



**Bear Mountain Wind**  
LIMITED PARTNERSHIP

**RAPTOR AND MIGRATORY BIRD AND BAT MONITORING AND FOLLOW-UP  
REPORT 2010 AND RECOMENDATIONS FOR 2011**

Prepared for:

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## EXECUTIVE SUMMARY

Long-term monitoring of migratory birds and bats associated with the construction and operation of Bear Mountain Wind in northeast BC has been conducted since autumn 2007 as a commitment of federal and provincial environmental approvals. The objectives and methods have been previously documented, and results and updates to the methods are in earlier annual reports. This 2010 annual report to the Technical Advisory Committee (TAC) for spring, summer and autumn constitutes the first full year of operational monitoring. Surveys conducted in 2010 included stand watches for migratory raptors, acoustic monitoring of bats, carcass searches to estimate turbine-related bird and bat fatalities, and breeding bird surveys.

Since autumn 2007, 89 days of migratory raptor stand watches have recorded 1367 raptor observations; most headings and behaviours were consistent with raptors on migration, not raptors that are hunting or breeding – activities that are regarded to put raptors at greater risk from wind turbines. Only a small proportion of raptors use turbine airspace, most are using the adjacent Kiskatinaw Valley. The sole raptor fatality recovered during carcass searches was outside the migration period. The data from 2010 is consistent with that from previous years, and given that carcass searches to monitor all birds are recommended for 2011, no further raptor stand watches are considered necessary.

Bat activity at Bear Mountain measured by acoustic detectors was highly variable from night to night within and among stations; detections also varied on consecutive nights at the same station. Seasonal trends in bat activity were greatest in July and August, also the months with the highest bat fatalities. Myotis bat species were the most frequently detected (71%) and comprised 44% of fatalities. Myotis and Big Brown Bats are not considered migratory tree bats, they may use trees and may make short seasonal migrations between summer roosts and winter hibernacula; migratory tree bats are obligate foliage roosters that undertake longer migrations. Migratory tree bats were 9% of acoustic detections yet accounted for 45% of fatalities; mostly Silver-haired Bat. The greatest migratory tree bat activity occurred from mid-July to late-August, suggesting both summer residents and migrants are present.

There were more myotis and Big Brown Bat fatalities compared to migratory tree bats than has been reported at other wind energy facilities in North America. This is likely due to the presence of resident myotis and Big Brown Bats. More myotis / Big Brown Bat fatalities occurred at southern turbines than at northern turbines; migratory tree bat fatalities were evenly distributed. Most (75%) of fatalities occurred on nights with mean wind speeds less than 6 m/s, similar to other findings in North America. Interpretations of the impact of the 4.57 bats/turbine/year fatality rate to local, regional, and continent-wide bat populations is unclear in the absence of bat demographics and migration routes in northeast BC. Fatalities at North American wind energy facilities vary between 0 and up to 60 bats/turbine/year. Based solely on fatality rate comparisons, and acknowledging that more information about northeast BC bats may change the assessment, the impacts on bats are considered to be a non-significant, low to moderate. The challenge before a more fulsome interpretation of the results from this monitoring can be

gained is for regulators and researchers to collectively seek greater baseline bat knowledge in northeast BC.

Twenty-two bird fatalities were recovered, one of which was at-risk, a provincially blue-listed black-throated green warbler. No federally listed bird species were found. The majority of fatalities occurred from late-July to mid-September; corresponding to seasonal southward migrations. No significant relationships between weather variables and bird fatalities were determined. While some projects have shown relatively high estimated fatality rates; the estimated 2.41 birds/turbine/year at Bear Mountain falls within the lower range of the impacts on birds reported from other wind energy projects in North America.

Based on point count surveys, breeding bird species diversity was only marginally higher at greater distance from the turbine array and abundance showed no differences. The indirect effect of turbines on breeding birds is considered to be non-significant; rather the small differences are likely habitat related.

The impacts of the Project are consistent with the findings of the EA Application, such that the design mitigations incorporated into the project (turbine design, lighting, location and spacing) are sufficient to address impacts to birds and bats, and no additional mitigation is considered necessary.

Recommendations for adaptations and or continuation of bird, bat and raptor studies conducted in 2010, and required by the Program for 2011, are:

### **Migratory Bats**

- Monitor the 2010 sites for bat activity, with the exception of the Anabat T27, to ensure continuity.
- Conduct acoustic monitoring in the north of the turbine array, and below / in the escarpment.
- Continue the extended (three season) carcass searches from mid/late-April to late September.

### **Raptors**

- No further migration studies (stand watches) are recommended. Potential impacts to raptors will be assessed through the carcass search program.

### **Migrating and Breeding Bats and Birds (Carcass Searches)**

- Continue the extended (three season) carcass searches, from mid/late April to late-September.
- Conduct two searcher efficiency and scavenger removal trials (summer, and fall).

### **Breeding Birds**

- No further point count surveys are recommended (additional analysis of existing data has been completed at the request of the TAC and is included in this report).
- No radar surveys are recommended.

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## **1.0 INTRODUCTION**

### **1.1 GENERAL**

As part of the commitments for the Environmental Assessment Certificate E07-03 issued for Bear Mountain Wind Project (BC EAO 2007), Bear Mountain Wind LP (the Proponent) is required to carry out a Raptor and Migratory Bird and Bat Monitoring and Follow-up Program (the Program) (Hemmera 2007). The Program includes monitoring and follow-up studies for the pre-operation and operation phases of the Project for nocturnal migrant and breeding birds, migrating raptors, and migrant bats. This report provides results from the first complete year of operational monitoring and includes spring and fall studies for migrating raptors, spring through fall acoustic monitoring of bat activity, carcass search results (for birds and bats), and breeding birds surveys; as required in the Program (Hemmera 2007).

This report has been reviewed by the Technical Advisory Committee (TAC) established during the EA review to assess the observed impacts to birds and bats and to decide on operational monitoring and mitigation (if any). It provides the agreed upon and recommended alterations to the design of studies listed in the Program to be conducted in 2011.

This report is also considered to meet the requirements of the federal Environmental Assessment Screening Report, Environmental Assessment Conditions, for Follow-up and Mitigation (NRCan 2009). In conjunction with the Program developed in 2007, the recommendations herein constitute the operational monitoring plan for raptors and migratory birds and bats. Accordingly, this report is provided to NRCan to apprise of the progress of the monitoring Program.

This report is based on field studies carried out by Hemmera and Robertson Environmental Services, and builds on earlier studies (RESL 2007a and 2007b; Hemmera 2008, 2009 and 2010).

### **1.2 PROJECT DESCRIPTION AND STUDY AREA**

The Bear Mountain Wind Park Project (the Project) is a wind power generating facility located southwest of the City of Dawson Creek on Crown Land (**Figure 1-1**). The Project was awarded an Electricity Purchase Agreement (EPA) with BC Hydro in July 2006 to provide clean, renewable wind energy to BC Hydro, generating enough energy annually for approximately 38,000 homes. Bear Mountain Wind Limited Partnership (Bear Mountain) has installed 34 wind turbine generators with a 138kV transmission line interconnecting to the BC Hydro transmission system.

The Bear Mountain Wind Park (the Project) was subject to environmental assessment under the provincial *BC Environmental Assessment Act*, and received an Environmental Assessment Certificate E07-03 in August 2007, under the direction of the BC Environmental Assessment Office (EAO). The Project was also subject to a federal environmental assessment pursuant to the *Canadian Environmental*

*Assessment Act*, and received an Environmental Assessment Decision Report for a revised Project description in May 2009 (NRCan 2009).



**Figure 1-1 View of turbines 0 – 34 (note, no turbine #9), and survey locations, Bear Mountain.**

During the Application review and following the receipt of the Environmental Assessment Certificate a number of changes to the project design, as described above, were proposed by the proponent (see Bear Mountain Wind LP 2007). This revised project design, approved by the EAO and ILMB, was constructed and used as the basis for this report. The changes included a reduction in the number of turbines from 57 to 34, including fewer turbines in the environmentally more-sensitive northern part of the Project area and a resultant reduction of the rotor swept area by 40 %. It is pertinent to note that the Program was developed to manage the potential for impacts to migrating birds and bats from the original design presented in the EA Application (57 turbines), and has not been altered to account for the reduction to 34 turbines (as above and Hemmera 2008) that reduce the potential for impacts to birds and bats.

The project was under construction through 2008 and 2009, and the first fully operational turbine was completed by July 7, 2009. The project has been fully operational with 34 turbines since November 2009.

### **1.3 OBJECTIVE**

As part of the review of the Environmental Assessment Application, the EAO at the request of the Ministry of the Environment (MOE, now the Ministry of Natural Resource Operations, MNRO) required the completion of a document describing monitoring to be conducted under the Program. The Program was part of the mitigation measures included in the Application, and it provides detail on the monitoring and follow-up actions (termed adaptive management in the Application) for the management of impacts and mitigation for raptors and migrating birds and bats – to ensure that there are no significant adverse effects as a result of the project. The Program provides a reporting system to the TAC.

Monitoring conducted in 2007, 2008 and in spring 2009 provided baseline data (additional to that collected in the EA studies) for use in comparison to data collected during operations (from fall 2009 on). A key feature of the Program is the potential for analysis of such data to be used to adapt the Monitoring and Follow-up Program to respond to changes and for greater mitigation efficacy.

The following report describes the methodology and results of the Program completed in 2010, and provides discussion of the findings as well as recommendations for future study.

## 2.0 BAT ACTIVITY / ACOUSTIC MONITORING

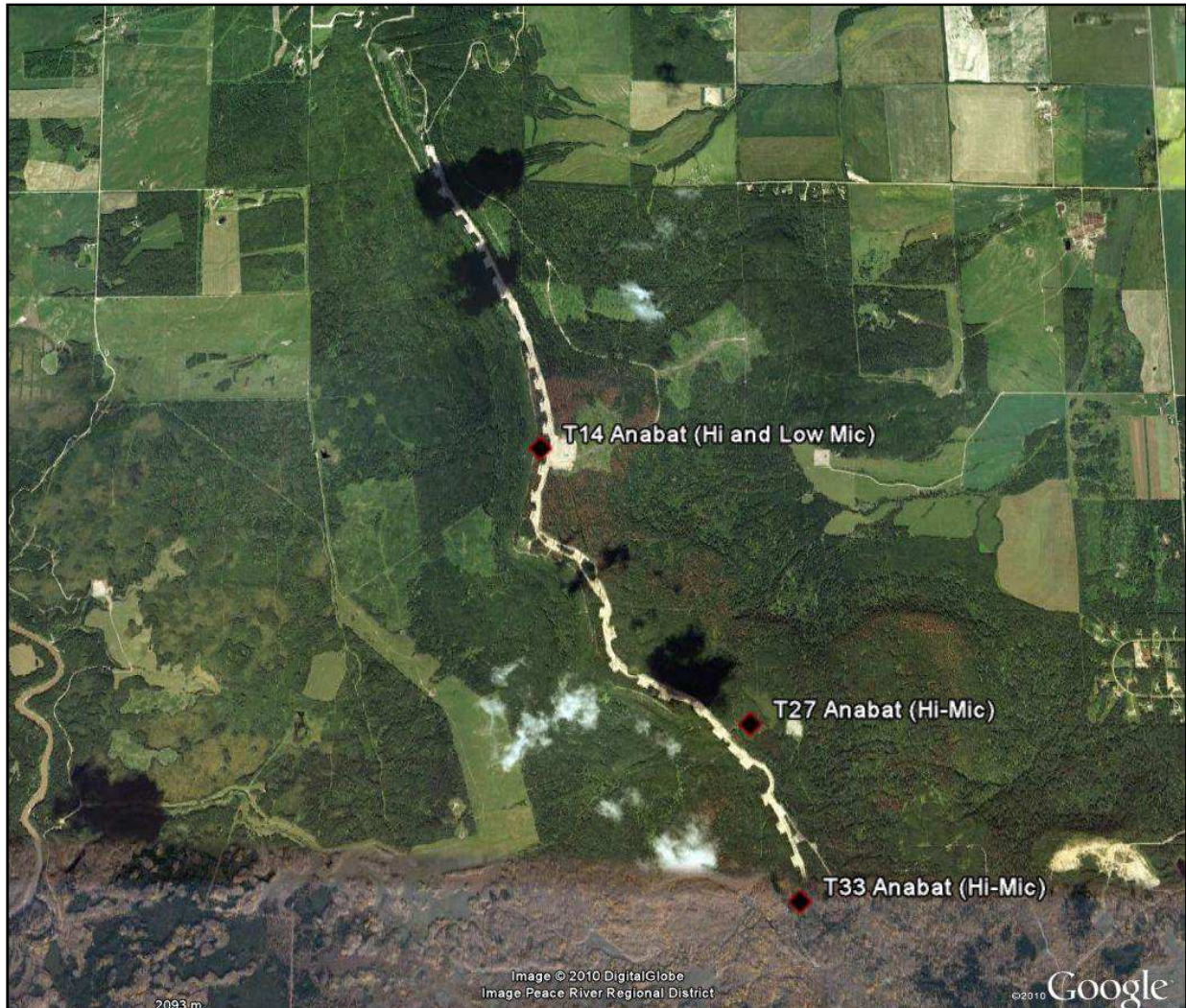
### 2.1 METHODS

Similar to 2009 (Hemmera 2010a), bat activity was monitored by acoustic detection of bat ultrasonic echolocation calls at four stations following the Alberta protocol (Lausen *et al.* 2008). Each acoustic monitoring station consisted of an Anabat SD1 or Anabat II/ZCaim bat detector that stores data on a compact flash card and is powered by a rechargeable 12 V battery and associated solar panel. These detectors allow long-term passive monitoring of bat activity, and acoustic files can accumulate on the flash card for up to one month until the data are downloaded.

The four Anabat detectors were mounted on three tower/mast structures. Two stations were at the same tower, T14, with microphones set in the high and low positions; the other two stations (in proximity to T27 and T33) had single Anabat units with the microphones mounted 30 m up the tower structures (**Table 2-1**). The single low microphone was mounted 2.5 m from the ground and the three high microphones were mounted 30 m from the ground. The two heights provided information on bats flying in different strata. The locations (**Figure 2-1**) and set ups were identical to the 2009 acoustic monitoring stations.

**Table 2-1 Locations of Anabat detectors during the 2010 acoustic monitoring period**

Station	Mounting Structure	Nearest Turbine	Mic. Height (m)	Mic. Orient.	UTM Easting	UTM Northing	Elev. (m)	Survey Duration
T14H	30 m mast	T14	30	W/NW	661516	6176182	970	13 April-28 Sept
T14L	30 m mast	T14	~2.5	W/NW	661516	6176182	970	13 April-28 Sept
T27	60 m mast	T27	30	W/NW	663106	6174278	945	13 April-28 Sept
T33	30 m mast	T33	30	W/NW	663421	6173081	923	13 April-28 Sept



**Figure 2-1** Locations of Anabat detectors during 2010 surveys

The detector units and battery were in a protective plastic housing set on a wooden platform mounted on a metal mast, approximately 2.5 to 3 m from the ground. The associated solar panel was mounted nearby facing south to ensure maximum sunlight. The microphones were either mounted directly onto the Anabat (standard mic) if it was a low (2.5 m) setting or elevated to 30 m up the mast (**Table 2-1**) with an audio cable connected between the Anabat and the microphone. High microphones (Hi Mic, Titley Scientific) were used for the elevated locations as they are designed with high sensitivity to compensate for deteriorated signal quality from the 30 m long cable. Hi Mics were housed within a short section of ABS pipe and capped to protect from water damage. Microphones were positioned to face down over a reflective plexi-glass plate that was mounted 45° to horizontal resulting in the microphone sampling an area parallel to the ground. The entire assembly was then mounted on a carriage that could be raised and

lowered via a pulley system on the mast. One detector (T14) used a standard microphone at 2.5 m directly mounted to the detection system on the same mast as a Hi Mics at 30 m (**Table 2-1**).

Detectors were programmed to begin and end recording each day at 30 min before sunset and 30 min after sunrise. Data were downloaded and checked at roughly 2 week intervals. For downloads, flash cards were removed and downloaded to a laptop computer using the Anabat CFC Read program. New cards that were pre-programmed with appropriate start and end times were installed in each Anabat to replace the cards with the data recordings. Anabat files and their associated log files were viewed at each card exchange to verify that the detectors were functioning correctly. All Anabat systems were removed on 28 September. Overall sampling was 648 detector nights (**Table 2-2**).

**Table 2-2 Sampling nights by Anabat detector for the 2010 acoustic monitoring period**

Sampling Station	Anabat #	April	May	June	July	August	September	Total # Nights Sampled
T14H	SN03496 SN3736 CF02198	18	31	18*	15*	31	28	141
T14L	SN03549	18	31	30	31	31	28	169
T27	SN02194 Cf3721	18	31	30	31	31	28	169
T33	CF 02194	18	31	30	31	31	28	169

**Note:** \* Detector malfunctioned 23 June-17 July

After the Anabat data files were downloaded from the flash card they were reviewed using AnalookW (Version 3.7w), and files not containing a bat call (noise) were removed. The bat files were then sorted into subfolders for each night of activity (i.e., files recorded between 2000 hours of one night and 0600 hours of the following morning). The data were sorted as they were submitted from the field to help verify that the Anabats were functioning properly. Finally, the Anabat files were analysed using AnalookW.

Bat activity was expressed as the number of bat passes per night. A pass was defined as a file with two or more echolocation calls separated by > 1 s from other sequences or files. To standardize for the number of detectors, an index passes/detector night (activity recorded by one detector from sunset to sunrise) was used. The number of passes/night is an index of bat activity within detection range of the Anabat microphone (~15-25 m). However, this index cannot be used to infer population abundance or the number of individuals using a site (Hayes 2000, Kunz *et al.* 2007). The number of passes/night at a site was not normally distributed even with log or square root transformations. Therefore, to test for differences in activity among the four sites Kruskal Wallis non-parametric tests were used with the number of passes the dependent variable and Anabat site the grouping variable. Mann-Whitney (U-statistic) non parametric tests were used for two-group tests to compare 2009 and 2010 activity at T14L, T14H, and T27 (T33 malfunctioned in 2009).

Identification of calls was based on the Titley electronics library of Anabat calls for North American bat species. Because the focus was on identifying migratory tree bats, the species with the highest mortality at wind farms (Arnett *et al.* 2008; Baerwald 2008), identification of call sequences emphasized the discrimination of Hoary, Eastern Red Bat, and Silver-haired Bats (herein referred to as migratory tree bats) from other bats (myotis bat species) including Little-Brown Myotis (*M. lucifugus*), Northern Myotis (*M. septentrionalis*), Long-legged Myotis (*M. volans*), and possibly Western Long-eared Myotis (*M. evotis*). No attempt was made to discriminate the myotis species bats. Call sequences were assigned to 7 groups: 1) Hoary Bat, 2) Silver-haired Bat, 3), Eastern Red Bat, 4) Silver-haired/Big Brown Bat group, 5) Silver-haired/Hoary/Big Brown Bat group, 5) myotis group, and 6) unidentified bat group (Table 2-3). Following Baerwald (2008), files identified as in groups 1) to 4) were assigned to a 'migratory tree bat' category for analyses. Some files assigned to the Silver-haired/Big Brown Bat or Silver-haired/Hoary/Big Brown Bat groups could be Big Brown Bats, a species that occurs in the study area.

**Table 2-3 Criteria for classifying bat call sequences to seven species groups**

Group	Criteria
Hoary Bat	Either broad band FM search phase calls with fluctuating frequencies (a characteristic of <i>Lasiurus</i> sp. calls) or flat search phase calls with a narrow band width, a maximum frequency <25 kHz, and a minimum or characteristic frequency below 20 kHz (see O'Farrell et al. 1999; 2000).
Silver-haired Bat	Flat (narrow band width) search phase calls with a maximum frequency <30 kHz and a minimum frequency 2226 kHz.
Eastern Red Bat	Broad band FM search phase calls with fluctuating frequencies with the characteristic frequency fluctuating between 40 and 60 kHz.
Silver-haired/Big Brown Bat	Because of extensive overlap in the call parameters of broad band FM calls of the Big Brown Bat and Silver-haired Bat (Betts 1998), we assigned all broad band FM calls with a maximum frequency < 60 kHz and a minimum frequency or characteristic frequency < 30 kHz to the Silver-haired/Big Brown Bat group.
Silver-haired / Hoary / Big Brown Bat	Fragmented calls that were below the minimum and maximum frequency range of myotis calls but with insufficient call structure to assign to a more specific group.
Myotis	Broad band FM calls with a minimum frequency or characteristic frequency > 30 kHz.
Unidentified bat	Highly fragmented calls where the maximum, minimum, or characteristic frequency could not be determined.

Monthly trends in acoustic activity and fatalities were assessed from bar graph plots. To test the efficacy of acoustic data for predicting nightly fatalities, the nightly fatalities of total bats, myotis, and migratory tree bats were compared with nightly acoustic activity indices (passes/detector night) for these groups for the months of June, July, August, and September. The migratory tree bat acoustic group includes files of the Big Brown Bat, i.e., files assigned to the Silver-haired/Big Brown Bat and Silver-haired/Hoary/Big Brown Bat groups. Therefore, for the analyses with acoustic data, fatalities of the migratory tree bat category included Big Brown Bats. Only bats for which the night of death could be estimated were used in

this analysis (§3). Passes/detector night and nightly fatality counts were not normally distributed; a square root transformation was used to normalize the data. Nevertheless, fatality counts still deviated from normality.

