# Patterns and Timing of Bird Migration as it Relates to the Placement of Wind Turbines

Christopher Raithel
RI DEM Division of Fish and Wildlife
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**Executive Summary:** The seasonal timing of passage and relative abundance of birds migrating birds through southern New England are very well known. A large body of published and anecdotal evidence allows description of many aspects of diurnal migration, including behavior, daily timing, and preferred routes. Less well known are local patterns for nocturnal migrants, but even with this group existing literature and observations enable strong inferences to be made regarding their migratory timing and behavior. This information is useful in assessing potential risks to migrating birds by wind turbine placement in the coastal zone. Regarding the proposed sites in the vicinity of Point Judith and Galilee, Rhode Island, risks to nocturnal migrants are expected to be greater than for other species groups considered. Careful placement and construction of such turbines could reduce the risk of mortality to nocturnal migrants.

**Introduction**: Energy generation by wind turbines is an increasingly popular way to defray the economic and environmental costs of burning fossil fuels. Collision mortality of birds and bats and bird avoidance, which can result in an effective loss of nesting and foraging habitat, are potential consequences of wind turbines. The purpose of this report is to summarize potential impacts of wind turbines on significant foraging and nesting habitats, as well as migratory movements of birds and bats through Rhode Island.

**Summary of Issues**: The effects of turbines on bird populations are continually being evaluated (see Barclay et al. 2007 for tabled summary of existing studies). A common method for evaluating collision mortality involves manual searches for dead birds in wind turbine zones and then using those data and other inputs to model the actual mortality. Such models have often produced imprecise mortality estimates and can be difficult to parameterize (Madders and Whitfield 2003, Barclay et al. 2007, Smallwood and Thelander 2008), but future refinements will undoubtedly enhance their utility. Other studies have attempted to estimate mortality and avoidance by conducting before-after comparisons of bird densities in wind turbine areas or else (lacking the “before” component) comparing existing turbine areas to similar control areas (Madders and Whitfield 2003). All North American studies to date have involved terrestrial wind farm locations, many of which are of vast dimensions compared to anything that would be erected locally. For example, the Altamont Pass Wind Resource Area, in California, is approximately 17 x 17 km in extent (Smallwood and Thelander 2008). In addition, many studies on the relationship between bird behavior and collision risk of displacement have relied on diurnal observations (e.g., Osborn et al. 1998). However, an excellent framework exists for evaluating impacts to offshore turbines placed in migratory corridors. (Hüppop et al. 2006). This evaluation incorporated radar, diurnal sightings, thermal imaging, and acoustic monitoring.

**Degradation of nesting or foraging habitat**: Some studies have suggested that some birds, usually nesting species, avoid turbine areas while others are less inclined to do so. Therefore, the placement of wind turbines in terrestrial locations could render unusable the nesting and feeding habitat for certain birds. In the Galilee/Point Judith area, a turbine in the vicinity of East Matunuck State Beach would be the most problematic, because of nesting Piping Plovers and Least Terns at the west end of the westernmost parking area. Citing a turbine near a Piping Plover nesting area involves another layer of federal consultation through section 7 of the Endangered Species Act. The entire area of East Matunuck Beach west to the breachway cut to Point Judith Pond should be avoided. Other turbine placements in the Galilee area may also cause birds to avoid certain habitats. Although nesting birds in these areas are not a high concern, with the possible exception of Osprey, the salt marshes along the escape road t offer foraging opportunities for wading birds and shore birds. There are many other habitats nearby that could be used by displaced birds, so this concern is minor in the Galilee area.

**Bird migration:**

The study of bird migration in southern New England has a long history. In Massachusetts, William Brewster (1886) published an insightful monograph on local migration that is still relevant today. In Rhode Island, Howe and Sturtevant (1899) published a brief synopsis of local sea and land bird migration. Since these 19$^{th}$ century synopses, much more has been learned of the timing and patterns of bird migration, mostly confirming the observations of these early authors, but in some cases extending them. Operation Recovery, a coordinated effort to integrate diurnal and nocturnal field observations and mark-recapture data during the late 1950's and early 1960's, yielded a number of publications relevant to the questions considered in the present report (see Drury and Keith 1962, Nisbet 1963, Drury and Nisbet 1964, Nisbet and Drury 1967). Apart from these works, much of the modern knowledge concerning bird passage in Rhode Island could be considered anecdotal – that is; it has been gathered by dedicated and knowledgeable amateur observers. Richard Ferren, formerly of Berkshire Community College, has assimilated much of the historical record and produced an exhaustive treatise of the Birds of Rhode Island, including their migration patterns. This work has yet to be published but is available in draft form. Ferren is the most authoritative figure in Rhode Island ornithology for this generation. He has spent countless hours sitting at the Point Judith lighthouse watching can counting migratory seabirds. These observations, although not compiled in any one file, nevertheless have been published in *The Field Notes of Rhode Island Birds*, the long-standing compilation of bird records for the state. As is true for most areas of North America, the timing and relative abundance of migratory birds in Rhode Island is well known. Bird watchers and ornithologists are acutely aware of when each species is expected and where. Much of this sort of information has been used to compile annotated checklists of Rhode Island birds, delineating relative abundance and seasonal occurrence (e.g., Conway 1992). In addition to heterogeneous collection of field observations available in *The Field Notes of Rhode Island Birds*, a number of long-standing banding stations further refine the abundance and timing of migratory passerines, especially in the coastal area. RI DFW has also contributed greatly to the accumulation of bird records in Rhode Island. At Napatree

