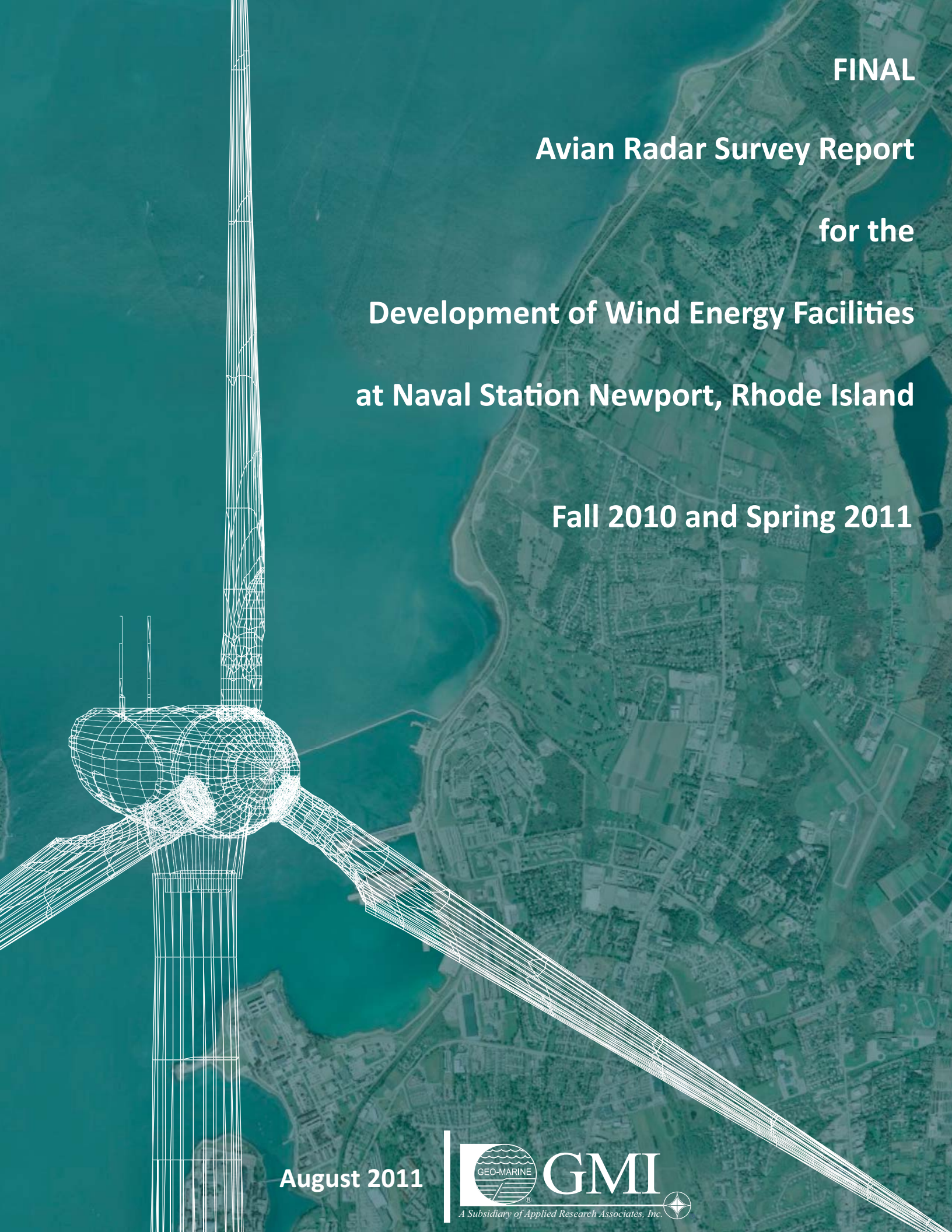


FINAL

Avian Radar Survey Report for the Development of Wind Energy Facilities at Naval Station Newport, Rhode Island

Fall 2010 and Spring 2011

August 2011

GEO-MARINE GMI
A Subsidiary of Applied Research Associates, Inc.

EXECUTIVE SUMMARY

Project Description

An avian radar baseline study was conducted in fall 2010 (12 October through 12 November) and spring 2011 (20 April through 19 May) for Naval Station (NAVSTA) Newport to provide data needed for environmental compliance documentation associated with the proposed construction, operation, and decommissioning of wind turbines at up to 12 potential sites. The study was conducted from the McAllister Point Landfill site with Geo-Marine's Mobile Avian Radar System (MARS®). The MARS® was equipped with a 3.9-inch (in.; 10-centimeter [cm]) wavelength, 30-kilowatt (kW) S-band (TracScan) radar for horizontal scanning and a 1.2-in. (3-cm) wavelength 25-kW X-band (VerCat) radar for vertical scanning.

Methods

The MARS® was set to operate 24/7 during the 30 day fall and 30 day spring survey period. The TracScan radar was set to scan a 4-nautical mile (NM) radius from the radar site on the McAllister Point Landfill (**Figure ES-1**). The VerCat radar was set to scan 1.5 NM in the expected direction of migration (northeast in spring, southwest in fall). TracScan operated for 709 hours (hrs) during fall and 643 hrs in spring; VerCat operated 540 hrs during fall and 607 hrs in spring.

For quality control, radar ground truth (radar validation) surveys and thermal imaging (TI)-vertically pointed radar (VPR) surveys were conducted during the study. A line-intercept survey protocol was used for conducting radar ground truth surveys. Total radar ground truth survey effort was 12.8 hrs during fall and 13.3 hrs during spring. The TI was a fixed focus FLIR Systems Standard Resolution (SR)-35 camera with a 1.4-in. (35-millimeter [mm]) lens and a 20-degree (°) field of view; the VPR was a 1.2-in. (3-cm) 25-kW X-band radar. Total survey effort for the TI-VPR survey was 15 hrs in fall and 11 hrs in spring. The TI data was used to correct for insect data counted by the VerCat radar.

TracScan data was analyzed to determine the average diurnal and nocturnal passage rate (adjusted number of bird tracks/kilometer [km]/hr) and flight direction. Data was analyzed separately for Over Land and Over Water areas. VerCat data was analyzed to determine bird flight altitude and percentage of birds in the potential turbine rotor swept zone (RSZ): VerCat data includes Over Water and Over Land areas.

TracScan Results

- Diurnal and nocturnal Over Land average passage rates were lower than the Over Water passage rates in all seasons with the exception of fall 2010 when the Over Land Passage nocturnal rates were slightly higher than Over Water Passage rates (**Table ES-1**).
- Diurnal and nocturnal Over Water passage rates were slightly higher in spring than fall (**Table ES-1**).

Table ES-1
Comparison of Over Land and Over Water average passage rates

Season/Year/Time	Over Land	Over Water
Fall 2010 Diurnal	6.37	21.34
Fall 2010 Nocturnal	15.48	14.45
Spring 2010 Diurnal	2.7	34.98
Spring 2010 Nocturnal	5.6	24.66

Figure ES-1. MARS® radar coverage of the Study Area.

During fall 2010 Over Land and during the day and at night the majority of birds were flying in southbound directions (i.e., to the southeast, south, and southwest). This movement indicates that southbound migration was occurring Over Land during the day and at night. More birds were migrating in southerly directions at night (10,154) than during the day (3,708).

Over Water during fall, diurnal flight direction frequency was similar in all of the ordinal directions indicating that most of the birds detected were non-migratory resident and winter resident birds on local movements in the area. At night Over Water, more birds were flying in northerly directions (primarily north, northeast; total 8,007) than in south directions (4,438). An analysis of Next Generation Radar (NEXRAD) data during selected survey days revealed that birds were flying in southerly directions. Fall 2010 nocturnal Over Water data has an unknown quantity of wave clutter contamination and should not be used for impact/risk assessment.

During the day Over Land in spring 2011, most birds were flying to the north and northeast. At night, most birds were flying to the northeast with slightly lower numbers to the north and east. Over the water during the day and at night, the majority of the birds were flying to the northeast. These diurnal and night directions were expected in spring as migratory birds fly north and northeast to their breeding grounds. More birds were migrating in northerly directions (N, NE) Over Land during the day (19,177) than during the night (6,067). Over Water similar numbers of birds were migrating to the north during the day (1,321) and at night (1,429).

VerCat Results

Fall 2010

- The median diurnal flight altitude was 247 feet (ft; 75 meters [m]) above sea level (asl) and the median nocturnal flight altitude was 452 ft (138 m) asl.
- The median diurnal flight altitude was within the RSZ on 13 days and the median nocturnal flight altitude was within the RSZ on 10 nights.
- The percentage of adjusted bird tracks was higher at night (64.38%) than during the day (35.52%). Fifty-three percent of the bird tracks were within the potential RSZ (50-450 ft [15-168 m] asl) during the day and 44% were within the RSZ at night.

Spring 2011

- The median diurnal flight altitude was 727 ft (222 m) asl; and the median nocturnal flight altitude was 770 ft (235 m) asl
- The median diurnal flight altitude was within the RSZ on 11 days during spring and the median nocturnal attitude was within the RSZ on 4 nights.
- The percentage of adjusted bird tracks was higher at night (58.61%) than during the day (41.39%). The percentage of birds within the potential turbine RSZ was similar during the day (33.20%) during the day and at night (29.63%).

Impact Analysis

The only other coastal site for which passage rate data were available was from Cape May, New Jersey. Although this data was not directly comparable to the data collected in this study because of the difference in reported metrics (birds/hr for Cape May and bird tracks [a single track may be comprised of one or more birds/km/hr]), passage rates are generally low at NAVSTA Newport when compared to Cape May (483 birds/hr). The radar passage rates at NAVSTA Newport were also lower than the radar passage

rates at inland locations in New York State where the passage rates (birds/km/hr) in spring ranged from 41 to 509 (overall mean of 254) and in fall from 112 to 535 (overall mean 324.7) (New York State Department of Environmental Conservation 2008).

Based on the results of the radar survey, the Naval Station Newport Study Area is not within a major migratory bird flight corridor. The number of birds in the Study Area was relatively low in comparison to bird passage rates for other proposed wind development sites for which public data is available. Most of these sites have passage rates over 100 targets/km/hr (New York State Department of Environmental Conservation 2008; Weston Solutions 2010) while passage rates in the NAVSTA Newport on most days during spring and fall is <50 bird adjusted bird tracks/km/hr. The lower the overall number of birds the lower bird-turbine collision potential; however, the percentage of birds in the potential turbine RSZ is in the moderate range (34-66%) during both the day (53%) and at night (43%) during fall and in the low range (0 to 33%) during the day (33.20%) and night (29.63%) at night during spring.

Avoidance would be expected to occur during diurnal hours because the single to multiple turbine locations would be visible and would be avoided by most birds. Nocturnal avoidance may also occur; however, visibility is lower at night and therefore may result in some bird-turbine collisions because of the moderate percentage of birds in the RSZ during fall. Based on the data analyzed, some bird-wind turbine collisions would likely occur during wind turbine operation; however, the number of individuals present is low which decreases the potential for bird-turbine collisions. No adverse impacts are anticipated to occur to migratory and resident bird populations because of the low diurnal and nocturnal passage rates over the Study Area. A three year post construction monitoring study will be conducted as part of the proposed action to document bird -turbine collision impacts, and determine appropriate mitigation, if necessary.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY **ES-1**

LIST OF FIGURES ..... **iii**

LIST OF TABLES ..... **iv**

LIST OF ACRONYMS AND ABBREVIATIONS ..... **v**

1.0 INTRODUCTION **1**

2.0 STUDY AREA **1**

2.1 LOCATION 1
2.2 ENVIRONMENTAL SETTING 1
2.2.1 Regional 1
2.2.2 Local 4

3.0 AVIAN RADAR ORNITHOLOGY **4**

4.0 MOBILE AVIAN RADAR SYSTEM **5**

4.1 TRACSCAN (HSR) RADAR 6
4.2 VERCAT (VSR) RADAR 6
4.3 THERMAL IMAGING-VERTICALLY POINTED RADAR (TI-VPR) 7
4.4 DATA PROCESSING 8

5.0 SURVEY METHODOLOGY **9**

5.1 AVIAN RADAR SURVEYS 9
5.1.1 Survey Design 9
5.1.2 MARS® Site Setup and Testing 9
5.1.3 Radar Operations 9
5.2 QUALITY CONTROL METHODS 11
5.2.1 Ground Truth (Radar Validation) Survey 11
5.2.2 Thermal Imaging-Vertically Pointed Radar 14
5.2.2.1 On-Site Data Capture and Processing 14
5.2.2.2 Operations 14
5.3 DATA ANALYSIS METHODS 14
5.3.1 Avian Radar 14
5.3.1.1 Introduction 14
5.3.1.2 Analysis of MARS® TracScan Data 15
5.3.2 Quality Control Data 24
5.3.2.1 Ground Truth (Radar Validation) Surveys 24
5.3.2.2 TI-VPR 25
5.3.3 Final Processing 26

6.0 RESULTS **27**

6.1 AVIAN RADAR 27
6.1.1 TracScan Radar 27
6.1.1.1 Passage Rates Over Land 27
6.1.1.2 Passage Rates Over Water 30
6.1.1.3 Comparison of Land and Water Passage Rates 30
6.1.2 Flight Direction 30

TABLE OF CONTENTS
(*continued*)

Page

6.1.2.1 Fall 2010 30
6.1.2.2 Spring 2011 34
6.1.3 VerCat 36
6.1.3.1 Initial Analysis 36
6.1.3.2 Final Analysis 41
6.2 QUALITY CONTROL 45
6.2.1 Ground Truth (Radar Validation) Surveys 45
6.2.1.1 Validation Surveys 45
6.2.1.2 Bird Species Occurrence 45
6.2.2 TI-VPR 45
6.2.2.1 Bird and Bat Species Occurrence 47
6.2.2.2 Bird Altitude Distribution 48

7.0 DISCUSSION/SUMMARY OF RESULTS 52

7.1 AVIAN RADAR 52
7.1.1 TracScan 52
7.1.1.1 Passage Rate 52
7.1.1.2 Flight Direction 53
7.1.2 VerCat 54
7.1.2.1 Fall 2010 54
7.1.2.2 Spring 2011 54
7.2 QUALITY CONTROL 54
7.2.1 Ground Truth (Radar Validation) Surveys 54
7.2.2 TI-VPR 54
7.3 SUMMARY OF ANTICIPATED BIRD-TURBINE COLLISION IMPACTS 55