## 2.2 RESULTS

### 2.2.1 General Activity

A total of 2,187 bat passes were recorded at the four Anabat stations between 13 April and 28 September 2010. There were 648 detector nights, and the mean overall activity was 3.7 passes/detector night.

**Table 2-4 Bat activity (bat passes/detector night) for each surveyed month at four Anabat stations at Bear Mountain from August – September 2009 and 13 April – 28 September, 2010.**

April	2009			2010			
	T14L	T14H		T14L	T14H		T14L
Number of Nights	-	-	-	18	18	18	18
Total Passes	-	-	-	20	3	10	9
Mean Passes/Night	-	-	-	1.1	0.2	0.6	0.5
Minimum Passes/Night	-	-	-	0	0	0	0
Maximum Passes/Night	-	-	-	4	2	3	3
Standard Deviation	-	-	-	1.2	0.5	1.0	0.9
May	2009			2010			
	T14L	T14H		T14L	T14H		T14L
Number of Nights	-	-	-	31	31	31	31
Total Passes	-	-	-	44	11	35	33
Mean Passes/Night	-	-	-	1.4	0.4	1.1	1.1
Minimum Passes/Night	-	-	-	0	0	0	0
Maximum Passes/Night	-	-	-	8	4	8	8
Standard Deviation	-	-	-	1.9	0.9	2.1	1.8
June	2009			2010			
	T14L	T14H	T27	T14L	T14H	T27	T33
Number of Nights	-	-	-	30	18	30	30
Total Passes	-	-	-	248	12	16	43
Mean Passes/Night	-	-	-	8.3	0.7	0.5	1.4
Minimum Passes/Night	-	-	-	0	0	0	0
Maximum Passes/Night	-	-	-	24	3	5	9
Standard Deviation	-	-	-	6.6	1.0	1.2	2.0

July	2009			2010			
	T14L	T14H	T27	T14L	T14H	T27	T33
Number of Nights	-	-	-	31	15	31	31
Total Passes	-	-	-	221	494	39	123
Mean Passes/Night	-	-	-	7.1	33.0	1.3	4.0
Minimum Passes/Night	-	-	-	0	0	0	0
Maximum Passes/Night	-	-	-	27	198	14	23
Standard Deviation	-	-	-	6.4	55.1	3.1	5.9
August	2009			2010			
	T14L	T14H	T27	T14L	T14H	T27	T33
Number of Nights	31	31	31	31	31	31	31
Total Passes	142	158	63	302	95	30	88
Mean Passes/Night	4.6	5.1	2.0	9.7	3.1	1.0	2.9
Minimum Passes/Night	0	1	0	0	0	0	0
Maximum Passes/Night	110	20	13	25	19	8	16
Standard Deviation	19.5	4.0	2.7	6.9	4.3	1.9	3.4
September	2009			2010			
	T14L	T14H	T27	T14L	T14H	T27	T33
Number of Nights	30	30	30	28	28	28	28
Total Passes	35	31	12	171	92	10	32
Mean Passes/Night	1.2	1.0	0.4	6.1	3.3	0.4	1.1
Minimum Passes/Night	0	0	0	0	0	0	0
Maximum Passes/Night	10	5	6	22	51	3	6
Standard Deviation	2.6	1.4	1.2	5.4	9.8	0.8	1.8

**Note:** Bat sampling did not begin until August in 2009.

### 2.2.2 Nightly/Seasonal Variation

As in previous years, bat activity at Bear Mountain was highly variable from night to night both within and among stations, with nightly passes recorded at a site ranging from 0 to 198 (**Table 2-4**). Bat detections often varied substantially on consecutive nights at the same station, e.g., 75 bat passes were recorded on 25 July at T14H, but no passes were recorded on 24 July. Night to night differences in bat activity are likely correlated with insect activity and local weather patterns (Horn *et al.* 2008). Nevertheless, activity on the same night was inconsistent among the stations, even for stations at the same location. On 19 July the high (T14H) Anabat recorded 198 bat passes, but the low detector (T14L) at the same station recorded only 13 bat passes. T27 recorded no passes that night. These different activity patterns among Anabat stations could reflect differences in prey abundance and foraging activity within the study area.

Activity rates were low in April and May at all four stations with mean passes/night ~1-2 and the maximum passes recorded in any night less than 10. Although the Anabat at station T14H malfunctioned for 16 nights in July, this site recorded its highest bat activity in July. Kruskal Wallis non parametric tests comparing nightly passes among the four stations in July, August, and September demonstrated that activity rates differed among sites for all three months: July ( $\chi^2=14.91$ ,  $df=3$ ,  $P=0.002$ ), August ( $\chi^2=137.89$   $df=3$ ,  $P=0.000$ ), and September ( $\chi^2=38.54$ ,  $df=3$ ,  $P=0.000$ ). The greatest bat activity was at T14H and T14L; the least activity was at T27 (**Table 2-4**).

### 2.2.2.1 Species Detected

Anabat files were assigned to seven groups (**Table 2-5**). The myotis group was predominant, representing 71% of the bat passes in 2010. Overall mean detection rates (passes/detector night) for myotis bats were 2.39 in 2010 (**Table 2-6**). The myotis group could consist of as many as four species: Northern Myotis, Little Brown Myotis, Long-legged Myotis, and Long-eared Myotis, though only Northern and Little Brown Myotis were detected as fatalities in 2010.

Migratory tree bat passes were 8.7% of the bat passes recorded in 2010. This is a conservative overestimate of migratory tree bat activity because some files assigned to the Silver-haired/Big Brown Bat and Silver-haired/Hoary/Big Brown Bat groups are likely those of Big Brown Bats. In April, when overall bat activity was low, activity rates of the migratory tree bat group and myotis group were similar (**Table 2-6**). However, in May, June, July, August, and September migratory tree bat activity was low in comparison to myotis bats with mean monthly activity rates < 1 pass/detector night for every month. Three recorded Anabat files were confirmed as Hoary Bat, seven as Silver-haired Bat, and four as Eastern Red Bat (**Table 2-5**). Mean monthly tree bat passes recorded at each of the Anabat stations was <1 (**Table 2-7**). Maximum migratory tree bat passes recorded in a single night was 21. Migratory tree bat activity was highest at T14H; which is likely underestimated as this detector failed to record from 23 June-17 July.

**Table 2-5 Bat passes recorded for seven species groups from 13 April – 28 September 2010**

Species Group	Total	%
myotis species	1557	71.2
Hoary Bat*	3	0.1
Silver-haired Bat*	7	0.3
Eastern Red Bat*	4	0.1
Silver-haired/Big Brown Bat*	61	2.8
Silver-haired/Hoary/Big Brown Bat*	117	5.4
Unidentified bat	438	20.1

**Note:** \* Groups assigned to the migratory tree bat category.

**Table 2-6 Passes/detector night for myotis and migratory tree bats in 2009 and 2010**

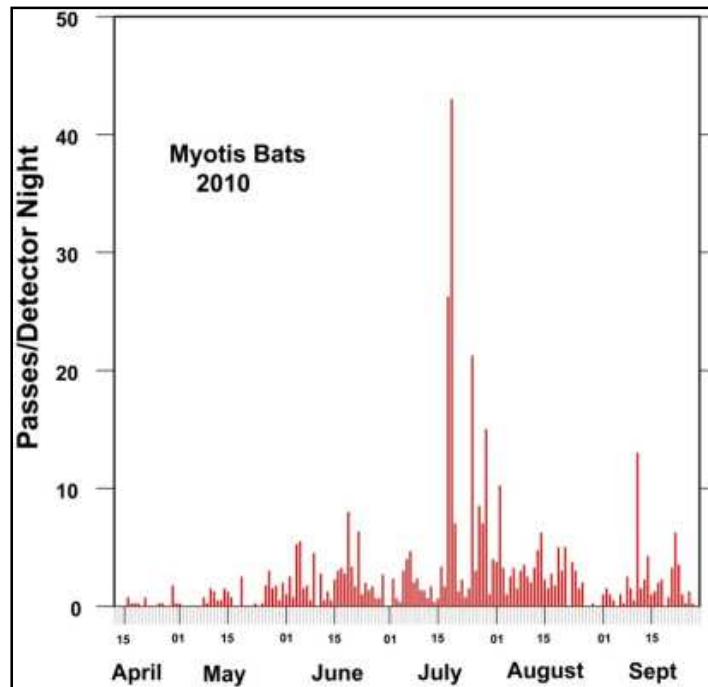
	April	May	June	July	August	September	All
<b>2009</b>							
Migratory Tree bats	-	-	-	-	0.65	0.22	0.44
myotis bats	-	-	-	-	2.89	0.56	1.74
<b>2010</b>							
Migratory Tree bats	0.24	0.10	0.06	0.72	0.51	0.06	0.29
myotis bats	0.26	0.71	2.29	5.55	2.66	1.92	2.39

**Table 2-7 Mean migratory tree bat passes recorded at four Anabat stations from 13 April – 28 September 2010**

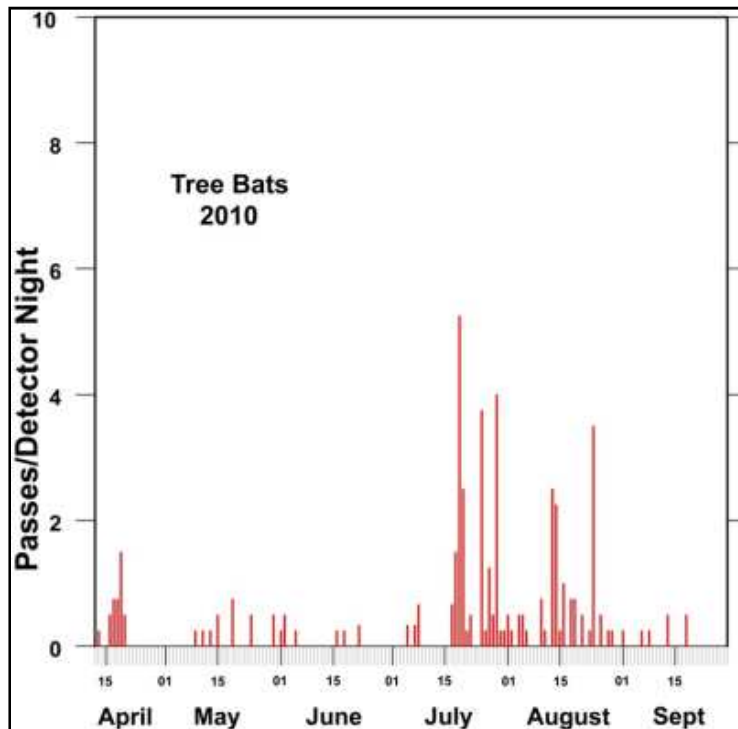
	T14L	T14H	T27	T33
Number of Nights	169	141	169	169
Total Passes	19	113	25	36
Mean Passes/Night	0.11	0.80	0.15	0.21
Minimum Passes/Night	00	00	0	0
Maximum Passes/Night	3	21	3	3
Standard Deviation	0.40	2.80	0.45	0.53

Myotis bats were detected from 16 April-27 September (**Figure 2-2**). The lowest activity was in April and May; the highest activity was mid- to late-July. The activity pattern suggests several peaks: June, July, and September. The decline in myotis activity from mid-June to mid-July, however, is likely an artefact of sampling. The Anabat at T14H, a site with high activity, malfunctioned from 23 June-17 July.

The myotis detections in April and May could represent local resident bats or transient bats dispersing from winter hibernacula to their summer range. The myotis activity in June-August is consistent with resident populations with the high activity in late-July resulting from the appearance of volant young-of-the-year in the population. The September activity may reflect an influx of myotis bats migrating to unknown autumn swarming or hibernation sites.



**Figure 2-2** Variation in nightly detections of the myotis bat group (passes/detector night) between 13 April and 28 September at four Bear Mountain Anabat stations in 2010



**Figure 2-3** Variation in nightly detections of migratory tree bats group (passes/detector night) between 13 April and 28 September at four Bear Mountain Anabat stations in 2010

Migratory tree bats were detected from 13 April- 18 September (**Figure 2-3**) with the highest activity rate from mid-July to late-August. Spring 2010 data showed no clear evidence for an influx of migrating tree bats, although passes of the migratory tree bat group were detected in April, May and June. All migratory tree bat passes from April-June were identified as groups that also contain Big Brown Bat; none could be confirmed as Silver-haired Bat or Hoary Bat - though two Silver-haired Bat carcasses were detected during searches in early June. Patterns of migratory tree bat activity, with scattered detections throughout the sampling period, suggest both residents and migrants at Bear Mountain (Cryan 2003). Baerwald (2008) observed fall migration activity of Hoary Bats and Silver-haired Bats peaking in mid to late-August in south-western Alberta. The timing of the fall migration in north-eastern British Columbia may be earlier.

The three confirmed Hoary Bat detections were 8 July (T33), 10 August (T14H), and 8 September (T14H). The seven confirmed Silver-haired Bat passes were from 29 July, 13 August, and 24 August all at T14H. The four Eastern Red Bat passes were 2 and 4 August at T14H; and 5 and 19 August at T33. All confirmed Eastern Red Bat, Hoary Bat, and Silver-haired Bats were recorded at the high stations (30 m).

#### ***2.2.2.2 Association of Acoustic Activity with Fatalities***

The general patterns of fatalities for both the myotis group and the migratory trees bats group were consistent with the seasonal trends in their acoustic activity (**Figures 2-2, 2-3** and **Figure 4-6**).

Most fatalities occurred in July and August when bat activity was greatest. Although there were sporadic detections in April and May there were no fatalities until 2 June (Silver-haired Bat). Similarly, although there was a minor peak in myotis activity in June, this was not reflected in the fatality counts.

The association of nightly variation in acoustic activity and fatalities was weak. Nightly fatalities of migratory tree bats showed no correlation with migratory tree bat acoustic activity for any month. Baerwald and Barclay (2009) found that only bat activity recorded at 30 m was correlated with fatalities in south-western Alberta. A separate analysis comparing Bear Mountain migratory tree bat passes/detector night for the three high microphone sites (T14H, T27, and T33) did not find an association with migratory tree bat fatalities for any month. Nightly variation in fatalities was correlated with myotis files/detector night ( $r = 0.50$ ,  $p = 0.0036$ ) and total bat files/detector night ( $r = 0.47$ ,  $p = 0.0071$ ). These weak correlations between nightly bat activity and fatalities may be attributed in part to the distribution of the count data; many nights with zero fatalities resulted in skewed (non-normal) data even with transformations, and the range of fresh fatalities was only 0-7. With the Anabat sites restricted to only three locations in the study area and the fatalities widely distributed across the 34 turbines (**\$4**), it is also likely that acoustic sampling by Anabat is insufficient to fully measure nightly variation in acoustic activity in the entire study area.

### **2.2.2.3 Comparison of 2009 and 2010 Nightly Activity Data**

Kunz *et al.* (2007) noted that changes associated with the construction of a wind energy project such as the presence of turbines that may attract bats and the associated loss of trees could change bat activity levels from those recorded during the preconstruction conditions. No sampling was done in April-July 2009 and T33 malfunctioned in 2009. Nevertheless, activity levels could be compared among T14L, T14H, and T27 in August and September for 2009 and 2010. The set ups, including microphone heights and orientations were identical in both years for these stations.

The general bat activity levels for all species groups combined (**Table 2-4**) show that at the low microphone site T14L, activity rates did increase after construction with passes/night greater in 2010 for August (Mann-Whitney U=295.5, P=0.008) and September (Mann-Whitney U=120.5, P=0.000). However, changes in bat activity from 2009 to 2010 at the higher microphone sites are ambiguous. There were differences among years for August but no differences for September. At T14H, activity rates were greater in 2010 for August (Mann-Whitney U=327.0, P=0.025), whereas at T27 activity rates were greater in 2009 for August (Mann-Whitney U=635.5, P=0.020). Both sites showed no yearly differences for September (T14H: Mann-Whitney U=120.5, P=0.000; T27: Mann-Whitney U=392.0, P=1.000).

An analysis of monthly migratory tree bat activity rates for 2009 and 2010 (**Table 2-6**) revealed no differences for August (Mann-Whitney U=478.5, P=0.977) or September (Mann-Whitney U=446.0, P=0.231).

## **2.3 BAT MONITORING SUMMARY**

- Acoustic surveys with Anabat detectors recorded 2,187 bat passes at four stations in 2010;
- Similar to previous years, bat activity was highly variable from night-to-night at the same station and could vary inconsistently on the same night among the four stations;
- Activity rates differed among stations; the highest activity rates were recorded at T14L and T14H;
- Myotis species bats were the dominant group recorded representing ~71% of the bat files. The overall mean activity rates for this group was 2.32 passes/detector night. Migratory tree bats represented ~9 % of the bat passes recorded and their overall mean activity rates were <1 pass/bat detector night;
- Myotis bats were detected from 16 April-27 September, greatest activity was mid to late-July with smaller peaks in June and September. The pattern is consistent with resident populations and an influx of myotis bats in September migrating to unknown autumn swarming or hibernation sites;
- Bats of the migratory tree bat category were detected from 13 April to 18 September with activity highest from mid-July to late-August. There is no clear acoustic evidence for an influx of migrating tree bats in spring, though two Silver-haired Bat fatalities were recovered in early June. Although passes of the migratory tree bat group were detected in April, May and June, some of these files could be Big Brown Bats. The patterns of migratory tree bat activity suggest both residents and migrants at Bear Mountain.

- Four Anabat files from August at T14H and T33 were identified as Eastern Red Bat, the first year this species was detected at Bear Mountain, and the first year since 1905 in British Columbia;
- A comparison of bat activity recorded in 2009 and 2010 at three Anabat sites during August and September revealed that activity rates increased at the low microphone site (T14L) in 2010. However, there were no changes in bat activity at the high microphone sites (T14H, and T27). There were no differences in acoustic activity of migratory tree bats among 2009 and 2010.
- Seasonal trends in bat acoustic activity were similar to the general patterns of bat fatalities with most fatalities occurring in July and August, the months with highest bat activity. Variation in nightly fatalities of all bats and myotis species bats were correlated with their nightly acoustic activity. Variation in nightly fatalities of the migratory tree bat group showed no correlation with acoustic activity for any month.

### 3.0 MIGRATORY RAPTOR MONITORING

The EA Application (Aeolis 2006) identified resident and migrating raptors in the study area and noted some use of the thermals and updrafts associated with the escarpment on the west side of Bear Mountain. Operational monitoring of raptor collision mortality has not shown significant mortality rates for most wind farm sites (Kerlinger 2007 and NRC 2007), and a recent review of the effects of wind turbines on birds summarizes that “In almost all areas, however, raptors are able to avoid wind turbines, resulting in very few or no collisions” (Kingsley and Whittam 2007). The Program was intended to augment the baseline information on raptor migration through the study area in spring and fall. Since autumn 2007 when the program began 89 days of raptor stand watches have been conducted. The 2010 year is considered the first full year of operations; the project was partially operational in fall 2009.

#### 3.1 METHODS

Eight days of raptor monitoring were conducted in spring 2010 and 15 days in autumn at Bear Mountain in accordance with the protocols established in 2007, 2008 and 2009 surveys and as proposed to regulators during the TAC review of the work conducted in 2009 (Hemmera 2010a); methods are similar to Environment Canada (2007). Two periods during the spring migration were sampled, one in late March / early April and another beginning during mid/late April and ending at the beginning of May. The timing of studies was guided by knowledge of migration patterns relative to weather conditions gained during previous years work on Bear Mountain and in other parts of the Peace Region. Autumn surveys were conducted from September to mid-October. Professional judgement of current conditions and the state of migration indicated an earlier (late-August) start as in previous years’ sampling (Hemmera 2010a) was not warranted as few raptors were migrating at this time in 2010. With the exception of several requested survey events in late March to sample golden eagle migrations, temporal representation throughout the migration periods was sought.

Spring 2010 surveys were conducted on 25, 27 and 28 March and 9, 14, 16, 21, and 26 April. The mean survey duration was 6.48 hours, ranging from 6.0 hours to 7.17 hours per survey. Autumn surveys were conducted on 11, 16, 17, 22, 23, 25, 26 and 28 September, and 7, 8, 9, 10, 12, and 19 October. These surveys typically lasted six hours; however, weather conditions forced some surveys to end early or run longer if raptors were still migrating (**Tables 3-2 and 3-4**).

Surveys typically started at 9 am, ending at 3 pm to capture data during the time of the day when peak raptor migration passage has previously been noted (approximately 11 am – 2 pm, see Hemmera 2010a). Surveys were only conducted when weather conditions were appropriate for observing raptor passage (good visibility and no or little precipitation), as per guidelines (EC 2007). For each species observed several metrics were collected, including species, heading, height when crossing ridge (if this occurred),

initial and final height and bearing to observation, and behaviours. Additionally, surveyors noted if raptors passed directly through the turbine airspace. Survey locations are provided in **Figure 1-1**.

