same species that are listed above. Finally, post-construction monitoring at the CWEP will provide information on risk to birds at offshore wind plants in North America. This is particularly important because the CWEP may be the first offshore project built in the Western Hemisphere.

If the CWEP is phased over several years, studies of the species in question at those turbines that are installed in the first phases will provide answers as to the degree of risk to those species that are in question. These studies, and those now being conducted at offshore wind plants in Europe, will provide the best answers regarding risk of collision, displacement, and the degree to which birds habituate to the presence of wind turbines.

Finally, new methods for observing birds near rotors and for measuring mortality at sea is crucial to understanding the impacts of wind turbines on birds in marine habitats.

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**Appendix I. Review of avian studies in the United States, Canada, and Europe.**

**UNITED STATES**

- **Vermont –** Searsburg near Green Mountain National Forest, 11 modern turbines in forest on hill/mountain top, nesting and migration season, 0 fatalities, Kerlinger 2000
- **New York** - Tug Hill Plateau, 2 modern turbines on farmland, 2 migration seasons, 0 fatalities, Cooper and Johnson1995
- **Pennsylvania –** Garrett (Somerset County), 8 modern turbines, farm fields, 12 months, 0 fatalities, Curry & Kerlinger, LLC, unpublished report
- **Massachusetts –** Princeton, 8 older turbines - type unknown, forest (hardwood) and brush, autumn & winter, 0 fatalities, Jacobs 1995
- **Minnesota –** Buffalo Ridge near Lake Benton, 100s of modern turbines in farm and grassland, several years, 53 fatalities (mostly songbirds and 1 hawk); some displacement found among grassland nesting songbirds; Osborn et al. 2000, Johnson et al. 2000, Johnson et al. 2000, Johnson et al. 2000, Leddy et al. 2000
- **Kansas –** St. Mary's, 2 modern turbines in grassland prairie, 2 migration seasons; 33 surveys, 0 fatalities, E. Young personal communication
- **Wisconsin –** Kewaunee County Peninsula, 31 modern turbines in farmland, 1+ year, 18 fatalities (3 waterfowl, 14 songbirds, some night migrants), report to Wisconsin Dept. of Natural Resources, Madison Gas & Electric, and Wisconsin Dept. of Public Service
- **Wisconsin –** Shirley, 2 modern turbines in farmland, 54 surveys, 1 fatality (night migrating songbird), report to Wisconsin Department of Natural Resources Bureau of Integrated Science Services and Richter Museum of Natural History Special Report
- **Iowa –** Algona, 3 modern turbines in farmland, three seasons, 0 fatalities, Demastes & Trainer (2000)
- **Colorado –** Ponnequin, 29 modern turbines in rangeland, 2.75 years - 1999-2001, 14 songbird, 1 duck, 1 American Kestrel fatality, Kerlinger, Curry, and Ryder 2001 unpublished
- **Wyoming –** Foote Creek Rim, 69 modern turbines in rangeland, 2 years, 55 fatalities (songbirds - one-half were night migrants - and 3 raptors), Johnson et al. 2000
- **Oregon –** Vansycle, 38 modern turbines in farm and rangeland, 1 year, 11 birds (7 songbirds [~ 4 night migrants], 4 gamebirds, Erickson et al. 2000
- **California** - Altamont Pass Wind Resource Area (APWRA), 5,400 older turbines mostly on lattice towers in grazing and tilled land, many years, large numbers of raptor fatalities (>400 reported) and some other birds, Howell and DiDonato,1991, Howell 1997, Orloff and Flannery 1992, 1996, Kerlinger and Curry 1997, 1999, Thelander and Rugge 2000
- **California –** Montezuma Hills, 237 older turbines, 11 modern turbines in farmland, 2+ years, 30+ fatalities (10 raptors, 2 songbirds, 1 duck), Howell and Noone 1992, Howell 1997

