Potential Impacts of Wind Turbines on Birds at North Cape, Prince Edward Island

A report for the Prince Edward Island Energy Corporation

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1.0 Introduction

As the demand for clean energy increases, wind power generating stations are being constructed across Canada. Wind power has been used in many countries in Europe and the United States with a great deal of success. However, concerns have been raised about the possible environmental impact of these turbines on birds, especially after endangered raptors were observed being injured and killed after flying into wind turbines in California. Research in this area has focused primarily on mortality caused by birds striking turbine blades and associated wires. Disturbance to breeding, wintering or staging birds as a result of turbines has not been examined as closely.

With respect to avian mortality at wind power generating stations, the greatest concern has been for raptors and migrating songbirds. The concern for raptors generally stems from the fact that many populations are small and thus even a few deaths can lead to declines (Morrison *et al.* 1998). Songbirds are also considered at risk because they are known to fly into human-made structures (e.g. office towers, TV/microwave towers) causing, on occasion, mass kills of thousands of individuals. While raptors and songbirds are generally at greatest risk of injury or death from turbines, the impact of such structures on all bird species should be considered on a site-by-site basis.

The goal of this report is threefold:

1. Review the literature on the effects of wind turbines on birds, with particular reference to the situation at North Cape;
2. Recommend ways of reducing potential impacts of turbines on birds at North Cape;
3. Recommend a program whereby potential effects of wind turbines on birds can be monitored at North Cape.

2.0 Birds Expected at North Cape

2.1 Introduction

The breeding bird fauna of North Cape is poor relative to areas elsewhere on Prince Edward Island. According to Erskine (1992), only 27 bird species were believed to breed at this site from 1985-1990 (Table 1), compared to 133 known breeding species for the Island as a whole (Hogan 1991). Of the species known to breed in the North Cape area, five are considered provincially rare (S1-S3; Atlantic Canada Conservation Data Centre 2001). These are discussed in Section 2.3. No colonial nesting species are known to breed at North Cape. It is likely, in the absence of recent survey data, that breeding bird populations at North Cape are low in both species diversity and abundance.

North Cape is not considered by the Canadian Wildlife Service to be a major staging area for migrating birds (PEI Energy Corp. 2000). However, being a point of land, many species may use it as a navigational point, passing through the area during spring and fall migration. Table 2 lists the 110 species, additional to those in Table 1, that are likely to be found at North Cape during migration and/or in the winter. Only three of those species are of special conservation concern, and these are discussed in Section 2.3. All other birds are discussed in Section 2.2, below.

2.2 Bird Groups

Merging tables 1 & 2, 137 species are likely to occur at North Cape at some time during the year. This collection of species includes: 32 species classified as waterbirds (seabirds and waterfowl), 10 raptor species, 15 shorebird species and 80 species classified as songbirds (and including pigeons, doves and crows). These bird groups exhibit different behaviours and habitat preferences, which should be considered when examining the possible impact of the North Cape wind facility.

2.2.1 Waterbirds (including seabirds, waterfowl and shorebirds)

Seabirds spend much of their lives in marine environments, generally coming no further inland than the shore. With the exception of gulls, this is true for all seabirds likely to pass by or breed at North Cape. Indeed, only two seabird species have been known to breed at North Cape (Table 1), neither of which is colonial. These are Great Cormorant *Phalacrocorax carbo* and Black Guillemot *Cepphus grille*. Seabirds seen at North Cape are most likely to be flying or swimming offshore, and most are unlikely to be affected by the wind facility. Similarly, most waterfowl and other waterbirds will be seen only along the shoreline and offshore waters. Shorebirds are not commonly seen at North Cape, although Ruddy Turnstones can be seen in the fall foraging on Irish moss (L. Holman pers. comm.). Section 4.2.1 discusses potential impacts of the wind facility on waterbirds.

2.2.2 Raptors

Only eight species of diurnal raptors are likely to occur at North Cape (Tables 1 & 2), and only one of these is known to breed (Merlin *Falco columbarius*). Most of the other raptor species will likely be found flying past the wind farm on migration. Two species of nocturnal owls are also likely to occur sporadically, perhaps during post-breeding dispersal in the fall (Table 2). The perching habits of raptors make them vulnerable to collision with wind turbines, especially those with a lattice structure. The potential impact of turbines on raptors is discussed in Section 4.2.2.

2.2.3 Songbirds

Most of the songbird species likely to occur at North Cape are migrants that either breed at North Cape (24 species; Table 1) or pass through on migration (56 species; Table 2). Songbirds can be affected by wind turbines as a result of their flight habits on migration. The potential impact of the North Cape operation on migrating songbirds is discussed in Section 4.2.3.

2.3 Species of Special Conservation Concern

Five bird species believed to have bred at North Cape are considered provincially rare as breeders (Table 1; *AC CDC* 2001). These are: Great Cormorant, Black Guillemot, Bicknell's Thrush (COSEWIC: Special Concern), Barn Swallow, and Northern Waterthrush. Additionally, three species designated by COSEWIC may occur at North Cape as non-breeders, if only rarely: Harlequin Duck (Special Concern), Peregrine Falcon (Threatened), and Piping Plover (Endangered). The potential impacts of the proposed wind farm on these species are discussed in Section 4.3.

Table 1. List of bird species believed to have bred in the North Cape area (Erskine 1992). Granks and Sranks (which denote provincial status) from AC CDC (2001). See Appendix B for ranking definitions.

English Name	Scientific Name	Type	Grank	Srank
Great Cormorant	*Phalacrocorax carbo*	Waterbird	G5	S3B
Merlin	*Falco columbarius*	Raptor	G5	S5B
Black Guillemot	*Cepphus grylle*	Waterbird	G5	S2B
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Songbird	G5	S5B
Bank Swallow	*Riparia riparia*	Songbird	G5	S5B
Barn Swallow	*Hirundo rustica*	Songbird	G5	S3B
American Crow	*Corvus brachyrhynchos*	Songbird	G5	S5
Swainson's Thrush	*Catharus ustulatus*	Songbird	G5	S5B
Bicknell's Thrush	*Catharus bicknelli*	Songbird	G4	S1?B
American Robin	*Turdus migratorius*	Songbird	G5	S5B
Cedar Waxwing	*Bombycilla cedrorum*	Songbird	G5	S5B
European Starling	*Sturnus vulgaris*	Songbird	G5	SE
Red-eyed Vireo	*Vireo olivaceus*	Songbird	G5	S5B
Nashville Warbler	*Vermivora ruficapilla*	Songbird	G5	S5B
Yellow Warbler	*Dendroica petechia*	Songbird	G5	S5B
Magnolia Warbler	*Dendroica magnolia*	Songbird	G5	S5B
Yellow-rumped Warbler	*Dendroica coronata*	Songbird	G5	S5B
Black-and-White Warbler	*Mniotilta varia*	Songbird	G5	S5B
American Redstart	*Setophaga ruticilla*	Songbird	G5	S5B
Northern Waterthrush	*Seiurus noveboracensis*	Songbird	G5	S3B
Common Yellowthroat	*Geothlypis trichas*	Songbird	G5	S5B
Chipping Sparrow	*Spizella passerina*	Songbird	G5	S5B
Savannah Sparrow	*Passerculus sandwichensis*	Songbird	G5	S5B
Song Sparrow	*Melospiza melodia*	Songbird	G5	S5B
White-throated Sparrow	*Zonotrichia albicollis*	Songbird	G5	S5B
Common Grackle	*Quiscalus quiscula*	Songbird	G5	S5B
American Goldfinch	*Carduelis tristis*	Songbird	G5	S5

Table 2. List of bird species potentially occurring as non-breeders (during migration or in the winter) in the North Cape area. Granks and Sranks (which denote provincial status) from AC CDC (2001). See Appendix B for ranking definitions.