8.0 LITERATURE CITED 55

APPENDICES

APPENDIX A MARS® OPERATIONAL HOURS

APPENDIX B GROUND TRUTH (RADAR VALIDATION) SURVEY METHODOLOGY

APPENDIX C DROPPED TRACK ANALYSIS

APPENDIX D FLIGHT DIRECTION DIAGRAMS

LIST OF FIGURES

Page

Figure 2-1 Location of NAVSTA Newport, Rhode Island 2
Figure 2-2 Potential wind turbine sites at NAVSTA Newport 3
Figure 4-1 GMI MARS® showing both VerCat (vertically scanning) radar (left) and TracScan (horizontally scanning) radar (right), the computer housing unit, and the generator 5
Figure 4-2 TracScan (HSR) coverage pattern 6
Figure 4-3 VerCat (VSR) coverage pattern 7
Figure 4-4 MARS® TI-VPR system 8
Figure 5-1 MARS® radar coverage of the Study Area 10
Figure 5-2 Ground truth (radar validation) survey locations 13
Figure 5-3 TracScan radar analysis areas. "East" Over Land and "West" Over Water 17
Figure 5-4 Histogram of total ground speeds between detections for 15 March 2008 from MARS® TracScan during the 2008-2009 New Jersey Ecological Baseline Study 18
Figure 5-5 Histogram of total ground speeds between detections for 15 March 2008 from MARS® VerCat during the 2008-2009 New Jersey Ecological Baseline Study 18
Figure 5-6 Histogram of unfiltered total ground speeds between detections from TracScan during the current stud 19
Figure 5-7 Total TracScan detections per day for 15 March 2008 (left) and 19 March 2008 (right) during the 2008-2009 New Jersey Ecological Baseline Study 19
Figure 5-8 Relationship between mean wind velocity and maximum range of targets (sea clutter) in TracScan during the 2008-2009 New Jersey Ecological Baseline Study 20
Figure 5-9 Histogram of total ground speeds between detections for 15 March 2008 after eliminating tracks that did not have nine continuous detections in a track for MARS® TracScan during the 2008-2009 New Jersey Ecological Baseline Study 20
Figure 5-10 Histogram of total ground speeds between detections for 15 March 2008 during the 2008-2009 New Jersey Ecological Baseline Study after applying the sea clutter filter 21
Figure 5-11 Histogram of filtered total ground speeds between detections during the fall survey 22
Figure 5-12 Histogram of filtered total ground speeds between detections during the spring survey 22
Figure 6-1 Nocturnal bird flight altitudes during the fall 2010 TI surveys in the Study Area. The corrected altitudinal count (CAC) = corrected count for birds for time sampled multiplied by the sample size correction factor 49
Figure 6-2 Nocturnal bird flight altitudes during the spring 2011 TI surveys in the Study Area. The corrected altitudinal count (CAC) = corrected count for birds for time sampled multiplied by the sample size correction factor 51

LIST OF TABLES

Page

Table 5-1 MARS® study radar operating parameters 11
Table 5-2 Ground truth (radar validation) survey data 12
Table 5-3 Total corrected count of birds, foraging bats, and insects detected during fall 2010 TI-VPR surveys 26
Table 5-4 Time corrected count of birds, foraging bats, and insects detected during spring 2011 TI-VPR surveys 27
Table 6-1 Fall 2010 passage rate[1] data summary for the Over Land sample area in the Study Area 28
Table 6-2 Spring 2010 passage rate[1] data summary for the Over Land sample area in the Study Area 29
Table 6-3 Fall 2010 passage rate[1] data summary for the Over Water sample area in the Study Area 31
Table 6-4 Spring 2011 passage rate[1] data summary for the Over Water sample area in the Study Area 32
Table 6-5 Comparison of Over Land and Over Water average passage rates 33
Table 6-6 Fall 2010 flight direction frequency Over Land analysis area 33
Table 6-7 Fall 2010 flight directions Over Land 33
Table 6-8 Fall 2010 flight direction frequency Over Water analysis area 33
Table 6-9 Flight directions Over Water 34
Table 6-10 Comparisons of flight directions recorded by MARS® and NEXRAD in relationship to winds for a subsample of dates 35
Table 6-11 Spring 2011 flight direction frequency Over Land analysis area 36
Table 6-12 Spring 2011 flight direction frequency Over Water analysis area 36
Table 6-13 Initial diurnal altitude[1] (Alt) quartile data for fall 2010 37
Table 6-14 Initial nocturnal altitude[1] (Alt) quartile data for fall 2010 38
Table 6-15 Initial diurnal altitude[1] (Alt) quartile data for spring 2011 39
Table 6-16 Initial nocturnal altitude[1] (Alt) quartile data for spring 2011 40
Table 6-17 Final diurnal altitude[1] (Alt) quartile data for fall 2010 41
Table 6-18 Final nocturnal altitude[1] (Alt) quartile data for fall 2010 42
Table 6-19 Altitude distributional summary for fall 2010 42
Table 6-20 Diurnal altitude[1] (Alt) quartile data for spring 2011 43
Table 6-21 Nocturnal altitude[1] (Alt) quartile data for spring 2011 44
Table 6-22 Altitude distributional summary for spring 2011 45
Table 6-23 Birds observed during ground truth (radar validation) surveys 46
Table 6-24 Total time corrected counts (TCC)[1] of birds, bats, and insects during fall 2010 nocturnal TI-VPR surveys 48
Table 6-25 Total time corrected counts (TCC)[1] of birds, bats, and insects during spring 2011 nocturnal TI-VPR surveys 48
Table 6-26 Nocturnal corrected altitude counts for flight altitudes during fall 2010 TI-VPR surveys in the Study Area 50
Table 6-27 Fall 2010 TI-VPR altitude distribution summary 50
Table 6-28 Nocturnal corrected altitude counts for flight altitudes during spring 2011 TI-VPR surveys in the Study Area 52
Table 6-29 TI-VPR altitude corrected nocturnal altitude distribution summary for the spring 2011 study period 52
Table 6-30 Comparison of Over Land and Over Water average passage rates 53
Table 6-31 Passage rate at Cape May 53

LIST OF ACRONYMS AND ABBREVIATIONS

°	Degree(s)
°C	Degree(s) Celsius
°F	Degree(s) Fahrenheit
µm	Micron(s)
µs	Microsecond(s)
ac	Acre(s)
agl	Above Ground Level
asl	Above Sea Level
CAC	Corrected Altitudinal Count
cm	Centimeter(s)
DoD	Department of Defense
DoE	Department of Energy
DVD	Digital Versatile Disc
E	East
ED	Environmental Division
ENE	East-Northeast
EO	Executive Order
ESE	East-Southeast
FPA	Focal Plane Array
ft	Foot (Feet)
ft/s	Foot (Feet) per Second
GMI	Geo-Marine, Inc.
GPS	Global Positioning System
ha	Hectare(s)
hr	Hour
HSR	Horizontally Scanning Radar
Hz	Hertz
ID	Identification
in.	Inch(es)
km	Kilometer(s)
kt	Knot
kW	Kilowatt(s)
m	Meter(s)
m/s	Meter(s) per Second
MARS®	Mobile Avian Radar System
MHz	Megahertz
mi	Mile(s)
min	Minute(s)
mm	Millimeter(s)
MW	Megawatt(s)
N	North
NAVSTA	Naval Station
NE	Northeast
NEXRAD	Next Generation Radar
NJDEP	New Jersey Department of Environmental Protection
NM	Nautical Mile(s)
NNE	North-Northeast
No.	Number

LIST OF ACRONYMS AND ABBREVIATIONS
(*continued*)

ns	Nanosecond(s)
NUWC	Naval Undersea Warfare Center
NW	Northwest
PC	Personal Computer
PRF	Pulse Repetition Frequency
QA/QC	Quality Assurance/Quality Control
Radar	Radio Detection and Ranging
Rec.	Recreation
RO	Radar Operator
rpm	Revolution(s) per Minute
RSZ	Rotor Swept Zone
s	Second(s)
S	South
SE	Southeast
SR	Standard Resolution
SSE	South-Southeast
SSW	South-Southwest
STE	Standard Error
SW	Southwest
TCC	Time-corrected Count
TI	Thermal Imaging
TV	Television
U.S.	United States
VGA	Video Graphics Array
VPR	Vertically Pointed Radar
VPS	Video Peak Store
VSR	Vertically Scanning Radar
W	West

1.0 INTRODUCTION

The United States (U.S.) Department of Defense (DoD) has proposed goals to increase renewable energy use at DoD installations in accordance with The Energy Policy Act of 2005 and Executive Order (EO) 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*. Naval Station (NAVSTA) Newport has studied a number of potential sites for wind turbines including the main base of NAVSTA Newport and isolated NAVSTA Newport parcels to the north of the base. These studies, based on the Department of Energy's (DoE's) Wind Power Classification System have determined that NAVSTA Newport has enough wind potential (i.e. typically sustained winds of 6.5 meters/second [m/s] or greater) to develop a utility-scale wind energy project (AWS Truewind 2008; DNV Global Energy Concepts 2010; National Renewable Energy Laboratory 2010). NAVSTA Newport is proceeding with a plan to develop the wind energy project at 12 potential sites. The number and size of the turbines located at each site will be made by using the Federal Aviation Administration maximum allowable turbine height at each site and determining the combination of turbine number and size that would meet the goal of producing 9 megawatts (MW) of wind-generated energy.

To meet environmental compliance requirements for the proposed wind energy project, the NAVSTA Newport Environmental Division (ED) identified the need to conduct avian radar studies to examine and address the potential for bird and bat collisions with the proposed wind turbines. NAVSTA Newport awarded a contract for Baseline Avian Radar Studies to Geo-Marine, Inc. (GMI).

This report provides a review of avian radar ornithology, avian radar, and ground truth (radar validation) surveys, as well as analysis methods and the results of the onsite radar investigations. This baseline study reports avian passage rates, flight altitudes, and flight directions, and percentages of birds in the rotor swept zone (RSZ) over and in the vicinity of the NAVSTA Newport during fall 2010 and spring 2011.

2.0 STUDY AREA

This section describes the location of Study Area, proposed turbine locations, and the environmental setting in the Study Area. The environmental setting describes aquatic and terrestrial coastal habitats that support many species of plants and animals.

2.1 LOCATION

NAVSTA Newport occupies approximately 1,388 acres (ac; 561.7 hectares [ha]) along a 10-mile (mi; 16.1-kilometer [km]) stretch of shoreline along Narragansett Bay on the west side of Aquidneck Island, within the towns of Newport, Middletown, and Portsmouth in Newport County, Rhode Island (**Figure 2-1**). Aquidneck Island is the largest island in Narragansett Bay.

Single or multiple wind turbine(s) would be located at up to 12 sites on NAVSTA Newport property (**Figure 2-2**). These site locations were identified in a pre-assessment of wind resources for NAVSTA Newport (AWS Truewind 2008).

2.2 ENVIRONMENTAL SETTING

2.2.1 Regional

The North Atlantic coastline of the U.S. contains a diversity of coastal and offshore habitats. Northeastern forests of the coastal plain historically covered the area in the vicinity of NAVSTA Newport. This Ecoregion is dominated by oak forests characterized by white oak (*Quercus alba*) and northern red oak

(*Quercus rubra*). Salt marshes are found throughout the coastal area of Rhode Island's salt ponds, bays, and estuaries.

Figure 2-1. Location of NAVSTA Newport, Rhode Island.

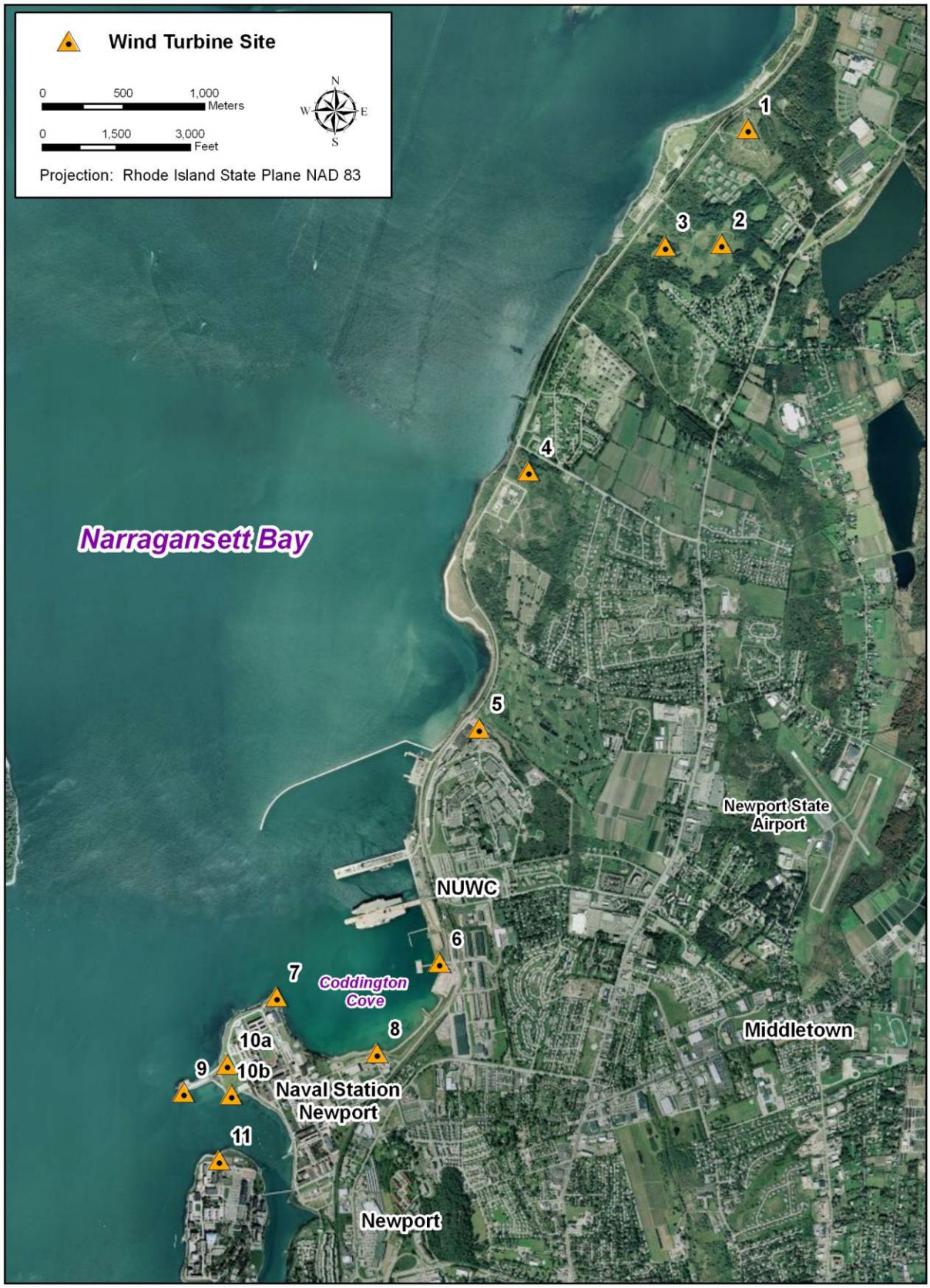


Figure 2-2. Potential wind turbine sites at NAVSTA Newport.