### 3.2 RESULTS AND DISCUSSION

#### 3.2.1 Spring 2010

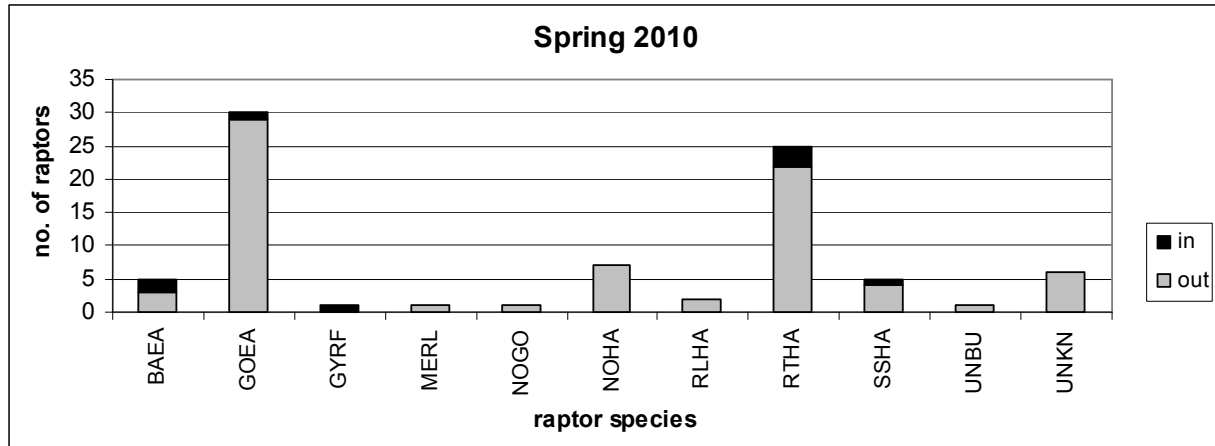
In spring 2010, 84 raptors of nine species were detected. Seven of these were not identified to species (unknown, UNKN or unknown buteo (hawk), UNBU) typically due to visibility constraints at the distance the birds were observed (**Table 3-1**).

**Table 3-1 Raptor species observed in the Bear Mountain Project area, spring 2010**

Common Name	Scientific Name	BC List	COSEWIC
bald eagle (BAEA)	<i>Haliaeetus leucocephalus</i>	Yellow	Not at Risk
golden eagle (GOEA)	<i>Aquila chrysaetos</i>	Yellow	Not at Risk
northern harrier (NOHA)	<i>Circus cyaneus</i>	Yellow	Not at Risk
sharp-shinned hawk (SSHA)	<i>Accipiter striatus</i>	Yellow	Not at Risk
northern goshawk (NOGO)	<i>Accipiter gentilis atricapilus</i>	Yellow	Not assessed
red-tailed hawk (RTHA)	<i>Buteo jamaicensis</i>	Yellow	Not at Risk
rough-legged hawk (RLHA)	<i>Buteo lagopus</i>	Blue	Not at Risk
merlin (MERL)	<i>Falco columbarius</i>	Yellow	Not at Risk
gyrfalcon (GYRF)	<i>Falco rusticolus</i>	Blue	Not at Risk

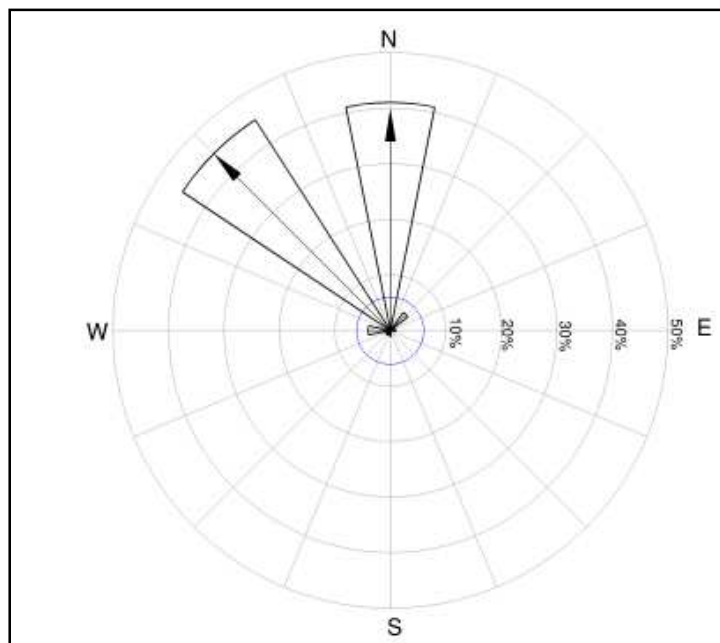
Most raptors observed (90.5%) did not exhibit flight paths, altitudes, and / or behaviours that put them within turbine airspace (flight under 150m and intersecting the ridge); 9.5% of the raptors did have potential to interact with turbines (**Figure 3-1**). These results are consistent with previous years (see Hemmera 2010a). No collisions were observed during spring 2010 raptor surveys and no raptor carcasses were detected during spring 2010 carcass search events on Bear Mountain (§ 4).

No birds were observed hunting directly within the Project area; however, a small portion of the raptors dropped low into the Kiskatinaw River Valley (approximately 3-5 km from Bear Mountain ridge) and exhibited hunting behaviour in the agricultural field / wetland meadow complexes. A pair of red-tailed hawks exhibited aerial flights typical of courtship and pair-bonding near the BSE survey location and were seen perching, primarily in trees along the escarpment closest to WTG17. A nest tree was located 50 m from the edge of a clearing and wetland complex southwest of Bear Mountain. This light-phase pair is presumed to be the same pair observed around the project area in 2009.



**Figure 3-1 Raptor species detected during spring 2010 surveys at Bear Mountain in relation to turbine air space (“in” or “out” side of turbine air space). n=84**

Most of the raptors observed (72 of 84 raptors, 85.7%) exhibited behaviour such as continuous soaring and gliding flight in a northerly direction (N, NE or NW) that is considered to represent migratory activity (**Figure 3-2**). and/or using the ridgeline near Feller’s Heights and Highway 52, approximately 10 km from Bear Mountain. This is similar to results from 2009 (Hemmera 2010a) and previous years observations. It appears that many of the raptors were heading for the ridgeline roughly north of Feller’s Heights as it is the next northward topographical feature and likely provides updrafts and/or thermals that migrating raptors can use to their advantage. Additionally, the agricultural fields within the Kiskatinaw River Valley appear to provide opportunistic foraging opportunities for migrating birds, particularly hawks/buteos. Based on these observations, most raptors do not appear to use the Bear Mountain Project area for hunting, rather focussing on agricultural fields outside the Project area.



**Figure 3-2 Raptor direction of travel, spring 2010, Bear Mountain. n=84, 4 observations did not exhibit a consistent direction of travel**

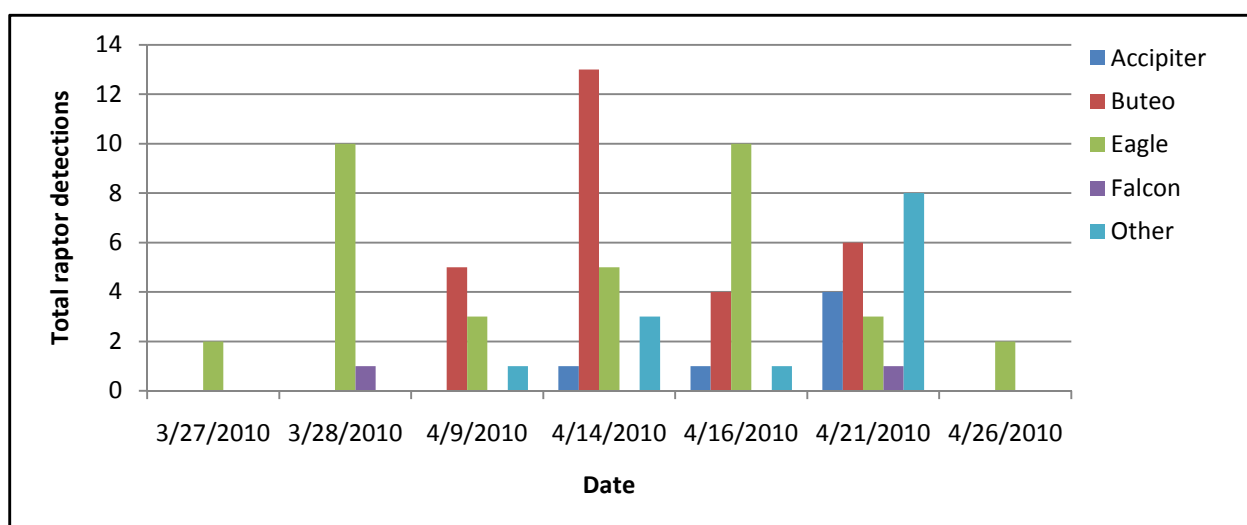
**Notes:** Proportion of total raptor detections moving in each of 16 directions delineated by 15 degree increments (i.e., N, NNE, NE, ENE, E,...). The blue concentric circle represents the proportion of observations that did not have an associated direction of travel.

Passage rates observed in spring 2010 varied from a low of 0 raptors/hr on March 25, 2010 to a high of 3.5 raptors/hr on 21 April 2010 (Table 3-2). The mean passage rate (and 95% confidence interval) over eight survey days was 1.6 (± 0.98) raptors/hr. As in previous years (see Hemmera 2010a), highest spring passage rates and raptor numbers were in mid-April. Passage rates are consistent with observations from spring 2008 and 2009 (Hemmera 2009a, 2010a).

**Table 3-2 Spring 2010 passage rates, Bear Mountain**

Date	Start	End	Survey Effort (hours)	Number of Raptors	Passage Rate (birds/hr)
25-Mar	9:45	16:10	6.42	0	0.0
27-Mar	9:15	16:15	7.00	2	0.3
28-Mar	9:20	16:30	7.17	11	1.5
9-Apr	10:15	16:45	6.50	9	1.4
14-Apr	9:30	16:00	6.50	22	3.4
16-Apr	9:15	15:15	6.00	16	2.7
21-Apr	8:00	14:15	6.25	22	3.5
26-Apr	9:00	15:00	6.00	2	0.3
			<b>MEAN</b>	<b>10.5</b>	<b>1.6 ± 0.98</b>
			<b>TOTAL</b>	<b>84</b>	

Spring 2010 surveys captured increased golden eagle activity over previous spring seasons (30 GOEA in 2010 compared to three GOEA in 2009 and nine GOEA in 2008), in part due to the three surveys conducted in late March targeting this movement (**Figure 3-3**). However, two surveys were conducted in late March 2009 (24<sup>th</sup> and 25<sup>th</sup> 2009) and failed to observe any golden eagles. Overall, golden eagles accounted for 36% (30) of the total raptor detections (n=84) in spring 2010. The next most numerous raptors were red-tailed hawks and northern harriers accounting for 27% (25) and 8% (7) of the total detections respectively. All of the northern harriers were observed on 21 April. There was a general lack of extended periods of poor weather in April 2010 and therefore, raptors did not appear to concentrate or stack up waiting for appropriate migratory conditions and hence there were no large movements or pulses observed as in 2009 (Hemmera 2010a).



**Figure 3-3** Distribution of raptor species by date (March 25 omitted – no raptors observed)

### 3.2.2 Autumn 2010

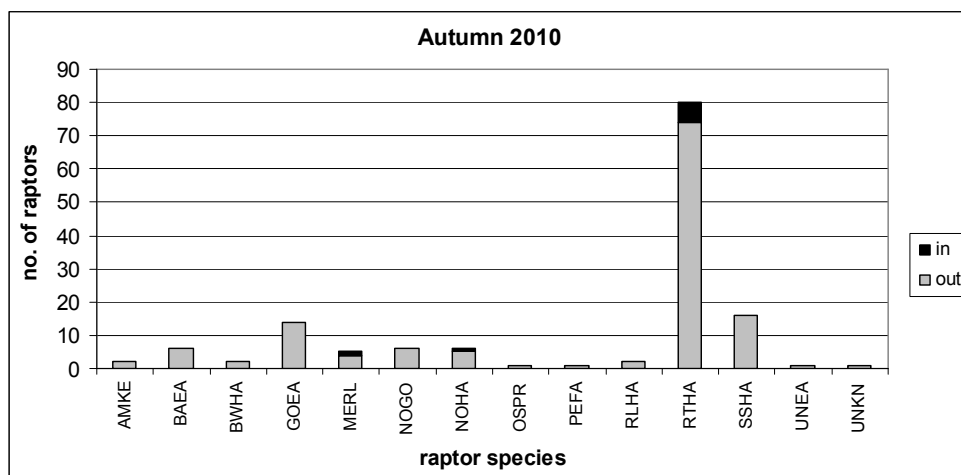
In fall 2010, 151 raptors of 12 species were detected. Two raptors were not identified to species (UNKN or unknown eagle, UNEA) typically due to visibility constraints at the distance the birds were observed (**Table 3-3** and **Figure 3-4**).

**Table 3-3** Raptor species observed in the Bear Mountain Project area, autumn 2010

Common Name	Scientific Name	BC List	COSEWIC
bald eagle (BAEA)	<i>Haliaeetus leucocephalus</i>	Yellow	Not at Risk
golden eagle (GOEA)	<i>Aquila chrysaetos</i>	Yellow	Not at Risk
northern harrier (NOHA)	<i>Circus cyaneus</i>	Yellow	Not at Risk
sharp-shinned hawk (SSHA)	<i>Accipiter striatus</i>	Yellow	Not at Risk
northern goshawk (NOGO)	<i>Accipiter gentilis atricapilus</i>	Yellow	Not assessed
broad-winged hawk (BWAH)	<i>Buteo platypterus</i>	Blue	Not assessed

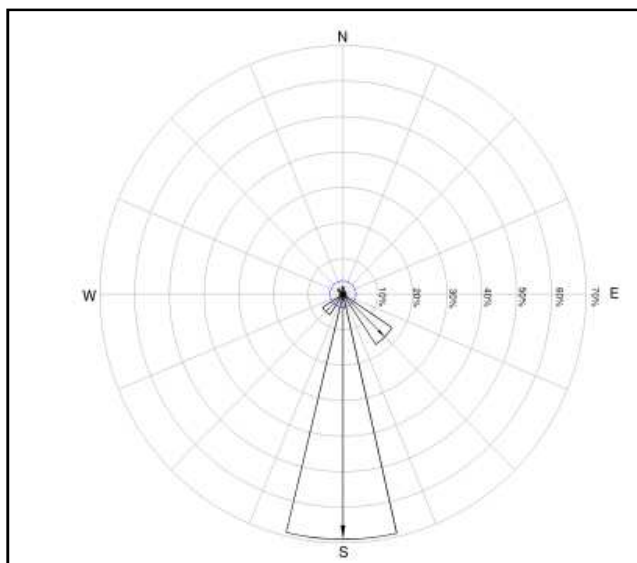
Common Name	Scientific Name	BC List	COSEWIC
rough-legged hawk (RLHA)	<i>Buteo lagopus</i>	Blue	Not at Risk
red-tailed hawk (RTHA)	<i>Buteo jamaicensis</i>	Yellow	Not at Risk
peregrine falcon (PEFA)	<i>Falco peregrinus anatum</i> , <i>tundrius</i> subspecies possible	<i>anatum</i> - Red <i>tundrius</i> - unknown	<i>anatum</i> Special concern <i>Tundrius</i> Special concern
American kestrel (AMKE)	<i>Falco sparverius</i>	Yellow	Not assessed
merlin (MERL)	<i>Falco columbarius</i>	Yellow	Not at Risk
osprey (OSPR)	<i>Pandion haliaetus</i>	Yellow	Not assessed

Most raptors observed (89.4%) did not exhibit flight paths, altitudes, and / or behaviours that put them within the turbine airspace (flight under 150m and intersecting the ridge), 5.3% did have potential to interact with turbines. For 5.3% of raptor observations there was unknown potential for interaction (i.e., a flight path that may have put them over the ridgeline below 150 m). No collisions were observed during autumn 2010 raptor surveys and no raptor carcasses were detected during autumn 2010 carcass search events on Bear Mountain (§ 4). Red-tailed hawk and sharp-shinned hawk were the most frequently seen raptor species followed by golden eagle, merlin, northern harrier, bald eagle and northern goshawk (Figure 3-4). Results from autumn 2010 are consistent with those from autumn 2009 (Hemmera 2010a).



**Figure 3-4 Raptor observations in relation to turbine air space (“in” or “out”side turbine air space), by species; Bear Mountain autumn 2010**

Most of the raptors observed (87 of 151, or 57.6% of behavioural observations recorded) exhibited behaviour such as continuous soaring and gliding flight in a southerly direction (S, SE or SW) that is considered to represent migratory activity; as opposed to kiting, hunting, or perching behaviours that are considered to indicate residency or possibly stopover behaviour (Figure 3-5). Fifty seven of the total 151 observations did not exhibit a consistent directional heading or migration behaviours; the majority of these (n=51) were red-tailed hawks hunting in the Kiskatinaw Valley below Bear Mountain, and many of the observations are considered to be a resident pair that was frequently recorded (§ 3.2.1).



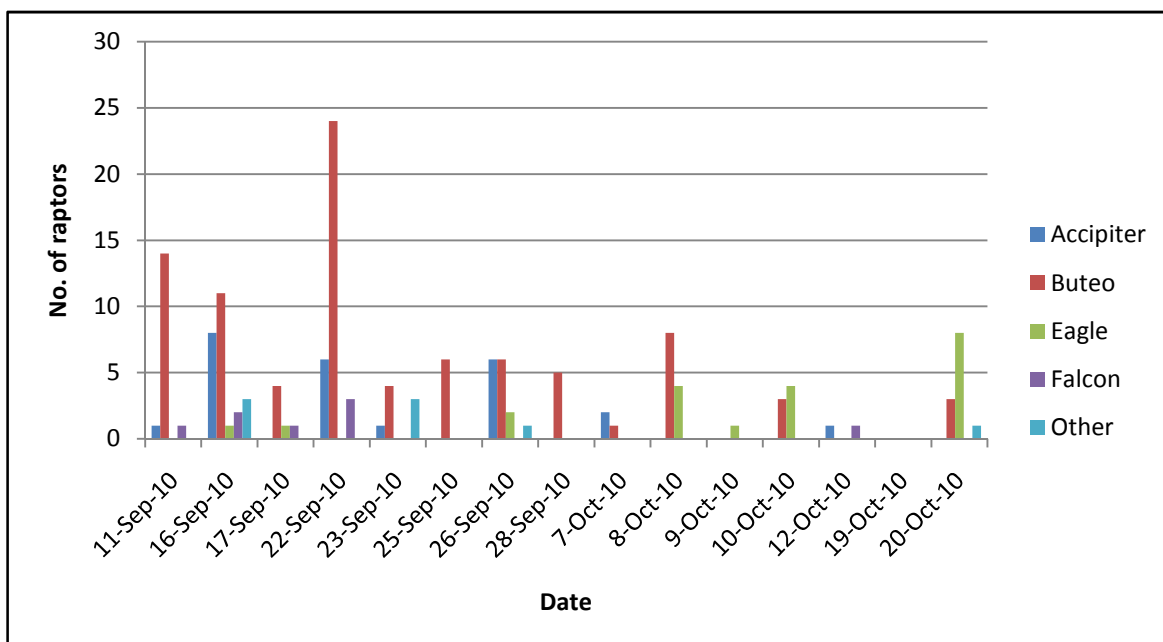
**Figure 3-5 Raptor direction of travel, autumn 2010, Bear Mountain. n=151, 57 observations are not shown – these did not exhibit a consistent direction of travel**

**Notes:** Proportion of total raptor detections moving in each of 16 directions delineated by 15 degree increments (i.e., N, NNE, NE, ENE, E,...). The blue concentric circle represents the proportion of observations that did not have an associated direction of travel.

Passage rates observed in autumn 2010 were highly variable (**Table 3-4**) ranging from a low of 0 raptors/hr on 19 October 2010 to a high of 5.50 raptors/hr on 22 September 2010. These results were lower than in previous years' of surveying (Hemmera 2010a). The mean passage rate (and 95% confidence interval) over 15 survey days was  $1.73 \pm 0.8$  raptors/hr. Passage rates fluctuated throughout the survey period likely relating to weather conditions, and no obvious peak in migratory raptor activity was observed (**Table 3-4** and **Figure 3-6**).

**Table 3-4 Survey effort and raptor passage rates, Bear Mountain, autumn 2010**

Date	Start	End	Survey effort (hrs)	No. of raptors	Passage rate (birds/hr)
11-Sep	10:30	15:00	4.50	16	3.56
16-Sep	8:50	15:00	6.17	25	4.05
17-Sep	10:00	16:00	6.00	6	1.00
22-Sep	10:00	16:00	6.00	33	5.50
23-Sep	9:20	15:30	6.17	8	1.30
25-Sep	9:45	16:00	6.25	6	0.96
26-Sep	9:50	16:00	6.17	15	2.43
28-Sep	10:00	16:00	6.00	5	0.83
7-Oct	10:00	16:00	6.00	3	0.50
8-Oct	10:00	16:00	6.00	12	2.00
9-Oct	9:40	16:00	6.33	1	0.16
10-Oct	9:30	13:30	4.00	7	1.75
12-Oct	10:00	16:00	6.00	2	0.33
19-Oct	10:00	11:45	1.75	0	0.00
20-Oct	9:35	17:30	7.92	12	1.52
<b>MEAN</b>			<b>5.68</b>	<b>10.07</b>	<b>1.73±0.8</b>
<b>TOTAL</b>			<b>85.25</b>	<b>151.00</b>	



**Figure 3-6 Raptor species composition and frequency, Bear Mountain autumn 2010**

### 3.2.3 Raptor Stand Watch Summary 2007-2010

Three spring (2008, 2009 and 2010) and four autumn (2007, 2008, 2009 and 2010) migration periods have been surveyed at Bear Mountain. There have been 1367 observations from fourteen species of raptors, and northern hawk owl (**Table 3-5**). Two spring (2008 and 2009) and two autumn (2007 and 2008) raptor migration period surveys were conducted prior to commencement of operations (n = 50 survey days), and one spring (2010) and two autumn (2009 and 2010) were conducted during operations (n = 39 survey days).