English Name	**Scientific Name**	**Type**	**Grank**	**Srank**
Red-throated Loon	*Gavia stellata*	Waterbird	G5	SZN
Common Loon	*Gavia immer*	Waterbird	G5	S1B, S4N
Pied-billed Grebe	*Podilymbus podiceps*	Waterbird	G5	S5B
Horned Grebe	*Podiceps auritus*	Waterbird	G5	SZN
Red-necked Grebe	*Podiceps grisegena*	Waterbird	G5	SZN
Northern Gannet	*Morus bassanus*	Waterbird	G5	S5N
Double-crested Cormorant	*Phalacrocorax auritus*	Waterbird	G5	S5B
American Bittern	*Botaurus lentiginosus*	Waterbird	G4	S4B
Great Blue Heron	*Ardea herodias*	Waterbird	G5	S4B
Canada Goose	*Branta canadensis*	Waterbird	G5	SEB, S5N
Green-winged Teal	*Anas crecca*	Waterbird	G5	S5B, S5N
American Black Duck	*Anas rubripes*	Waterbird	G5	S5B, S5M, S4N
Mallard	*Anas platyrhynchos*	Waterbird	G5	S4B, S5N
Northern Pintail	*Anas acuta*	Waterbird	G5	S4B
Blue-winged Teal	*Anas discors*	Waterbird	G5	S5B
Gadwall	*Anas strepera*	Waterbird	G5	S5B
American Wigeon	*Anas americana*	Waterbird	G5	S5B
Greater Scaup	*Aythya marila*	Waterbird	G5	S3M, S1N
Long-tailed Duck	*Clangula hyemalis*	Waterbird	G5	S4M, S3N
Black Scoter	*Melanitta nigra*	Waterbird	G5	S4N
Surf Scoter	*Melanitta perspicillata*	Waterbird	G5	S3N
White-winged Scoter	*Melanitta fusca*	Waterbird	G5	S3N
Common Goldeneye	*Bucephala clangula*	Waterbird	G5	S4N
Common Merganser	*Mergus merganser*	Waterbird	G5	S4N
Red-breasted Merganser	*Mergus serrator*	Waterbird	G5	S2B, S5N
Osprey	*Pandion haliaetus*	Raptor	G5	S5B
Northern Harrier	*Circus cyaneus*	Raptor	G5	S5B
Sharp-shinned Hawk	*Accipiter striatus*	Raptor	G5	S3S4B
Broad-winged Hawk	*Buteo platypterus*	Raptor	G5	S1?B
Red-tailed Hawk	*Buteo jamaicensis*	Raptor	G5	S2B
American Kestrel	*Falco sparverius*	Raptor	G5	S5B
Peregrine Falcon	*Falco peregrinus anatum*	Raptor	G4T3	SAN
Black-bellied Plover	*Pluvialis squatarola*	Shorebird	G5	S5N
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird	G5	S5N
Piping Plover	*Charadrius melodus*	Shorebird	G3	S1B
Killdeer	*Charadrius vociferus*	Shorebird	G5	S5B
Greater Yellowlegs	*Tringa melanoleuca*	Shorebird	G5	S5N
Lesser Yellowlegs	*Tringa flavipes*	Shorebird	G5	S5N

English Name	Scientific Name	Type	Grank	Srank
Spotted Sandpiper	*Actitis macularia*	Shorebird	G5	S5B
Ruddy Turnstone	*Arenaria interpres*	Shorebird	G5	S4N
Sanderling	*Calidris alba*	Shorebird	G5	S5N
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	G5	S5N
Least Sandpiper	*Calidris minutilla*	Shorebird	G5	S5N
White-rumped Sandpiper	*Calidris fuscicollis*	Shorebird	G5	S3S4N
Dunlin	*Calidris alpina*	Shorebird	G5	S3N
Short-billed Dowitcher	*Limnodromus griseus*	Shorebird	G5	S4N
Common Snipe Ring-billed Gull	*Gallinago gallinago* *Larus delawarensis*	Shorebird Waterbird	G5 G5	S5B S1B, S5N
Herring Gull	*Larus argentatus*	Waterbird	G5	S5B, S5N
Iceland Gull	*Larus glaucoides*	Waterbird	G5	S3N
Great Black-backed Gull	*Larus marinus*	Waterbird	G5	S4B
Common Tern	*Sterna hirundo*	Waterbird	G5	S3B
Rock Dove	*Columba livia*	Songbird	G5	SE
Mourning Dove	*Zenaida macroura*	Songbird	G5	S5B
Great Horned Owl	*Bubo virginianus*	Raptor	G5	S5
Barred Owl	*Strix varia*	Raptor	G5	S5
Ruby-throated Hummingbird	*Archilochus colubris*	Songbird	G5	S5B
Belted Kingfisher	*Ceryle alcyon*	Songbird	G5	S5B
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Songbird	G5	S5B
Downy Woodpecker	*Picoides pubescens*	Songbird	G5	S5
Hairy Woodpecker	*Picoides villosus*	Songbird	G5	S5
Northern Flicker	*Colaptes auratus*	Songbird	G5	S5B
Alder Flycatcher	*Empidonax alnorum*	Songbird	G5	S5B
Eastern Kingbird	*Tyrannus tyrannus*	Songbird	G5	S4B
Horned Lark	*Eremophila alpestris*	Songbird	G5	S2B, S5N
Tree Swallow	*Tachycineta bicolor*	Songbird	G5	S5B
Blue Jay	*Cyanocitta cristata*	Songbird	G5	S5
Common Raven	*Corvus corax*	Songbird	G5	S5
Black-capped Chickadee	*Poecile atricapilla*	Songbird	G5	S5
Red-breasted Nuthatch	*Sitta canadensis*	Songbird	G5	S5
Brown Creeper	*Certhia americana*	Songbird	G5	S5B
Winter Wren	*Troglodytes troglodytes*	Songbird	G5	S5B
Golden-crowned Kinglet	*Regulus satrapa*	Songbird	G5	S5B
Ruby-crowned Kinglet	*Regulus calendula*	Songbird	G5	S5B
Veery	*Catharus fuscescens*	Songbird	G5	S4B
Hermit Thrush Gray Catbird	*Catharus guttatus* *Dumetella carolinensis*	Songbird Songbird	G5 G5	S5B S4B
Blue-headed Vireo	*Vireo solitarius*	Songbird	G5	S5B
Tennessee Warbler	*Vermivora peregrina*	Songbird	G5	S5B