Forests provide habitats for a variety of animals (insects, birds and mammal species). Salt marshes are nursery grounds and foraging areas for many species of birds, fish, mammals, and invertebrates. Salt marshes also function as buffers from storms and flooding events. Salt marshes, associated plant communities, and estuaries in Rhode Island support approximately 200 million dollars of recreational and commercial fisheries (Coastal Resources Management Council 2010). Other critical habitats and/or uncommon habitats found in the coastal area surrounding Newport, Rhode Island include wetlands (Atlantic white cedar swamps, bogs and fens), freshwater tidal marshes, and pitch pine/scrub oak barrens. Habitat on Aquidneck Island ranges from native forest to urban landscaped habitats. Most of the forests on Aquidneck Island are comprised of hardwoods. The most common hardwood forest communities are mesic lowland, which are comprised primarily of red maple (*Acer rubrum*) and xeric upland dominated by red oak and white oak (Louis Berger & Associates 1997).

2.2.2 Local

At NAVSTA Newport, terrestrial habitats are landscaped with native and non-native grasses, shrubs, and trees. A freshwater wetland is located adjacent to Deerfield Pond on the northeast perimeter of the Newport Main Site. Native coastal habitat is not present on base (Louis Berger & Associates 1997). Coastal aquatic estuarine habitats adjoin the main base. Narragansett Bay, which borders NAVSTA Newport on the west, is one of the largest estuarine systems on the eastern U.S. seaboard. This estuary provides habitat for birds (waterfowl, shorebirds, gulls, and terns), finfish, shellfish, and marine mammals. The outlying land parcels owned by the NAVSTA Newport, particularly the old tank farms, are comprised of early succession habitats (grasslands, shrublands, and thickets) and small areas of scattered forest. Less common habitats at the tank farm sites includes small patches of hardwood forest and freshwater wetlands. The old tank farm sites provide habitat for a variety of wildlife species (Rhode Island Natural History Survey 2005) including frogs, birds (e.g., hawks, songbirds), small mammals (e.g., squirrels, raccoons) and large mammals (deer). On the main station at NAVSTA Newport, native habitat has mostly been replaced by urban landscaping. With the except of deer, the general types of wildlife described above for the tank farm also occur on NAVSTA Newport; however, the number of individuals is typically smaller because of the limited and developed habitat.

3.0 AVIAN RADAR ORNITHOLOGY

Radar is an acronym for Radio Detection and Ranging. All radars transmit a radio signal, and then receive the reflected signals (echoes) from objects in the atmosphere. The farther away a biological target, the longer it takes for an echo to return to the receiver and the weaker that echo is. Almost any object will reflect radar signals; the strength of the echo is dependent upon the object's composition, the wavelength of the radar signal, the power of the signal, and the distance from the radar to the object. Metal objects reflect radar energy strongly; water and land reflect less strongly. A bird has approximately the same reflectivity as a similar mass of water. Bird echoes are small and weak relative to those of larger metal objects (e.g., boats, airplanes). Therefore, radars are only capable of detecting birds at shorter ranges [1.1-2.2 nautical miles (NM) (usually within 2-4 km) for small birds (e.g. kinglets, flycatchers, warblers, sparrows) and out to 6.5-7.6 NM (12-14 km) for large birds (e.g., geese, ducks, gulls) or flocks of birds. Flock size is a variable term and depends on the size of an individual bird; a flock may be as few as 5 to 10 large birds or 25 small birds.

Empirical evidence shows that the strength of echoes, or "signals", from birds is generally related to the wavelength of the radar signal, the distance from the radar to the bird, the size of the bird, and the profile the bird presents towards the radar. Bird targets are generally more difficult to detect at increasing distance from the radar because the amount of reflectivity returned to the radar is small. The smaller the biological target (small reflective surface or cross-section), the more difficult it is for the radar to detect.

Therefore, low numbers of small biological targets are more likely to be detected at 1.7 NM (3.2 km) from the radar than at 3.5 NM (6.4 km); larger biological targets (i.e., flocks or large birds) can be detected at greater distances (i.e., throughout the radar coverage area). The power of the radar also affects the distance that bird biological targets can be detected.

Radars work primarily along line-of-site and scan in a circular or vertical sweep. Obstructions (e.g., towers, vessels) create a shadow which obscures radar detection of objects behind the obstruction. These obstructions, as well as ground clutter (e.g., buildings, hills, trees) and sea clutter (i.e., waves, swells) also reflect transmitted radar energy back to the radar. These radar reflections are known as clutter echoes. Echoes from waves are of similar or greater strength than birds, while tower and vessel echoes are usually much stronger than echoes from birds.

4.0 MOBILE AVIAN RADAR SYSTEM

The GMI Mobile Avian Radar System (MARS®) was stationed at a shoreline location on northern end of the McAllister Point Landfill to monitor bird movements over coastal waters adjacent to and Over Land in the areas where wind turbines were proposed to be sited on NAVSTA Newport. This section provides a description of the MARS® including standard operations and capabilities, and discusses the real-time data processing performed by the MARS®.

For this study, the MARS® was equipped with two radar systems (**Figure 4-1**):

- A TracScan (Horizontally Scanning Radar [HSR]) which determines the number, range, flight direction, speed, and heading of biological targets.
- A VerCat (Vertically Scanning Radar [VSR]) that determines the altitude and range of biological targets.

Figure 4-1. GMI MARS® showing both VerCat (vertically scanning) radar (left) and TracScan (horizontally scanning) radar (right), the computer housing unit, and the generator.

Both the TracScan (HSR) and VerCat (VSR) use commercially available marine-band radars that transmit radio signals and receive reflected signals from targets (echoes). These radars transmit for a very short duration (pulse length) and then receive signals from echoes until the next pulse is transmitted. The number of times per second that radar transmits a pulse and receives is the pulse repetition frequency (PRF). Radar manufacturers fix combinations of pulse length and PRF in the radar hardware. Commercially available marine-band radars effectively see in two dimensions, using the time between pulse and detection to determine the distance to the target, and the orientation of the radar antenna to determine bearing of the target.

4.1 TRACSCAN (HSR) RADAR

The TracScan (HSR) is used to track bird movements in the horizontal plane. Speed and direction of movement and echo intensity is measured for each track automatically. The TracScan (HSR) radar scans in the horizontal plane at 24 revolutions per minute (rpm), completing one scan (a full 360-degree [°] rotation) every 2.5 seconds (s) (**Figure 4-2**). Given a PRF of 1,500 times a second, the TracScan (HSR) can transmit 10.41 pulses for every degree of radar rotation.

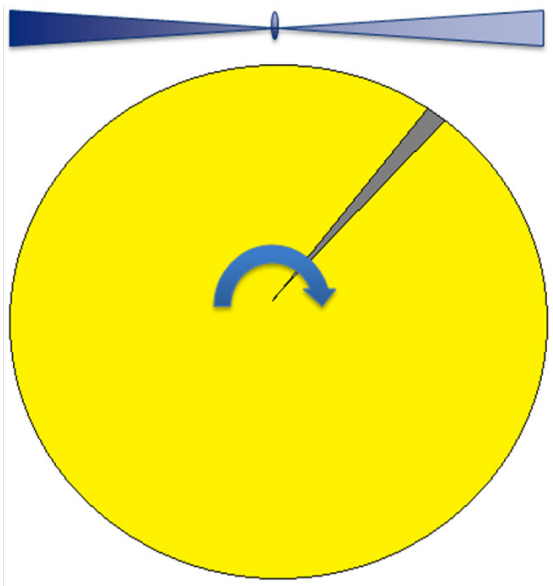


Figure 4-2. TracScan (HSR) coverage pattern.

4.2 VERCAT (VSR) RADAR

The MARS® VerCat (VSR) scans a 20° wedge in a vertical sweep from the horizon, through zenith to the opposite horizon (**Figure 4-3**). No signal is transmitted while the antenna is pointing below horizontal; however, given the 0.95° vertical resolution of the antenna, when the radar transmits a pulse horizontally, almost one half of the energy is projected below the horizon towards the ground or water. The radar scans at 24 rpm, completing one scan (a full 360° rotation) every 2.5 s. Given a PRF of 3,000 pulses per second, it can transmit 20.83 pulses for every degree of radar rotation. The radar signal is transmitted through an 8-foot (ft; 2.4-meter [m]) long array (T-bar) antenna. The antenna focuses the signals into a fan-shaped beam, which is 0.95° in the vertical scanning plane and extends 10° to either side of the scanning plane (20° total). Radar antennas are designed to operate scanning horizontally, not vertically. When the antenna is pointing at the sky, some radio energy leaks out the backside of the standard antenna and

bounces off the ground. The MARS® VerCat (VSR) antenna has been fitted with a custom-designed shield to minimize the impact of this ground-bounce clutter.

The VerCat (VSR) scan pattern results in a "radar curtain," that samples biological targets as they fly through the 20° by 180° scanning volume within 1.5 NM (2.8 km) of the radar. For this study, the VerCat (VSR) stopped transmitting when it reached the horizontal. The radar determines biological target altitude and downrange distance from the MARS® site. The VerCat (VSR) vertical beam width of 0.95° provides fine angular resolution from which estimates of biological target altitude can be determined. Biological targets flying within the beam parallel to the VSR scan can be tracked and accurate ground speeds measured; however, biological targets crossing perpendicular to the sweep of the beam appear stationary and biological targets crossing the sweep at angles between parallel and perpendicular have ground speeds reduced from true ground speeds. Consequently, the VerCat (VSR) is used only to measure the altitude of biological targets. Wind speeds in excess of 30 to 35 knots (kts) along the VerCat (VSR) scan axis will trip the VerCat's (VSR) motor safety breaker and shut down the radar. By shutting down operation, the radar protects itself from damage.

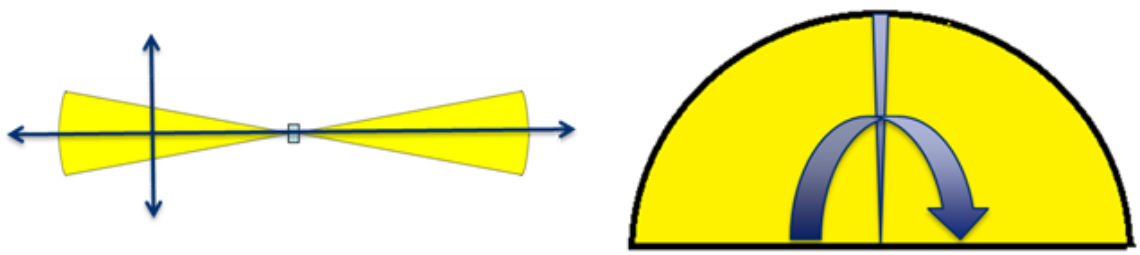


Figure 4-3. VerCat (VSR) coverage pattern.

4.3 THERMAL IMAGING-VERTICALLY POINTED RADAR (TI-VPR)

The Thermal Imaging (TI) – Vertically Pointed Radar (VPR) system for this study was stationed on the MARS® and consists of two components:

- TI, pointed up vertically to obtain target identification, behavior, and X/Y dimensional information (**Figure 4-4**):
- VPR, pointed up vertically to obtain altitude (Z dimension) of targets within the TI field of view.

The TI selected for this study is a fixed focus, un-cooled TI camera (FLIR Standard Resolution [SR]-35, FLIR Systems, Inc., Goleta, California) with a 1.4-inch (in.; 35-millmeter [mm]) lens and a 20° field of view. This camera is well-suited for short range surveillance use (i.e. monitoring activity within the potential turbine RSZ) with a minimum focus distance of only 3 ft (1 m). It has a standard resolution focal plane array (FPA) of 320 x 240 pixels with a pixel pitch of .0015 in. (38 microns [µm]) and a spectral range of 0.0003 to 0.0006 in. (7.5 to 13 µm). The camera is able to operate in temperatures ranging from -25 degrees Fahrenheit (°F) to 130°F (-32 degrees Celsius [°C] to 54°C).

The VPR (FURUNO FR-1525 Mark-3, FURUNO Electric Co, LTD., Nishinomiya, Japan) was coupled to a standard gain horn antenna (WR-90, Pasternack Enterprises, Inc., Irvine, California) with a beam width of 15°. A right angle waveguide elbow was used to point the horn antenna up parallel with the TI. The transmitter frequency was 9,410 ±30 megahertz (MHz; X-band, 1-in. [3 centimeter (cm)] wavelength) with peak power output of 25 kilowatts (kW) and a minimum range detection of 115 ft (35 m). The 0.25-NM (463-m) radar range setting was chosen to observe activity aloft within and above the

RSZ. Additional settings were 0.07 microseconds (µs) pulse length, 3000 hertz (Hz) PRF, and 0.05-NM (92.6-m) range rings.