**Table 3-5 Raptor species observed during spring and autumn stand watches at Bear Mountain, autumn 2007 – autumn 2010**

Common Name	Scientific Name	BC List	COSEWIC
golden eagle (GOEA)	<i>Aquila chrysaetos</i>	Yellow	Not at Risk
bald eagle (BAEA)	<i>Haliaeetus leucocephalus</i>	Yellow	Not at Risk
northern harrier (NOHA)	<i>Circus cyaneus</i>	Yellow	Not at Risk
Coopers hawk (COHA)	<i>Accipiter cooperii</i>	Yellow	Not at Risk
sharp-shinned hawk (SSHA)	<i>Accipiter striatus</i>	Yellow	Not at Risk
northern goshawk (NOGO)	<i>Accipiter gentilis atricapilus</i>	Yellow	Not assessed
broad-winged hawk (BWAH)	<i>Buteo platypterus</i>	Blue	Not assessed
red-tailed hawk (RTHA)	<i>Buteo jamaicensis</i>	Yellow	Not at Risk
rough-legged hawk (RLHA)	<i>Buteo lagopus</i>	Blue	Not at Risk
osprey (OSPR)	<i>Pandion haliaetus</i>	Yellow	Not assessed
American kestrel (AMKE)	<i>Falco sparverius</i>	Yellow	Not assessed
merlin (MERL)	<i>Falco columbarius</i>	Yellow	Not at Risk
peregrine falcon (PEFA)	<i>Falco peregrinus anatum, tundrius</i> subspecies possible	<i>anatum</i> - Red <i>tundrius</i> - unknown	<i>anatum</i> Special concern <i>tundrius</i> Special concern
gyrfalcon (GYRF)	<i>Falco rusticolus</i>	Blue	Not at Risk
Northern hawk owl	<i>Surnia ulula</i>	Yellow	Not at Risk

Survey effort in the pre-operation period was 50 days (296.5 hours), and 835 raptors were observed and monitored at Bear Mountain. A full summary of the pre-commissioning period is in Hemmera (2010a). During operation 39 days of raptor stand watch surveys have been conducted (226.1 hours); 532 raptors have been observed.

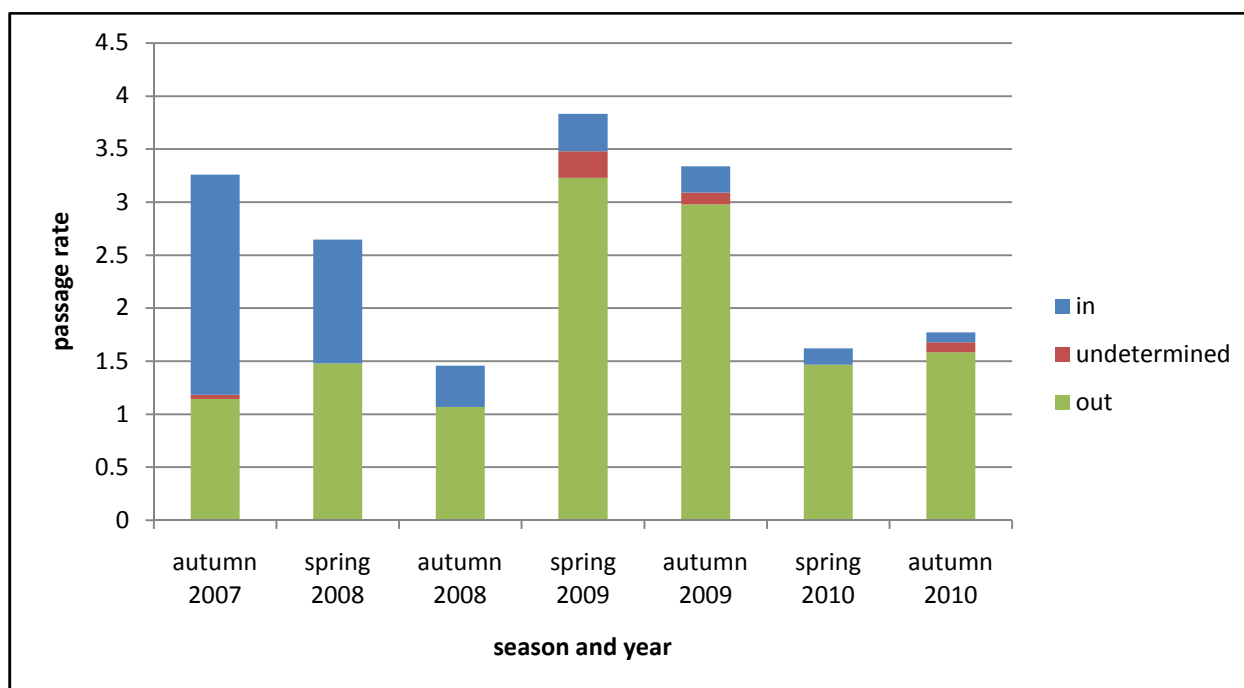
Most raptors observed during pre-operation and operation, in both seasons, were considered to be on migration (**Table 3-6**). Direction of travel and behavioural observations (gliding, flapping and soaring behaviours indicate migration, and kiting, hunting, roosting or perching behaviours are considered to indicate residency or stopover behaviours). Directions of travel considered indicative of migratory behaviour were N, NW and NE in spring, and S, SW and SE in autumn. Many of the small proportion of

raptors that were not on migration were likely repeat observations of Kiskatinaw Valley resident red-tailed hawks.

**Table 3-6 Proportion of raptor observations considered on migration in spring and autumn stand watches at Bear Mountain, autumn 2007 – autumn 2010 for pre-operation and operation phases of the project**

Season	Project Status	On Migration
Autumn (2007, 2008)	Pre-operation	82.0%
Spring (2008, 2009)	Pre-operation	60.7%
Autumn (2009, 2010)	Operation	72.8%
Spring (2010)	Operation	85.7%

The proportion of raptor observations that were considered to be in the rotor-swept area of proposed turbines, as compared to those that were considered to be outside turbine air space changed during the pre-operation monitoring period. In autumn 2007 and spring 2008 the passage rates of raptors considered in the turbine air space were high (around or more than half of all observations), but since autumn 2008 those considered in the turbine-swept area were a much lower proportion of the total (Figure 3-7).

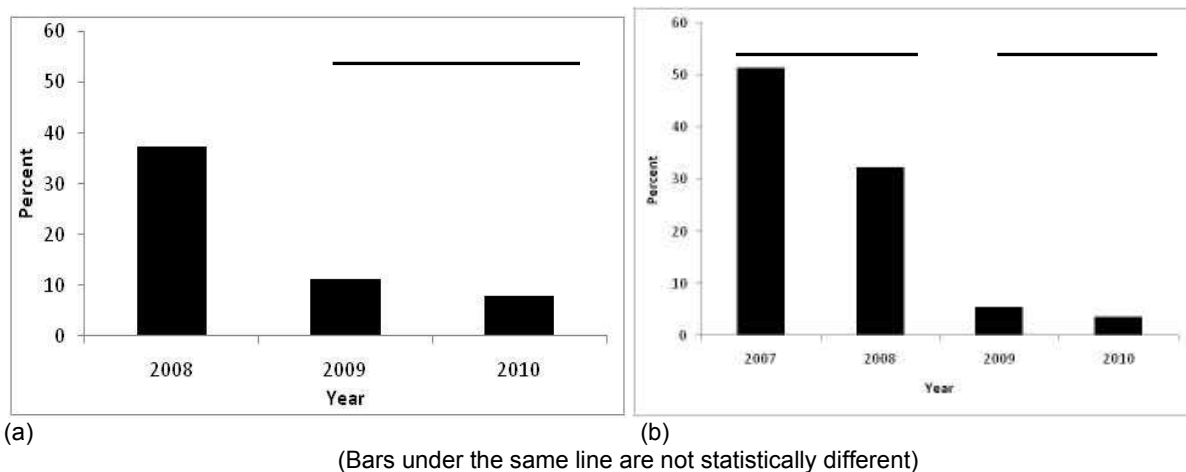


**Figure 3-7 Passage rates (birds/hr) of raptors in relation to turbine air space (“in” or “out” side of turbine air space); Bear Mountain autumn 2007 – spring 2009**

In 2009 (Hemmera 2010a) there were statistically significant differences in the proportion of raptors using turbine air space during spring migrations between 2008 and 2009 (fewer raptors in turbine air space in

2009 compared to 2008), in the proportion of raptors in the turbine air space during autumn migrations between 2007 and 2008 (fewer raptors in turbine air space in 2008 compared to 2007), between autumn 2008 and 2009 (fewer raptors in turbine airspace in 2009 compared to 2008); and between 2007 and 2009 a decrease in the proportion of raptors that were considered in turbine air space. Possible explanations for this trend include neophobia, where raptors show a reluctance to approach new things (cleared areas in autumn 2008, plus construction, and towers in 2009), and different weather/climate patterns between years during migration (more or less need for raptors to approach the Bear Mountain escarpment depending on temperature and winds). Also, as construction progressed and turbines were erected, it was increasingly easier to assess whether raptors were actually flying through the turbine airspace, rather than relying on predictions of where as yet un-built turbines might be.

A more fulsome analysis of these results, including the data from 2010 was conducted to explore the difference in observations between multiple years, rather than between pairs of years as above. Normality of the data was assessed as being right skewed, using normal probability plots and the Shapiro-Wilk normality test. A square root transformation was applied in an unsuccessful attempt to normalize the data, therefore, non-parametric statistics were used. Kruskal-Wallis One-Way Analysis of Variance was used to test for differences between years in the percentage of raptors flying within turbine air space during spring and autumn. When statistically significant differences were found, pair-wise comparisons were conducted using the non-parametric Mann-Whitney test to identify differences between years, of raptors in the rotor-swept area. The spring data show a significant difference between 2008, and 2009 and 2010 (**Figure 3-8a** and **Table 3-7**). The autumn data show significant differences between 2007 and 2008, and 2009 and 2010 (**Figure 3-8b** and **Table 3-8**). There have been no changes noted in the proportion of raptors in (and out) of turbine air space in the last two years for both spring and autumn.



**Figure 3-8 Proportion of raptors in turbine air space in spring (a) and autumn (b)**

**Table 3-7 Probabilities (a) and test statistics (b) for Mann-Whitney test for the proportions of raptors in turbine air space spring 2008 – 2010, Bear Mountain**

Kruskal-Wallis Test Statistic (K) = 7.6, P = 0.02 (assuming Chi-square distribution with 2 df)  
and Mann-Whitney test.

Two-sided Probabilities			
Year	2008	2009	2010
2008	1		
2009	0.03	1	
2010	0.01	0.91	1

(a)

Test statistics (Chi-square approximation with 1 df)			
Year	2008	2009	2010
2008	1		
2009	4.7	1	
2010	6.5	0.01	1

(b)

**Table 3-8 Probabilities (a) and test statistics (b) for Mann-Whitney test for the proportions of raptors in turbine air space autumn 2007 – 2010, Bear Mountain.**

Kruskal-Wallis Test Statistic (K) = 31.2, P < 0.001 (assuming Chi-square distribution with 3 df)  
and Mann-Whitney test.

Two-sided Probabilities				
Year	2007	2008	2009	2010
2007	1			
2008	0.09	1		
2009	< 0.001	0.001	1	
2010	< 0.001	0.001	0.48	1

(a)

Test statistics (Chi-square approximation, 1 df)				
Year	2007	2008	2009	2010
2007	1			
2008	2.9	1		
2009	16.8	10.9	1	
2010	17.8	11.6	0.49	1

(b)

### 3.3 DISCUSSION

The potential for the Bear Mountain Wind project to have an impact on raptors was driven in part by the known impacts from other projects, especially Altamont Pass in California, USA and Tarifa, Spain, and uncertainty about the impacts at Bear Mountain because there were no operational projects in BC. The impacts on raptors at Altamont Pass (Thelander *et al.* 2003) are anomalous compared to those of wind energy projects in other locations (Erikson *et al.* 2001, NRC 2007), and are primarily driven by a combination of high raptor numbers and the presence of abundant prey for red-tailed hawk and golden eagle (Curry and Kerlinger 1998, Thelander *et al.* 2003). At Tarifa impacts are primarily to winter resident griffon vulture and summer resident common kestrel, rather than to migrating raptors which use routes some distance from turbines (Barrios and Rodriguez 2004). The impacts were attributed to hunting behaviours and the relation to heterogeneous wind patterns across the wind energy project. Impacts to raptors at wind energy sites in North America other than Altamont Pass, and at Tarifa are very low;

typically around 0.05 raptors / turbine / year (Kuvlesky *et al.* 2007), or like Bear Mountain (below and Kerlinger 2002, Schmidt *et al.* 2003) too few or no carcasses were found for analyses to be conducted.

Migratory raptor monitoring in 2010 and previous years show raptors are present, but that they infrequently are close enough to interact with turbines at Bear Mountain. An exception was a pair of Kiskatinaw Valley resident red-tailed hawks that successfully fledged two juveniles – all of whom were observed kiting and gliding within 100 m of turbines without incident. In 2010, less than 10% of spring and autumn observations were in turbine airspace. These raptor interaction estimates are conservative because from most stand watch sites at Bear Mountain the location of a raptor relative to airspace between turbines (no impact) or in turbine airspace (potential for impact) is difficult to judge. Observers consider any raptor over the Bear Mountain ridge within 150 m of ground level (turbines are 120 m high) to be potentially in turbine airspace. Most of the observations of raptors during stand watches at Bear Mountain are over the Kiskatinaw Valley and Fellers Heights to the south and west of Bear Mountain.

The behaviours exhibited by raptors when observed are typically gliding, soaring, or for smaller raptors flapping in powered flight. These behaviours and their direction of travel (66% of spring observations, n=395 and 77.7% of autumn observations, n=972) are indicative of raptors that are on migration, not of raptors that are exploiting available prey items (hunting), an activity that appears to put them more at risk of colliding with turbines (Barrios and Rodriguez 2004, Thelander *et al.* 2003, NRC 2007, Kuvlesky *et al.* 2007). Hunting activity was frequently observed in the agricultural fields of the Kiskatinaw Valley below Bear Mountain, particularly by red-tailed hawks. This, and other likely opportunistic feeding while on migration, has been observed in agricultural fields surrounding Bear Mountain and Dawson Creek over the survey period, particularly during inclement weather (*pers. obs.*).

One raptor fatality was documented at Bear Mountain during 2010 (none during 2009). A female northern harrier was found near turbine 1 in June 2010, apparently hit by turbine blades – nape laceration. The fresh carcass was found by the plant manager during the daily early-morning survey of the entire project area after a night with extremely low and dense cloud cover. Corrections for searcher efficiency, carcass removal, and search area bias were not applied to the single raptor observation. This fatality was included with other birds when estimating bird fatalities. Searcher efficiency for raptors (large bird category) was very high (100%) and there is confidence that any larger birds would be found either in carcass search events, or during daily site checks by the plant manager.

### **3.4 RAPTOR MONITORING SUMMARY**

Migratory raptor stand watch activities in 2010, and previous to that since autumn 2007, show an extensive knowledge of raptor migration patterns that is now known from Bear Mountain. From 89 days of migratory raptor stand watches (522.6 hours) there have been 1367 raptor observations. The majority of the observations are consistent with headings and behaviours for raptors that are on migration, not

raptors that are hunting or breeding in the wind energy project area – activities that are regarded to put raptors at more risk from wind turbines. Further, the observations show that only a small proportion of the raptors observed at Bear Mountain use airspace in which the turbines are operating; most are using what appears to be a migration route over the adjacent Kiskatinaw Valley. The sole raptor fatality recovered during carcass searches (**§4**) was recovered in early June, outside the migration period.

The raptor stand watch activities completed are consistent with the requirements of the Program (Hemmera 2007) and the provincial and federal environmental assessment approvals; with amendments as identified by TAC (Hemmera 2008, 2009a and b, 2010a and b). Further, the impacts on raptors from operation continue to suggest that there are no significant adverse impacts to raptors from Bear Mountain Wind Park (Aeolis 2006). There are no indications that operational mitigation is required. Given the on-going carcass search events at Bear Mountain, which give an understanding of actual impacts, continuation of raptor stand watches in 2011 to predict impacts based on raptor numbers, behaviours and migration routes is considered unnecessary.

## 4.0 BAT AND BIRD FATALITY MONITORING (CARCASS SEARCHES)

The pilot carcass search program conducted in 2009 (Hemmera 2010a), concluded that the effort required to search forested portions of the study plots coupled with the searchers low ability to detect small birds and bats in this habitat would be better spent searching smaller areas with a higher likelihood of carcass deposition more frequently. Based on this conclusion and through discussion with the TAC, a reduction in plot size was considered appropriate to allow all turbines to be visited in a single day by two searchers working independently. Plot sizes varied but typically included the turbine pad, access road, and transmission line right of way (**Figure 4-1**). The turbine pad and access road were generally clear of vegetation (with the exception of the edges), while the transmission line right of way was a combination of bare ground, chipped wood, and regenerating vegetation (typically fireweed and a mix of clover and grasses). Searches were conducted twice weekly, with either 2 or 3 days between searches. Bias trials were conducted to evaluate searcher efficiency and scavenger removal using fresh (previously frozen) carcasses and to provide correction factors for estimating fatalities. A correction factor was also developed to correct fatality estimates for varying plot sizes.

### 4.1 METHODS

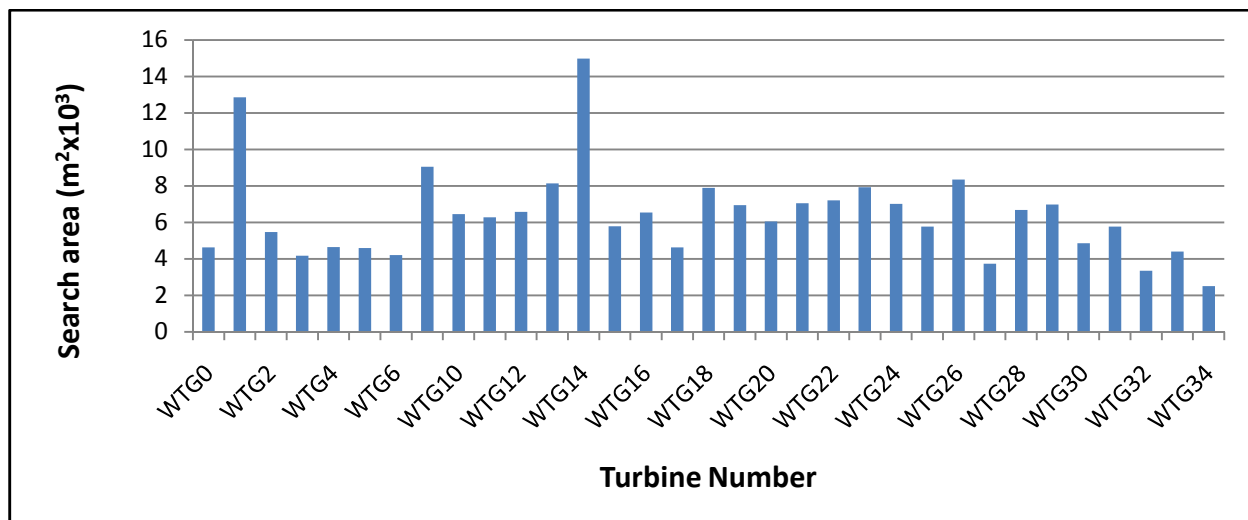
Thirty-four variable sized plots (**Figure 4-1**) were searched twice per week between 20 April and 27 September 2010; the period when resident birds and bats were present and with peak movements of temperate migrant songbirds, waterfowl, raptors, shorebirds, neotropical migrants, and migratory bats. Mean plot size was  $6411 \text{ m}^2 \pm 850 \text{ m}^2$  (95% CI) or approximately 40 m x 40 m. Plots were typically not centered on turbines, but extended further into the cleared area (usually east of the turbines) rather than to the west (often cliff/bluff and/or heavily forested). This corresponds to a greater search area on the lee side of the predominant (SW) wind direction where a greater number of carcasses were expected to be deposited. All turbines were searched during each event with the exceptions of August 16 and 17 and September 9 and 10 (half of the plots were searched each day and the pairs were each considered an independent event). Each turbine was sampled 48 times during the period. Thirty-two of the plots focussed on the turbine pad, access road, and transmission line right of way and mainly avoided forested areas (except approximately 5 m directly adjacent to these cleared areas). Two 100 m x 100 m plots were set up around T1 and T14; including forested areas to obtain an estimate for carcasses in forest areas that were not searched at the other turbine locations.







**Figure 4-1** Search plots and turbine locations surveyed twice weekly during 2010 bat and bird fatality monitoring (Tiles 1-3)



**Figure 4-2 Search plot areas by turbine number**

Searches were conducted twice weekly, with either three or four nights between searches (two or three days), the mean search interval was 3.45 nights  $\pm$  0.17 (95% CI). A nightly average value is reported and used in fatality estimates as that is the time when bats and most migratory birds are at risk of collision. The mean number of days between searches was 2.39  $\pm$  0.22. The order in which turbines were searched followed a four event pattern:

- **Event 1:** searchers start on opposite ends of the array working towards the middle (searcher 1 - T0-17; searcher 2 - T34-18);
- **Event 2:** searchers start in the middle working toward the ends (searcher 1 - T18-34; searcher 2 - T17-0);
- **Event 3:** one searcher starts one quarter of the way from the north end of the array and proceeds to the three-quarter mark of the array while the other searcher searches the ends of the array (searcher 1 - T10-27; searcher 2 - T0-8 and 34-27); and
- **Event 4:** opposite of Event 3 (searcher 1 - T27-34 and 8-0, searcher 2 - T27-10).