English Name	Scientific Name	Type	Grank	Srank
Northern Parula	*Parula americana*	Songbird	G5	S5B
Chestnut-sided Warbler	*Dendroica pensylvanica*	Songbird	G5	S5B
Cape May Warbler	*Dendroica tigrina*	Songbird	G5	S5B
Black-throated Blue Warbler	*Dendroica caerulescens*	Songbird	G5	S4B
Black-throated Green Warbler	*Dendroica virens*	Songbird	G5	S5B
Blackburnian Warbler	*Dendroica fusca*	Songbird	G5	S5B
Palm Warbler	*Dendroica palmarum*	Songbird	G5	S5B
Bay-breasted Warbler	*Dendroica castanea*	Songbird	G5	S5B
Blackpoll Warbler	*Dendroica striata*	Songbird	G5	SAN
Ovenbird	*Seiurus aurocapillus*	Songbird	G5	S5B
Mourning Warbler	*Oporornis philadelphia*	Songbird	G5	S5B
Wilson's Warbler	*Wilsonia pusilla*	Songbird	G5	S4B
Canada Warbler	*Wilsonia canadensis*	Songbird	G5	S4B
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Songbird	G5	S5B
American Tree Sparrow	*Spizella arborea*	Songbird	G5	S5N
Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*	Songbird	G5	S3B
Fox Sparrow	*Passerella iliaca*	Songbird	G5	SZB
Lincoln's Sparrow	*Melospiza lincolnii*	Songbird	G5	S5B
Swamp Sparrow	*Melospiza georgiana*	Songbird	G5	S5B
White-crowned Sparrow	*Zonotrichia leucophrys*	Songbird	G5	SZN
Dark-eyed Junco	*Junco hyemalis*	Songbird	G5	S5B
Lapland Longspur	*Calcarius lapponicus*	Songbird	G5	S3N
Snow Bunting	*Plectrophenax nivalis*	Songbird	G5	S5N
Bobolink	*Dolichonyx oryzivorus*	Songbird	G5	S3B
Red-winged Blackbird	*Agelaius phoeniceus*	Songbird	G5	S5B
Brown-headed Cowbird	*Molothrus ater*	Songbird	G5	S4B
Purple Finch	*Carpodacus purpureus*	Songbird	G5	S5B
Common Redpoll	*Carduelis flammea*	Songbird	G5	S5N
Pine Siskin	*Carduelis pinus*	Songbird	G5	S2B, S3S4N
Evening Grosbeak	*Coccothraustes vespertinus*	Songbird	G5	S3B, S4N
House Sparrow	*Passer domesticus*	Songbird	G5	SE

3.0 Avian Mortality at Wind Energy Facilities

There are three main causes of bird mortality at wind powered energy facilities: 1) birds do not detect the rotating turbine blades and suffer injuries as a result of flying into them; 2) migrating birds are attracted to warning lights on the turbines, becoming confused to such a degree that they either suffer exhaustion, or collide with the structures; and 3) birds collide with power lines and guy wires connected to the station. The relative impact each factor plays depends upon the site, season and weather conditions (Moorehead & Epstein 1985, Portland General Electric Company 1986). An overview of each factor is given below.

3.1 Mortality Caused by Turbine Blades

The impact of turbine blades on birds appears to be small, but mortality does occur. Keeping in mind that mortality rates are very site-specific, Howell and Noone (1992) estimated that bird fatalities in California ranged from 0 to 37 birds/turbine/year. Both migrant and resident birds are known to be involved with collisions.

In Europe, many studies have been conducted on the effects of wind turbines on bird mortality. Most of these studies examined small, solitary turbines (100 - 150 kW). (In comparison, the North Cape turbines are 660 kW.) Winkleman (1994) looked at the proportion of birds colliding in relation to the total number of birds passing the wind turbines. The estimated average number of victims varied from 0.04 to 0.09 birds/turbine/day, depending on the site and the season. Of these collisions, 43% were caused by birds being swept down by the wake behind a rotor, 36% flew directly into the rotor, and the cause of death was unknown for the remaining 21%. Winkleman (1994) believes that the total number killed per 1,000 MW of wind energy is low relative to other human-related causes of death.

While both migrant and resident birds are known to be involved with collisions, numbers of both are low. Birds typically migrate at altitudes of greater than 500 feet (approximately 153 m), well above the top of turbine blades (National wind coordinating committee 2000). The wind towers at North Cape, including the turbine blades, stand about 75 m tall. Collisions by migrants are most likely to occur during the first two hours after nightfall at the initiation of migration when birds are at a low climbing altitude (Bonneville Power Administration 1987). The number and type of birds likely to stopover at North Cape during migration (and therefore be in a position to take off from the site, and potentially hit the turbines) is not known.

Most mortality of resident birds reported in the literature appears to be of raptors, and these are mostly from the Altamont Pass area in California. For example, a two-year study at this site examined about 16% of the approximately 7,000 turbines in the Pass. One hundred and fourteen dead birds were found between February 1989 and February 1990 (BioSystems Analysis Inc. 1990), and 68 were found the next year (Orloff & Flannery 1992). Of these birds, 65% were raptors, the majority of which were Red-tailed Hawks *Buteo jamaicensis*, American Kestrels *Falco sparverius*, and Golden Eagles *Aquila chrysaetos*. It is worth noting that Red-tailed Hawks and American Kestrels are likely to occur fairly regularly at North Cape (Tables 1 & 2). Fifty-five percent of raptors killed in the California study died as a result of directly striking a wind turbine, 8% from electrocution, 11% from wire collision and 26% died of unknown causes

(Orloff & Flannery 1992). In total, 63% of all deaths were attributed to turbine collision, 12% to electrocution, 5% to wire collision, and 20% could not be determined (BioSystems Analysis Inc. 1990).

There are several reasons why birds may collide with wind turbines, one of the most important and obvious being that they are unable to detect the towers. Two main hypotheses are used to explain this difficulty in raptors: 1) motion smear (the degradation of visibility of rapidly moving objects); and 2) the inability of the birds to divide their attention between hunting and monitoring the horizon for obstacles (Hodos *et al.* 2001). With regards to the latter, it seems unlikely that hunting raptors cannot focus both on the ground and on the horizon, as their eyes have two foveal regions; one for frontal vision and one for looking down (Hodos *et al.* 2001).

Motion smear, therefore, is likely to be the main reason raptors (and perhaps other birds) cannot see the blades of the turbines during days of good visibility (Hodos *et al.* 2001, McIsaac 2001). Motion smear is more pronounced nearer the tips of the blades where velocity is greater (Hodos *et al.* 2001). Several studies have tried to reduce motion smear by painting different patterns on the blades (Hodos *et al.* 2001, McIsaac 2001). To be effective, this treatment has to maximize the time between successive stimulations of the same retinal region (Hodos *et al.* 2001). Much research is still required on this topic, but it appears that a thin-stripe, staggered pattern is the most visible to birds. If such a treatment is not possible, then painting a single blade black is the next most effective technique, not to mention a great deal cheaper and easier (Hodos *et al.* 2001).

3.2 Mortality Caused by Turbine Lighting

Aircraft warning lights are placed on all tall human-made objects. By necessity, these lights must be highly visible to humans from the air. Consequently birds, which have similar visual acuity to humans, are also able to see the lights, and are subsequently attracted to them.

Incredible mass mortalities have occurred at some towers. For example, an estimated 30,000 birds of 56 species were killed at the Eau Claire, Wisconsin tower on the nights of 18 and 19 September 1963 (Kemper 1964). This is an exceptional report, but searching the literature reveals countless other examples of mass kills. In 1972, over 1,000 birds were killed in one night at TV towers in Tennessee and Florida (Able 1973). Towers will not kill huge numbers of birds every night during migration, but small numbers of deaths are frequent. For example, an average of 1517 birds per year were killed over a 29-year period from 1955 to 1983 at a single TV tower in Tallahassee, Florida, with most mortality occurring in the spring (20%) and fall (65%; Crawford and Engstrom 2001). Of days during which at least one bird was killed, the median number of birds killed was three and the mean was 12.3 (Crawford and Engstrom 2001). Only 0.1% of the days studied had kills of more than 500 birds (Crawford and Engstrom 2001). Birds that are most often affected include warblers, vireos, thrushes and sparrows (Case *et al.* 1965, Caldwell & Wallace 1966, Crawford and Engstrom 2001).