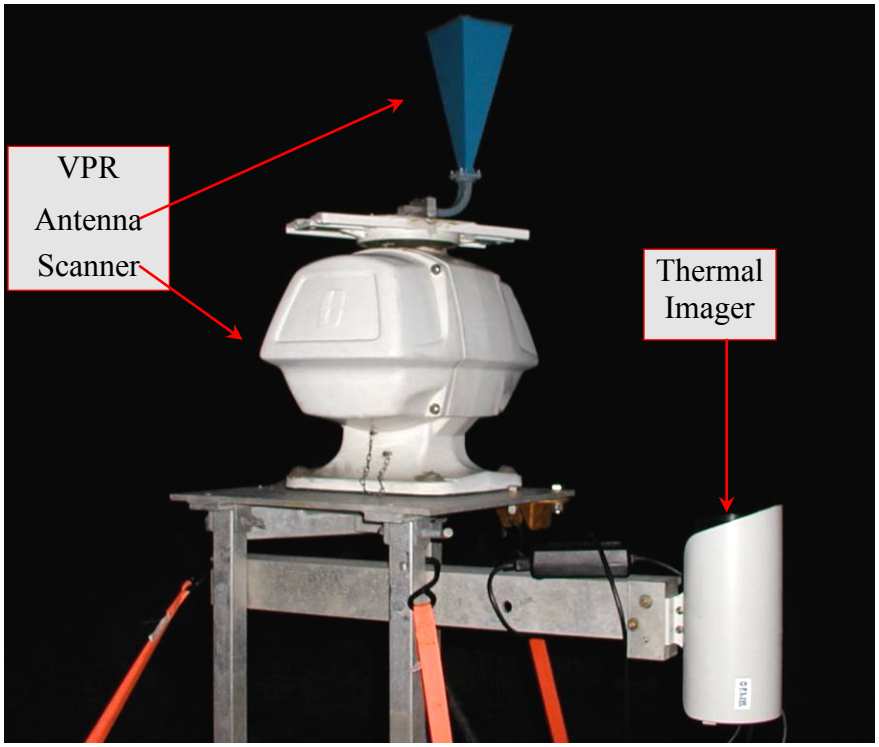


Figure 4-4. MARS® TI-VPR system.

4.4 DATA PROCESSING

The GMI MARS® replaces commercial marine radar processors with high-resolution processors. Radar echoes are digitally captured and sampled at 4,096 levels of resolution. After each radar scan, the MARS® software processes these high-resolution data to generate dynamic maps of background clutter and exploit the small differences between clutter and biological targets.

GMI proprietary algorithms attempt to exploit the distinction between background clutter and moving biological targets in order to detect small radar echoes in the presence of background clutter. The MARS® software maintains a real-time clutter map that incoming radar echoes are compared against. "Detection" is any echo with a reflectivity that is sufficiently above the real-time background clutter. The definition of "sufficient" is complicated by the variable nature of radar echoes. Biological target echo strength depends upon the biological target's reflective area (radar cross-section) and this is dependent on the size of the bird, flight orientation relative to the radar, and even wing position. These variables can change greatly and rapidly between successive 360° radar scans. After making the detection, MARS® automatically archives information about each detection in a track (range bearing, flight bearing, size, and strength) to a database for future analysis.

The TI is analyzed by replaying data and identifying the biological targets (i.e., birds, bats, insects) observed during the survey period. The VPR data were processed identically to that described above for the radar.

5.0 SURVEY METHODOLOGY

This section describes the avian radar survey design and methods, data analysis methodologies, and the quality control methods and analysis methodologies for the study.

5.1 AVIAN RADAR SURVEYS

5.1.1 Survey Design

Ground clutter and sea clutter are serious issues for all onshore and offshore avian radar studies. Ground clutter (e.g., buildings, trees, hills, ridges, etc.) can block a portion of the radar beam and eliminate radar coverage above and beyond the obstruction. False biological tracks (resulting from numerous detections) are known to be generated by wave movement (GMI 2010).

Prior to deployment of the MARS®, GMI avian radar biologists conducted a reconnaissance visit to determine potential radar site locations with a minimum of potential ground and sea clutter. Ideally, the land-based radar should be sited at an elevated location in a flat open area without nearby ground clutter. Sites for the radar were found to be very limited in the Study Area because of the ground clutter on the base and off-base (i.e., buildings, trees on base, high trees or brush at the old tank farms), and a ridgeline east of the coast. No acceptable sites were located on the main base, old tank farms or the ridgeline north of the base. The only semi-open site identified for the radar was at the MacAllister Point Landfill along Narragansett Bay.

GMI used a MARS® unit that had been designed for coastal avian radar studies for the New Jersey Ocean Wind Ecological Baseline Study (GMI 2010). The MARS® dual radar system for this study consisted of a 3.9-in. (10-cm) wavelength 30-kW TracScan radar with an open array antenna for horizontal scanning and a 1.2-in. (3-cm) wavelength, 25-kW VerCat radar with an open array antenna for vertical scanning.

5.1.2 MARS® Site Setup and Testing

The MARS® was set-up on the northern end of the McAllister Point Landfill (**Figure 5-1**) on 12 October 2010. The TracScan was set to turn clockwise (360°) and the VerCat was oriented to sweep from the northeast (40°) to the southwest (220°). The TracScan was set to collect data within a 4-NM (7.4-km) radius and VerCat was set to collect data to 1.5 NM (2.8 km) from the radar (**Figure 5-1**). The radar unit was tested and final adjustments were completed by the avian radar operator to provide for maximum detection of avian targets within the Study Area.

Set-up and testing of the MARS® was re-initiated on 20 April 2011. The radars were checked and adjusted to ensure the TracScan and VerCat radars were operating properly. Radar settings were set to match the settings used during the fall 2010 study and tested to determine if the radars were meeting radar detection standards.

5.1.3 Radar Operations

Operating parameters for the study are summarized in **Table 5-1**. Since the MARS® can operate for four days unattended on generator power, avian radar operators were scheduled to be at the unit at least every four days to fuel the system, perform standard maintenance, check radar operations, and conduct ground truth (radar validation) surveys. The avian radar operator ensured that the unit was level and that the radars, processing computers, and weather station were operational.

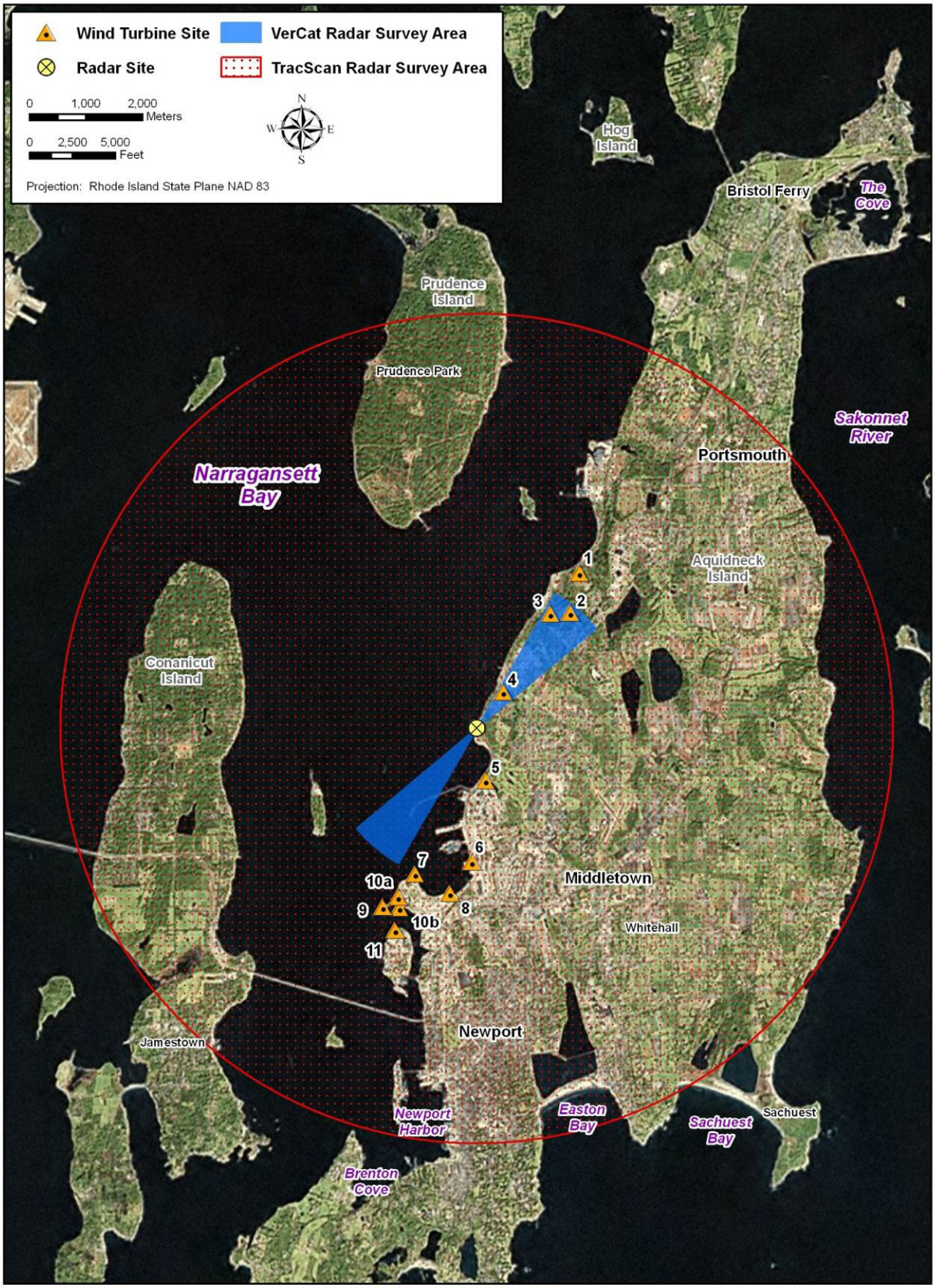


Figure 5-1. MARS® radar coverage of the Study Area.

Table 5-1
MARS® study radar operating parameters

Radar Parameters	Vertical Scanning Radar	Horizontally Scanning Radar
Radar Type	FR 2125-B	FR 2135S-B
Band Type	X-band	S-band
Transmit Peak Power	25 kilowatts (kW)	30 kW
Transmit Frequency	9410±30 megahertz (MHz)	3050±30 MHz
Transmit Pulse Length	70 nanoseconds (ns)	300 ns
Pulse Repetition Frequency	3000 hertz (Hz)	1500 Hz
Beam Width (horizontal)	20 degrees (°)	2.3°
Beam Width (vertical)	0.95°	25°
Maximum Study Range	1.5 nautical miles (NM; 2.8 kilometers [km])	4 NM (7.4 km)
Antenna Polarization	Vertical	Horizontal
Wave Length	1.2 inches (in.; 3 centimeters [cm])	3.9 in. (10 cm)

The 30-day fall radar study period commenced on 12 October and ended on 12 November 2010 and the 30-day spring radar study period started on 20 April and ended on 19 May 2011.With the exception of time for routine maintenance, MARS® operated continuously during most of the study. TracScan data were not collected on 17-18 October 2010 and VerCat data were not collected from 17-19 and 26-28 October 2010 because of a computer failure, and on 16 October and 08 November 2010 because of high winds (>30 kts). TracScan operated for 709 hours (hrs) and VerCat ran for 540 hrs during the fall study period. During the spring study period, TracScan operated for 643 hrs and VerCat ran for 607 hrs. During the spring survey period, VerCat shut down because of high winds on 28 April 2011and 11 May 2011. No VerCat data were analyzed on 24 April and 19 May 2011 because of an all day rain event. Daily operational hours are listed in **Appendix A**.

5.2 QUALITY CONTROL METHODS

In areas with high rates of diurnal bird movements, it is almost impossible to capture diurnal bird activity in three dimensions and relate the visual data to the radar data. To simplify this process, GMI has developed a line-intercept protocol for making onshore and offshore observations (**Appendix B**). This protocol represents a straight-forward way to identify sources of radar echoes when the radar is in surveillance mode. Because the protocol concentrates on birds crossing a specific azimuth line over the land or water, estimates of bird target range, altitude, and flight direction along with the identity and number can be made by the observer and subsequently confirmed or unconfirmed by the radar operator.

At night, insects and foraging bats can be detected by the VerCat and recorded as false bird tracks. GMI has developed a TI-VPR system to address this problem. This system compares thermal imaging results (number of birds, insects, and bats) with the VPR in same sample volume which allows a correction factor to be applied to remove insect targets from the data.

5.2.1 Ground Truth (Radar Validation) Survey

The protocol for validating sources of radar tracks is a variation of the line-intercept sampling protocol used by ecologists to count animal tracks crossing a line (**Appendix B**). Although the line in this protocol is imaginary, when a bird crosses the vertical plane above the line, the data on the bird's identity, number observed, flight altitude, and flight direction are recorded.

Four areas were selected for fall radar validation surveys, the North Breakwater, North Jetty, NAVSTA Newport Recreation Area, and Bishops Rock. Pritchard Field was surveyed from Bishop Rock. Eight validation events were conducted at four sites (**Table 5-2** and **Figure 5-2**). Total fall ground truth survey effort was 12.8 hrs.

Two areas were selected for the spring radar validation surveys, Narragansett Bay and the cove (**Figure 5-2**). All surveys were conducted from the south point on the McAllister Point Landfill site. Validation surveys were scheduled for 26-29 April and 17-19 May 2011. Heavy fog forced cancellation of surveys from 26-28 April 2011. Surveys were conducted by the radar operator in early May to replace these missed survey days. Rain limited survey effort from 17-19 May 2011. A total of 26 validation events were conducted during spring (**Table 5-2**). Total spring ground truth survey effort was 13.3 hrs.