Point, a coastal promontory in southwestern Rhode Island, DFW personnel (Raithel) have made several surveys there per year, at all seasons beginning in 1980. These data are assembled in a digital file and were used to make the activity charts included in this report. All data collection methods for birds have limitations; banding stations capture mostly small passerine birds; hawk watchers generally ignore non-raptors, and the Napatree Point data are weak for Neotropical migrants, which are very difficult to detect there. However, in aggregate these data sources clearly define the relative abundance and seasonality of detectable passage migrants through Rhode Island.

Less well studied, and somewhat speculative for certain avian groups, is how migratory behavior contributes to detection. This is especially true for migrant songbirds and bats, most of whose major migratory movements are nocturnal and cannot be directly observed. Even so, some direct observational evidence and inference allow a qualified construction of spring and fall behavior of migratory birds. This report is divided into three primary species groups: seabirds, hawks and other diurnal migrants, and nocturnal migrants including songbirds and bats.

**Seabirds**: this broad category of species includes waterfowl, loons and grebes, and cormorants and their allies (inc. Gannets etc.), and gulls. With the exception of the locally nesting Double-crested Cormorant, Herring Gull, and Greater Black-backed Gull, these birds occur in RI as passage migrants or during the winter. They breed mostly in arctic regions or Maritime Canada and winter off the southern coasts of North America. As such, their migratory pathways in spring and fall either follow the outer coast or pass through the interior. Therefore, as noted by Howe and Sturtevant (1899), migration of these birds through Rhode Island is protracted and not dramatic, either because it passes to the west of RI, well offshore, or even at night for some waterfowl. More birds are visible in fall than spring (see Veit and Petersen 1993).Therefore, seabird migration in Rhode Island waters could be characterized as diffuse: that is, there is no dramatic clustering, no narrow temporal window of passage, and no defined and consistent routes through Rhode Island. This pattern is possibly attributable to the broad breeding and wintering ranges demonstrated by most species in this category. Because many seabirds (but not all) migrate during the day, they should have some capacity to avoid turbines. In fact, mass collision events involving seabirds are virtually unknown (Hüppop et al. 2006). Wintering seabirds are actually known to avoid turbines, a phenomenon that could be interpreted as a “taking” of winter and migratory habitat, but that issue is not the point of this report.

**Figure 1. Generalized migration routes of seabirds in spring. many sea birds, including geese, waterfowl and loons, migrate through the interior of New England to reach breeding grounds in the Arctic. Primary routes identified are west of Watch Hill (A) and northward through Narragansett Bay (B). Another component of spring migration passes well offshore (C) and is not visible (except possibly from Block Island) from Rhode Island.**

**Figure 1a. Most waterfowl and loons.**

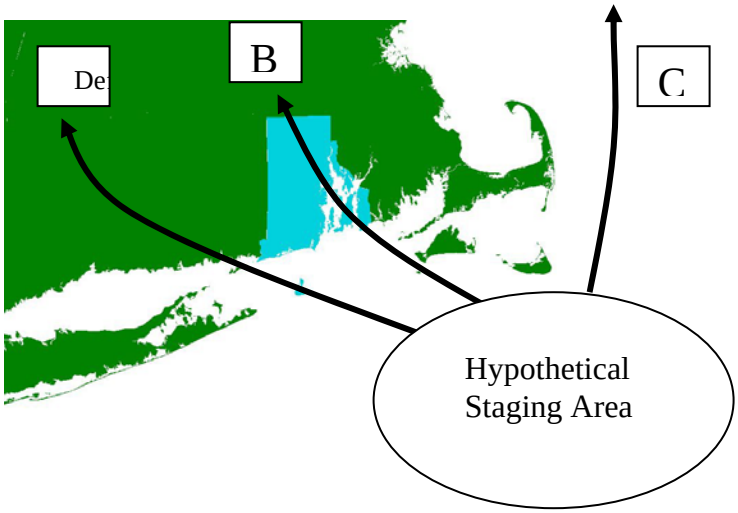



**Figure 1b. Double-crested Cormorants winter in southern North America and in spring follow a more coastal route without the westward interior pathway. Flocks cross southern New England at high altitudes and also follow the coast. Most flocks seem to pass over eastern Massachusetts and emerge in the Gulf of Maine (Veit and Petersen 1993), heading to breeding grounds along the Maine coast and eastern Canada. In fall this same route is used in reverse (Nisbet and Baird 1959).**