Cochran and Graber (1958) were the first to experimentally show that birds are attracted to the red warning lights of towers. Their counts of avian flight calls on two nights at a 303 m tower near Champaign, Illinois indicated that migrants were concentrated near the structure. Turning off the red warning lights on the tower eliminated this aggregation. Several hypotheses have been proposed to explain why birds are attracted to the lights. One suggests that migrants perceive the red tower lights as stars, and subsequently attempt to maintain a constant bearing with respect to them. As a result, they spiral closer to the structure and eventually strike the guy wires (Kemper 1964).

It is believed that the number of birds killed on any given night is dependent on local weather conditions and the number of birds aloft, with mass mortalities usually occurring during poor weather conditions such as fog, low cloud cover (Seets & Bohlen 1977), and precipitation (Case *et al.* 1965, Seets & Bohlen 1977, Elkins 1988). The refraction and reflection of the emitted light by water droplets in the air increase the "sphere of illumination" and ultimately confuse the migrant songbirds (Elkins 1988). Another hypothesis suggests that birds become spatially disoriented by refracted and reflected light from aircraft warning lights on tall towers during rainy, misty weather because of the loss of true visual cues to the horizontal (Herbert 1970). Yet another hypothesis suggests that birds become confused by tall, lighted structures when, under overcast conditions, birds are deprived of celestial cues and lose their ability to orientate (Jaroslow 1979).

Research delving into the causes and mechanisms of light attraction is in relative infancy. There are many published reports of this phenomenon, but none provide data to support a hypothesis of cause. However, it is notable that no mass kills have ever been reported at a wind power generating station, and no kill at these generating stations has ever been directly attributed to lighting. This is probably because the height of wind turbines is considerably lower than the heights of most TV towers; Crawford and Engstrom (2001) concluded that towers 90 m or lower pose little significant threats of mortality to migrating birds (see also Section 4.2.3).

The U.S. Fish and Wildlife Service recommends that only white (preferred) or red strobe lights should be used on towers at night, and that these should be the minimum number, intensity, and minimum number of flashes per minute (i.e. longest duration between flashes) allowable (USFWS 2000). The use of solid red or pulsating red warning lights should be avoided, as research has shown that these lights disrupt night-migrating birds (causing curved, circling or hovering behaviour) at a much higher rate than white strobe lights (Gauthreaux and Belser 1999). Red strobe lights have yet to be studied (USFWS 2000).

3.3 Mortality Caused by Wires

Bird collisions and electrocutions caused by the wires associated with wind turbines are also a concern (e.g. Portland General Electric Company 1986, Haussler 1988). Birds that fly fast in tight flocks at low altitudes such as waterfowl and shorebirds appear to be particularly susceptible to collisions with wires (James & Haak 1979, NUS Corporation 1979, Association of Bay Area Governments 1987). In addition to waterfowl, raptors are also frequent victims of wire kills (Enderson & Kirven 1979, Olsen & Olsen 1980). Overhead wires are believed to be one of the main causes of injury and death to Merlins in Great Britain (Olsen & Olsen 1980).

Waterfowl and shorebirds may show avoidance behaviour to turbines, but significant numbers have been known to collide with associated power lines (Anderson 1978, NUS Corporation 1979, Moorehead & Epstein 1985). At a power plant in Illinois, an estimated 400 birds per fall season (0.4 percent of the peak number present) were killed by colliding with overhead power lines; mostly Blue-winged Teal *Anas discors* (Anderson 1978). Another example, involving shorebirds, comes from Trinidad, California. More than 150 Red-necked Phalaropes (*Phalaropus lobatus*) were killed on 6 May 1969 by striking electric wires along the coast (Gerstenberg 1972).

Several recommendations have been made to reduce wire-induced bird mortality (Anderson 1978, NUS Corporation 1979, Beaulaurier 1981, Moorehead & Epstein 1985, Association of Bay Area Governments 1987, Dedon *et al.* 1989):

- Lines should be built underground if possible;
- Line visibility should be increased by adding flags or marker balls, and increasing the size of the wire (to larger than 230kV);
- Lines should not be built over water or other areas of high bird concentrations;
- Small lightning shield wires should be eliminated where lines cross wetlands and migration routes;
- Lines should be made parallel to prevailing wind directions;
- Lines crossing rivers should be placed at oblique rather than right angles;
- Lines should be placed close to trees and below tree level.

Also, to prevent the electrocution of large raptors, lines should be designed with adequate space between conductors to prevent a bird from simultaneously touching two phases (Portland General Electric Company 1986). Further mitigation recommendations are presented in Section 5.

Luckily, the North Cape site has already implemented the first recommendation, as all distribution wires are buried. The generators are located in the top of the towers and the wiring harness follows down inside the towers to the concrete bases, out to an exterior panel. For environmental, visual, and operational reasons, all conduit from the exterior panels to the transformer pad are about three feet underground, located along the shoulders of the access roads.

3.4 Disturbance Effects on Birds

Mortality has generally been the main focus of avian research at wind power generating stations, but perhaps just as important is the disturbance these stations may cause to birds breeding, staging or wintering in the area. This disturbance could be in the form of habitat loss (as a result of tower and road construction), obstruction of regular flight paths, or human activity around breeding sites.

Numerous studies have shown that most migrating and wintering bird species alter their flight paths to avoid turbines (Rogers *et al.* 1977, Howell 1990, Howell & Noone 1992, Orloff 1992, Orloff & Flannery 1992, Mossop 1998, Danish Wind Industry Association 1998, Still *et al.* 1994, Winkleman 1994, Dirkson *et al.* 2000, Danish Wind Industry Association 2001). Several studies have shown that sea ducks are aware of turbines and avoid them (Dirksen *et al.* 2000). Radar studies conducted both in the day and night in Denmark showed that birds tended to change their flight paths 100-200 m before reaching turbines and passed above them at a safe distance (Danish Wind Industry Association 2001). Another study showed that Common Eiders and Black Scoters avoided turbines, and would not approach within 100 m even with decoys placed closer (Danish Wind Industry Association 1998). Other European studies have shown a reduction in bird numbers of up to 95% at distances of 250-500 m from wind turbines (Winkleman 1994). Wintering terrestrial bird species also appear to become habituated to turbines and disturbance effects and mortality rates are believed to be low (Dirksen *et al.* 2000).

While birds appear to avoid flying near turbines, the presence of these structures does not seem to deter birds from their foraging areas (Danish Wind Industry Association 1998). For example, eiders display normal landing and foraging behaviour at distances greater than 100 m from turbines (Danish Wind Industry Association 1998).

Breeding birds appear to have a greater tolerance to turbines than wintering sea ducks. Local breeding populations of waterfowl, grouse, shorebirds, gulls, and passerines were not significantly affected by the erection of three turbines in a bog in the Orkney Islands (Meek *et al.* 1993). There was also little effect on breeding birds at other wind sites in Great Britain with many examples of birds nesting in close proximity to the turbines (Percival 1998). Productivity also does not appear to be negatively affected: in a 66-turbine site, mean productivity of breeding birds was the same as in surrounding areas (Guyonne & Clave 2000). However, reduced breeding bird populations have been noted at a few wind farms where breeding habitat was destroyed by the installation of the turbines, and where people and vehicles in the area were continuously present (Percival 1999). It should be emphasized that results of studies of productivity in relation to turbines are likely to vary a great deal from site to site.