Table 5-2
Ground truth (radar validation) survey data

Event No.	Date	Local Time	Location	Survey Azimuth
1	10/28/2010	13:52 to 14:49	North Breakwater	250
2	10/29/2010	09:52 to 10:50	North Jetty	25
3	10/29/2010	16:08 to 16:58	North Jetty	25
4	11/3/2010	07:18 to 11:51	North Jetty	305
5	11/3/2010	15:51 to 18:41	Bishop's Rock	20
6	11/3/2010	15:51 to 18:41	Pritchard Field	90
7	11/5/2010	14:04 to 15:30	Bishop's Rock	20
8	11/5/2010	16:15 to 17:30	NAVSTA Newport Rec. Area	110
9	4/29/2011	8:52 to 10:55	McAllister Point Landfill (Bay)	270
10	4/29/2011	8:52 to 10:55	McAllister Point Landfill (cove)	225
11	4/29/2011	16:50 to 1850	McAllister Point Landfill (Bay)	270
12	4/29/2011	16:50 to 1850	McAllister Point Landfill (cove)	225
13	5/7/2011	10:50 to 11:20	McAllister Point Landfill (Bay)	270
14	5/8/2011	10:55 to 11:25	McAllister Point Landfill (Bay)	270
15	5/8/2011	18:30 to 19:30	McAllister Point Landfill (Bay)	270
16	5/9/2011	11:30 to 12:00	McAllister Point Landfill (Bay)	270
17	5/9/2011	18:30 to 19:00	McAllister Point Landfill (Bay)	270
18	5/10/2011	18:20 to !8:50	McAllister Point Landfill (Bay)	270
19	5/11/2011	12:00 to 12:30	McAllister Point Landfill (Bay)	270
20	5/12/2011	10:40 to 11:00	McAllister Point Landfill (Bay)	270
21	5/12/2011	19:20 to 19:50	McAllister Point Landfill (Bay)	270
22	5/17/2011	9:30 to 10:30	McAllister Point Landfill (Bay)	270
23	5/17/2011	9:30 to 10:30	McAllister Point Landfill (cove)	225
24	5/17/2011	17:05-to 17:20	McAllister Point Landfill (Bay)	270
25	5/17/2011	17:05 to 17:20	McAllister Point Landfill (cove)	225
26	5/18/2011	9:30 to 10:30	McAllister Point Landfill (Bay)	270

Note: Events 5 and 6, 9 and 10, 11 and 12, 22 and 23, and 24 and 25 were conducted concurrently
Rec. = Recreation

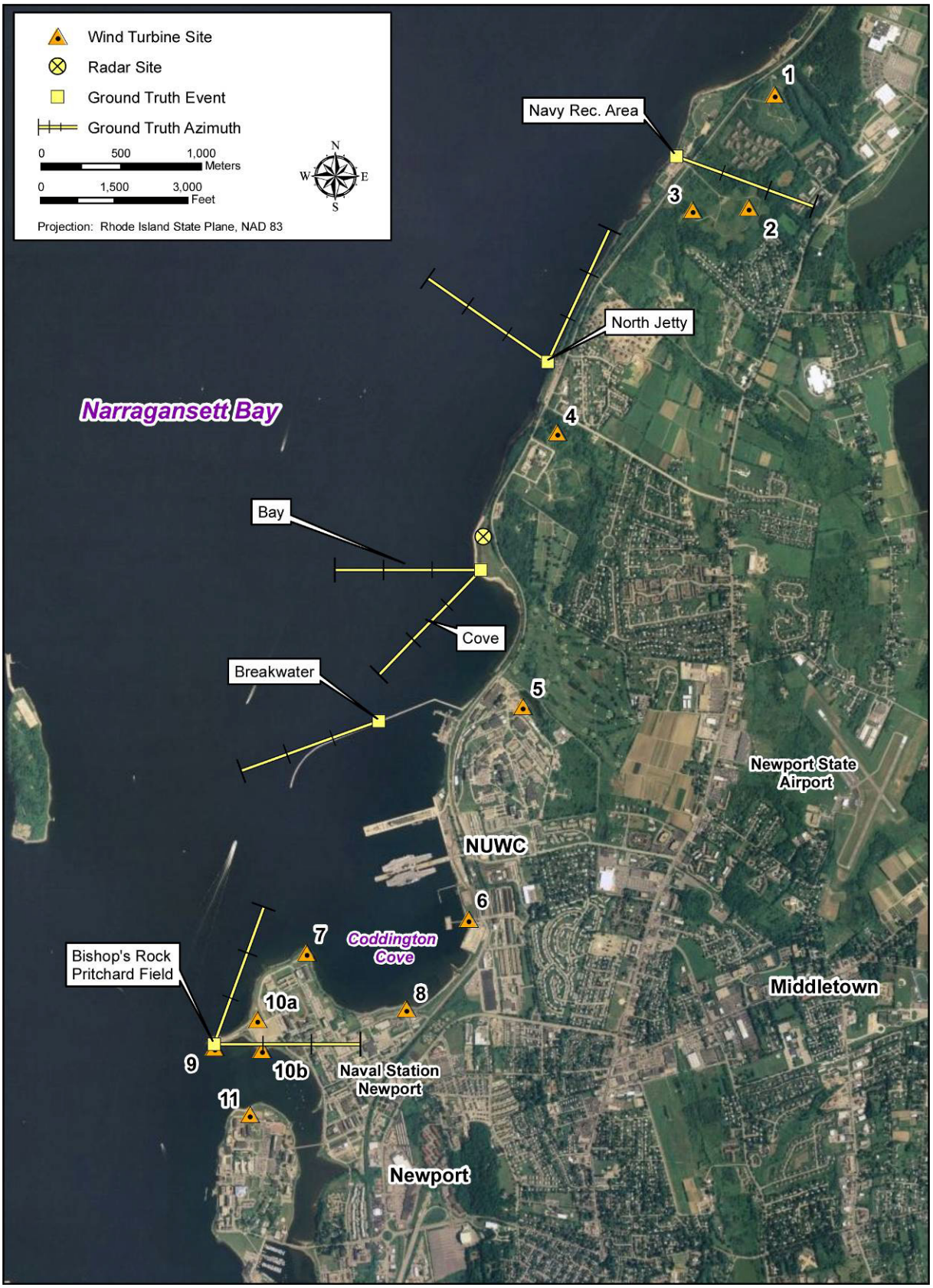


Figure 5-2. Ground truth (radar validation) survey locations.

Upon arrival at the survey site, the observer recorded pertinent data on the "Ground Truth Data Sheet". Data recorded included: project name, date, global positioning system (GPS) position of the observer and the azimuth of their observation azimuth (line). The survey azimuth was then added to the radar display by the radar operator (RO). The RO then notified the ground observer via cell phone of the survey start time. The RO in the MARS® began observing the radar displays surrounding the designated survey azimuth. During the first four survey events, the RO notified the ground observer when a target crossed the survey azimuth and requested a confirmation of the sighting. If the bird target was observed (confirmed) in "real time" by the ground observer, the information was entered into the radar detection database by the RO. If the bird target was not observed (unconfirmed) by the RO, the information was recorded on the ground truth data sheet by the observer. To increase the quantity of data collected, the RO called sightings to observer and the observer called sightings to the RO during events 5 through 8.

5.2.2 Thermal Imaging-Vertically Pointed Radar

5.2.2.1 On-Site Data Capture and Processing

Output from the TI and VPR was combined into a single video display before being recorded. The MARS® VPR signal was converted from a video graphics array (VGA) output into composite video (personal computer [PC] to television [TV] converter). This output was then sent to a video multiplexer (Colorado Video, Boulder, Colorado) and combined with the video output from the TI into a single video display. The combined output was recorded on digital versatile disc (DVD) via a Sony Model VRD-MC5.

5.2.2.2 Operations

Based on past Next Generation Radar studies conducted in the region, GMI's Senior Radar Ornithologist, Dr. Sid Gauthreaux, recommended that nocturnal TI-VPR surveys be conducted for a one hour period starting one hour after sunset on nights without precipitation (i.e., drizzle, fog, and rain) or low cloud cover. Surveys were conducted on 10 nights between 12 October and 11 November 2010.

5.3 DATA ANALYSIS METHODS

5.3.1 Avian Radar

5.3.1.1 Introduction

Echoes from ground clutter on land are much more persistent and stronger than echoes from biological targets. If a biological target (bird, bat, insect) is flying over background ground clutter, then the target will be eliminated when background clutter is eliminated during on-site processing. GMI identifies ground clutter within the radar coverage area and selects a non-clutter area(s) for radar analysis.

European radar studies of local and migratory bird movements in offshore areas selected for wind development projects have noted that rain and waves affect marine radar performance when the radar is operated in the conventional horizontal scan mode (Tulp et al. 1999; Christensen et al. 2004). Off-the-shelf marine radars with array antennas project nearly half of their radiation below the horizontal, and even slight wave action can generate sea clutter echoes that make tracking echoes from birds difficult to impossible. This problem has resulted in some studies conducting bird movement studies only when the sea is relatively calm. In a study of bird movements and collision risks at the offshore wind farms at Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Blew et al. (2006) used marine radar in a horizontal scanning mode with a range of 1.5 NM (2,780 m). They stated that "A prerequisite for the use of horizontal radar is a calm sea state (wind speeds less than 3.9 kts [2 m/s]). Otherwise, the signals will be concealed by sea clutter, caused by the reflection of the radar waves by a rough water surface" (Blew

et al. 2006). Marine radar has a sea clutter filter, but use of this filter may decrease the detection of small birds.

At least one European offshore radar study has reported results from a horizontally scanning marine radar (S-band, 30-kW, 25° beam width, 6-NM [11-km] range) with digital processing similar to MARS® TracScan (Kreijgsveld et al. 2005). The authors noted that sea clutter produced 85% of the tracks (false tracks) displayed on radar and cautioned readers that even after the application of a clutter removing procedure, the data still contained an unknown number of false tracks within the ranges affected by sea clutter. MARS® TracScan also produces false tracks from sea clutter detections.

At sea, clutter from waves and swells varies greatly from scan to scan, and although the MARS® algorithms take the nature of the target and the clutter variations into account when determining whether to record the detection as a moving target, the dynamic reflectivity of waves often makes this task impossible. When sea clutter is high, targets of interest may be suppressed along with sea clutter targets or blocked. If detections of sea clutter are not suppressed then they may produce false tracks. Rain also produces undesirable dynamic clutter in VerCat and TracScan. Echoes from rain may greatly inflate the number of detections.

Quality Assurance/Quality Control (QA/QC) procedures were developed for coastal radar surveys during GMI's Ocean Wind Ecological Baseline Study for the New Jersey Department of Environmental Protection (NJDEP) to minimize false tracks resulting from ground clutter and sea clutter (GMI 2010). These procedures are explained in this section. Filtering rules developed from these tests and analyses were used to process avian radar data for this study; justification for these filters is also discussed below.

5.3.1.2 Analysis of MARS® TracScan Data

TracScan data were used for calculating passage rates and flight directions. After the auto capture and on-site processing of the data were completed, the data were removed from the host computer for further analysis. TracScan can detect precipitation (i.e., rain, sleet, snow); these detections can be processed and generate false tracks and greatly increase bird passage rates. In addition, false flight direction can also result from the generation of false tracks (sea clutter). TracScan can also detect wave movement (sea clutter/false tracks). It is important to remove false tracks that result from detections of rain and sea clutter to assure that the results of the analyses relate to biological targets and not to false tracks. Avian TracScan radar data analysis protocols for this study are discussed in detail below.

Rain Clutter

The on-site weather station database was queried to determine the rain start and end times during the study. Time with rain was eliminated from the database before beginning TracScan avian radar data processing.

Initial Clutter Analysis

Diurnal and nocturnal TracScan data from the Study Area were plotted to determine areas where the radar had detected biological targets. Radar detections were very limited Over Land within the Study Area. The limited radar coverage Over Land was because of the low elevation of the site, the presence of a ridgeline to the east the radar site, and the ground clutter (buildings, trees) on land. In contrast, Over Water detections of biological targets Over Water west of the radar were not limited by obstructions until the beam reached a land mass (e.g., island). Over Water coverage was limited to the far south and north.

To ensure the processed radar data were not adversely affected by ground and sea clutter, the radar survey area was sub-sampled over both land and water within the Study Area. Two partial arcs, one Over Land

and one Over Water, of equal size and distance from the radar site which exhibited a similar density of target detections, were selected for the radar analysis (**Figure 5-3**).

Sea Clutter

When the velocity measured between two detections was plotted in a histogram, sea clutter detections were particularly evident during initial raw data processing for the NJDEP Study (**Figure 5-4**). The excessively high ground speeds (100+ kts [51.4 m/s]) are not representative of biological tracks (bird flight speeds are generally <80 kts [41.1 m/s]) and are classified as false tracks. It is unknown how the plotting algorithms produce these false tracks, but sea clutter may be responsible, because the histograms of velocity measured between detections with MARS® VerCat do not contain the abnormally fast velocities (**Figure 5-5**).

Prior to processing, a flight speed histogram was generated for the raw TracScan data from this study (**Figure 5-6**). The flight speed distribution was similar to that detected during initial processing of the NJDEP Study (**Figure 5-4**). Therefore the filtering rules developed during the 2008-2009 NJDEP Study (GMI 2010) were used on the TracScan data collected during this study to reduce detections from sea clutter and false tracks. The development of these rules is discussed below.

The distribution and density of processed detections were plotted for each day during the NJDEP Study (**Figure 5-7**). To examine the relationship between sea clutter detections and wind velocity, the maximum range of detections was determined by inspecting the daily plots of all detections. The density of detections is greatest near the radar (red colored targets) and decreases as a function of range (orange>yellow>green>light blue>dark blue; **Figure 5-7**). The range at which the outer edge of the dark blue targets occurred was recorded. These measures were then correlated with the mean wind velocity at the 1000-millibar level (approximately 300 ft [91 m] above the sea) from published data (http://vortex.plymouth.edu/upcalc-u.html). The resulting relationship (**Figure 5-8**) indicates that about 83% of the variation in maximum range of detections can be explained by mean wind velocity. Therefore sea clutter conditions are related to mean wind speed. Similar to the results of GMI's research, Kreijgsveld et al. (2005) reported that 85% of the recorded data from TracScan type radar can be attributed to sea clutter. This is important because detections from sea clutter (and rain) must be removed in data processing to assure that the results of the analyses relate to biological tracks and not to false tracks.