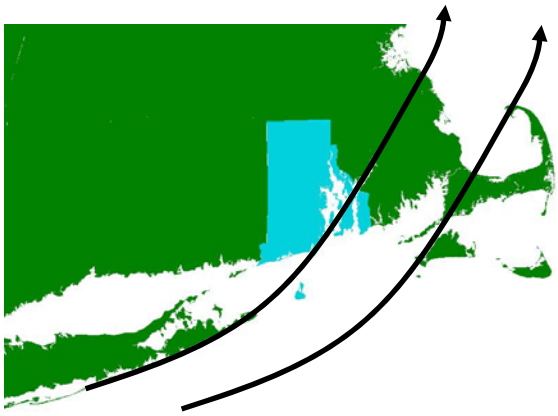
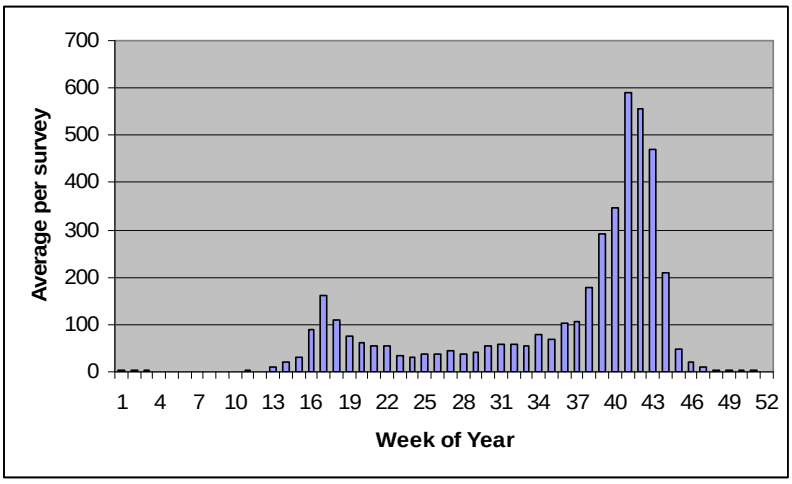


**Figure 2. Seasonal abundance of Double-crested Cormorants at Napatree Point. The Double-crested Cormorant, like most coastal migrants, is more commonly observed in fall than in spring (see also Veit and Petersen 1993). Some of the migration passes seaward of RI, probably outside of Long Island (NY) and is not visible from the RI coast. Week 40 includes 1 October.**




## <u>Specific comments related to migratory behavior of seabirds</u>.

**Loon**s: Both species of loons that regularly transit Rhode Island waters are direct flyers – they flap consistently and do not soar or glide. They have a very consistent migratory altitude – they neither hug the water nor fly very high, instead preferring a height of between 20-100 meters (estimated). Migrating loons are observed primarily in the early AM, before dawn to about 7:00 AM. Migratory activity may increase toward dusk, but I have few data from that time. Loons are diffuse migrants and have a long migratory period in both spring and fall. They pass Rhode Island in small, loose flocks containing 1 to about 10 individuals and do not dramatically cluster while migrating.

**Geese and Brant**: Canada and Greater Snow Geese are obvious coastal migrants through Rhode Island, especially during the fall. Geese tend to migrate at very high altitudes, sometimes at the very limit of visibility. They also are direct flyers but differ from loons in associating in large flocks sometimes exceeding 100 individuals. Brant, by contrast are seen migrating low over the water in large strings. Because all these species are sometimes seen migrating in the very early morning and have already (for geese other than Brant) achieved a high altitude, it is thought that some component of their migration

occurs at night. This is especially true for Brant, which I have never seen traveling overland during the daytime (although they are known to do so, e.g., in New York's Hudson River Valley and Lake Ontario Plain (Ewald and Sherony 2001).

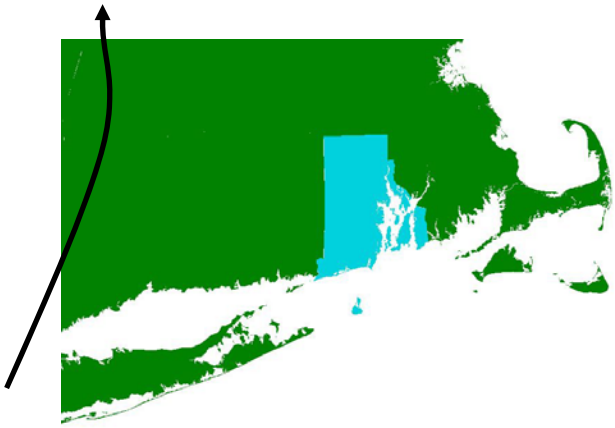
**Other Waterfowl**: The species of waterfowl that most interested Howe and Sturtevant was the White-winged Scoter. To the early gunners, it was obvious that spring White-wings migrated from the vicinity of Cape Cod westward, turning inland over the Connecticut shoreline just west of Watch Hill. These birds were thought to be bound for interior arctic breeding grounds. White-wings that follow this pattern are usually seen at very high altitudes and during late afternoon. By the time they cross over Rhode Island, they are already several hundred meters in altitude.