Nevertheless, birds at North Cape will probably be only minimally disturbed by the wind turbines if, as proposed, little forest is cleared around the individual turbines and human activity is generally limited to maintenance (but see comments on Bicknell's Thrushes in Section 4.3.1). Offshore waterbirds should not be affected by the turbines.

3.5 Impacts of Fog on Bird Mortality

Many studies have shown that poor weather conditions increase the occurrence of collisions with towers (Case *et al.* 1965, Seets & Bohlen 1977, Elkins 1988, Still et al 1994; see Section 3.2). Even in poor weather conditions, however, it is worth noting that there has never been a mass kill recorded at any wind turbine in the world (Winkleman 1992).

Despite this fact, it is not surprising that, at some sites, the rate of collision with towers increases during fog events. The behaviour of migrating birds was examined at a 366 m tower in North Dakota during various weather conditions (Avery *et al.* 1977). Most losses in the fall occurred during poor visibility as migrants milled around the tower, while most spring mortalities occurred on clear nights as birds struck guy wires (Avery *et al.* 1977). Taxonomic groups also showed differences in mortality: rails and finches were killed mostly on clear nights, while warblers died in greater numbers on overcast nights (Avery *et al.* 1977).

Examining visibility data from Summerside, PEI (the nearest Environment Canada weather station that collects visibility data), provides a general idea of the seasonal frequency of fog events on the western portion of PEI. A direct comparison between Summerside and North Cape cannot be made, as the two sites are separated by about 70 km. However, Summerside data clearly show that winter months have, by far, the lowest visibility, while spring, summer and fall months record very few hours with a visibility of less than 1 km (Figure 1). Fortunately, it is also during this time of year that birds would be migrating (April-June and August-October) and breeding (June-August). With few foggy hours during these critical periods, the possibility of significant mortality at the wind facility as a result of fog is low.

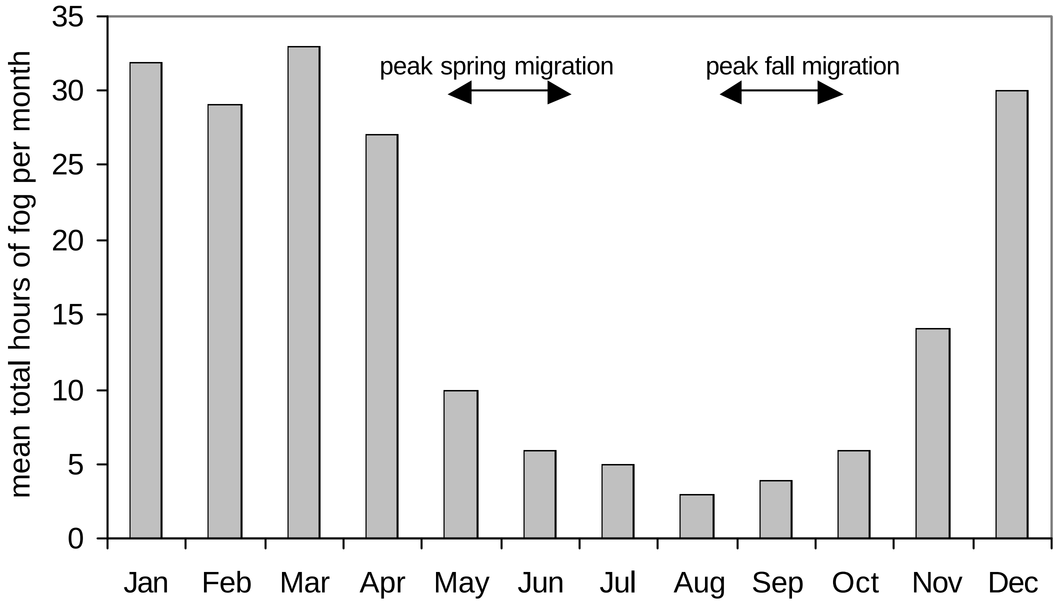

Figure 1. Mean number of hours per month with visibility <1 km from 1941 to 1993 at Summerside, Prince Edward Island (about 70 km southeast of North Cape). Peak bird migration periods are also shown.

4.0 Potential impacts of wind turbines on birds at North Cape

4.1 Introduction

Wind turbine operations can influence bird populations in a number of ways. The noise and activity of operations have the potential to disturb local breeding and/or foraging birds, causing a decrease in nesting success and physical health and contributing to increased mortality. Wind plants can also directly contribute to bird mortality through collisions with wind turbines and guy wires, exacerbated by light attraction. Specific data and interpretation on each of these aspects were presented in Section 3.

Presented here is an overview of how operations at North Cape are likely to influence local bird populations, based on published literature and available data on weather and bird populations at North Cape.

4.2 Potential Effects on Taxonomic Groups

Many studies have shown that chances of high bird mortality are low during all seasons. Even turbine sites placed in the path of important bird migration corridors have had few bird deaths (Mossop 1998, Howell & Noone 1992). Birds appear to show avoidance behaviour if turbines are visible (Rogers *et al.* 1977, Howell 1990, Howell & Noone 1992, Orloff 1992, Orloff & Flannery 1992, Mossop 1998). Fog, however, can decrease visibility of towers and should be addressed. Below is a discussion of how birds of the most prevalent taxonomic groups may be affected by the North Cape wind plant.

4.2.1 Waterbirds

Wind turbines will have little impact on cormorants, waterfowl and shorebirds. These birds appear to exhibit avoidance behaviour to such an extent that there has been essentially no mortality recorded, including areas with high use by, and density of, these species (Rogers *et al.* 1977, Howell & Noone 1992, Still *et al.* 1994, Colson & Associates 1995, Mossop 1998). Additionally, these species generally restrict their movements to areas offshore and along the shoreline. Turbines placed even slightly inland, as are most of the turbines at North Cape, should not pose a threat (Howell & Noone 1992). However, the three turbines closest to the shore (two on the west shore, one on the east) should be monitored carefully for impacts on waterbirds (see Appendix A).

Collision with transmission wires can be a concern for waterfowl, as discussed in Section 3.3. Because all wires at the North Cape wind site are buried underground, they should not pose a threat to waterbirds.

Gulls are identified as being especially vulnerable to wind turbine mortality, due to their habit of flying within 30 m of the ground (Airola 1987). In a study at the wind farm at Blyth Harbour, Great Britain (Still *et al.* 1994), Great Black-backed Gulls were killed by turbines disproportionately to both their overall abundance and natural mortality. These collisions appeared to be associated with poor weather and low visibility. However, as mentioned in Section 3.1, mortality of any species due to turbine collision is still very unusual, even in areas with high concentrations and frequent movements of breeding gulls (Still *et al.* 1994). Potential mitigation measures are provided in Section 5.