This search regime was designed to account for individual searcher and time of day biases. Carcass searches were typically initiated within an hour of civil daylight to reduce the probability of scavengers removing carcasses, as such, start times varied throughout the season. Searchers typically walked the perimeter of the plot looking outward along the edges of the turbine pad and into the forested boundary. Following the perimeter search, the rest of the plot would be searched along transects spaced 5 – 10 m depending on ground cover (vegetated or areas with chipped wood were given more search effort than areas with bare ground). No correction was provided for habitat type; however, the vast majority of the area sampled was bare ground. Normal plot searches took approximately 20 minutes to complete while full searches around T1 and T14 typically took between 45 minutes and one hour.

#### 4.1.1 Data Collection

The following data, consistent with EC (2007) were collected during carcass searches:

- Date, start and end time, and search area at each turbine; and
- For each carcass the following information was recorded: date and time of detection, condition (intact, scavenged, or feather spot) and estimated time of death (where possible), extent and type of injury, species, sex and age (where possible), distance and direction of nearest turbine, UTM coordinates of location, substrate type, photograph (generally).

Weather variables including wind speed, direction, temperature, and barometric pressure were derived from data from meteorological tower 17 (in the middle of the turbine array **Figure 4-1, Tile 2**) to provide a standardized characterization of nightly weather.

Categories used to estimate the carcass condition were (as per Johnson *et al.* 2003):

- Intact – none to minor decomposition with no signs of predation or scavenging;
- Scavenged – a full or partial carcass exhibiting signs of predation/scavenging;
- Feather Spot (birds only) – ten or more feathers at a single location (indicator of scavenging or predation).

Recovered carcasses were placed in a labelled Ziploc bag (date, time, UTM, species and sex/age if possible, and unique ID number) and stored in an on-site freezer. Bat species and sex (penis presence / absence) were determined using the identification key from Nagorsen and Brigham (1993). Bats were aged by the absence/presence of swollen digits (Nagorsen and Brigham 1993) and/or pale bands on either side of digit joints indicating incomplete ossification associated with juvenile bats (Hutson and Racey 2004). Provincial and federal permits required as part of this monitoring program were sought and obtained from regulatory agencies (BC MOE and EC/CWS).

#### 4.1.2 Searcher Efficiency Bias Trial

Typically, researchers looking for avian and bat carcasses only detect a portion of the carcasses available in a study area (Smallwood *et al.*, 2009). It is necessary to test searcher efficiency to provide a correction index for the number of bird and bat carcasses that were potentially missed during survey efforts.

A searcher efficiency bias trial was conducted by an independent third party placing marked carcasses randomly in the plots prior to a scheduled survey event. A total of 45 previously frozen, fresh carcasses (29 birds and 16 bats) were used for the trial on 15 September 2010. All carcasses were marked using a small piece of duct tape with a unique identifier either around the tarsus (bird carcasses) or around the forearm (bat carcasses). Carcass placement was conducted using random number generation in ArcGIS

to create UTM coordinate pairs within each plot (approximately six coordinate sets per plot). Final carcass placement was determined in the field; UTM coordinates along the access road were avoided due to road grading on the day of carcass planting.

No estimate of searcher efficiency in forested areas can be provided for 2010; however, Hemmera 2010a provides estimates from 2009. The forested portion of the site was searched at two plots (T1 and T14) and fatalities out to 70 m from plot centre were estimated based on data extrapolations from the area searched within increasing 10 m concentric intervals from plot centre and patterns of carcass deposition.

#### 4.1.3 Carcass Removal (Scavenger) Bias Trial

A scavenger removal trial was conducted to determine the length of time that carcasses persist prior to being removed or consumed by scavengers. This trial immediately followed the searcher efficiency trial, and involved the same carcasses (n=45; 29 bird, 16 bat) in the same locations. Carcass presence was checked daily over a seven day period and persisting carcasses were removed after seven days.

#### 4.1.4 Search Area Bias

Due to the unequal search areas around turbines, a correction for search area bias was determined for each 10 m radial increment from hypothetical plot centre (turbine base) in each quadrant (NE, NW, SE, and SW). These turbine specific correction factors included the amount of each polygon searched and the probability that a carcass would be deposited in that polygon based on data collected from recovered carcasses. To determine the area of each search polygon, a hypothetical plot area of radius 70 m (in increasing 10 m concentric circles) was centred on each turbine, divided into four quadrants (NE, NW, SE, SW), and overlaid on the actual plot areas searched at each turbine. The proportion of each hypothetical 10 m polygon in each quadrant searched was then calculated and multiplied by the overall proportion of birds and bats detected in each segment (extrapolated from array wide patterns of carcass deposition) to yield a turbine specific search area correction factor accounting for areas not searched.

#### 4.1.5 Fatality Estimate

Total fatalities and fatalities per turbine were adjusted to account for searcher efficiency and scavenger removal estimates using Baerwald (2008), but adapted to include a term for search area bias:

$$F_e = \left[ \frac{(C/S_c)}{(\sum_{i=1}^l R_i)} \right] + \left\{ \left[ \frac{C}{S_c} - C \right] - S_c \left[ \left( \frac{C}{S_c} - C \right) R_i \right] \right\} + \sum_{i=1}^7 (C \times (1 - A_{s,i}) \times P_i)^*$$

Where  $F_e$  = estimated fatalities,  $C$  = number of carcasses found,  $S_c$  = searcher efficiency,  $R_i$  = proportion of carcasses remaining by the  $i$ th day following initiation of a scavenger removal trial (Smallwood 2007), and  $l$  = search interval in days (mean search interval used). In term three, the correction for search area

bias,  $A_{s,i}$  = area searched in each 10 m interval extending from turbine centre and  $P_i$  = probability of a fatality in a given segment based on fatality data is included. Term three is repeated for each of four quadrants NE, NW, SE, SW which experienced differing rates of carcass deposition and then summed together prior to summing with terms one and two.

#### 4.1.6 Variation in Nightly Fatalities and Weather

Weather data used in fatality correlations (from Met 17) included wind speed at 78 and 38 m, wind direction, temperature, and barometric pressure. All data was provided in 10 min intervals. Wind data was averaged for each night between 22:00 and 05:00 and 22:00 and 01:00 while temperature and barometric pressure were averaged between 22:00 and 01:00 to correspond to the time of night when migratory bats are typically most active (Arnett *et al.*, 2008, Horn *et al.*, 2008). A term to account for a 24 hr change in pressure was determined by subtracting the mean nightly barometric pressure of the previous night from the present mean nightly value. As per Arnett *et al.*, (2005) the proportion of 10 minute intervals on each night with wind speeds less than 4 m/s, between 4-6 m/s, and greater than 6 m/s were also calculated to assess possible correlations with nightly fatalities. To determine the effects of weather variables on nightly fatalities, fatality data from the nights prior to a search event (i.e., fatalities for which night of death could be accurately estimated) were used as an index of bat fatalities.

Initially, univariate analyses (linear regressions) were performed to test correlations between corrected fatality estimates and weather variables. Corrected bat fatalities were split into three categories: migratory tree bats, myotis / Big Brown Bat, and total bat fatalities, this categorization reflects different behaviours and peaks in activity associated with the bat species. Migratory tree bats (Eastern Red, Silver-haired, and Hoary) are known long-distance migrants, obligate tree roosters, and may breed in the project area. Myotis species and Big Brown Bats are grouped together as they likely breed and roost in the project area following dispersion from winter hibernacula (which could exist in the project area). They are known to make localized migrations up to 300 km and may roost in trees, though this is not obligate (Nagorsen and Brigham 1993). Correlations between corrected bird fatalities and weather variables were conducted for the spring and fall migratory periods. All p-values are reported to a 0.05 significance level. Following initial univariate correlations, a stepwise multiple linear regression model was developed to predict nightly variation in total bat fatalities, migratory tree bat fatalities, myotis / Big Brown Bat fatalities, and bird fatalities.  $R^2$  values are provided to assess the amount of nightly variation in fatalities explained by weather variables. A total of 34 nights had at least one fresh bat fatality while only 13 nights had at least one fresh bird fatality. To determine the “best” model for each species group, Akaike’s Information Criterion (AICc) was used, with lower AICc values providing a better fit. AICc values are provided with  $R^2$  and p-values for each model presented.

#### 4.1.7 Variation of Fatalities within Turbine Array

Two approaches were used to detect potential differences in fatality distribution within the turbine array. The first grouped fatalities into four sections based on turbine position. Turbines T0-8 at the northernmost end of the project were grouped together as were turbines T10-17, T18-25, and T26-34 at the south end. The second grouped fatalities into north (T0-17) and south (T18-34). The data could not be normalized despite log, square root, and reciprocal transformation, so Wilcoxon / Kruskal-Wallis non-parametric tests were used to assess differences between the means of the groupings. Analyses were conducted on uncorrected fatality data as fatality estimates do not adjust zero values. Using corrected fatalities for this analysis has the potential to bias results towards turbines where at least one fatality was detected.

## 4.2 RESULTS

### 4.2.1 Distribution of Bat Fatalities

Fifty-three bat carcasses of six species were detected during 2010 (**Table 4-2**). The first bat fatality was on 3 June and the last on 25 September. The identification of Northern Long-eared Myotis (blue-listed) is pending DNA confirmation due to the morphologic similarities with Little Brown Myotis and Western Long-eared Bat (not confirmed present at Bear Mountain) (ASRD and ACA 2009). The Eastern Red Bat fatalities are the first confirmation of this species in BC since 1905; northeast BC likely represents the northwest range limit. Both were found fresh on the morning of 3 August 2010 at turbines 34 and 27. Eastern Red Bat calls were confirmed on 2 and 4 August.

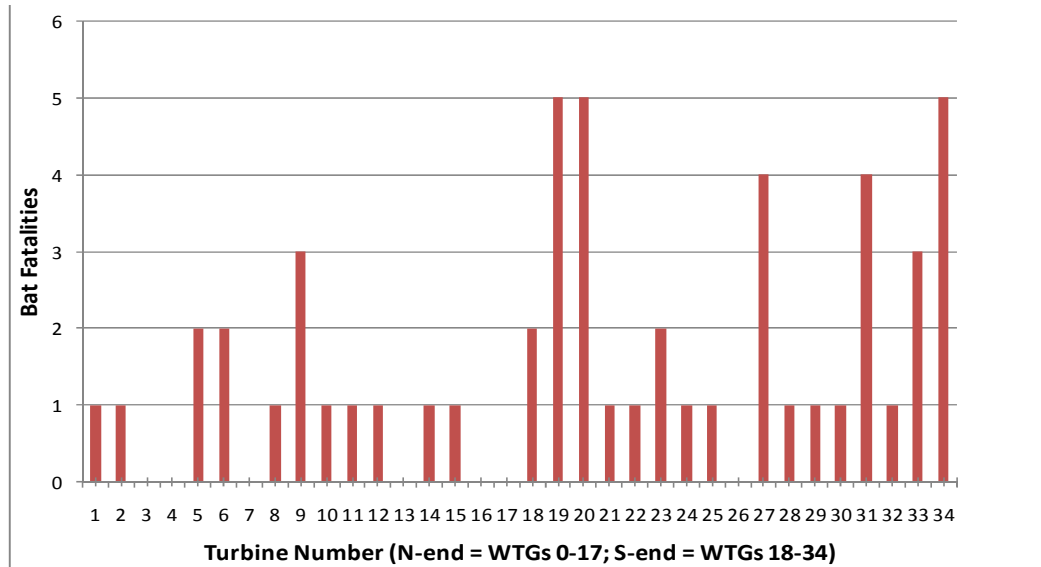
**Table 4-2 Uncorrected bat fatalities by species, Bear Mountain 2010**

Species Code	Latin Name	Common Name	Total Fatalities (%) n = 53
EPFU	<i>Eptesicus fiscus</i>	Big Brown Bat*	6 (11.3%)
LABO*	<i>Lasiurus borealis</i>	Eastern Red Bat*	2 (3.8%)
LACI*	<i>Lasiurus cinereus</i>	Hoary Bat*	1 (1.9%)
LANO*	<i>Lasionycteris noctavigans</i>	Silver-haired Bat*	21 (39.6%)
MYLU	<i>Myotis lucifugus</i>	Little Brown Myotis	18 (34.0)
MYSE	<i>Myotis septentrionalis</i>	Northern Long-eared Myotis	5 (9.4%)

**Note:** \* indicates migratory tree bat.

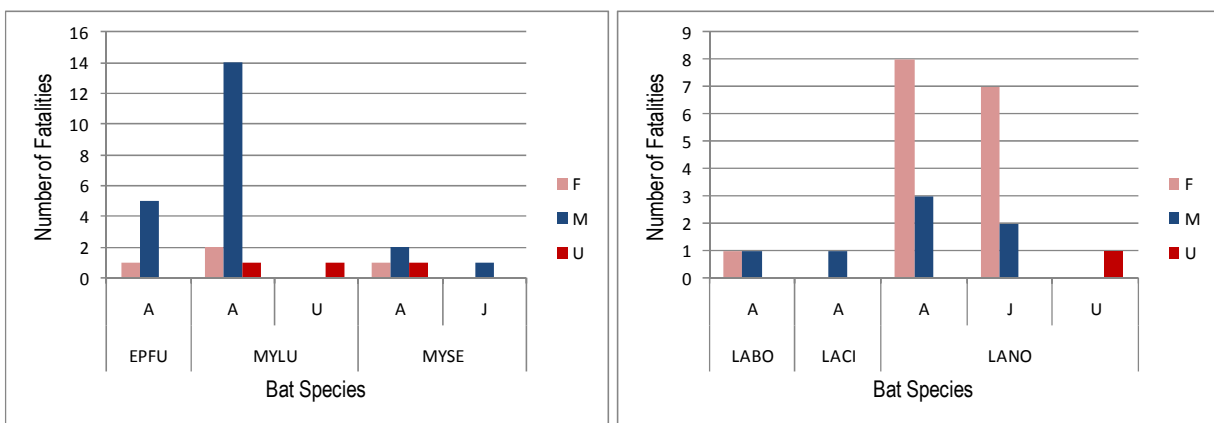
More bat fatalities occurred at the south end of Bear Mountain (**Figure 4-3**); mean uncorrected bat fatalities per turbine at the north and south ends of the turbine array were  $0.44 \pm 0.10SE$  and  $1.12 \pm 0.18SE$  respectively. Significantly more bat fatalities occurred at the south end than at the north end (Wilcoxon one-way test  $X^2 = 8.53$ ,  $df = 1$ ,  $P = 0.0035$ ). Further examination of this trend was conducted using a Wilcoxon one-way test with the number of migratory tree bats and myotis/ Big Brown Bat fatalities as the measurement variables and the location (north or south of turbine array) as the nominal variable. The mean number of migratory tree bat fatalities per turbine between the north and south ends were not significantly different (Wilcoxon one-way test  $X^2 = 3.02$ ,  $df = 1$ ,  $P = 0.082$ ); but, the mean number of myotis /

Big Brown Bat fatalities per turbine differed significantly, with higher mean fatalities at the south end than at the north end (Wilcoxon one-way test  $X^2 = 5.58$ ,  $df=1$ ,  $P= 0.0182$ ).

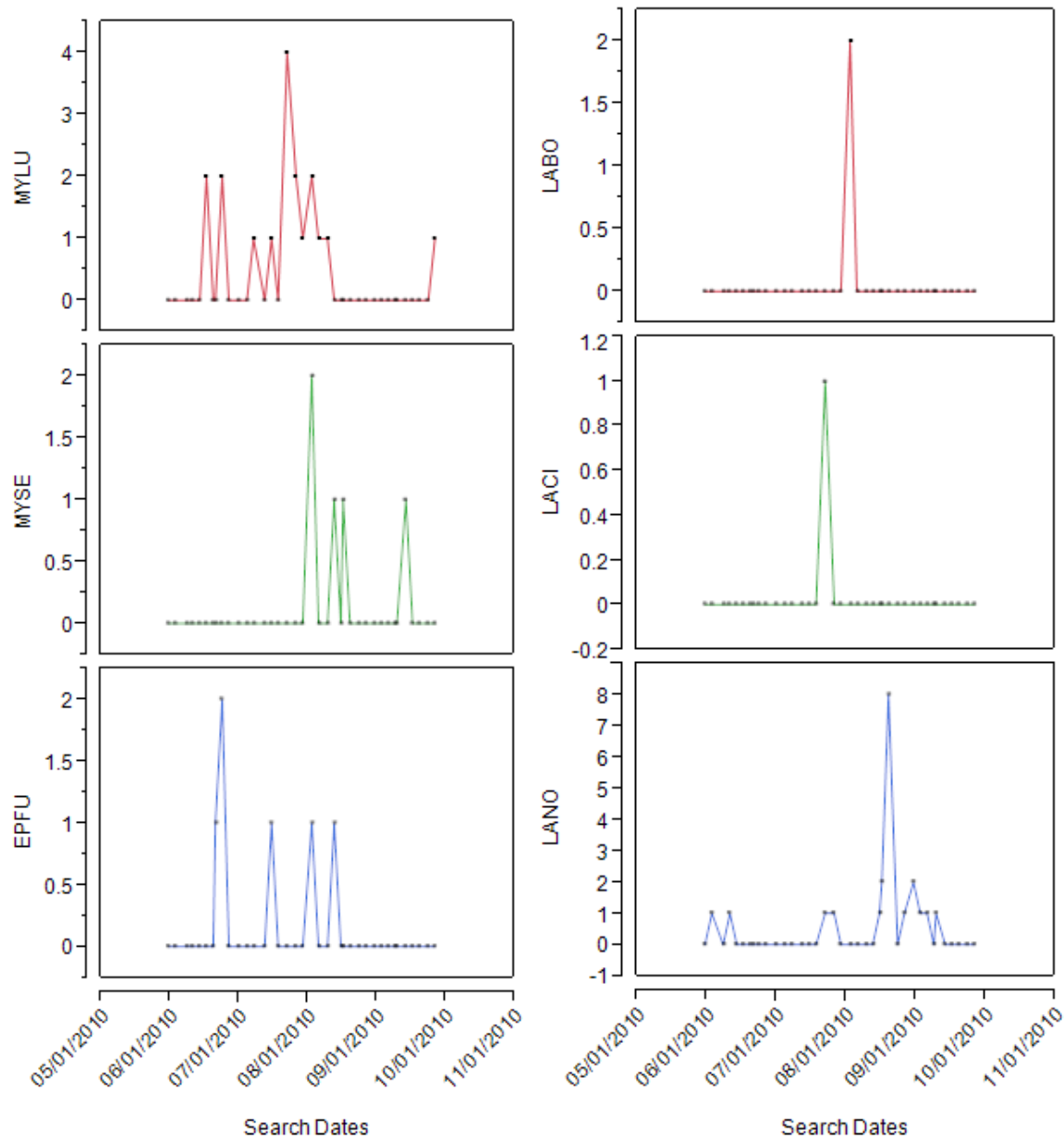


**Figure 4-3** Number of bat fatalities recovered by turbine, Bear Mountain 2010 (n = 53)

Most species recovered during carcass searches were Silver-haired Bat (21/53 fatalities) and Little Brown Myotis (18/53) (Figure 4-4). The fatalities of these species demonstrated different demographics, with primarily adult males of Little Brown Myotis (14 of 17 where sex and age determination was possible and no juveniles) and primarily female Silver-haired Bat (15 of 21, including seven juveniles). The male-skewed distribution of Little Brown Myotis fatalities is consistent with the sex structure of these species found during 2006 mist-net sampling (Aeolis 2006).