<u>Reduction of Sea Clutter False Tracks</u>

The following procedures were completed during the analyses of TracScan data to reduce the number of false tracks that result from detections of sea clutter:

1) Eliminated tracks with distances greater than 0.06 NM (0.1 km) between successive detections (i.e., tracks with velocities above 100 kts [51 m/s]).

This procedure eliminated the detections with speeds greater 100 kts (than 185 km/hr) and eliminated the mode of velocities between 100 and 315 kts (51 and 162 m/s); compare **Figures 5-9** and **5-10**). This procedure also had a tremendous effect on the frequency of velocities. The highest velocity counts dropped from nearly 37,000 to approximately 3,000.

2) Sea Clutter Filter

This GMI proprietary filter was developed to eliminate false tracks that resulted from detections of sea clutter within 1.5 NM (2.8 km) of the radar. When applied, the second mode of the ground speed histogram was greatly reduced (**Figure 5-10**) and the speeds were comparable to those measured with VerCat (**Figure 5-6**) during the same time period.

Figure 5-3. TracScan radar analysis areas. "East" Over Land and "West" Over Water.

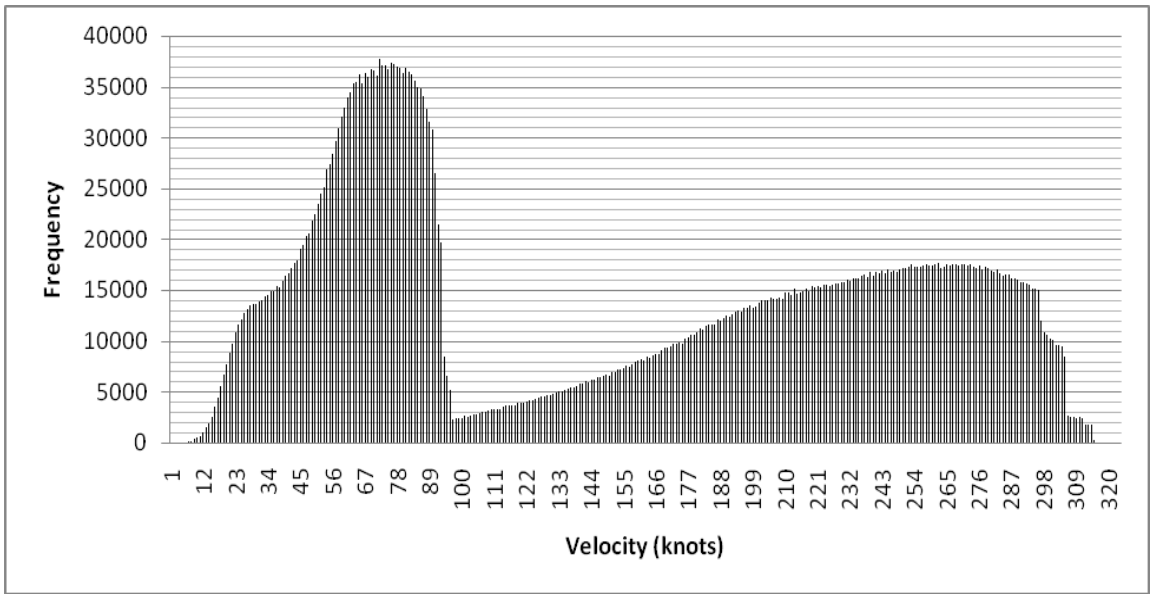


Figure 5-4. Histogram of total ground speeds between detections for 15 March 2008 from MARS® TracScan during the 2008-2009 New Jersey Ecological Baseline Study. Note the extraordinary number of detections and the extremely high velocities with no filtering.

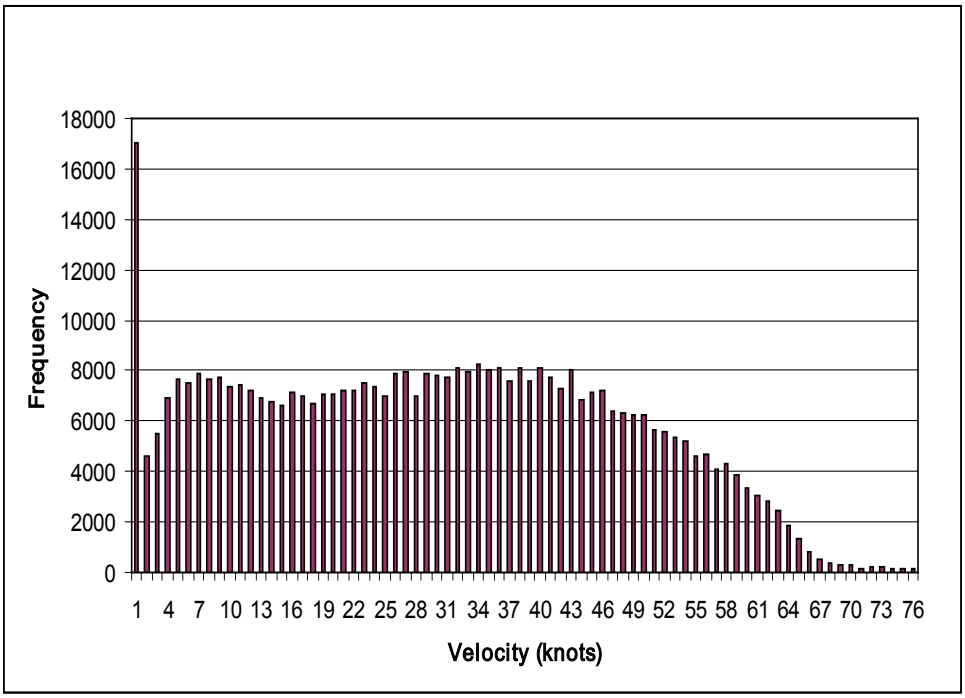


Figure 5-5. Histogram of total ground speeds between detections for 15 March 2008 from MARS® VerCat during the 2008-2009 New Jersey Ecological Baseline Study. Note the absence of a second mode of velocities and the lower frequency of velocities above 46 kts (24 m/s or 79 feet per second [ft/s]).

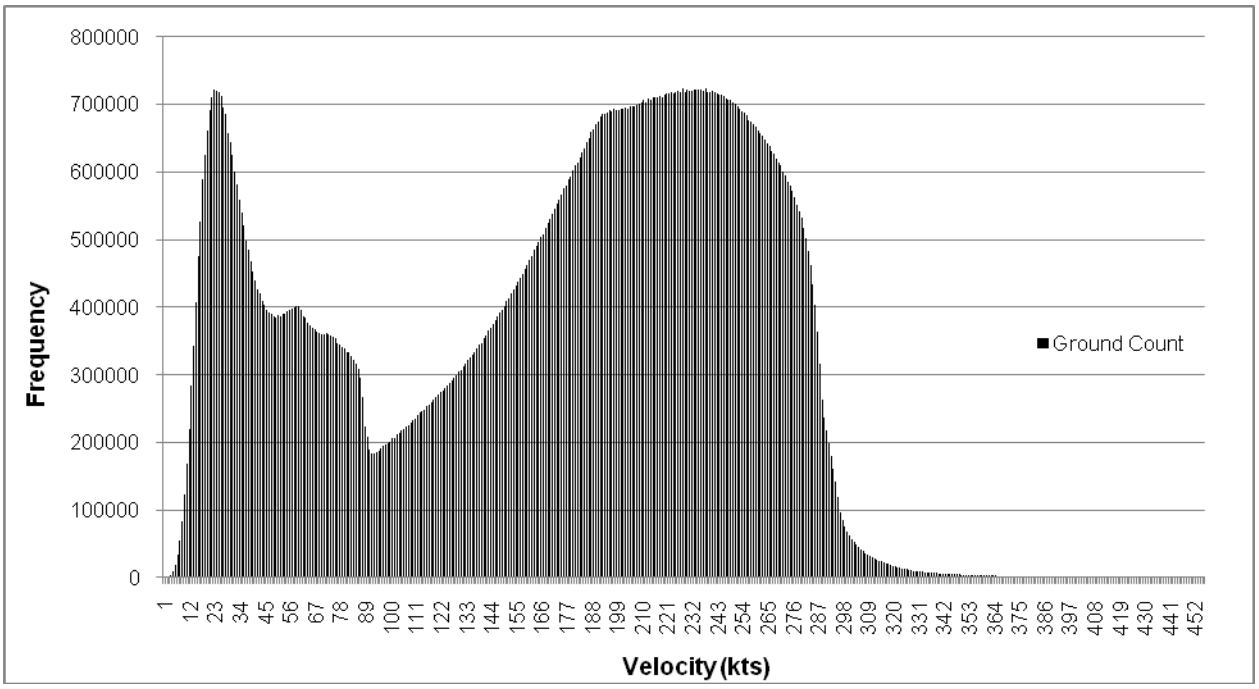


Figure 5-6. Histogram of unfiltered total ground speeds between detections from TracScan during the current study Note the extraordinary number of detections and the extremely high velocities with no filtering.

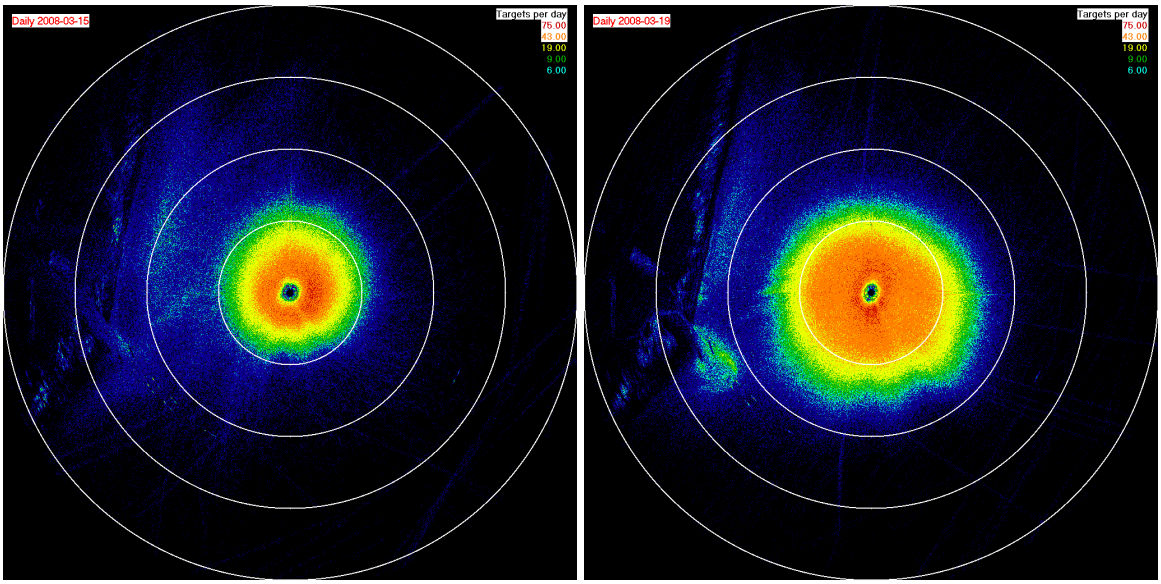


Figure 5-7. Total TracScan detections per day for 15 March 2008 (left) and 19 March 2008 (right) during the 2008-2009 New Jersey Ecological Baseline Study. Maximum winds on 15 March were 7 to 8 kts and on 19 March were 18 to 19 kts.

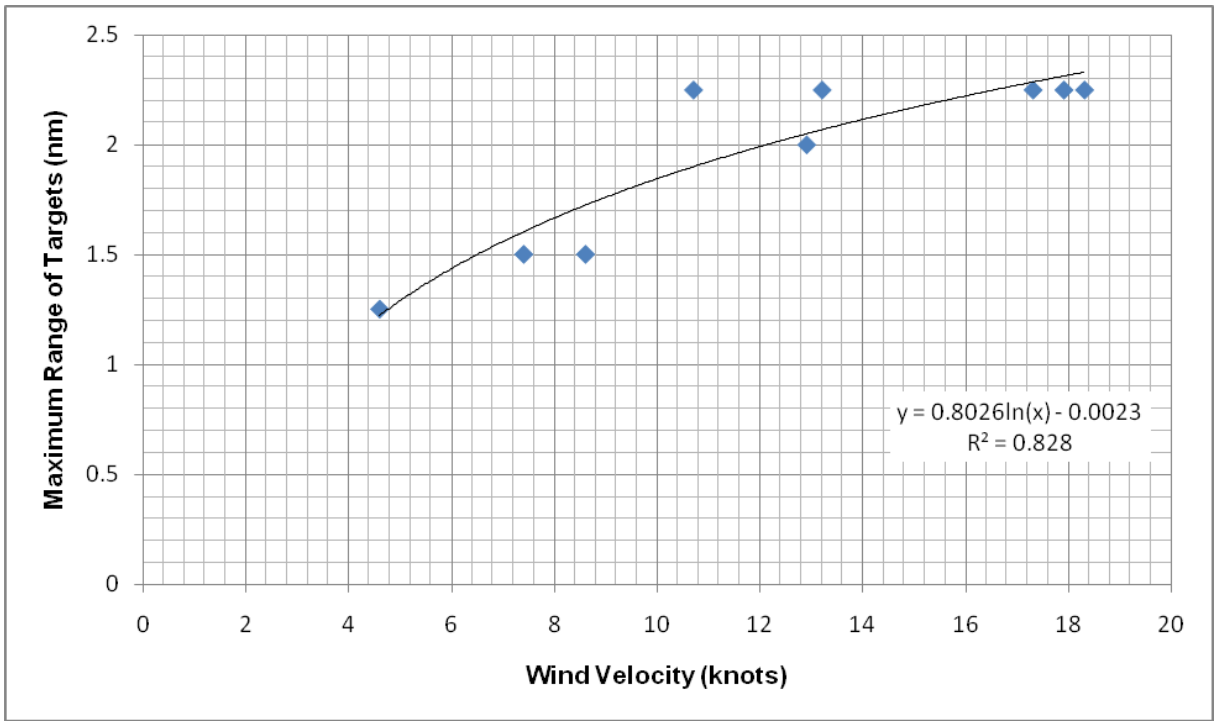


Figure 5-8. Relationship between mean wind velocity and maximum range of targets (sea clutter) in TracScan during the 2008-2009 New Jersey Ecological Baseline Study. Note that 82% of the maximum range of targets can be explained by wind velocity.