**Double-crested Cormorants** have a different flight profile and a more flexible migratory repertoire. Cormorants also migrate in large flocks, but their flight is less direct and includes much gliding and soaring. Flocks can either hug the water or, if they are traveling overland can attain very high altitudes, much like geese. When cormorants are leaving the ocean to cross overland, they first "kettle" like some raptors do. That is, they soar and circle upwards, apparently riding thermals to get enough altitude to pass over land. Likewise, when descending from an overland flight they spiral downward to the ocean and then level off to continue their route.

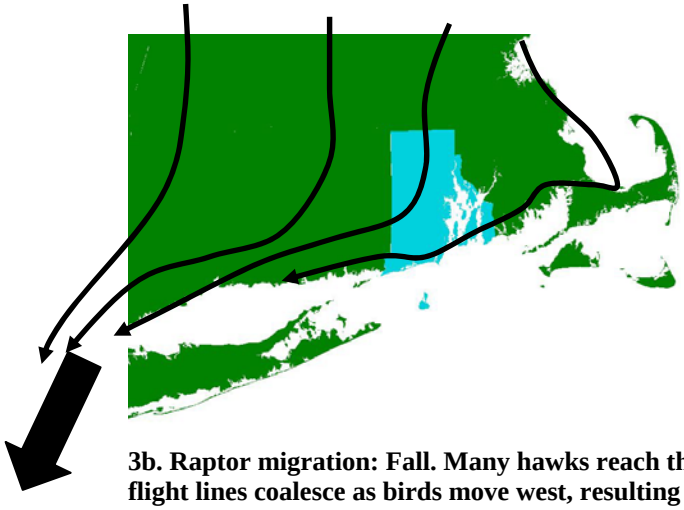
**Diurnal Migrants**: This broad group, which includes raptors (Accipiters, Buteos, Falcons, Ospreys, and Eagles), and a variety of other birds such as hummingbirds, swallows, swifts, and finches, is very common in the coastal zone of Southern New England, especially in fall. Spring observations of these groups are far less numerous in spring in Rhode Island because many birds take an interior route to breeding grounds in northern North America. Raptors have especially been a source of concern relative to turbine operations (Osborn et al. 1998, Madders and Whitfield 2003, Smallwood and Thelander 2008). Although these studies have focused on estimating raptor mortality and/or turbine avoidance, they have measured effects on resident, not migrant, birds. Their utility in assessing raptor mortality in Rhode Island coastal zone is therefore questionable because most raptors found along the Rhode Island coast are transients. In spring, raptors migrate diurnally from the southern United States or the Neotropics to northern and temperate North America. Most raptors avoid over-water flights in spring and fall. Their primary northward route in this area is west of the Hudson River Valley, so spring migration in Rhode Island is not very conspicuous in the coastal zone. In the fall, however, many hawks fly south-eastward, especially in conditions of strong NW wind. When they reach the coast they bend westward and follow along it, avoiding an open-ocean crossing. For this reason, hawk-watching stations in western New England have consistently more migrants than those in eastern New England. For example, the migration-watching station at Lighthouse Point (New Haven) is positioned to intercept raptors moving southward through the Connecticut River Valley and also "captures" most birds from eastern New England because they also have to pass this point on their way west. Similarly, Cape May (NJ) is probably the pre-eminent hawk-watching place in eastern North America because it acts as a funnel for coastal southbound migrants. Migratory raptors are driven to the coast by sharp cold fronts featuring NW winds. In

other conditions they probably still migrate but do not enter the coastal zone and are not visible in Rhode Island. Most raptors that utilize coastal routes are low-altitude migrants and typically fly from near-ground level to about 200 m high. Flight altitudes are typically lower in windy or overcast conditions, higher in windless clear skies.

**Figure 3. Generalized pathways of migratory raptors through southern New England**.



**3. a. Raptor migration: Spring. Most spring migrants follow an interior route that bypasses Rhode Island.**



**3b. Raptor migration: Fall. Many hawks reach the coast in fall, deflected by strong NW winds. The flight lines coalesce as birds move west, resulting in larger flights (black arrow) to the west of Rhode Island.**