**Figure 4-4** Bat fatalities by species and age for, a) myotis / Big Brown Bat, and b) migratory tree bats. A = adult, J = juvenile, M = male, F = female, U = unknown, EPFU = Big Brown Bat, MYLU = Little Brown Myotis, MYSE = Northern Long-eared Myotis, LABO = Eastern Red Bat, LACI = Hoary Bat, LANO = Silver-haired Bat)



**Figure 4-5 Bat species recovered during carcass searches by date, Bear Mountain 2010 (EPFU = Big Brown Bat, MYLU = Little Brown Myotis, MYSE = Northern Long-eared Myotis, LABO = Eastern Red Bat, LACI = Hoary Bat, LANO = Silver-haired Bat)**

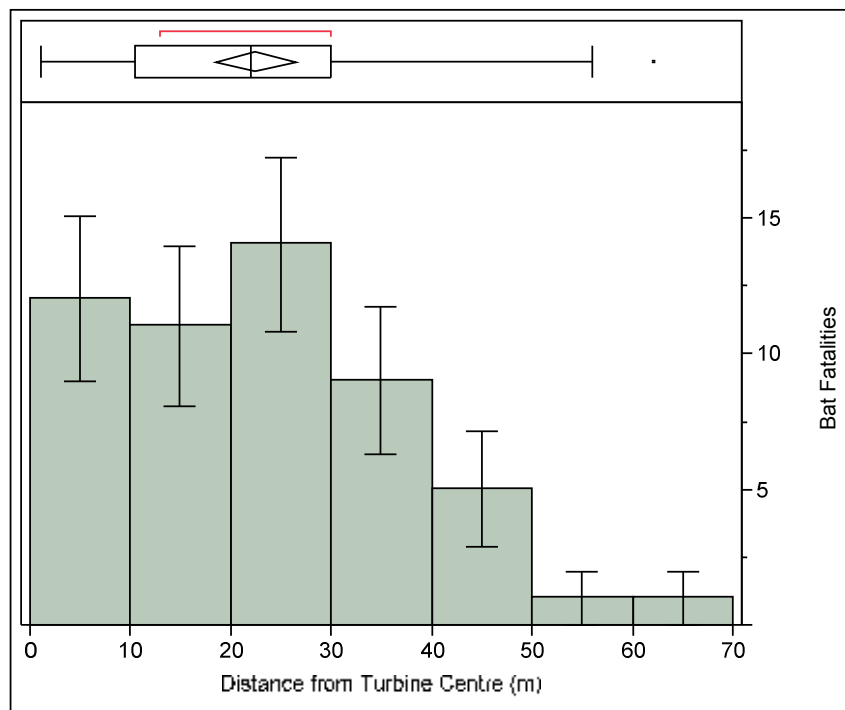
Little Brown Myotis and Big Brown Bat fatalities were recovered during approximately the same period; which might be expected of individuals from resident populations (Figure 4-5). Several of the Silver-haired Bat fatalities considered outliers are likely spring migrants. The two Silver-haired Bat detections from late July could be local breeders. The sole Hoary Bat fatality could be a local breeder, the first acoustic detection of this species on 8 July indicate a summer resident. The first acoustic detection of Eastern Red Bat on 2 August may indicate it is an early migrant in north-east BC. The first Northern Long-

eared Myotis fatality was found at the beginning of August, with fatalities collected until the end of September, potentially associated with movement to fall swarming locations and/or migration to winter hibernacula. Eight Silver-haired Bat fatalities were found on 19 August (the highest number of bat carcasses recorded during a search event), though only six were considered fresh. Of the total carcass detections, 24 were of migratory tree bats while 29 were myotis/Big Brown Bat; however, there was no significant difference between the mean number of migratory tree bat and myotis/Big Brown Bat fatalities per turbine (Wilcoxon  $X^2 = 0.05$ ,  $df = 1$ ,  $P = 0.816$ ).

The mean distance of bat fatalities to the centre of the closest turbine was  $22.38 \text{ m} \pm 1.98\text{SE}$  (**Figure 4-6**). The one bat carcass recovered between 60-70 m from turbine centre is an outlier (see box plot above **Figure 4-7**). Ninety percent of bat carcasses were found within 43 m of the nearest turbine and approximately 75% were within 30 m (**Figure 4-6** and **Table 4-3**).

**Table 4-3 Bat carcasses recovered in successive 10 m intervals from turbine centre, Bear Mountain 2010**

Distance from WTG	0-10	10-20	20-30	30-40	40-50	50-60	60-70	Total
No. of bats	12	11	14	9	5	1	1	53
Proportion of bats	22.64	20.75	26.42	16.98	9.43	1.89	1.89	100



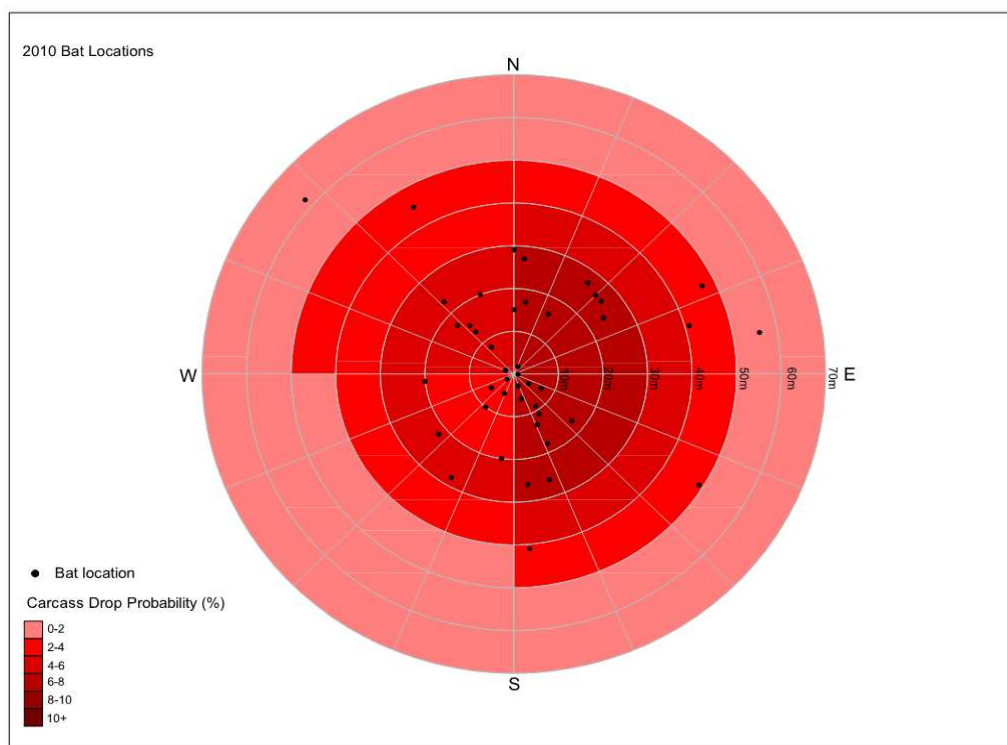
**Figure 4-6 Bat fatalities (with standard error bars) and distance from centre of nearest turbine (m), with a box plot showing quartiles – note outlier value beyond 60 m**

The mean distance carcasses were deposited was greater in the northeast (mean = 28.06, SE±3.5) and northwest (mean = 25.08, SE±4.03) quadrants than for the southeast (mean = 18.31, SE±3.49) and southwest (mean=15.89, SE±4.65) (Table 4-4). However, the difference between means was not significant (Kruskal-Wallis  $X^2 = 6.10$ ,  $df = 3$ ,  $p = 0.107$ ).

**Table 4-4 Bat fatalities for each quadrant assuming turbine as plot centre, Bear Mountain 2010**

Quadrant	NE	NW	SE	SW	Total
BAT	16	12	16	9	53
Percentage Bat	30.19	22.64	30.19	16.98	100

These values are represented graphically in Figure 4-7, which plots the locations of bat carcasses recovered during carcass searches with the probability of a carcass being deposited in each polygon based on area searched and the number of carcasses recovered in each segment.



**Figure 4-7 Distance, direction, and associated probability of deposition of recovered bat carcasses from turbine centre**

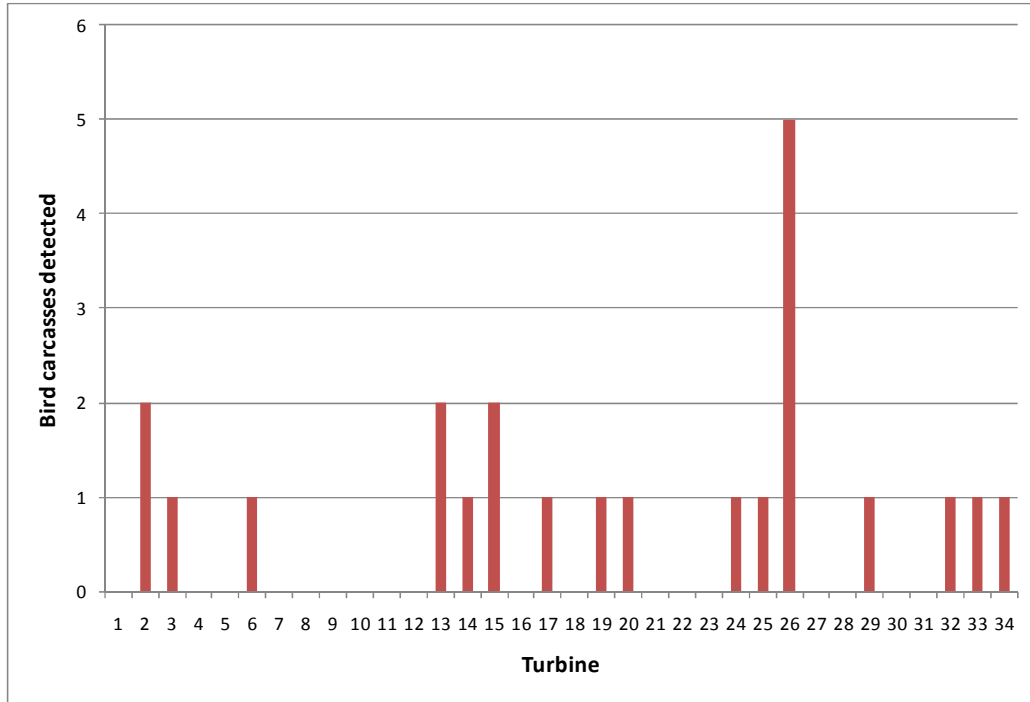
**4.2.2 Distribution of Bird Fatalities**

Twenty-three bird fatalities were detected during carcass searches throughout the study period (Table 4-5 and Figure 4-8). Twenty-two of these were songbirds. A single raptor fatality, an adult female northern harrier, was found incidentally on 9 June 2010. No raptors were found during actual carcass search

events or witnessed during raptor stand watch surveys conducted during spring (n = 8) and fall (n = 12) migration periods. While all of the detections were from birds known to breed locally, three of the detections (red-breasted nuthatch) are not seasonal migrants. One provincially blue-listed species was detected during searches. A black-throated green warbler was found on 10 August.

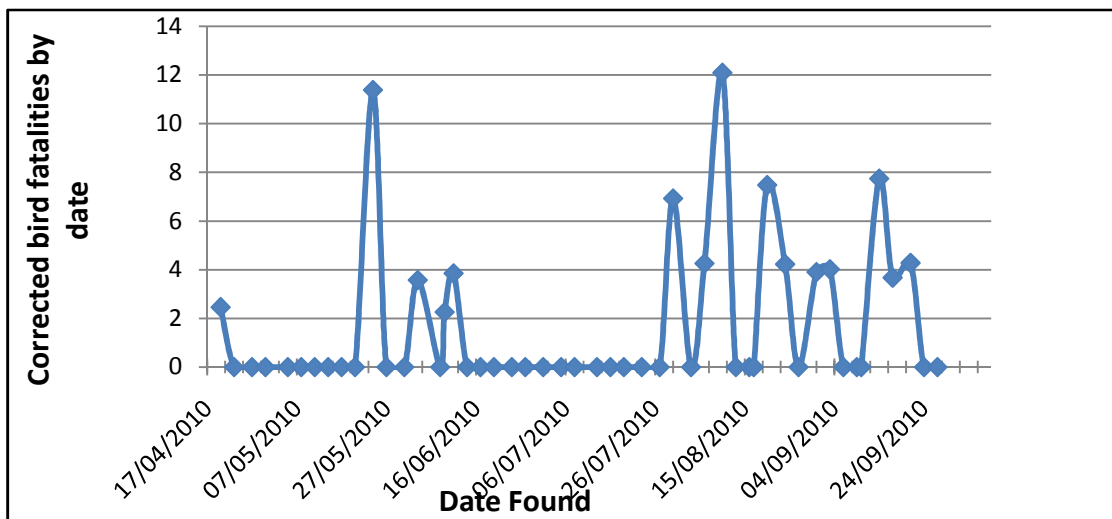
**Table 4-5 Uncorrected bird fatalities by species, Bear Mountain 2010**

Date Found	Species	Nearest WTG	Distance	Direction	Mortality date
4/20/2010	RBNU	34	18	18	
5/24/2010	SWTH	26	24	270	4/24/2010
5/24/2010	TEWA	20	39	161	4/24/2010
5/24/2010	WTSP	14	19	34	4/24/2010
6/3/2010	TEWA	26	15	309	
6/9/2010	NOHA	1	21	294	6/9/2010
6/11/2010	PUFI	2	28	334	6/10/2010
7/30/2010	YEWA	25	6	106	7/29/2010
7/30/2010	BHCO	1	56	209	
8/6/2010	LEFL	32	59	116	
8/10/2010	SWTH	26	60	353	8/9/2010
8/10/2010	BTNW	26	21	25	8/9/2010
8/10/2010	YEWA	29	39	44	8/9/2010
8/20/2010	RBNU	19	50	337	8/19/2010
8/20/2010	RBNU	15	9	133	8/19/2010
8/24/2010	BHVI	24	36	81	
8/31/2010	LEFL	26	13	44	8/30/2010
9/3/2010	NOWA	33	45	110	9/2/2010
9/3/2010	UNVI	5	51	96	
9/14/2010	DEJU	13	19	343	
9/14/2010	UNWA	13	19	343	
9/17/2010	PISI	15	5	62	9/16/2010
9/21/2010	LISP	17	34	343	9/20/2010



**Figure 4-8** Number of bird fatalities recovered by turbine, Bear Mountain 2010

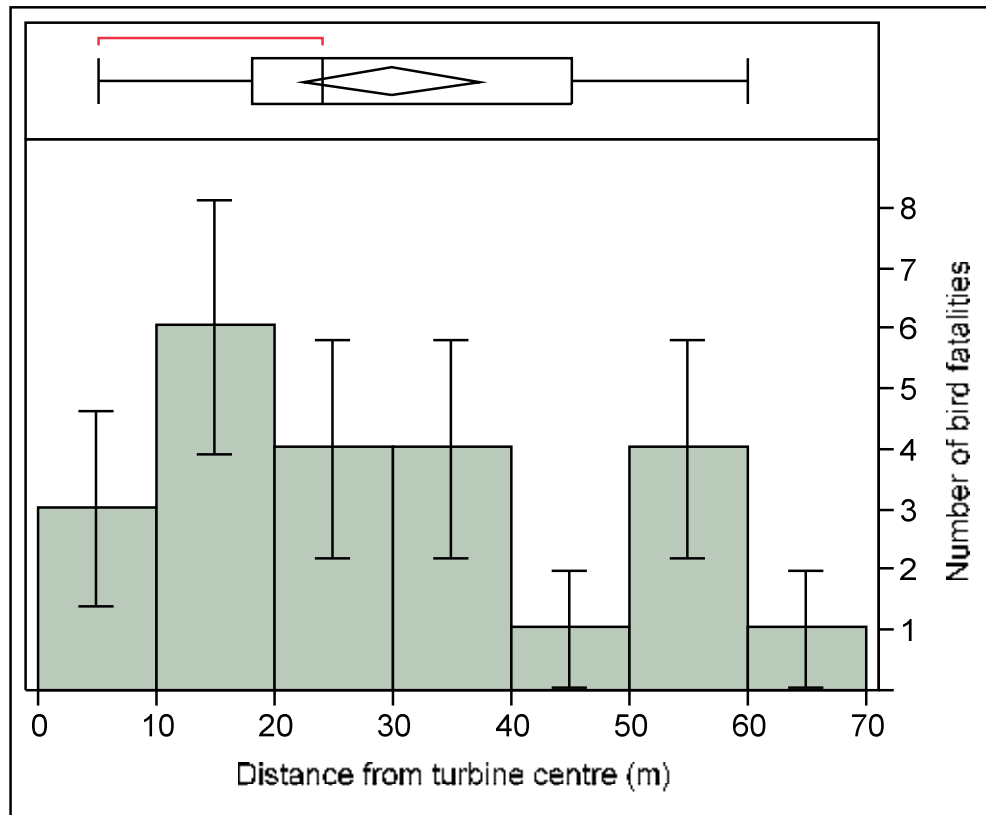
Bird fatalities showed two peaks attributable to spring and fall migration (**Figure 4-9**). Incoming spring migrants (up to mid-June) accounted for 18% (4/22) of fatalities, resident breeders not on migration accounted for 27% (6/22) of fatalities, while 55% (12/22) fatalities were fall migrants (from beginning of August, some species will begin southward migration prior to this).



**Figure 4-9** Seasonal distribution in bird fatalities recovered at Bear Mountain, 2010

The mean distance of bird fatalities from the centre of the nearest turbine was  $29.82 \pm 3.60$  m SE. Approximately 75% of bird fatalities were detected within 45 m of turbine centre. **Figure 4-10** shows a

histogram of the number of birds fatalities distributed at each 10 m increment from turbine centre. A box plot indicating quantiles (the ranges between equally sized subsets of the data) and mean are provided above the histogram.



**Figure 4-10 Bird fatalities with distance from centre of nearest turbine**

The distribution of bird fatalities was approximately equal between the north and south sections of the turbine array; 43% and 57% respectively. There was no significant difference in the number of bird fatalities per turbine between the north and south ends of the turbine array (Wilcoxon one-way test  $X^2 = 0.106$ ,  $df = 1$ ,  $P = 0.7445$ ).

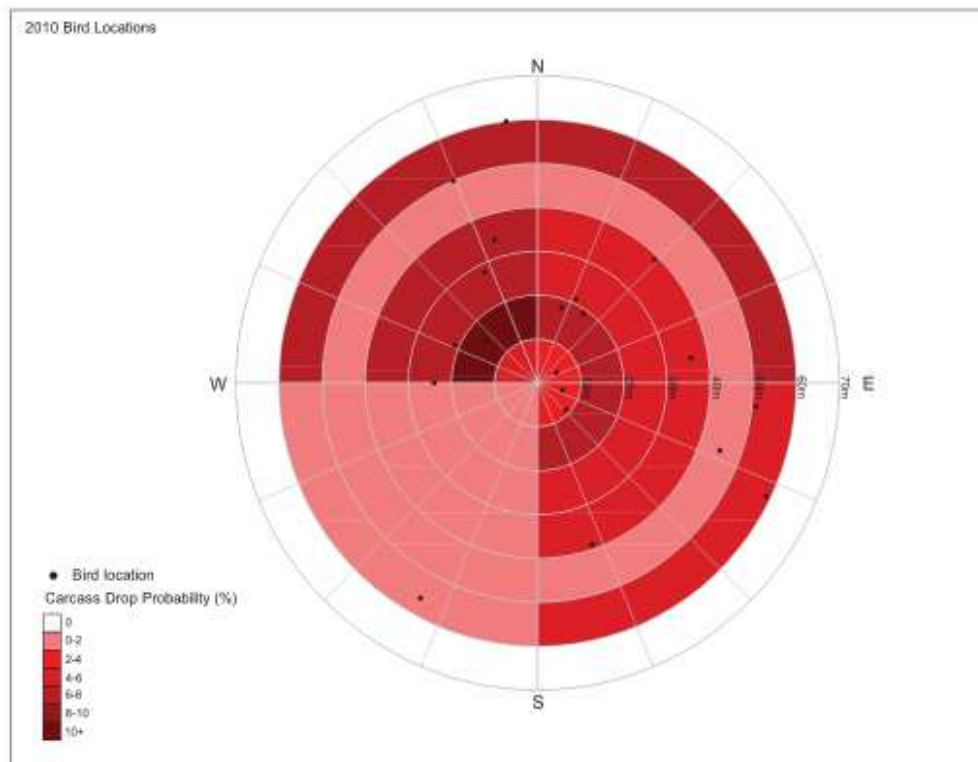
The proportion of bird carcasses recovered in each quadrant surrounding turbines and in each distance interval shows most carcasses were found close to turbines and in the northeast, northwest and southeast quadrants and not in the southwest, the quadrant closest to the predominant wind direction (Table 4-6).

**Table 4-6 Distribution of carcasses recovered during carcass searches by quadrant and 10 m distance interval, Bear Mountain 2010**

Quadrant	NE	NW	SE	SW	Total
No. of birds	7	9	6	1	23
Proportion of birds	30.43	39.13	26.09	4.35	100

Distance from WTG	0-10	10-20	20-30	30-40	40-50	50-60	60-70	Total
BIRD	3	6	4	4	1	5	0	23
Percentage Bird	13.04	26.09	17.39	17.39	4.35	21.74	0.00	100

These values are represented graphically in Figure 4-11, which plots locations of bat carcasses recovered during carcass searches with the probability of a carcass being deposited in each polygon based on area searched and the number of carcasses recovered in each segment.



**Figure 4-11 Distance and direction of bird carcasses recovered during carcass searches from turbine centre with probability of carcass deposition**

#### 4.2.3 Fatality Estimates

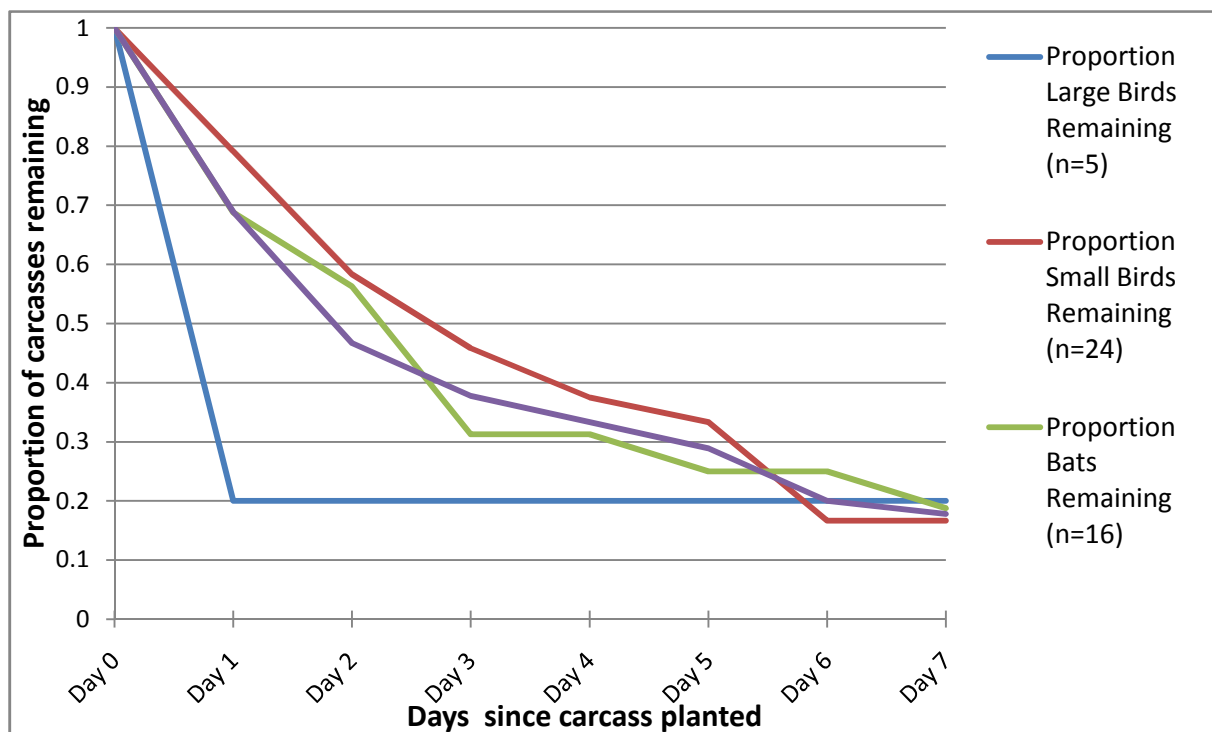
Bird and bat fatality estimates are provided below based on searcher efficiency and carcass removal trial results. Correction for search area bias is described above in the methods section.