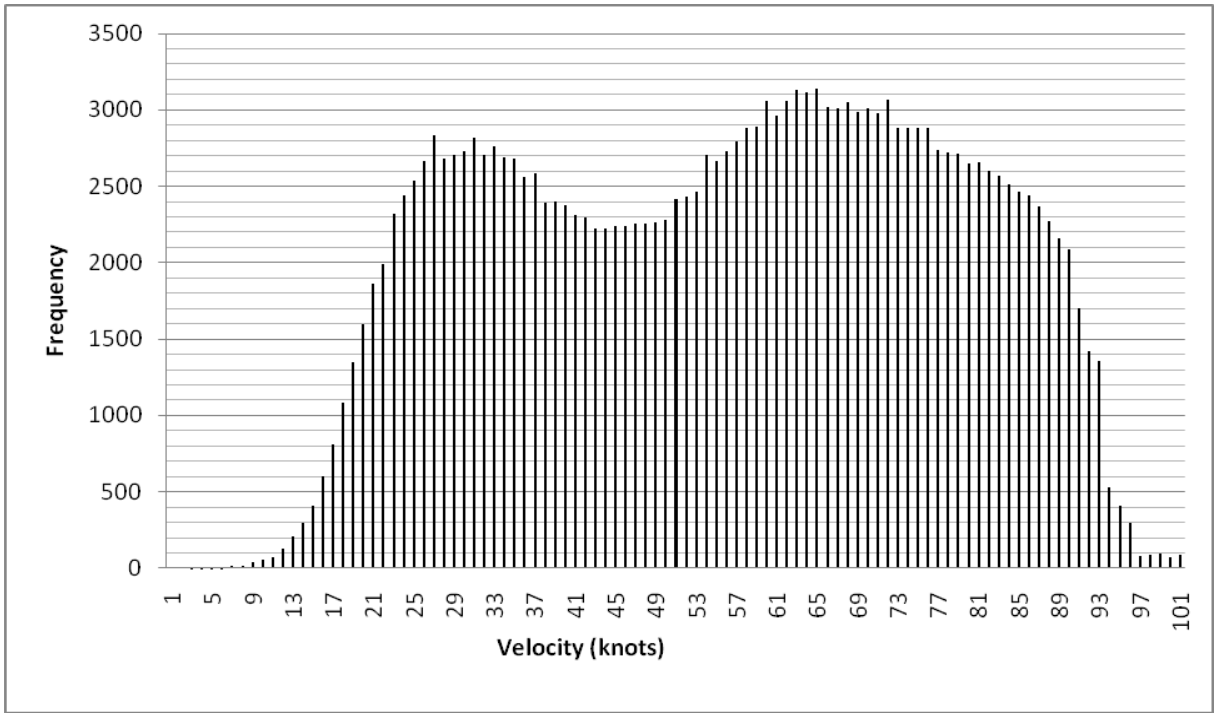


Figure 5-9. Histogram of total ground speeds between detections for 15 March 2008 after eliminating tracks that did not have nine continuous detections in a track for MARS® TracScan during the 2008-2009 New Jersey Ecological Baseline Study.

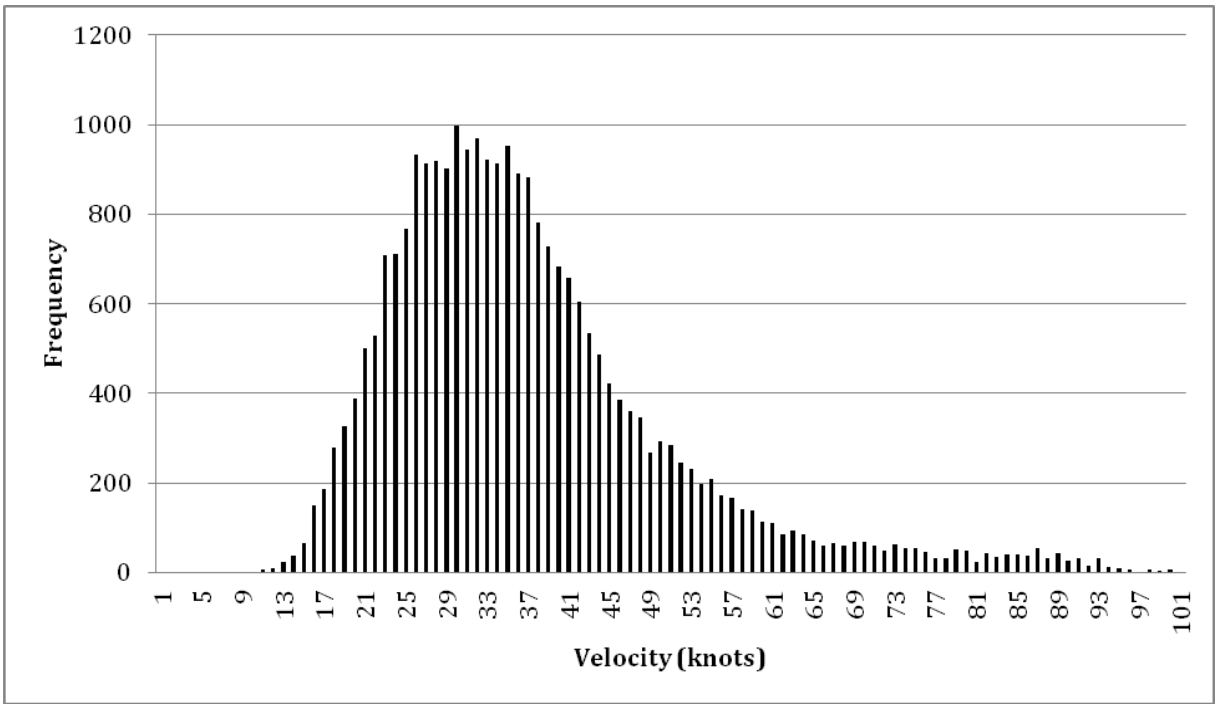


Figure 5-10. Histogram of total ground speeds between detections for 15 March 2008 during the 2008-2009 New Jersey Ecological Baseline Study after applying the sea clutter filter.

3) All tracks with gaps in detections were treated initially as separate tracks to avoid treating two unrelated tracks as one and generating false tracks.

4) Selected only tracks with nine or more continuous detections (number of echoes per track).

Although the above procedures likely eliminated some real bird tracks, it is better to follow a more conservative approach and avoid the possibility of having a large number of false tracks generated by sea clutter.

MARS® TracScan data from this study were processed using all four procedures. The resulting flight speed histogram (**Figure 5-11** and **Figure 5-12**) was similar to that for the NJDEP Study (**Figure 5-10**).

Rain Clutter Elimination

The on-site weather station database was queried to determine the rain start and end times during the study. Time with rain was eliminated from the database before beginning TracScan avian radar data processing.

Recounted Tracks

When a target is tracked it is not uncommon for a detection to be missed. If a single detection is missed while tracking a target, the processing algorithm assigns a new track identification (ID) to that target when reacquired. This could inflate the number of tracks if some of the reacquired tracts are the same as the original tract. An analysis of this problem during the NJDEP Study (**Appendix C**) resulted in the development of a correction factor that reduces the number of total tracks by the percentage of tracks (24.87%) determined to be recounts. Since dropped tracks are a function of the radar algorithms, it was

assumed that the percentage of dropped tracks would be similar for this study because the correction factor was developed from data collected in a similar location (coastal, Over Land and water), weather conditions, and bird species.

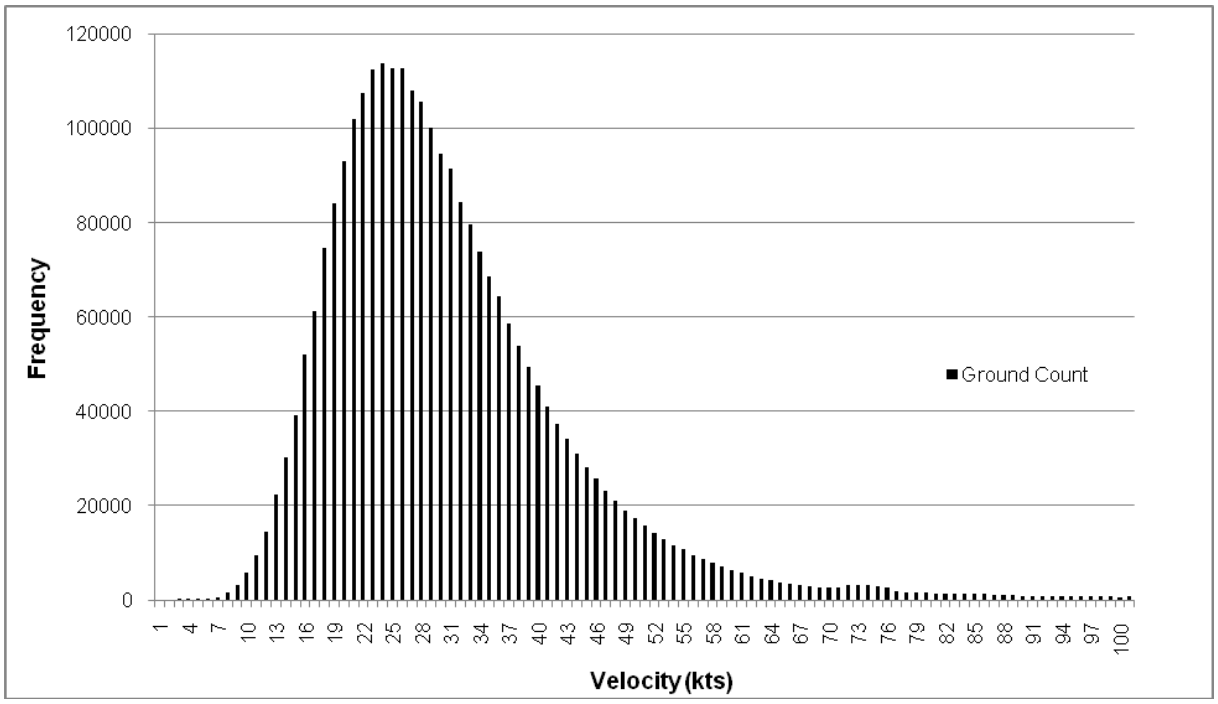


Figure 5-11. Histogram of filtered total ground speeds between detections during the fall survey.

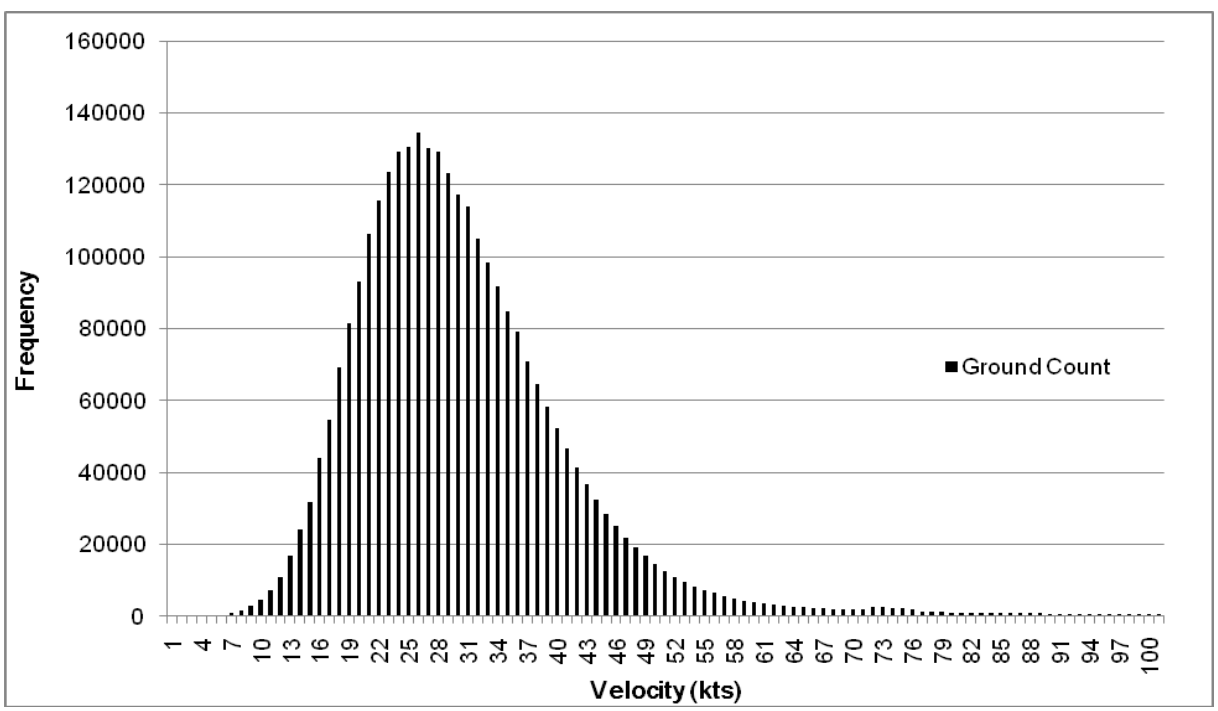


Figure 5-12. Histogram of filtered total ground speeds between detections during the spring survey.

Presentation of Analysis Results

The metric "number of bird tracks" is used throughout the data analysis sections of the report. This metric includes both tracks of birds and tracks of migratory bats; however, the vast majority of tracks are thought to be produced by birds.

The results of the TracScan data analysis are presented as passage rates (adjusted number of bird tracks/km/hr). Baseline passage rates (number of bird tracks/km/hr) are determined during data processing and then are "adjusted" by applying (multiplying) the recounted track correction factor (**Appendix C**) by the baseline passage rate with the end product being adjusted number of bird tracks/km/hr. Flight direction data are also presented; flight direction data were sorted into eight ordinal directions (**Table 5-3**).