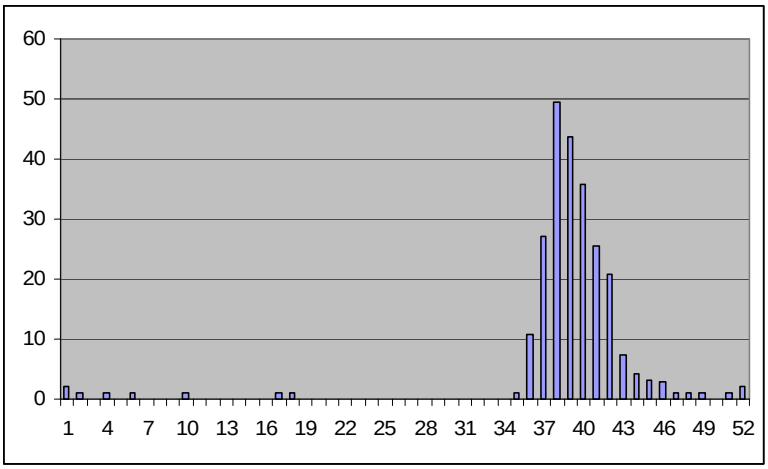



**Figure 4. The Sharp-shinned Hawk is the most abundant migrant hawk in the coastal zone of Rhode Island. This figure is the counts of Sharp-shinned Hawks averaged per week for all data collected since 1982 at Napatree Point. Week 40 is early October. Note the near absence of the species in the spring.**

## Specific comments about migrating raptors and bats.

**Ospreys** are, along with Peregrine Falcons, the most likely raptors to cross large expanses of water. As a result, they do not cluster along the coast and have a broad passage route through Rhode Island. The Osprey population has been increasing for several years, but they are still not very abundant during migration. Day migratory totals at Napatree Point rarely exceed 50 individuals. The Osprey migrates earlier in the fall than most other raptors and large counts are rare after October 1.

**Accipiters**, including the Sharp-shinned and Cooper's Hawks, are the most common migratory hawks in Rhode Island. Accipiters are forest species that seem to avoid over-water crossings and they are also deflected easily by strong cross-winds. For this reason they tend to migrate in streams of birds that follow the immediate coast. Accipiters are abundant but still fairly diffuse migrants – they not form large flocks. As with most diurnal migrants, Accipiter migration peaks in the AM and usually ends by 9:00 AM or so.

**Falcons**. Of the three falcon species that occur in Rhode Island, the American Kestrel was formerly a common fall migrant, but continental populations of this species have declined so dramatically that it is now uncommon even in fall. Falcons are very strong flyers; they tend to follow the coast but also cross the ocean in migration, especially under conditions of light wind. Peregrine Falcons routinely cross extensive water barriers and are conspicuous migrants in coastal areas irrespective of wind direction.

**Bats** are included here because they share similarities with migrating raptors. They display the same pattern of arriving along the coast following strong cold fronts, and are more commonly seen during fall than spring. Although several species bats occur in

Rhode Island, only three are expected to occur as coastal migrants; the Red Bat, Hoary Bat, and the Silver-haired Bat. Other species of Rhode Island bats are either permanent residents (Big Brown) or migrate westward to utilize caves and mines in western New England (Little Brown) during the winter. The fall flight of migrating bats is impossible to quantify at present. The Red Bat is sometimes seen migrating in the morning, and at Napatree Point several sightings allow a coarse delineation of its migratory window through RI.

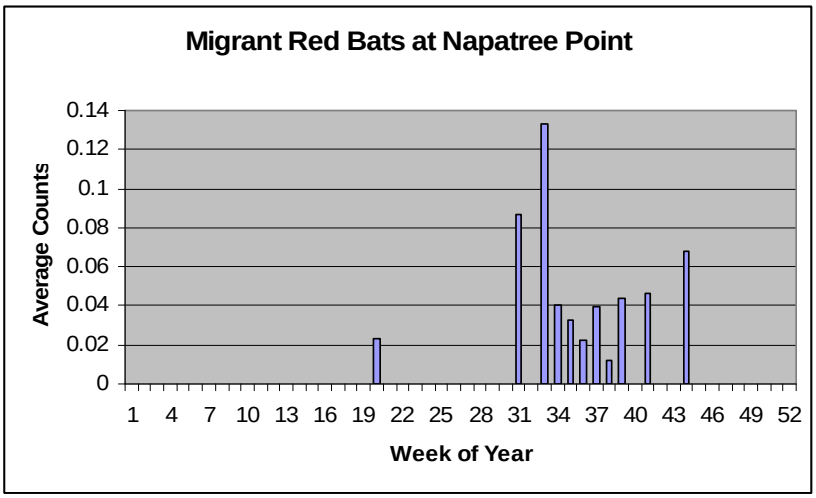



**Figure 5. Seasonal occurrence of migrant Red Bats (*Lasius borealis*) at Napatree Point, RI. As with raptors, most bats appear between late September and October after cold fronts. Note that the Y axis values on the chart above are quite small; the maximum count of 4 Red Bats occurred on 18 September 2007.**

**Songbirds**: this generic category of birds includes the nocturnal migrants that winter in the tropics and migrate into North American during the nesting season, but also more short-range migrants that winter in southern North America. This is a large category of birds that includes many groups, including warblers, flycatchers, and vireos, but they share migratory similarities. They all perform lengthy nighttime migrations at high altitudes, are relatively weak flyers, and tend to get deflected by strong winds. Large flocks of these birds have been documented alighting on the shore and even on ocean-going vessels, and massive mortality events associated with collisions with coastal features, including tall buildings and light houses, have occurred in southern New England and New York (see Bull 1964) and elsewhere (see Hüppop et al. 2006).