#### 4.2.3.1 Searcher Efficiency

Searcher efficiency values were calculated for both birds and bats using a total of 45 previously frozen, fresh carcasses (29 bird and 16 bats) planted on a single day, September 15, 2010. Searcher efficiency values were 63% for small birds, 100% for large birds, and 91% for bats. The mean overall searcher efficiency was 74%.

#### 4.2.3.2 Carcass Removal

The proportions of bird and bat carcasses remaining after each day following the initiation of a scavenger removal trial are provided in **Figure 4-12**. All persisting carcasses were removed after seven days.



**Figure 4-12** Proportion of birds and bats remaining on the nth day following scavenger removal trial

#### 4.2.3.3 Fatality Estimates

A total of 53 bats and 23 birds were found during carcass searches between April 20 and September 27, 2010. These fatalities were adjusted to account for searcher efficiency, scavenger removal, and search area biases. Based on these corrections, 156 bats and 82 birds were killed by turbines at Bear Mountain in 2010 yielding a mean value of  $4.57 \pm 0.81SE$  bats/turbine and  $2.41 \pm 0.65SE$  birds/turbine. Extrapolation of the fatality results (proportion of each of six species recovered) to the corrected values for bat fatalities indicates Little Brown Myotis and Silver-haired Bats would likely make up the majority of fatalities (**Table 4-7**).

**Table 4-7 Total estimated bat fatalities by species based on proportion of species recovered during carcass searches**

Species	Corrected Fatalities
Big Brown Bat	18
Eastern Red Bat	6
Hoary Bat	3
Silver-haired Bat	62
Little Brown Myotis	53
Northern Long-eared Myotis*	15

**Note:** \* Pending genetic confirmation.

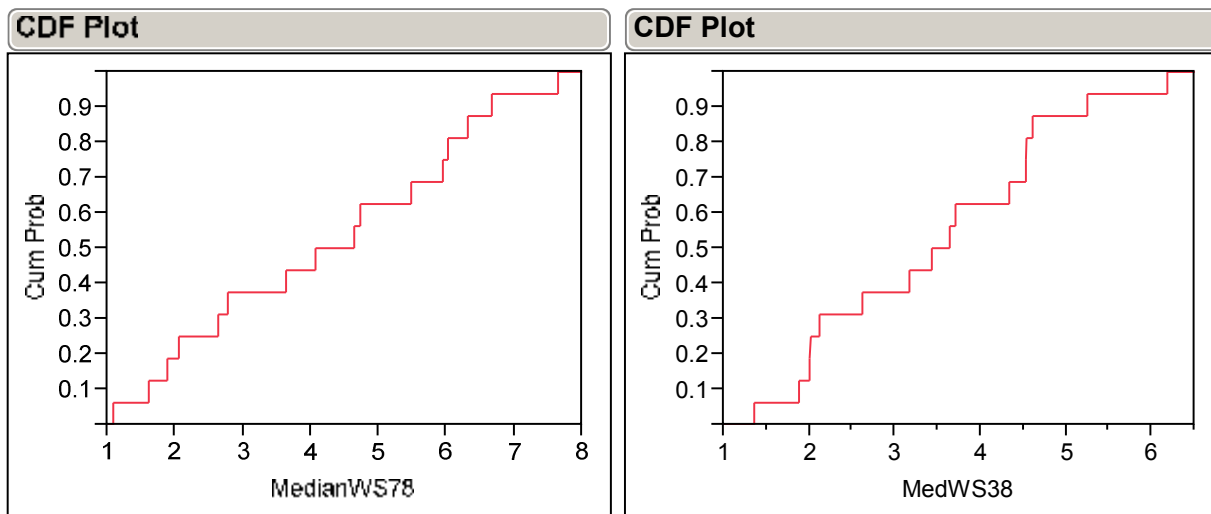
#### 4.2.4 Nightly Variation in Fatalities

##### 4.2.4.1 Bats

Corrected bat fatality estimates were used for correlation analyses with wind speed at both 78 m and 38 m heights. At 78 m, fresh bat fatalities were correlated with median nightly wind speed ( $r = -0.43$ ,  $p = 0.0139$ ) and mean nightly wind speed ( $r = -0.42$ ,  $p = 0.0366$ ), indicating that more bats were killed on nights with lower winds; however, there was no correlation between nightly fatalities and the proportion of 10 min nightly intervals with wind speeds less than 4 m/s, between 4-6 m/s, or greater than 6 m/s. At 38 m, bat fatalities were only correlated with median wind speed ( $r = -0.37$ ,  $p = 0.0364$ ). Other variables correlated with fresh nightly bat fatalities include wind direction ( $r = -0.48$ ,  $p = 0.0049$ ), Myotis files/detector night ( $r = 0.50$ ,  $p = 0.0036$ ), and total bat files/detector night ( $r = 0.47$ ,  $p = 0.0071$ ).

Wind speed and direction did not appear to influence myotis/Big Brown Bat fatalities; however, fatalities were associated with both total myotis activity ( $r = 0.58$ ,  $p = 0.0005$ ) and total bat activity ( $r = 0.59$ ,  $p = 0.0004$ ). Migratory tree bat fatalities were correlated with wind direction ( $r = -0.49$ ,  $p = 0.0041$ ), median wind speed at 78 m ( $r = -0.41$ ,  $p = 0.0198$ ), and 24 hour change in barometric pressure ( $r = -0.49$ ,  $p = 0.0052$ ). Migratory tree bat fatalities were higher when the pressure was either stable or dropping. There was no correlation between tree bat activity and fatalities. None of the bat groupings showed a significant correlation with mean nightly temperature despite a known correlation between temperature and activity (Hemmera 2010a).

The maximum median wind speed at 78 m on nights with at least one fatality was 7.64 m/s. 75% of nights with fresh bat fatalities had wind speeds below 6 m/s, approximately 40% of nights with fresh fatalities had median wind speeds less than 4 m/s, and approximately 35% of nights with fresh fatalities had median wind speeds between 4-6 m/s. At 38 m the results were similar with more than 60% of nights with at least one fresh fatality having mean nightly winds speeds less than 4 m/s. **Figure 4-13** shows a cumulative probability distribution of bat fatalities and median wind speed at 78 and 38 m.



**Figure 4-13 Cumulative probability distributions of bat fatalities and median wind speed (78 and 38 m)**

The highest mean nightly wind speed at 78 m with at least one fresh fatality was 7.7 m/s with approximately 50% of observations occurring on nights with mean wind speeds less than 4 m/s. Approximately 75% of fresh fatalities occurred below 6 m/s, and 25% between 4 and 6 m/s.

**Table 4-8 Summary of nightly values on nights with at least one fresh bat fatality**

	Median	Mean	StDev	SE
Median WS 78m	4.35	4.19	2.03	0.51
Mean WS 78m	4.16	4.30	1.87	0.47
Mean Temperature	11.64	12.43	4.45	1.11
Change in Pressure	0.05	-0.57	7.01	1.75
Mean Total bats / DN (detector night)	3.50	5.10	5.63	1.37

Fresh fatalities were recorded during a range of mean nightly temperatures (5.3 – 21.1°C) with a median value of 11.64°C and mean value of 12.43°C. Only 10% of the nights with at least one fresh fatality had a mean temperature below 6 degrees Celsius. Bat fatalities also occurred most frequently during relatively stable weather conditions as 95% of nights with at least one fresh fatality experienced a mean change in pressure of  $\pm 3.22$  hPa from the previous night with the mean 24 hr pressure change on nights with at least one fatality -0.57 hPa and the median 0.05 hPa. 10% of nights with at least on fresh fatality did not have any acoustic bat activity recorded. **Table 4-8** summarizes median and mean nightly values where at least one fresh bat fatality was recorded.

Several multivariate models were run to determine the amount of variation in night fatalities could be explained by weather variables and nightly acoustic (activity) data. The “best” model was derived using a forward stepwise regression model in JMP V9 using minimum AICc as the stopping rule. Wind direction,

nightly average barometric pressure, and nightly myotis activity explained 44% of nightly variation in total fresh bat fatalities ( $r^2 = 0.44$ ,  $p = 0.0008$ ,  $AICc = 180.15$ ). A second model, programmed to include wind speed yielded a slightly higher  $AICc$ .

<b>MODEL 1: (<math>r^2 = 0.44</math>, <math>p = 0.0008</math>, <math>AICc = 180.15</math>)</b>			
<b>Term</b>	<b>Estimator</b>	<b>SE</b>	<b>P</b>
Intercept	39.799	19.495	0.051
Wind Direction	-0.019	0.009	0.046
Barometer	-0.040	0.022	0.087
Myotis/DetectorNight	0.915	0.321	0.008

<b>MODEL 2: (<math>r^2 = 0.53</math>, <math>p = 0.0003</math>, <math>AICc = 182.08</math>)</b>			
<b>Term</b>	<b>Estimator</b>	<b>SE</b>	<b>P</b>
Intercept	42.332	18.068	0.027
MedianWS78	-5.419	1.927	0.009
MeanWS78	5.235	2.042	0.016
Barometer	-0.046	0.021	0.034
Myotis/DetectorNight	0.809	0.305	0.013

When bat activity was removed from the model parameters, the best fit model included terms for wind direction, median wind speed at 78 m and proportion of 10 minute intervals with wind speed less than 4 m/s ( $r^2 = 0.36$ ,  $p = 0.0046$ ,  $AICc = 188.76$ ).

<b>(<math>r^2 = 0.36</math>, <math>p = 0.0046</math>, <math>AICc = 188.76</math>)</b>			
<b>Term</b>	<b>Estimator</b>	<b>SE</b>	<b>P</b>
Intercept	20.126	5.612	0.0013
Wind Direction	-0.023	0.011	0.0434
MedianWS78	-1.708	0.710	0.0229
<4m/s <sup>-1</sup> wind speed at 38m	-8.361	4.214	0.0571

For myotis and Big Brown Bat fatalities, the best fit model involved total bat activity per night and mean nightly barometric pressure ( $r^2 = 0.47$ ,  $p = 0.0005$ ,  $AICc = 131.91$ ).

<b>(<math>r^2 = 0.47</math>, <math>p = 0.0005</math>, <math>AICc = 131.91</math>)</b>			
<b>Term</b>	<b>Estimator</b>	<b>SE</b>	<b>P</b>
Intercept	20.736	9.025	0.0296
Barometer	-0.024	0.010	0.0264
24hr Change Press	0.069	0.053	0.2072
All bats detector nights	0.490	0.113	0.0002

The best model for migratory tree bats included wind direction, median and mean wind speeds at 78 m, and a 24 hr change in mean nightly barometric pressure ( $r^2 = 0.50$ ,  $p = 0.0008$ ,  $AICc = 164.88$ ).

( $r^2 = 0.50$ , $p = 0.0008$ , $AICc = 164.88$ )			
Term	Estimator	SE	P
Intercept	4.160	1.778	0.0273
Wind Direction	-0.010	0.008	0.2164
Median Windspeed at 78m	-4.434	1.802	0.0208
MeanWind speed at 78m	4.317	1.893	0.031
24hr Change BaroPress	-0.138	0.102	0.1879

#### 4.2.4.2 Birds

No significant relationships between weather and bird fatalities were detected. Despite attempts at developing a stepwise regression model to explain nightly variation in bird fatalities based on weather variables; none of the models explained a significant amount of variation in the nightly fatality data. This may be due to a small sample size, only 13 nights had bird fatalities recorded. Correlations between weather and fatalities were also investigated for migrant birds alone to reduce the number of zero values; however, no significant correlations were detected. Data transformations (log, square root, reciprocal) on the fatality data did not yield any significant results.

### 4.3 DISCUSSION

#### 4.3.1 Bats

The higher proportion of myotis and Big Brown Bat fatalities (55% of total bat fatalities) compared to migratory tree bats (45%) at Bear Mountain runs counter to other studies and reviews that have found migratory tree bats to have the greatest risk from wind energy developments (Johnson *et al.* 2004, Arnett *et al.*, 2008 and Baerwald 2008). The percentage of each species' contribution to total fatalities was: 34% for Little Brown Myotis, 11% for Big Brown Bat and 9% for the provincially blue-listed Northern Long-eared Myotis (positive identification pending).

The previously highest proportion of myotis fatalities reported at a wind energy facility is from Castle River, Alberta where Little Brown Myotis comprised 23% of the total fatalities (Brown and Hamilton 2002). At other sites in Alberta, McBride Lake and Summerview, myotis fatalities have comprised 9% and 1% respectively (Brown and Hamilton 2006a and 2006b). Big Brown Bat and Northern Long-eared Myotis fatalities have been negligible at most USA wind energy facilities, with the exception of the Top of Iowa project, where almost 11% of total bat fatalities were Big Brown Bat (Jain 2005). The finding of more myotis/Big Brown Bat fatalities than migratory tree bats at Bear Mountain coupled with the activity data (71% of bat detections in 2010 were myotis species) is indicative of a resident population of myotis / Big

Brown Bat exposed to operating turbines for a longer period, compared to most of the migratory tree bats, which pass through the site for a shorter period while on migration.

No clear interpretations of the male-skewed, and all adult, Little Brown Myotis fatalities and the female skewed, with juvenile, Silver-haired Bat fatalities at Bear Mountain can be drawn. Fatalities at wind energy facilities indicate overall more male fatalities than females for Hoary, Silver-haired, and Eastern Red bats, and Eastern Pipistrelle, with no data for Little Brown Myotis (Arnett *et al*, 2008). In contrast, like at Bear Mountain, the sex ratio of Alberta Silver-haired Bat fatalities (and Hoary Bat) showed a bias towards females (Baerwald 2008). The age structure of fatalities in Alberta was relatively evenly distributed (Baerwald 2008), unlike Bear Mountain which showed some species with no juvenile fatalities,

The high proportion of myotis/Big Brown Bat fatalities is likely due to the nearby presence of resident bats and suitable foraging habitat nearby. Sandstone and conglomerate cliffs running along the south-western edge of Bear Mountain (turbine 14 southward) likely provide some roosting and breeding habitat for resident bats; however, no colonies were detected during four nights of stand watch observations (\$6) and searches of the rocky outcrops for roosting bats or sign (guano and pellets). During stand watch surveys, a single bat was seen exiting a cliff in the vicinity of turbine 26. A Long-eared Myotis was captured within metres of the cliff face and myotis bats were detected or observed flying in close proximity to the cliff face during 2005 (Aeolis 2006). The presence of these cliffs and abundant foraging habitat at the south end of the project (more wetlands and bog habitat than at the north end) potentially explains why fatalities rates are higher for resident bats at the south end of the turbine array; this pattern does not hold for migrant bat fatalities which were more evenly distributed along the turbine array. Radar Lake, a likely foraging site, is approximately 3 km south of turbine 34 and bats may travel along the rocky outcrop or spine of Bear Mountain to such foraging locations. While the higher myotis/Big Brown Bat fatalities seem to be associated with higher mean, project-wide activity; there is no statistical correlation between activity and the location of bat fatalities. Acoustic detection activity was highest toward the north of the turbine array (T14); however, the majority of bat fatalities occurred at the south end of the project and only a single fatality was detected at T14 (T14 had the greatest carcass search effort by area).

Carcass searches during 2010 at Bear Mountain re-confirmed the presence of Eastern Red Bat in British Columbia (two fatalities on 3 August and four acoustic call sequences on August 2 and 4 at T14H, and August 5 and 19 at T33). The Eastern Red Bat detections were likely migrants based on timing.

Interpretations of the impact of the estimated 156 bat fatalities at Bear Mountain to local, regional, and continent-wide bat populations is unclear. Population estimates in northeast BC are lacking and migration routes, both continent-wide and at a local scale, are unknown. Species distributions are also being expanded; Eastern Red bat were unknown in northeast BC and at Bear Mountain prior to 2010. Bats are long-lived with low reproductive rates (one to two per season) and may only breed every other year. Bat fatalities reported by Baerwald (2008) in SW Alberta vary between  $1.26 \pm 0.18$  bats/turbine and  $31.41 \pm$

3.04 bats/turbine with three of eight sites having fatalities greater than 20 bats/turbine/year. Fatalities at North American wind energy facilities vary between 0 and greater than 40 bats/turbine/year (Barclay *et al.* 2007), and many wind energy facilities from eastern USA have higher fatality bat fatality rates than the mean of 4.57 estimated fatalities / turbine / year observed at Bear Mountain (Arnett 2008). Mean bat fatalities per turbine are higher at Bear Mountain than at the only two facilities in the Pacific north-west that provide data; both however are in very different habitats - non-forested grasslands in Washington and Oregon. As Bear Mountain is the first operational wind energy facility in north-eastern BC, there are no nearby facilities for comparison of fatality rates.

Variation in nightly total bat fatalities at Bear Mountain was weakly correlated with decreasing mean and median nightly wind speeds; however, 75% of fresh bat fatalities occurred on nights where the mean wind speed was less than 6 m/s. There was no significant relationship between wind direction, temperature, or barometric pressure. Nightly myotis/Big Brown Bat fatalities increased with increasing activity at bat detectors though migratory tree bats did not show a similar relationship. Migratory tree bat fatalities were correlated with more southerly wind directions (a south-west wind direction predominates at Bear Mountain) and stable to slightly dropping barometric pressure. In comparison, Arnett *et al.* (2008a and 2005) indicates a negative association between wind speed and bat fatalities (including a negative relationship between fatalities and the nightly number of 10 minute intervals with wind speeds greater than 6 m/s at wind energy facilities with high levels of migratory bat fatalities in Pennsylvania and West Virginia. Bat fatalities at these sites also increased with barometric pressure and were highest in the first few nights following a storm event, especially on nights with low wind speeds. Baerwald (2008) reported that nightly Silver-haired Bat fatalities increased with the fraction of moon illuminated and nightly bat activity while Hoary Bat activity was linked to falling barometric pressure but not nightly activity. Cryan and Brown (2007) found that Hoary Bat fall activity was linked to low wind speeds, low moon illumination, high cloud cover, and low barometric pressure, variables indicative of passing storm fronts.

#### **4.3.2 Birds**

The estimated number of bird fatalities was 82, with the majority occurring from late July to mid-September and corresponding to seasonal southward migration of most passerines. No significant relationships between weather variables and bird fatalities were determined. While some projects have shown relatively high estimated fatality rates; 9.59 birds/turbine/year and 24.5 bats/turbine/year at 120 120m tall turbines in Maple Ridge, New York (Curry and Kerlinger 2007); the Bear Mountain estimated fatality of 2.41 birds/turbine/year falls within the range of most projects considered to have low impacts. Fatalities per turbine reported in Erickson *et al.* (2005) and NRC (2007) range from 0.63 bird fatalities per turbine (Vansycle, Oregon) to 9.33 fatalities per turbine (Buffalo Ridge, Tennessee) on an annual basis.

No federally at-risk birds were recovered during carcass searches, and one provincially listed (blue-listed black-throated green warbler) was recovered. The birds recovered were largely species common to the

region and occurring in relatively high abundance (§ 5). Given the relatively low estimated fatality rate (with corrections for searcher and scavenger bias), and only one individual of an at-risk species affected (uncorrected), the fatalities are not expected to significantly impact local, regional, or migratory bird populations, impacts are considered low.

Despite attempts to investigate correlations between variation in nightly bird fatality rates and weather variables, no statistically significant results were obtained. This is likely due to the small sample size of carcasses for analysis and many nights had no impacts.

#### **4.4 FATALITY MONITORING SUMMARY**

The fatality monitoring studies conducted for the first full year of operations at Bear Mountain are consistent with the requirements of the Program (Hemmera 2007) and the provincial and federal environmental assessment approvals for the Bear Mountain Wind Park; with amendments as identified by TAC (Hemmera 2008, 2009a and b, 2010a and b). The study conducted is consistent with industry standards for such monitoring and the results are considered to be an accurate, if slightly conservative, prediction of the actual impacts of the project.