  **California** - San Gorgonio Pass Wind Resource Area, thousands of older turbines, 120 studied in desert, 2 years, 30 fatalities (9 waterfowl, 2 raptors, 4 songbirds, etc.), Anderson et al. 2000
- **California** - Tehachapi Pass Wind Resource Area, thousands of turbines, 100s of mostly older turbines studied, in Mojave Desert mountains (grazing grassland and scrub), 2+ years, 84 fatalities (raptors, songbirds), Mitchell et al. 1991, Orloff 1992, Anderson et al. 2000

- **Texas** - no reports available from more than 200 modern turbines, fatalities have yet to be reported, communication from FPL Energy official
- **Iowa** - no reports available from more than 200 modern turbines other than Algona, farmland, fatalities have yet to be reported, communication from FPL Energy official

**CANADA**

- **Quebec** - Le Nordais, Gaspe, 2 projects, 133 modern turbines in forest, 26 studied, two seasons, no fatalities, Province of Quebec Ministry of Environment 2000
- **Alberta** –Medicine Hat and Lethbridge, 2 projects, no reports of avian fatalities

**EUROPE**

The list of avian studies at wind parks in Europe that follows is not complete and represents a work in progress. The literature in Europe is more diffuse and difficult to locate.

**United Kingdom**

As of early 2001, the British Wind Energy Association listed more than 40 commercial wind power facilities having more than 1 turbine and supplying more than 0.5 megawatt of electricity. In addition, there are at least 5 individual sites where there was only one commercial sized turbine. A total of about 750 turbines were operating at the end of 2000 in the UK providing more than 350 megawatts of power. At none of these facilities has there been a report of significant mortality.

The Royal Society for the Protection of Birds (RSPB), the largest bird protection organization in the world, stated that wind power can reduce the overall impact of the energy sector on birds. "The use of renewable forms of energy, such as wind power, can help make a significant reduction in such impacts (referring to the energy sector). However, the local effects of wind power can be such that they could outweigh the benefits." The local effects referred to by RSPB include loss of habitat and direct mortality through collisions with turbine rotors.

- **Llandinam, Wales –** Behavioral and fatality studies were done at this farmland site where there are 103 turbines (30.9 megawatts) revealed minimal impact
- **Mynydd Cemmaes, Wales –** Same types of studies, 24 turbines in farmland, 2 dead birds (1 snipe and 1 Black-headed Gull)
- **Blyth Harbour, Northumberland –** 9 modern turbines on seawall adjacent to the sea, no apparent displacement of shorebirds (Purple Sandpiper, Sanderling) on the jetty or sea and waterbirds (eiders, gulls, cormorants), weekly searches revealed 20 carcasses in 1 year (34 in 2.5 years,12 eiders in first 2.5 years then numbers declined and no fatalities were found 1996-1997, no significant impacts
- **Blyth Offshore, Northumberland –** 2 modern wind turbines 1.5 km offshore – erected in 2000, no studies yet available

- **Bryn Titli, Wales –** 22 relatively modern wind turbines in sheep-grazing and heather moorlands, behavioral studies of wintering raptors (Red Kite, Peregrine Falcon, Kestrel, and Common Buzzard) and ravens; no fatalities reported.

Overall, wind turbines have posed little damage or disturbance to birds in the UK.

## Spain

A total of 2,500 megawatts from about 4,000 turbines was projected for Spain by the end of 2,000. There are several important areas of wind power development in Spain. In the north, wind plants have been erected in Galicia, Navarre, and elsewhere, mostly after 1998. These areas are wide open pastures, hayfields, and some other habitats. This author examined several areas in Galicia in 1996 and found bird use to be low at these sites. There do not seem to be any post-construction studies from most sites in Spain because the facilities are so new, but studies are likely to be forthcoming. The other major wind area in Spain is at Tarifa, overlooking the Straights of Gibraltar, where there are more than 1,000 old and modern turbines. This is the only wind farm area in Spain where mortalities have been reported.

- **Tarifa, Andalucia** - about 1,000 turbines ranging from older commercial grade turbines to modern turbines, lattice and tubular towers on steep hillside grazing land. Morocco is visible in the distance and the wind park is situated at one of the world's largest migratory concentration points of raptors (more than 100,000 pass per autumn), storks and cranes (more than 50,000 pass per autumn), song, and other birds. Several studies have been conducted. The numbers of migrating birds found has been minimal. It should be noted that Griffon Vultures (2+ m wingspan) have been impacted as have Kestrels.