**Information**: "Operation Recovery" was a concerted effort to delineate migratory patterns through southern New England. Part of this work was very significant study that accessed RADAR images and tracked flocks of migratory birds over two years (Drury and Keith 1962, Nisbet 1963, Drury and Nisbet 1964, Nisbet and Drury 1967). Since the

1960's, very little research of this sort has occurred in our area, but a huge body of information has accumulated through banding stations and by l observations. These observations have added to and refined the conclusions offered by the earlier studies. Therefore, even though the specific migratory patterns of these birds in this area are difficult to document, some strong inferences can be made regarding songbird migratory behavior in the coastal zone.

**Physiology**: Most songbirds are small-bodied animals, some warblers, for example, weighing less than 10 grams, depending on body condition. Since these birds must expend a great deal of energy in flight, they have developed the ability to store huge amounts of fat. When birds are in full migratory condition, it is not uncommon for their body mass to consist of 50% fat reserves. They build this fat reserve by foraging on rich food sources prior to migration. These birds are primarily nocturnal migrants, a behavior that is related to lower predation risk and better migratory conditions (lower wind, cooler) during the nighttime hours (Weidner et al. 1992). When migrating, these birds rise from their daytime covers just after dark. They migrate in loose flocks that on RADAR appear to be ghostly "blobs". RADAR studies have also shown that such flocks migrate at about 1000" altitude and fly at an average air speed of 25 mph (Drury and Keith 1992). In 8 hours of nocturnal flying they can cover several hundred miles, depending on wind conditions. Most migrant songbirds utter distinctive flight calls while migrating, and observers active in the pre-dawn hours can actually hear them passing overhead. I have spent several hours at Watch Hill listening to the characteristic flight calls made by these birds and watching their behavior when the sun rises. Many birds descend just before dawn, but some flocks continue on through the day, possibly because there is no convenient place to stop. When birds descend to the ground at dawn, one can hear the flight calls passing overhead and becoming louder. Finally, just before dawn, the calls cease entirely, indicating that the birds have reached the ground. In the short period before the pre-dawn and sunrise, there may be many birds on the ground but they are quiet and secretive.

**Reorientation flights**: In the hour just after sunrise, many migrant songbirds make short re-orientation flights. They apparently assess their position then fly from the immediate vicinity of the coast toward the mainland or westward along the barrier beach. There are a number of published observations of this phenomenon and several theories to account for it. One popular theory of this dawn reorientation is that migrating birds have been deflected from their preferred migratory routes so they were over open water when dawn approached Moore 1990). Faced with this undesirable situation, they head landward, often exhausted, and alight on the first solid objects they encounter. Under conditions of fog, which is common along the coast in spring, birds migrating in the pre-dawn are literally flying blind and are apt to strike obstructions near the coast. After this initial critical landfall, the birds that have survived are relatively safe. If they can see when the sun rises, they will re-orient, if they cannot see because of fog or rain, they will not usually fly (but see Wiedner et al. 1992). Therefore, the chance of a collision after dawn is less than before dawn.

**Timing**: Although the general season of songbird migration varies by species, these patterns are comparatively well known. However, Radar studies (Drury and Keith 1962) revealed that within those broad windows major migratory pushes are actually quite rare and are correlated with weather conditions. For example, in the two seasons that they studied, only a handful of major overnight migrations accounted for the bulk of the entire spring movement. Other studies have also validated the sporadic nature of large migratory flights (Hassler et al. 1963, Hüppop et al. 2006)

**Migratory Pathways**: It has been known for many decades that, in southern New England, the main spring migratory corridor for northbound migrants is through western New England. Under most conditions, passage migrants become less common as one moves eastward toward Cape Cod (Howe and Sturtevant 1899, Griscom and Snyder 1955, Nisbet and Drury 1967). This pattern is more complicated during fall. During fall (between late July and October for most species), there are more birds and more inexperienced birds (the young of the year), so the chance for coastal displacement is greater. Banding studies have shown unequivocally that south-bound adult migrants generally stay to interior routes, while juveniles tend to make up the vast majority of migrants found in the coastal zone during fall. Although a few species of songbirds specialize on long over-water flights as a migratory strategy, it is likely that many fall migrants get deflected out over water as during spring, and then make landfall at dawn. This situation may be exacerbated by prevailing NW weather that follows fall cold fronts, conditions that are known to spur migration of songbirds (Hassler et al. 1963, Wiedner et al. 1992).