The 2010 results indicate that there are impacts to birds during migration and to bats (both resident and migrating). The level of impacts to birds is considered to be low despite the unavailability of comparisons with the likely substantial incidental take of migratory birds from other wind energy projects and other activities in northeast BC such as residential, forestry, oil and gas, agriculture, transportation, communications and electrical distribution (Erikson *et al.* 2001, Drewitt and Langston 2008, Newman *et al.* 2009). This assessment of low impacts is based on fatality rates that are lower than or consistent with operating projects from elsewhere in North America, and the very low impacts to at-risk species known to be affected. A single individual of an at-risk bird species (provincially blue-listed, not federally listed), black-throated green warbler, was recovered during carcass searches. In this respect the impacts of the project are consistent with the findings of the EA Application (Aeolis 2006), such that the design mitigations incorporated into the project (turbine design, lighting, location and spacing) are sufficient to address impacts to birds and no additional mitigation is considered necessary.

The impacts to resident and migratory bats are less clear, due to poor understandings of northeast BC bat population numbers, species distributions, migration routes, and the unknown cumulative impact in the Peace region of other projects and activities that affect bats. However, there is now good knowledge of impacts at Bear Mountain, and the estimated fatality rates are at the low-end of the range for those reported from other operating North American wind energy projects, particularly for some from eastern North America and southern Alberta where rates over ten times higher have been reported. In contrast to findings from other North American wind energy facilities (Arnett 2008, Barclay 2007, Baerwald 2008), impacts from Bear Mountain to myotis and Big Brown Bats species, generally considered to be less at risk

from wind energy projects, are proportionally higher than to migratory tree bats. Based solely on fatality rate comparisons, and acknowledging that more information about northeast BC bat populations may change the assessment, the impacts on bats are considered to be a non-significant, low to moderate. The challenge before a more fulsome interpretation of the results from this monitoring can be gained is for regulators and researchers to collectively seek greater baseline bat knowledge in northeast BC.

The impacts of the Project on bats continue to be somewhat unclear, as they were at the time of the EA Application (Aeolis 2006). The uncertainty is not around the fatality rates of the Bear Mountain Project, which are at the low end of the range of other operating projects in North America (0.0 – 42.7 bats/turbine Barclay et al. 2007 and 0.5– 69.6 bats/turbine, Arnett *et al.* 2008), rather it is directly related to a lack of baseline knowledge of bats in northeast BC. At this time there is no indication that mitigations over and above those incorporated into project design (turbine design, location and spacing) are necessary. Bat fatalities were correlated with mean and median nightly wind speeds; 75% of nights with fresh bat fatalities were had mean wind speeds below 6 m/s; consistent with Arnett *et al.* 2008 and Baerwald *et al.* 2009). Turbines in the south portion of Bear Mountain have disproportionately higher impacts than those in the north, and as such mitigations if deemed necessary in the future could be focused in that area.

Consistent with the requirements of the Program (Hemmera 2007), a similar carcass search program is recommended in 2011 to increase the sample size and allow for a more accurate understanding of the conditions leading to bird and bat fatalities. Analyses in 2011 should also incorporate habitat variables to possibly explain higher numbers of myotis / Big Brown Bat fatalities at the south of the turbine array.

Data from Bear Mountain in 2010 and beyond will continue to contribute to a greater understanding of bird and bat fatalities at turbines in northeast BC.

## 5.0 BREEDING BIRDS

Point counts along transects were conducted to assess whether species diversity and relative abundance change as distance from the turbine array increases (**Figure 5-1**), a measure of the indirect disturbance effects of turbines on bird presence and abundance (Pearce-Higgins *et al.* 2009). A total of 51 point counts were conducted between June 3 and June 27. During the first week of June ten point counts were conducted at the edges of turbine pads during carcass search events. Between 11 and 27 June 2010 an additional 41 point count stations were sampled. Of the 51 stations, 28 were sampled twice during the breeding season while 13 were sampled once.



**Figure 5-1** Breeding bird point count locations, Bear Mountain 2010

Though the survey methodology differed between this study and the encounter transects conducted for the EA Application (Aeolis 2006) the overall diversity and abundance of species results are fairly similar. The ten species with the highest abundance in each year was very similar, except for yellow-rumped warbler, 5<sup>th</sup> most abundant in 2010 and not in the top ten in 2005, and brown-headed cowbird, 9<sup>th</sup> most abundant in 2005 and not in the top ten in 2010. **Table 5-1** indicates the ten most abundant bird species by survey year.

**Table 5-1 Ten most abundant breeding bird species recorded at Bear Mountain, 2010 and 2005**

2010 Point Counts			2005 Encounter Transects		
Species	Count	Proportion	Species	Count	Proportion
WTSP	118	10.73	WTSP	283	10.57
YEWA	100	9.09	YEWA	219	8.18
SWTH	82	7.45	SWTH	190	7.09
AMRO	79	7.18	AMRE	190	7.09
YRWA	64	5.82	WAVI	159	5.94
AMRE	52	4.73	LEFL	115	4.29
LEFL	50	4.55	AMRO	101	3.77
WAVI	50	4.55	YBSA	81	3.02
DEJU	48	4.36	BHCO	77	2.88
YBSA	42	3.82	DEJU	72	2.69

Of the provincially listed warblers found in north-eastern BC, the survey results between 2005 and 2010 differed; however, it should be noted that much of the mature aspen and spruce habitat sampled in 2005 was either not sampled or did not exist in 2010 (due to forestry activity unrelated to the Bear Mountain project), nor were the breeding bird surveys designed to provide comparisons with the encounter transects conducted in 2005.

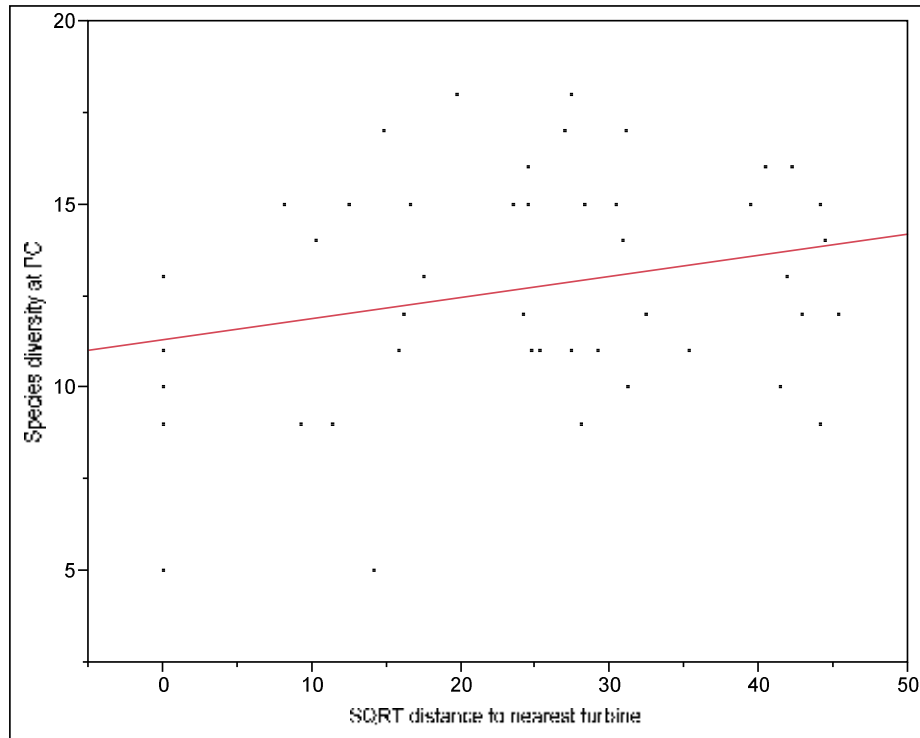
**Table 5-2 Provincially listed warbler species observed at Bear Mountain in 2010 and 2005**

2010 Point Counts			2005 Encounter Transects		
Species	Count	Proportion	Species	Count	Proportion
BTNW	9	0.82	BTNW	64	2.39
CAWA	8	0.73	CAWA	27	1.01
COWA	4	0.36	COWA	5	0.19
no detections			BBWA	1	0.04

**Notes:** BTNW = Black-throated green warbler, blue-listed.  
CAWA = Canada warbler, blue-listed and SARA sch 1, threatened.  
COWA = Connecticut warbler, red-listed.  
BBWA = Bay-breasted warbler, red-listed.

## 5.1 SPECIES DIVERSITY

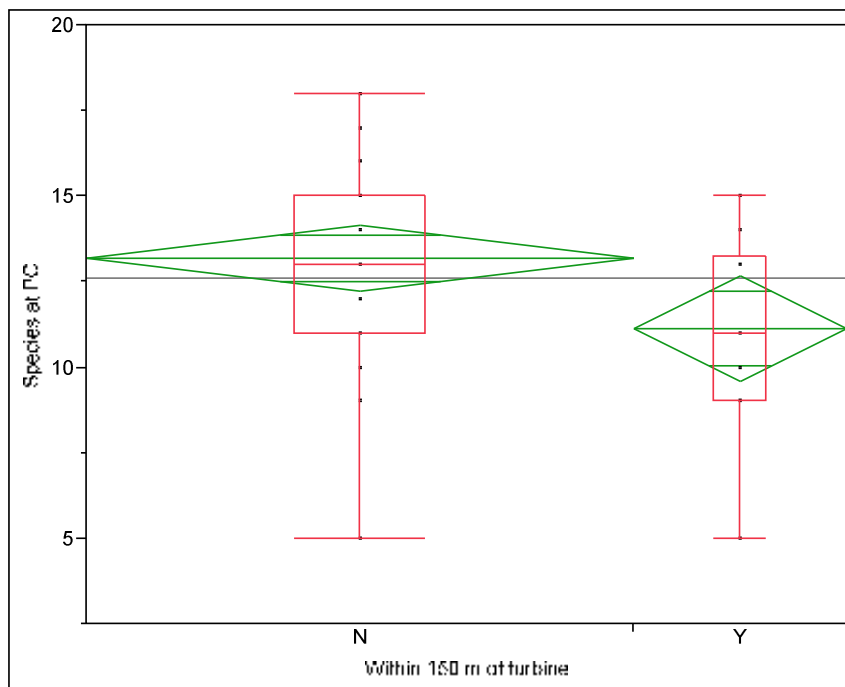
A regression line fitted to a bi-variate plot of species diversity and square root transformed distance to nearest turbine (**Figure 5-2**) indicated that species diversity is higher at greater distance from the turbine array; however this relationship was weakly significant ( $r = 0.28$ ,  $F = 0.0465$ ).



**Figure 5-2 Linear regression of species diversity and distance to nearest turbine plot indicating weak positive correlation ( $r = 0.28$ ,  $F = 0.0465$ )**

All plots within approximately 100 m of a disturbance (cut block) or linear corridor (quad trail, transmission, line, turbine array) were pooled together to test whether there was a difference in species diversity related to edge habitat. The results were not significant ( $t = 0.42$ ,  $df = 48$ ,  $p = 0.675$ ).

Plots within 150 m of a turbine were also pooled to compare species diversity at point count stations within 150 m of a turbine to plots further than 150 m from turbines. Point count stations further than 150 m away from turbines had a significantly greater number of bird species than those within 150 m of a turbine ( $t = -2.27$ ,  $df = 48$ ,  $p = 0.0278$ ). The mean number of species per point count station within 150 m of a turbine was  $11.14 \pm 0.77SE$  while the mean number of species recorded at stations beyond 150 m was  $13.19 \pm 0.48SE$ .



**Figure 5-3** Box plot and mean values of point count stations within 150 m of a turbine and further than 150 m from a turbine. Y = within 150 m, N = outside 150 m

## 5.2 RELATIVE ABUNDANCE

T-tests were performed on relative abundance data to determine whether there was a difference in the total number of birds recorded at point count stations within and outside 100 m of edge habitat and within and outside of 150 m of turbines. There was no significant difference between the number of birds recorded at point count stations within and outside 100 m of edge habitat ( $t = 0.57$ ,  $df = 48$ ,  $p = 0.57$ ). There was a slightly stronger but also non-significant difference in the relative abundance of birds recorded within and outside 150 m of turbines ( $t = -1.94$ ,  $df = 48$ ,  $t = 0.058$ ).

## 5.3 HABITAT INFLUENCE

Habitat in and surrounding 2010 breeding bird point count locations was separated into six general habitat types (Table 5-3) and four structural stages (Table 5-4). A Tukey-Kramer HSD (Honestly Significant Difference) test was used to test for differences in species diversity (Tables 5-3 and 5-4) and abundance (Tables 5-5 and 5-6) related to habitat influences.

**Table 5-3 Mean species detections by habitat type during breeding bird point counts 2010.**

Habitat Type	Number	Mean species detected	Std Error	Lower 95%	Upper 95%
Bog	3	13.6667	1.6003	10.441	16.892
Broadleaf	11	12.5455	0.8357	10.861	14.23
Coniferous	6	12.1667	1.1316	9.886	14.447
Disturbed	9	10.4444	0.924	8.582	12.307
Mixed	18	13.0556	0.6533	11.739	14.372
Shrub	3	16.6667	1.6003	13.441	19.892

**Table 5-4 Mean species detections by structural stage during breeding bird point counts 2010.**

Structural Stage	Number	Mean species detected	Std Error	Lower 95%	Upper 95%
1	9	10.4444	0.9097	8.613	12.276
3	3	16.6667	1.5757	13.495	19.838
5	8	12.375	0.9649	10.433	14.317
6+	30	12.9333	0.4983	11.93	13.936

More species were present in shrub habitat (including regenerating cut blocks) than in disturbed habitat (turbine pads). Mean values of species detected (diversity) for these habitat variables show significant differences in species diversity (mean species detected per habitat type) between shrub and disturbed habitat (Difference = 6.22,  $p=0.0185$ ) (**Table 5-3**). No differences were detected between other habitat types. Significantly more species were detected in shrub habitat (structural stage 3) than in disturbed habitat (structural stage 1) (Difference = 6.22,  $p=0.0070$ ) (**Table 5-4**).

**Table 5-5 Mean relative abundance by habitat type during breeding bird point counts 2010**

Habitat Type	Number	Mean	Std Error	Lower 95%	Upper 95%
Bog	3	19	4.8456	9.234	28.766
Broadleaf	11	23.9091	2.5305	18.809	29.009
Coniferous	6	20.5	3.4264	13.595	27.405
Disturbed	9	16.6667	2.7976	11.028	22.305
Mixed	18	22.6111	1.9782	18.624	26.598
Shrub	3	33.3333	4.8456	23.568	43.099

**Table 5-6 Mean relative abundance by structural stage during breeding bird point counts 2010**

Structural stage	Number	Mean	Std Error	Lower 95%	Upper 95%
1	9	16.6667	2.7697	11.092	22.242
3	3	33.3333	4.7973	23.677	42.99
5	8	21.625	2.9377	15.712	27.538
6+	30	22.5667	1.517	19.513	25.62

There were no significant differences in the relative abundance (total detections) between the habitat types sampled (**Table 5-5**); however, there were significantly more detections in shrub habitat (structural stage 3) than in disturbed habitat (structural stage 1) (Difference = 16.67,  $p=0.0213$ ) (**Table 5-6**).

### **5.3.1.1 Breeding Birds Summary**

While significantly more bird species (higher diversity) was observed at point count stations greater than 150 m from turbines than stations within 150 m, and there was a weak positive correlation with higher bird diversity farther from turbines, there was no significant difference in the relative abundance of birds at stations within and outside 150 m. The difference between the means of bird diversity within and outside 150 m was small, approximately 2 birds. Noise from turbines may make detections more difficult, introducing a bias to the results from point counts conducted near turbines.

The results of the assessment do not clearly indicate the influence of Bear Mountain turbines on bird diversity and presence. The differences between sites close to and far from turbines are small, and likely confounded by the differing habitat conditions on the Bear Mountain ridge and the conditions far away. The ridge has disturbed habitat close to turbines, and pine, spruce and (occasionally) aspen forests, all with lower diversity and relative abundance of birds. Farther from the ridge on lower elevation terrain the dominant aspen forests are interspersed with large shrub clearings (the result of forestry activity). The diversity of habitats and presence of shrubland farther from the ridge contribute to the higher species diversity and abundance at a distance from turbines.

The surveys on breeding birds shows no clear influence of wind turbines on breeding bird diversity and abundance, as such no further surveys are considered necessary.

## 6.0 BAT ROOST SURVEYS

A series of four late afternoon/evening searches were conducted in mid to late July (15, 17, 24, and 27) along the escarpment west of Bear Mountain between turbines 14 and 34 to detect signs of roosting bats and obtain exit counts from potential roost sites. These surveys began at the base of the escarpment and potential crevices were examined with binoculars or a flashlight if possible to do so safely. During these searches a single bat emerged from the escarpment close to turbine 26; though an informal stand watch survey until about 20 minutes after sunset did not yield any further bat observations. No signs of bat roosts were detected, though bushy-tailed woodrat nests were abundant in the crevices. Following searches along the escarpment a stand watch location atop the escarpment was selected to monitor until approximately 20 minutes after sunset to attempt and detect emerging bats; however, only the single bat was detected. It is likely that few bats had emerged by the time the stand watch had ended.

Further surveys using these techniques are not recommended. However, more knowledge of use of the escarpment by myotis and Big Brown Bats is required. These bats have been shown by this study to be impacted by turbine-related fatalities in greater proportions than at most other North American projects (§4.2.4.1). The greater than expected proportion of myotis and Big Brown Bat fatalities may be related to their use of the escarpment as a roost site(s) and/or hibernacula. Such knowledge, particularly on the timing of activity (i.e., month / season), will aid understanding how the escarpment is being used (i.e., individuals roosting, maternal colonies, hibernacula), and, if required, may guide the timing and location of any operational mitigation. The sampling plan proposes the use of two passive Anabat recorders moved between a number of locations on and below the escarpment through the spring, summer and autumn seasons in 2011.

## **7.0 RECOMMENDATIONS FOR 2011 STUDIES**

Recommendations for adaptations and or continuation of bird, bat and raptor studies conducted in 2010 and required by the Program for 2011 are outlined below. These recommendations have been reviewed and finalised during the meeting of the TAC in February 2011.

### **Migratory Bats**

- Monitor the 2010 sites for bat activity in 2011, with the exception of the Anabat T27 site, to ensure continuity of data and comparative data on year-to-year variation.
- Acoustic monitoring in the north of the turbine array is recommended to gain an understanding of migratory bat activity across the entire site. It is proposed to shift Anabat T27 to a turbine in the north of the array, subject to turbine manufacturer consent.
- Conduct acoustic monitoring of bat activity along and below the escarpment during spring, summer and autumn 2011 to ascertain the level and type of use for informing the location and timing of any required mitigations.
- Conduct monitoring from mid/late-April to the last week of September, a continuation of the extended monitoring started in 2010.
- Continue carcass searches.

### **Raptors**

- No further migration studies (stand watches) are recommended. Potential impacts to raptors will be assessed through the carcass search program.

### **Migrating and Breeding Bats and Birds (Carcass Searches)**

- Conduct carcass searches similarly to 2010, from mid/late April to late September. This is a continuation of the extended monitoring started in 2010.
- Conduct two searcher efficiency and scavenger removal trials (summer, and fall) using bird and bat carcasses.

### **Breeding Birds**

- No further point count surveys are recommended.
- No radar surveys are recommended.

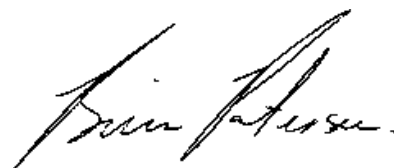
## 8.0 CONCLUSION

Bear Mountain Wind has met the monitoring requirements of the Monitoring and Follow-up Program (Hemmera 2007 with updates in Hemmera 2008, 2009a and b, 2010a and b), plus the addition of raptor stand watch surveys in autumn 2010 at CWS request. This has been completed through implementation of bat and raptor monitoring over 3 years between autumn 2007 and autumn 2010, a pilot carcass search program implemented in autumn 2009 following commissioning of the first turbines, and a full season of operational monitoring including raptor migration surveys (spring and fall), acoustic bat surveys, breeding bird surveys, and carcass searches in 2010.

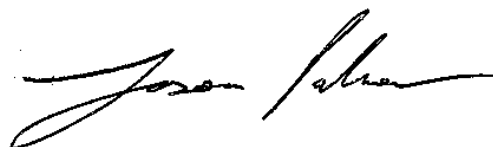
The combination of studies completed at Bear Mountain (Aeolis 2006, Hemmera 2007, 2008, 2009a and 2010a, and this document) is a powerful dataset to understand migratory birds and bats and raptor use of the site. At this point in time, the long-term data from Bear Mountain indicate that the operational effects of the project to bat populations are non-significant (low to moderate as per the EA Application, Aeolis 2006). However, interpretations of Bear Mountain results are unclear given the general lack of understanding regarding bat population sizes and migration routes, particularly in north-eastern BC. Bat data from other parts of the region is desired. The impacts to migratory and resident (breeding) birds continue to be non-significant, (low) as predicted in the EA Application (Aeolis 2006). Existing design mitigations included in the project (turbine design, location and spacing) are considered to adequately address the impacts to birds and bats, no changes are considered necessary.

To compare with results from 2010 and to increase our understanding of operational impacts, primarily to bats but also birds, further carcass search events are recommended in 2011 (as per the program, Hemmera 2007). The ongoing monitoring required by the Program, adaptations to which are recommended in this report, provides an effective process tool for the identification of impacts and assessment of the need for mitigation to manage impacts. The current process for ongoing monitoring with oversight by the TAC provides an effective tool for identifying and managing potential impacts such that mitigation measures are not required at this time.

Regards,  
**Hemmera**



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