  In one study where rigorous searches were made at 87 turbines, an estimated 30 vultures and 49 Kestrels were killed (Marti Montes and Barrios Jaque 1995). The vultures are permanent residents with a population of about 400+ pairs that frequent the general area of the wind plant. Kestrels are resident nesters, wintering birds, and migrants. The behavior of the vultures (constant soaring at low altitudes looking for dead livestock) and the steep terrain on which the turbines are situated combine to make the wind park risky to this species. This is analogous to Golden Eagle and Red-tailed Hawk mortality in the Altamont where birds hunt at low altitudes amidst a large number of turbines that are on steep hills.

  In a second study, only 1 Griffon Vulture and 1 Short-toed Eagle were found dead during 14 months of study. Fatality rate per turbine was estimated to be 0.03 birds per turbine per year. More than 45,000 vultures and 2,500 Short-toed Eagles flew over the site during the study period. Very few migrants were impacted. Researchers feel that migrants fly well above the wind turbines and that it is residents that have greater potential for impact. Tarifa seems to be the only place in Europe where raptor fatalities may be high, but study results have been inconsistent and vary dramatically. It is unlikely that raptor populations are or have been impacted by the turbines at Tarifa.

  [Observations of migrating raptors made by this author during spring 1996 at Tarifa and radar observations made by researchers during the same spring confirm that migrating raptors, storks, cranes and other birds fly around or above the turbines. Black Kites, a numerous species, simply flew around the ends of turbine rows, before continuing their northward migration. They did not fly within 50 m of the turbines, except on rare occasions. It was obvious that these birds deviated so as to avoid the turbines.]

There appear to be no records of fatalities of birds at wind turbines in Spain, other than from Tarifa.

**Netherlands**

Approximately 336 megawatts of wind power are being produced annually in the Netherlands. Most wind energy in the Netherlands is located along the coast of the North Sea in low-lying regions. Some of these low-lying situations are in the polders and are surrounded by wetlands. Fatality information was gathered at several of these facilities, as was behavioral data.

- **Oosterbierum Wind Park –** 18 mid-sized wind turbines (300 kilowatts per turbine) in farmland adjacent to Wadden Sea, birds (waders and songbirds) changed flight paths at 100+ m when approaching turbines, disturbance was found to be minimal.

- **Urk Wind Park, Lake Ijsselmeer –** 25 mid-sized wind turbines (300 kilowatts per turbine) situated along 3-kilometer dike at edge of Lake Ijsselmeer, mortality and behavior of mostly wintering sea ducks were studied, <63 fatalities documented (mostly diving ducks and a few dabblers) during autumn and winter when wintering waterfowl were present in peak numbers, disturbance occurred within 300 m of the turbines - diving ducks avoided these areas
- **Lake Ijsselmeer –** a "lake" inland a short distance from the sea, 4 wind turbines (200 m between turbines), wintering diving duck (hundreds on the lake) behavior, risk documented to be low, at night ducks "can cope rather well with wind turbines in semi-offshore situations," On moonless nights, ducks turned away at closer distances tha on brighter nights. It is possible that long strings of turbines create barrier effects because ducks were reluctant to fly between turbines. No fatalities were reported and no fatality data were included. (In 1996-1997, 28 600 kilowatt turbines were installed in Lake Ijsselmeer. Studies of that site were not found.

- **Other Wind Plant Studies in Netherlands**
  - Early-mid 1980s – 7 small wind turbines at a coastal site – no collisions or fatalities documented
  - 1987 - 75 small wind turbines at several sites were studied – 21 fatalities reported

The fatalities at the wind plant at Oosterbierum adjacent to the Wadden Sea were more numerous than at most wind plants in the world. In general, the wind power facilities located in coastal marsh and lowland areas of the Netherlands appear to pose a higher risk to birds than inland sites. The numbers of migrants in these areas is very high and turbines are located among migration stopover and resting sites, which together may account for the risk.