4.2.2 Raptors

Along with gulls and migrant songbirds, raptors have been identified as one of the three groups most vulnerable to wind turbine collisions (Airola 1987). Raptor deaths at wind farms are attributed to electrocutions, wire collisions and flying into the turbines when in pursuit of prey. Raptors appear to have no trouble avoiding the turbines when simply flying or soaring (Howell 1990, Orloff 1992, Orloff & Flannery 1992). Raptor mortality at wind sites appears to be species-specific; susceptible species found at North Cape include Red-tailed Hawk, Sharp-shinned Hawk *Accipiter striatus* and American Kestrel, especially on migration. Potential mitigation measures are noted in Section 5. Bald Eagle *Haliaeetus leucocephalus*, Northern Harrier *Circus cyaneus*, and Rough-legged Hawk *Buteo lagopus*, all common species at North Cape, are rarely, if ever, affected at other sites (Orloff 1992).

4.2.3 Migrant Songbirds

Songbird mortality is greatest for low-flying birds on migration and generally occurs during poor weather conditions when birds are attracted to aircraft warning lights, become disoriented, and fly into the tower or nearby wires (Moorehead & Epstein 1985). The chance of collision with turbines is significantly increased if the blade height is above 150 m (Rogers *et al*. 1977). The turbines at North Cape are about 73 m from rotor tip to the ground, well below the critical height of most migrating songbirds. At rotor heights similar to North Cape, it is estimated that less than 0.1% of nocturnal migrants passing through the wind power generating station at rotor height will collide (Winkleman 1992). Therefore, expected mortality can be roughly predicted depending upon the number of birds passing through the area during migration, a factor that is currently unknown.

4.2.4 Resident Birds

During the breeding season, bird movement is reduced. By simply having fewer birds using an area, the number of collisions should be reduced. During the winter, the frequency of bird mortality associated with wind turbines should also be very low, but crows, finches and Snow Bunting *Plectrophenax nivalis* could be at risk simply as a result of their presence in the area.

4.3 Species of Special Conservation Concern

The chance of endangered or threatened species being killed by the turbines at North Cape is low, given their relatively low regional population sizes and overall scarcity at this site. As mentioned in Section 2.3, there are several species of special conservation concern in this area, four considered nationally rare and three considered provincially rare. They are discussed below. One species not mentioned is the Barrow's Goldeneye (*Bucephala islandica*), which may, on rare occasions, fly past North Cape but, like the Harlequin Duck, is probably not in any danger of collisions with the wind towers unless it strays inland.

4.3.1 Bicknell's Thrush (COSEWIC - Special Concern)

The Bicknell's Thrush breeds in dense low spruce and fir either at high elevations or in coastal habitat (Erskine 1992). The species is believed to have bred at North Cape in the past (Erskine 1992), but based on playback surveys conducted in June 2001 it is not currently believed to be breeding (D. Busby, pers. comm.) Suitable Bicknell's Thrush breeding habitat is present at the wind facility, however, suggesting that the species may breed there again in the future (D. Busby, pers. comm.). This possibility should be carefully monitored. Even if Bicknell's Thrush were present at the site, their risk of mortality as a result of the wind turbines should be low, as the species spends most of its time during the breeding season hidden in dense low vegetation. Furthermore, there are no documented cases of mortality of Bicknell's Thrush due to collisions with towers, although several birds *suspected* to be Bicknell's Thrush have been recovered below towers in Leon Co., FL and in Atlanta, GA (Rimmer *et al*. 2001). Concerns have also been raised about the closely-related Swainson's Thrush being killed at communications towers in Saskatchewan (A. Smith, pers. comm.).

Destruction of breeding habitat as a result of tower construction may be a larger issue for the Bicknell's Thrush, although such destruction is stated to be minimal (PEI Energy Corp. 2000). Nonetheless, every effort should be made to reduce disturbance to birds during the breeding season through a reduction of human activities in and around the forest surrounding the wind turbines. Finally, annual surveys for Bicknell's Thrush should be conducted at North Cape each June.

4.3.2 Harlequin Duck (COSEWIC - Special Concern)

The Harlequin Duck should not be affected by wind turbine operations. This species is occasionally found at North Cape during the winter months along the shoreline and in offshore waters (D. Busby, G. Martin, pers. comm.). Generally, the species is not expected to come inland and even if it did, it would probably show avoidance behaviour like other species of waterfowl (Rogers *et al*. 1977, Howell & Noone 1992, Still *et al*. 1994, Mossop 1998). However, disturbance may be a concern if wind turbines closest to the shore disrupt roosting behaviour. This possibility should not be overlooked.

4.3.3 Piping Plover (COSEWIC - Endangered)

The Piping Plover breeds on sandy beaches along the coastline and is in decline in the Maritimes (Boyne 2001). It is important that remaining breeding beaches remain undisturbed. However, the coastal habitat at North Cape is not suitable for breeding or foraging Piping Plover (K. Bredin, pers. comm.), so there is little threat of collision by this species.

4.3.4 Peregrine Falcon (COSEWIC - Threatened)

The Peregrine Falcon has never bred on Prince Edward Island. However, its numbers are increasing throughout its historic range in the Bay of Fundy (Johnstone 1997). As a result, non-breeding Peregrine Falcons may be more likely now to pass through the North Cape area than they have been in the past, and can be seen in the fall around the cliffs at North Cape (L. Holman pers. comm.). Peregrines are susceptible to collisions with wires (Enderson & Kirven 1979, Olsen & Olsen 1980) but there is only one previous record of a turbine kill, in the Orkney Islands (Meek *et al.* 1993). Therefore, it is highly unlikely that any peregrine mortality would occur as a result of the turbines at North Cape.

4.3.5 Great Cormorant (AC CDC - S2B)

The Great Cormorant is known to have bred in the North Cape area as recently as 1991 (Erskine 1992, R. Diblee unpubl. data), and is currently listed as being a very rare breeding bird in Prince Edward Island generally (*AC CDC* 2001). This species seldom flies inland, instead restricting its movements to the shoreline and offshore waters. It was recorded on 7/56 (12.5%) "Superwatch" 15-minute observation periods made on a single day in mid-April from 1998-2001 (G. Martin unpubl. data). Impact of the wind turbines on Great Cormorants is expected to be negligible, but disturbance may be a concern if wind turbine operations disrupt breeding behaviour.

4.3.6 Black Guillemot (AC CDC - S2B)

Similar to the Great Cormorant, the Black Guillemot is suspected to have bred at North Cape (Erskine 1992), and is currently listed as being a very rare breeding bird in Prince Edward Island generally (*AC CDC* 2001). This species generally flies along the shoreline or offshore, and should not be affected by wind turbine operations at North Cape. It was recorded on 13/56 (23%) "Superwatch" 15 minute observation periods in mid-April from 1998-2001, and was always seen resting offshore (G. Martin unpubl. data).

4.3.7 Barn Swallow (AC CDC - S3B)

Although Barn Swallows are an abundant species across North America and Europe, they are considered a rare breeder in Prince Edward Island (*AC CDC* 2001). They naturally build nests on cliffs, but they have also developed the habit of building nests on human structures when available. It is possible that this species will nest on structures at the wind power facility, although probably not on the turbines themselves. The Bank Swallow may also nest on nearby cliffs. Since swallows forage by catching insects in the air, they may be at risk of injury or death caused by collisions with the wind turbines.

4.3.8 Northern Waterthrush (AC CDC - S3B)

This warbler is believed to have bred at North Cape in the past. Even if it is present at the site, however, its risk of mortality due to turbines during the breeding season should be low, based on information available on songbirds in general (see Section 4.2.3).