**Figure 5. Generalized migratory routes for nocturnal migrants through southern New England.**

**Figure 5a. Spring. Most spring songbird migration passes through interior New England, but under conditions of strong west winds (white arrow) it can be deflected eastward and even offshore (hatched line). Many migrants descend just before dawn. If birds are over the ocean at this time (circle), they move toward the nearest landmass (small arrows).**

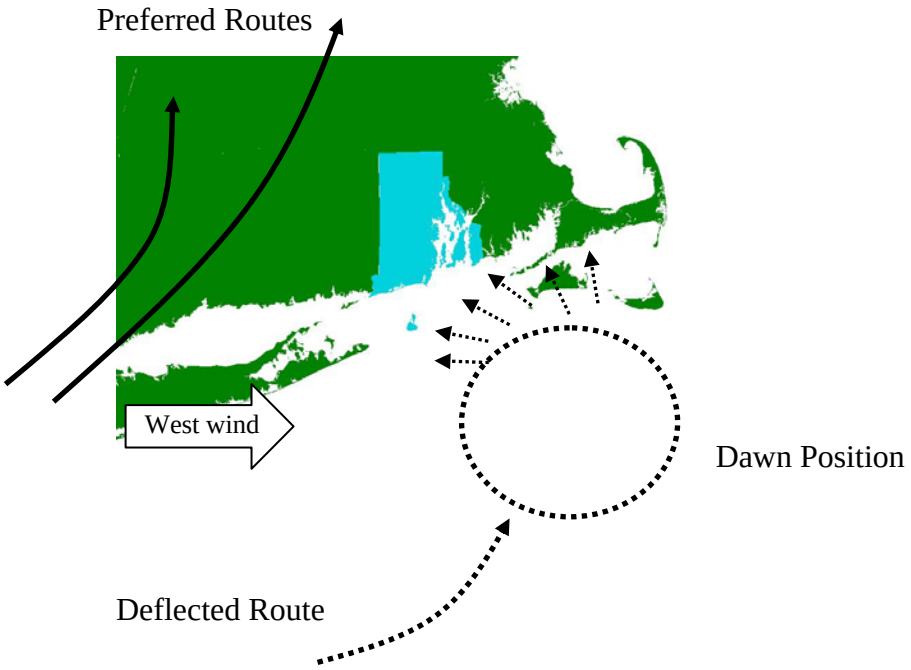
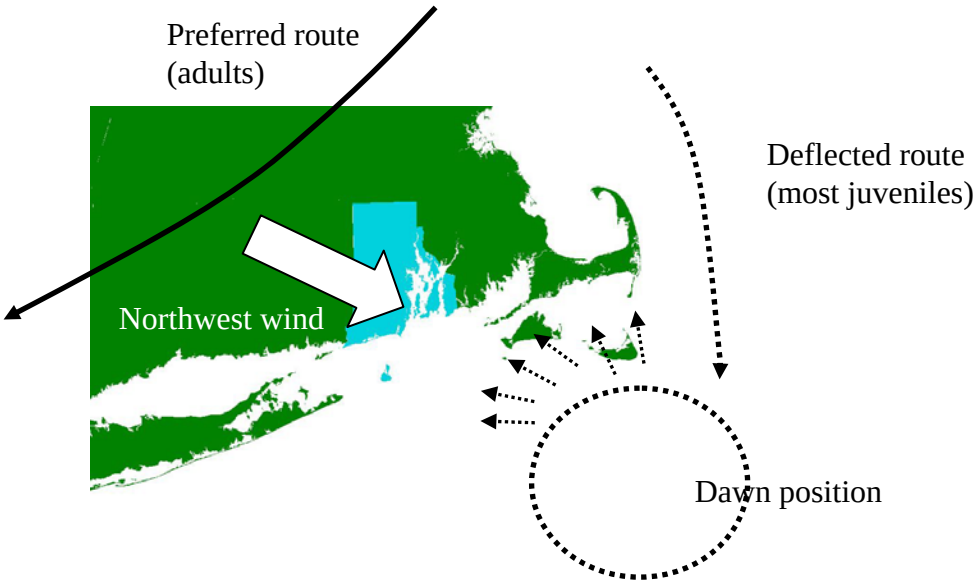


**Figure 5a. Fall. Fall songbird migration features a split migratory pathway. Experienced adults pass through interior New England, but juveniles are often deflected eastward and even offshore (hatched line). Their behavior is similar to spring in seeking land at dawn.**




**Discussion**: Most seabirds are diurnal, diffuse migrants that do not demonstrate dramatic clustering in the coastal zone and rarely collide with towers. Therefore the risk to migratory sea birds associated with one land-based site near the coast is probably equivalent to the next, although land-based sites would differ from those placed at sea. In other words, there is no placement in the area between Point Judith and Galilee that would dramatically reduce risks to diurnal migrating seabirds. However, the overall risk should be minimal, because such birds are well scattered and should be able to detect the towers and avoid them while transiting.