[Summary of 108 European wind power study sites by Winkelman in 1995 revealed 303 fatalities, of which 124 were proven to collide with turbines. It is likely that the actual number was larger. No rare or threatened species were involved.

## Denmark

Denmark is the leading country in the world with respect to per capita generation of electricity via wind power. At the end of 2000, about 6,000 wind turbines were producing about 2,000 megawatts of power in this small country, thereby providing more than 10% of the population with emission free electricity. Studies of avian impacts have been conducted at several sites. Fatality information is lacking and it does not seem that this is a major focus of research.

- **Tuno Knob, Kaategat –** A behavioral study was conducted at 10 modern, 500 kilowatt turbines located several kilometers off the Danish coast in the sheltered waters of the Kaategat. The turbines were erected in 1995 and intensively studied via radar and direct visual methods. The area is a prime feeding area for thousands of wintering eiders and some scoters (also gulls and some other waterbirds present). The study showed that birds did fly in the height range of the rotors, but demonstrated avoidance. There was little in the way of significant disturbance effects, although eiders were reluctant to feed with in about 100 m of the turbines. No fatalities were reported, although the study was not designed to assess mortality.

- **Rodsand Offshore Wind Farm –** This large windplant (about 90 turbines, ~200 megawatts) is planned for an area 10 km southwest of Gedser on the west coast of Denmark. Bird studies are now being conducted to examine potential impacts. Several hundred thousand waterfowl, 15,000 raptors, and 200,000 songbirds move through the area. Results of a preliminary study are available.

- **Esbjerb –** Reference to this study was found, but the original was not. Five turbines of varying sizes were examined. Reduction in breeding birds beneath the turbines was documented and 7 fatalities were located.

To date, significant impacts to birds from wind turbines have not been reported from Denmark, despite the proliferation of wind power in this country.

### Germany

Although there are more wind turbines (about 8,000 commercial units as of 2000) and more wind power generation capacity (4,500+ megawatts) in Germany than any other country in the world, there is little information about birds and turbines in that country that is readily available. Most wind plants are located inland from the coast, although significant efforts to develop Helgoland, where there is currently a single, 2 megawatt turbine now operating. This island is located off the north coast of Germany and is known to be an important migration concentration point in the Baltic Sea.

- **Drochtersen Wind Plant, Saxony –** 7 older turbines in a grassland/meadow site were investigated to determine the impact of turbines on these songbirds and waders. Although lapwings "avoid close proximity to the wind power generators" other birds did not seem to be impacted by the turbines and were distributed evenly in the area.

- **Summary of Studies at 13 wind parks in Lower Saxony –** Study in 1997 suggested that birds are less sensitive to the presence of wind turbines than previously thought. (Habituation was not investigated or suggested, but it is likely that after wind turbines are on the land for several years, birds are not deterred by them to the degree as when they were first constructed.)

- **Jade Wind Park and Dewi Test Field, Wilhelmshaven –** Several species of shorebirds (golden plover, lapwing) and songbirds (skylark, Meadow Pipit) were examined in these German wind parks. They did not seem to be as sensitive as was suggested earlier and did not maintain large distances from the wind turbines.

- **Cuxhaven Wind Farm, Nordholz –** Several small wind turbines in open, grassy fields and farmland. Twelve species of breeding and resting birds including shorebirds and songbirds were examined in relation to wind turbine locations. A slight, but insignificant reduction in numbers of birds occurred after the wind turbines were constructed. Some birds, like Syklarks, reached their highest densities within 250 m of turbines.

- **Northwestern German Wind Plants -Lower Saxony –** Six wind power facilities were examined to determine the presence of wind turbines on nesting birds. Studies resulted in similar findings with respect to nesting and resting grassland birds in northwest German wind plants.

The above information was assembled from abstracts. The original papers are being sought to provide greater detail.

## Sweden

There are currently somewhat less than 500 commercial wind turbines operating in Sweden that generate slightly less than 200 megawatts. More wind power is planned for the future. There were no studies of avian impacts readily available and there have been no reports of large-scale fatalities or impacts from wind plants, which are mostly located in Gotland, Oland, and along the west coast.