5.0 Methods of Reducing Mortality at Wind Energy Facilities

Several methods have been proposed to reduce bird mortality at wind power sites (Strickland *et al.* 2001). These are:

- Paint the turbine blades to make them more visible to birds (see Section 3.1);
- Install anti-perching devices;
- Ensure that turbines are no taller than 100-150 m;
- Install bird flight "Diverters";
- Install warning devices that employ sound or visual cues;
- Use white strobe lighting (Gauthreaux and Belser 1999).

The North Cape wind power site has already taken several steps to reduce bird mortality, the most important of which is the employment of turbines of solid tubular design (as opposed to lattice design, which is known to attract perching raptors, thereby leading to injury or death). The towers at North Cape are also well below 150 m (at approximately 73 m), and all wires are buried underground. The lighting on the turbines at North Cape currently consists of red (flashing) lights (not strobe lights). It is not known how this type of lighting will affect birds, although red lights are generally believed to be most disruptive to migrating birds (Gauthreaux and Belser 1999).

We recommend that the PEI Energy Corp. monitor any bird mortality at North Cape for one full year using a defined protocol (see Appendix A). If mortality appears to be a serious issue at this site, then the facility should seriously consider changing its lighting and perhaps painting blades, depending on the species affected (i.e. if raptors are killed, blades should be painted; if migrating songbirds are killed, the lighting should be changed).

6.0 Monitoring Bird Mortality at Wind Energy Facilities

Every wind turbine site is unique and thus requires a distinct protocol for monitoring bird mortality. However, a number of factors should be common to all monitoring protocols (Morrison 1998, Anderson *et al.* 1999). These are:

- A measure of bird use; that is, how many birds pass by the turbines (or within a certain distance of the turbines) during a given time period?
- A measure of bird mortality; that is, the number of carcasses found per unit area and/or search time.

Both of these variables must be measured in order to determine changes in impact with season or site modifications. For example, if the number of mortalities recorded declines in the summer, this could either be because the total use of the site by birds also declined, or because actual mortality due to turbines declined (while use stayed the same). It is impossible to draw conclusions about the impact of a site under varying conditions without both of these variables being measured (Anderson *et al.* 1999).

Most studies also benefit from a measure of bird use at a reference, or control, site located some distance from the turbines. Because PEI Energy Corp. wishes to utilize current employees of the Atlantic Wind Test Site to conduct this work, most of whom will not have any specific bird identification expertise, the recommended protocol needs to be quite simple. If budget permits, we would recommend that a contractor with bird identification skills be employed for at least several weeks during peak spring and fall migration to conduct species-specific surveys; during the rest of the year, employees can be asked to simply count the number of birds passing the turbines during each observation period. Training employees to recognize general bird types is also a possibility. A draft monitoring protocol is provided in Appendix A.

7.0 Summary

With the exception of Altamont in California, most research has shown that bird mortalities at wind energy facilities are not biologically significant at the local or regional level, or with respect to migratory populations. The chance of bird collisions occurring on days with good visibility is low (Crockford 1992). The probability of significant casualties at wind power operations appears to be site- and species-specific. As Colson and Associates (1995) state,

> "the most important step that can be taken to avoid future adverse bird interactions is to locate facilities based on careful siting studies and away from critical habitat."

Most studies seem to reach the same conclusion: impacts are not likely to be significant if wind turbines are located in areas of poor habitat, low bird densities and without significant populations of susceptible species of high conservation importance (Crockford 1992). Aside from the possible presence of breeding Bicknell's Thrushes at North Cape, this site generally fits these criteria. If, however, Bicknell's Thrushes are ever found breeding at North Cape, every effort should be made to monitor the species and ensure that any adverse effects are minimized.

If PEI Energy Corp. takes the mitigative measures suggested in Section 5.0, in particular with respect to lighting, there should be little impact on the bird-life of the area. To back up this statement, however, it is *extremely* important that some level of monitoring be undertaken at the site over the course of one full year. A draft protocol for such a monitoring program is presented in Appendix A.

8.0 Acknowledgements

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Appendix A

Draft Bird Mortality Monitoring Protocol for the Wind Power Facility at North Cape, Prince Edward Island

The following protocol should be peer-reviewed before implementation. The goal of this study is to determine the effects of eight wind turbines erected at North Cape, PEI, on birds breeding, staging or migrating in the area. Currently, very little is known about the type and abundance of birds using this site, factors that should be determined in order to examine any effect of the wind turbines. The protocol is standardized so that results can be compared among potential and existing wind power facilities elsewhere in Canada or North America. The project is limited by PEI Energy Corp.'s requirement that it be conducted by existing staff at the Atlantic Wind Test Site, most of whom are not trained in bird identification. We highly recommended that a contractor with significant bird identification experience be hired to conduct the protocol during key periods of migration and breeding, or that employees at the Atlantic Wind Test Site (AWTS) be trained to do so. Through the winter months, existing staff at the AWTS should be able to fulfill the basic protocol.

The number and species of birds at North Cape will vary seasonally, within a season, and according to weather conditions and other environmental factors. For this reason, it is important to make every attempt to monitor the site at all times of year, for two to five years. Most wind test sites are monitored every two weeks (Anderson *et al.* 1999), which should be a reasonable interval for North Cape as well, given the small number of turbines involved. Once per month should be adequate during the winter.

The objectives of this study are as follows:

1. Determine *bird utilization rate* (# birds observed per unit time and/or area) at each turbine and at paired control sites located at some distance from the turbines;
2. Determine *bird mortality rate* (# carcasses found per unit area) at these same points;
3. Using the above two variables, calculate *bird risk* (mortality/utilization) at each point;
4. Compare bird risk at turbines and controls;
5. Identify annual periods of high and low risk;
6. Determine the influence of weather on passage rate and mortality risk.

Methods

Each of the eight turbines should be considered a single survey point. Each turbine should also be compared with a control point located about 250 m (or some other chosen distance) away in a randomly chosen direction (using a random numbers table), with the stipulation that the habitat should be similar between the turbine point and the control point (i.e. if the randomly chosen control point falls into the water, another point should be randomly chosen until appropriate habitat is hit). Control points should be flagged and georeferenced with a GPS. This paired design should allow comparison of bird utilization and mortality rates immediately surrounding the turbines, and 250 m from the turbines. Note that 250 m may be suitable to determine impacts on small birds like songbirds, but may not be suitable for birds like raptors that range large distances.

Each of the 16 points should be surveyed once a month from November-April, and every two weeks from May-October. Surveys should begin at first light, so that carcasses are more likely to be found before they are scavenged. The points should be visited randomly, although each turbine point and its associated control point should be visited successively (e.g. turbine 7, control 7, turbine 1, control 1, etc.). Additional counts should be conducted following large fog events (i.e. 24 hours or more of fog) during the migration seasons.

At each point, the observer should record the location, along with the date, start time and weather (temperature, visibility, wind speed and direction, precipitation). After these data have been recorded, a 5-minute point count should be conducted wherein all birds that are near (e.g. within 50 m of) the turbine (or, for control points, within 50 m of the center of the point) should be recorded. For each bird, the following variables should be recorded (from Morrison 1998):

1. Species (if known). If not known, each bird seen should simply be recorded by number.
2. Behaviour (flying, perching, soaring, walking, etc).
3. If flying or soaring, the zone of passage. Four suggested zones (from Morrison 1998) are: a) within the blade sphere; b) close to the blades including passes along the edge of the rotation zone; c) not in the blade sphere but below the bottom tip of the blade; or d) out of and well above the top of the blade. If at a control point, the bird's location should be recorded in reference to the heights associated with the above zones (e.g. zone d = greater than 75 m high).