Migrating raptors and other diurnal migrants show dramatic clustering in the coastal zone during fall but not in spring. The fall pathways of migrating raptors have been affirmed by multiple observers. Strong NW wind shunts birds along each coastal promontory, including Sakonnet Point, Brenton Point, Beavertail, Point Judith, and Napatree Point. Raptors usually funnel southward on the lee of these points, turn westward when they get to the end, turn northward again and eventually cross a water barrier to continue westward. This pattern is very obvious and consistent. Point Judith is not a great concentration point for migrating raptors. Birds that do reach the point, usually during strong NW winds, turn northward and proceed up the west side of the peninsula. Eventually many of these birds cross the Galilee marshes. Even though raptors seem to suffer relatively high mortality at turbines (Smallwood and Thelander 2008), this effect may be related to their foraging behaviors and may not apply to birds actively migrating. American Kestrels seem to be particularly susceptible to turbine-related mortality

(Osborn et al. 1998, Madders and Whitfield 2003, Smallwood and Thelander 2008). At any rate, there is suspicion that many diurnal migrants can avoid towers and the mortality from wind turbines should be slight (Barclay et al. 2007). Most diurnal migrants do not migrate during inclement weather, so there is no potential for disastrous collisions.

**Figure 6: Closer view of fall raptor migratory routes through Rhode Island. Clustering and deflection occurs at each major coastal point, but more hawks are seen at Napatree Point than elsewhere.**

**Conclusions**: The largest risk from turbines to bird populations is expected to involve nocturnal migrants, especially during conditions of fog. Peak migratory seasons are known for most species, but prediction of large nocturnal flights and the conditions that drive them to the ground remain difficult. All towers and tall objects along the immediate coast have the potential, eventually, to cause catastrophic collisions for nocturnal migrants. Therefore the relevant question becomes whether local placement protocols of the towers themselves can reduce this risk. The most logical point of landfall for distressed migratory songbirds is at Point Judith, the most seaward promontory. If these birds behave similar to the way they do at Cape May, their dawn reorientation flights should occur northward along the western past of the Point Judith peninsula. Because these migrants are seeking vegetative cover at dawn, it is likely that towers set back from the barrier beach, preferably with several hundred yards of vegetation between the shoreline and the tower, will reduce the risk of bird contact. At least, birds that reach the shore will have an opportunity to get in cover before they make their reorientation flight. Since these secondary flights occur during daylight, the birds should be able to see and avoid the tower.

Barclay, R. M. R., E. F. Baerwald, and J. C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology 85:381-387.

Bull, J. 1964. *Birds of the New York Area*. Harper and Row, New York. 540 pp.

Drury, W. H. and J. A. Keith. 1962. Radar studies of songbird migration in coastal New England. The Ibis 104(4): 449-489.

Drury, W. H. and I. C. T. Nisbet. 1964. Radar studies of orientation of song bird migrants in southeastern New England. Bird Banding 35: 69-119.

Ewald, B. M. and D. F. Sherony. 2000. A summary of the Hamlin Beach Lakewatch fall and winter waterbird migration data 1993-1999. Monograph No. 1, Federation of New York State Bird Clubs.

Griscom, L. and D. E. Snyder. 1955. *The Birds of Massachusetts*. Salem, Peabody Museum. 295 pp.

Hassler, S. S., R. R. Graber, and F. C. Bellrose. 1963. Fall migration and weather, a radar study. The Wildon Bulletin 75(1):56-77.

Howe, R. H. Jr. and E. Sturtevant. 1899. *The Birds of Rhode Island*. Privately published. 111 pp.

Hüppop, O, J. Dierschke, K-M Exo, E. Fredrich, and R. Gill. 2006. Bird migration studies and potential collision risk with offshore wind turbines. Ibis 148(s1):90-109.

Madders, M and D. P. Whitfield. 2006. Upland raptors and the assessment of wind farm impacts. Ibis 148(s1):43-56.

Moore, F. R. 1990. Evidence for redetermination of migratory direction following wind displacement. The Auk 107: 425-428.

Nisbet, I. C. T. 1963. Measurement with radar of the height of nocturnal migration over Cape Cod, Massachusetts. Bird-banding 34(2):57-67.

Nisbet, I. C. T. and J. Baird. 1959. The autumn migration of the Double-crested Cormorant through eastern New England. Massachusetts Audubon 43: 224-227.

Nisbet, I. C. T. and W. H. Drury Jr. 1967. Orientation of spring migrants studied by Radar. Bird-banding 38(3): 173-186.

Osborn, R. G., C. D. Dieter, K. F. Higgins, and R. E. Usgaard. 1998. Bird flight characteristics near wind turbines in Minnesota. American Midland Naturalist 139(1):xxx-xxx.

Smallwood, K. S. and C. Thelander. 2008. Bird mortality in the Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 72(1):215-223.

Veit, R. R. and W. R. Petersen. 1993. *Birds of Massachusetts*. Massachusetts Audubon Society. 515 pp.

Wiedner, D. S., Kerlinger, P., Sibley, D. A., Holt, P., Hough, J. and R. Crossley. 1992. Visible morning flight of neotropical landbird migrants at Cape May, New Jersey. The Auk 109(3): 500-510.