Once all 16 points have been surveyed for bird activity (this should take about an hour and a half), the points should be revisited and an area of 50 m radius around each turbine (or the center of each control point) should be searched for carcasses. It is important that these searches occur on the same day as the point counts. It is possible to have two different observers conducting the point counts and the carcass counts, so long as they are not at the same point at the same time (to avoid disrupting the point counts). The carcass searches will take longer to complete than the point counts, as all tall grass clumps, shrubs and openings to animal burrows should be searched thoroughly (Morrison 1998). If the carcasses cannot be identified, they should either be collected (requires a permit from the Canadian Wildlife Service) or photographed for future identification. Either way, each carcass should be removed from the search zone after photographing or identification to avoid re-finding it on a later search.

For each carcass found, the observer should record its identity (to species if possible), the condition of the carcass, the estimated time of death (or time since death), the probable cause of death, and justification for why this cause was chosen. The distance and direction from the base of the turbine (or the center of the control point) should also be noted (and georeferenced with a GPS if possible).

Most carcasses are scavenged within about five days of dying (Kostecke *et al*. 2001), so clearly not all birds killed at the turbines will be found by this method. At a study of bird mortality at a TV tower in Florida, an average of 2,248 dead birds were found per year when scavenger control was applied, compared with only 642 carcasses per year when no scavenger control was applied (Crawford and Engstrom 2001). A separate study to determine carcass persistence rates at North Cape should also be conducted at some point in the year (see Anderson *et al.* 1999).

Observers may discover live birds that have been injured due to potential turbine collisions. These birds should either be captured and examined to determine the cause of injuries (again, permits are required), or the physical abnormalities should be described on the data forms (Anderson *et al.* 1999).

Sample data forms are included at the end of this Appendix.

Analyses

The bird utilization rate (# birds observed/unit time) and bird mortality rate (# dead birds/point) can be calculated for each turbine and control point. Utilization rate can also be calculated separately for each passage zone (a-d). An index of risk can then be calculated as the ratio of mortality to utilization. This ratio can be compared for turbine and control sites, to see if the area immediately around turbines is considered to be more dangerous than the area at some distance from the turbines. Habitat differences between turbine and control points must be taken into account (by measuring standard habitat variables at each point). This ratio can also be compared across the season to determine if risk is higher during the migration, breeding, or wintering seasons, and across various weather conditions to determine if risk is higher during periods of low visibility.

Of particular interest at North Cape will be whether or not the turbines nearest the shore impact waterbirds, especially the sensitive (albeit rare) Harlequin Duck. This protocol should allow comparison of the different turbines to determine if turbines closer to the shore have more passes by waterbirds, and whether or not this translates to greater mortality of waterbirds, than turbines in the forest. Alternatively, this protocol will allow examination of whether or not turbines in the forest have greater impacts on forest breeding birds, especially the sensitive Bicknell's Thrush (which may, at some time in the future, be found breeding at this site), and whether or not the turbines closest to Black Marsh impact on bog-nesting birds (e.g. Palm Warbler *Dendroica palmarum*, Common Yellowthroat *Geothlypis trichas*). While breeding songbirds in general are not expected to be greatly affected by the turbines (see Section 4.2.3), it is important to keep these various scenarios in mind.

The documents, "Avian Risk and Fatality Protocol" by Morrison (1998) and "Studying wind energy/bird interactions: a guidance document" by Anderson *et al.* (1999) should be referred to when finalizing this bird mortality protocol.

SAMPLE DATA FORM

Date: ____________ Start time: _________Point Number:________ÿ Turbine ÿ Control Observer: _____________________

Temperature: _______°C Visibility: ÿ low ÿ medium ÿ high Wind speed: _____ Wind direction: ______ Precipitation: ÿ none ÿ rain ÿ snow ÿ fog

A. POINT COUNT

Bird Species (if known)	First minute	Second minute	Third minute	Fourth minute	Fifth minute
BCCH	F, d				
YRWA	P	P	P	F, b	

For each minute, record behaviour (F = flying, P = perching, W = walking) and, if flying, zone (a, b, c or d).

In the example above, a black-capped chickadee was observed flying past the turbine at zone d (above the blades) in the first minute, and a yellow rumped warbler was observed perching for the first three minutes, then in the fourth minute it flew past the turbine in zone b.

B. CARCASS SEARCH

Bird species (if known)	Identification procedure	Location relative to turbine	Carcass condition	Estimated time of death	Probable cause of death	Justification of cause, additional comments

The identification procedure should be recorded as Observer ID, Collected, or Photographed. The distance and direction of the carcass from the turbine should be noted and georeferenced if possible. Carcass condition should be recorded as whole, scavenged, skeleton, or other (describe in comments section). Cause of death should be noted as turbine strike, shooting, poisoning, or unknown.

Appendix B
Atlantic Canada Conservation Data Centre
Definitions of S (subnational, or provincial) ranks

SRANK	Definition
S1	Extremely rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
S2	Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to rarity or other factors.
S3	Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in at some locations. (21 to 100 occurrences).
S4	Usually widespread, fairly common throughout its range in the province, and apparently secure with many occurrences, but the Element may be of long-term concern (i.e. may be on a watch list). (100+ occurrences).
S5	Demonstrably widespread, abundant, and secure throughout its range in the province, and essentially ineradicable under present conditions.
S#S#	Numeric range rank: A range between two consecutive numeric ranks. Denotes range of uncertainty about the exact rarity of the Element (e.g. S1S2).
SH	Historical: Element occurred historically throughout its range in the province (with expectation that it may be rediscovered), perhaps having not been verified in the past 20 - 70 years (depending on the species), and suspected to be still extant.
SU	Unrankable: Possibly in peril throughout its range in the province, but status uncertain; need more information.
SX	Extinct/Extirpated: Element is believed to be extirpated within the province.
S?	Unranked: Element is not yet ranked.
SA	Accidental: Accidental or casual in the province (i.e. infrequent and far outside usual range). Includes species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range; a few of these species may even have bred on the one or two occasions they were recorded.
SE	Exotic: An exotic established in the province (e.g. Purple Loosestrife or Coltsfoot); may be native in nearby regions.
SE#	Exotic numeric: An exotic established in the province that has been assigned a numeric rank.
SP	Potential: Potential that Element occurs in the province, but no occurrences reported.
SR	Reported: Element reported in the province but without persuasive documentation, which would provide a basis for either accepting or rejecting (e.g. misidentified specimen) the report.

SRF	Reported falsely: Element erroneously reported in the province and the error has persisted in the literature.
SZ	Zero occurrences: Not of practical conservation concern in the province, because there are no definable occurrences, although the species is native and appears regularly. An SZ rank will generally be used for long distance migrants whose occurrences during their migrations are too irregular (in terms of repeated visitation to the same locations) or transitory. In other words, the migrant regularly passes through the province, but enduring, mappable Element Occurrences cannot be defined.
Qualifiers	
Breeding Status	
B	Breeding: Basic rank refers to the breeding population of the element in the province
N	Non-breeding, wintering: Basic rank refers to the non-breeding population of the element in the province.
M	Non-breeding, migratory: Basic rank refers to the non-breeding population of the element in the province
Other Qualifiers:	
?	Inexact or uncertain: for numeric ranks, denotes inexactness, i.e. SE? denotes uncertainty of exotic status. (The ? qualifies the character immediately preceding it in the SRANK)
C	Captive or cultivated: Element is presently extant in the country or province only in captivity or cultivation.