Table 5-3
Ordinal flight degree designations

Ordinal Directions	Degree Range
North (N)	338° to 22°
Northeast (NE)	23° to 67°
East (E)	68° to 112°
Southeast (SE)	113° to 157°
South (S)	158° to 202°
Southwest (SW)	203° to 247°
West (W)	248° to 292°
Northwest (NW)	293° to 337°

When the velocity between two detections is plotted in a histogram for VerCat data, a large number of velocities are classified in the zero (<1) knot category (see **Figure 5-5**). When a target flies through the radar beam perpendicular to the sweep of the beam, the target has zero velocity, because its echo appears at the same position in subsequent sweeps of the radar beam; however, the number of zero velocity entries is far too high in comparison with targets passing through the beam at angles slightly different from perpendicular. Although application of the filters reduces the number of zero velocity targets, many remain after processing. Eliminating all zero velocity targets from processing was considered, but doing so would have eliminated all birds flying perpendicular to the sweep of the beam. This was not acceptable and all zero velocity targets remaining after filtering are included in the analysis.

Because VerCat can detect precipitation (i.e., rain, sleet, snow, virga), the detections can be processed and generate false biological tracks and greatly increase the median altitude of targets aloft. In addition, VerCat can also detect wave movement (sea clutter) and record flying insects as targets. It is important to remove false tracks that result from detections of rain, sea clutter, and insects to assure that the results of the analyses relate to bird and bat targets and not to false tracks.

Rain Clutter Elimination

The on-site weather station database was queried to determine the rain start and end times during the study. Time with rain was eliminated from the database before beginning VerCat avian radar data processing.

Reduction of Sea Clutter Detections

The following procedures were completed during the analyses of VerCat data to reduce the number of false tracks that resulted from detections of sea clutter:

1) Computed velocity between detections from raw detection data from VerCat and eliminated detections with speeds above 100 kts (51.4 m/s).
2) Split tracks with a missed detection into two separate tracks.
3) Eliminated tracks with less than seven detections.
4) Eliminated detections below 6 ft (1.8 m).

After processing the VerCat data, a biologist examined the results to see if the number of tracks and their altitudinal distribution were abnormally high. If the data were suspected to be contaminated, they were removed from the final data presentation.

Data Analysis Presentation

Data analysis was limited to altitudes between 1 and 3,000 ft (3-914 m) above the MARS® site. Relevant descriptive statistics for the analyzed data include the observed diurnal and nocturnal altitude distributions including the mean, median, and the 25% and 75% quartiles. The 25% and 75% quartiles are calculated in order to assess the potential presence of altitudinal outliers at the two extremes of the altitude distribution. For example, the presence of high-altitude outliers (e.g., several high-flying birds) will tend to increase the altitude value of the 75% quartile relative to the value that would occur if no outliers were present. Likewise, the presence of low-altitude outliers (or a greater number than the usual or expected number of low-flying birds) will tend to decrease the altitude value of the 25% quartile. The median altitude (or, equivalently, the 50% quartile) was defined as that altitude at which half the total number of birds observed were flying below the median, and half were flying above the median.

Comparisons of the mean and median altitude were conducted to obtain a rough estimate of the deviation of the given altitude data from a normal distribution and also the direction of any skew in the data. Generally, the greater the difference between mean and median, the greater the deviation from normality and the greater was the skew. If the mean altitude was greater than the median altitude, then the given altitude distribution would be skewed upward (i.e., toward higher altitudes) because of the presence of several outliers with high altitudes. Conversely, if the mean altitude was less than the median altitude, then the given altitude distribution would be skewed downward (i.e., toward lower altitudes) because of the presence of a greater number of bird counts with low altitudes. If the mean and median were equal, then there would be no skew, and the given altitude distribution would be statistically normal.

At this time, the Proposed Action for the project includes the possibility of using a small, medium, or large turbine or turbines. The potential RSZ for small to large turbines is approximately 100-500 ft (30-152 m) above ground level (agl). Diurnal and nocturnal altitude data were summarized into altitude ranges (bins). The altitude ranges (adjusted to sea level) were 1-99 ft (3-30 m; below RSZ), 100-500 ft (30-152 m; within RSZ) and >501 ft (152 m; above the RSZ).

5.3.2 Quality Control Data

5.3.2.1 Ground Truth (Radar Validation) Surveys

Radar validation survey data were analyzed in real-time. The RO recorded the validation results in the radar system database.

5.3.2.2 TI-VPR

To analyze the data, the combined (multiplexed) TI and VPR recorded image was separated using a model 497-2C de-multiplexer (Colorado Video Inc., Boulder, Colorado). The TI image was then sent to a Model 443CS video peak store (VPS; Colorado Video, Inc., Boulder, Colorado) to analyze tracks and the VPR image was transmitted to another monitor to view target altitudes and times. The VPS works by storing a new incoming pixel if it is brighter than the corresponding pixel already stored in frame memory. This results in a visible track being displayed on the screen for a bright target moving against a dark background (i.e., a warm biological target against a cold sky). This enables the visual extraction of track characteristics which are used in determining target identifications. The classification criteria from Gauthreaux and Livingston (2006) were used to determine target identification. Using this method (1) bright targets with mostly straight tracks showing modulation (wing beats) were classified as birds, (2) dimmer targets with minimal to no modulation along the track at low altitudes were classified as insects, and (3) bright targets showing irregular tracks (e.g., sharp turns, pauses) with minimal modulation were classified as foraging bats. It is impossible to distinguish between birds and bats in linear flight unless they are flying at very low altitudes and can then be identified by their shape. Although foraging birds are possible, all of the low level foraging targets were classified as bats. The speed at which a target crossed the TI screen and its altitude provided additional information that could be used to identify the type of target. It is important to note that the direction of movement is not evident from a completed VPS image; therefore the analyst must also observe the movement in time lapse to determine the direction of movement. Also, in some instances when multiple targets are present in a completed VPS image it is difficult to determine target-altitude associations, thus observations must be made as the VPS image is generated.

During fall 2010, TI-VPR sampling was conducted 15 times during 10 nights, while in spring 2011 sampling was conducted 11 times over nine nights. Total survey effort was 15 hrs during fall 2010 and 11 hrs during spring 2011. Three hrs were eliminated from analysis in spring because of excessive low cloud cover. GMI analyzed 5-minute (min) samples for every 15 min for each hour of data collected. Each 5-min period was randomly chosen within each 15-min block for each hour, for a total of 20 min sampled for each hour. This protocol was derived from testing and analysis of TI-VPR data collected for the NJDEP Study (GMI 2010). For each data point, GMI recorded the following information: date, time, target identification (bird [BD], insect [I], foraging bat [BT], or unknown [U]), direction (degrees), altitude (ft) and comments (e.g., flight behavior).

To obtain the percentage of birds per hour, a total count of all targets (birds, insects and bats) corrected for the time sampled was first calculated. This was done by counting the total number of targets for each 5-min sample of each hour (raw count) and then multiplying that number by three to obtain the total count for an hour (time-corrected count [TCC]). Then the total TCC for birds was divided by the total TCC for all targets yielding a percentage of birds for each hour.

Altitudinal distributions for birds were obtained in 50-ft (15.24-m) bands of elevation up to (2,200 ft [671 m]). Correction factors were calculated and applied to each bird based on its altitudinal band to account for the increase in the sample area of the beam with altitude. In this analysis, the corrected count for birds for time sampled was multiplied by the sample size correction factor to obtain the final count within each altitudinal band (corrected altitudinal count [CAC]).

5.3.3 Final Processing

Fall 2010

Prior to final processing of VerCat data, the correction factor for insect contamination of the VerCat data were determined by analyzing the TI-VPR data to determine the ratio of birds to total targets. Since TI-VPR surveys were not conducted nightly the ratio of birds to total targets combined for all sample days was used to determine the correction factor. The resulting ratio for all samples combined was 156 insects: 876 total targets indicating that approximately 17.81% of the radar targets were insects, and that 79.8% were birds (**Table 5-3**). VerCat data were corrected by multiplying the percent of birds (79.8) by the total VerCat targets.

Table 5-3
Total corrected count of birds, foraging bats, and insects detected during fall 2010 TI-VPR surveys

Date	Total Targets	No. Birds	No. Foraging Bats	No. Insects	Percent Birds	Percent Bats	Percent Insects
10-14-10	54	48	0	6	88.9	0.0	11.1
10-14-10	63	57	0	6	90.5	0.0	9.5
10-16-10	3	3	0	0	100.0	0.0	0.0
10-21-10	24	21	3	0	87.5	12.5	0.0
10-21-10	18	18	0	0	100.0	0.0	0.0
10-22-10	72	72	0	0	100.0	0.0	0.0
10-28-10	108	36	3	69	33.3	2.8	63.9
10-28-10	231	177	0	54	76.6	0.0	23.4
10-29-10	63	60	0	3	95.2	0.0	4.8
10-29-10	105	102	3	0	97.1	2.9	0.0
11-03-10	21	3	0	18	14.3	0.0	85.7
11-10-10	30	18	12	0	60.0	40.0	0.0
11-10-10	39	39	0	0	100.0	0.0	0.0
11-11-10	27	27	0	0	100.0	0.0	0.0
11-11-10	18	18	0	0	100.0	0.0	0.0
TOTAL	**876**	**699**	**21**	**156**	**79.8**	**2.8**	**17.8**

No. = number

Spring 2011

Prior to final processing of spring VerCat data, the correction factor for insect contamination of the VerCat data was determined by analyzing the spring TI-VPR data to determine the ratio of birds to total targets. Since TI-VPR surveys were not conducted nightly the ratio of birds to total targets combined for all sample days was used to determine the correction factor. The resulting ratio for all samples combined was 81 insects: 267 total targets indicating that approximately 30.3% of the radar targets were insects, and that 65.2% were birds (**Table 5-4**). VerCat data were corrected by multiplying the percent of birds (65.2) by the total VerCat targets.

Table 5-4
Time corrected count of birds, foraging bats, and insects detected during spring 2011 TI-VPR surveys

Date	Total Targets	No. Birds	No. Foraging Bats	No. Insects	Percent Birds	Percent Bats	Percent Insects
04-21-11	0	0	0	0	0.0	0.0	0.0
04-29-11	45	36	3	6	80.0	6.7	13.3
04-29-11	54	42	3	9	77.8	5.6	16.7
05-06-11	9	9	0	0	100.0	0.0	0.0
05-07-11	63	45	0	18	71.4	0.0	28.6
05-11-11	9	3	0	6	33.3	0.0	66.7
05-12-11	45	12	3	30	26.7	6.7	66.7
05-12-11	42	27	3	12	64.3	7.1	28.6
TOTAL	**267**	**174**	**12**	**81**	**65.2**	**4.5**	**30.3**

No. = number

6.0 RESULTS

The results of the avian radar and quality control surveys are presented in this section. Diurnal (i.e., civil sunrise to civil sunset) and nocturnal (civil sunset to civil sunrise) survey data for both the TracScan and VerCat radars are reported in this section. All results are considered preliminary until the final report is submitted.

6.1 AVIAN RADAR

6.1.1 TracScan Radar

6.1.1.1 Passage Rates Over Land

Fall 2010

For the fall study period, the total average nocturnal passage rate (adjusted number of bird tracks/km/hr) Over Land was higher (15.48) than the diurnal passage rate (6.37) Over Land (**Table 6-1**). Daily daytime and nocturnal passage rates over the land analysis area were low with diurnal passage rates ranging from 0.28 to 20.93 and nocturnal passage rates ranging from 0.93 to 30.32. Most of the daily diurnal passage rates Over Land were <10 while most of the daily nocturnal passage rates Over Land were <30.

Spring 2011

The total average nocturnal passage rate Over Land was slightly higher (5.60) than the diurnal passage rate (2.70) Over Land during the spring study period (**Table 6-2**). Diurnal passage rates were low with passage rates ranging from 0.3 to 4.97. Nocturnal passage rates were also low but slightly higher (range: 0.2 to 17.34) than diurnal passage rates. Most of the daily diurnal passage rates Over Land were <5 while most of the daily nocturnal passage rates Over Land were <10.

Table 6-1
Fall 2010 passage rate[1] data summary for the Over Land sample area in the Study Area

Date	Diurnal			Nocturnal		
	Clear	Fog	Total	Clear	Fog	Total
10-12-10	ND	ND	ND-	*1.40*	-	*1.40*
10-13-10	4.52	-	4.52	8.20	-	8.20
10-14-10	11.06	-	11.06	26.45	-	26.45
10-15-10	1.11	-	1.11	16.52	-	16.52
10-16-10	2.50	-	2.50	26.14	-	26.14
10-17-10	2.76	-	2.76	30.32	-	30.32
10-18-10	4.14	-	4.14	24.39	-	24.39
10-19-10	11.27	-	11.27	24.20	-	24.20
10-20-10	8.97	-	8.97	17.05	-	17.05
10-21-10	3.55	-	3.55	25.71	-	25.71
10-22-10	1.98	-	1.98	29.03	-	29.03
10-23-10	2.32	-	2.32	7.79	-	7.79
10-24-10	20.93	-	20.93	*21.77*	-	*21.77*
10-25-10	1.46	-	1.46	15.24	-	15.24
10-26-10	-	-	-	3.47	-	3.47
10-27-10	17.02	1.08	3.41	4.25	0.95	2.60
10-28-10	-	0.96	0.96	22.53	8.94	13.17
10-29-10	10.25	-	10.25	20.65	-	20.65
10-30-10	3.14	-	3.14	9.75	-	9.75
10-31-10	4.81	-	4.81	14.1	-	14.10
11-01-10	12.32	-	12.32	17.7	-	17.70
11-02-10	12.23	-	12.23	19.67	-	19.67
11-03-10	9.68	-	9.68	12.33	-	12.33
11-04-10	-	-	-	8.47	-	8.47
11-05-10	0.46	0.22	0.41	4.15	-	4.15
11-06-10	11.58	-	11.58	9.37	-	9.37
11-07-10	14.81	-	14.81	9.80	-	9.80
11-08-10	0.28	-	0.28	0.93	-	0.93
11-09-10	3.58	-	3.58	6.27	-	6.27
11-10-10	10.22	-	10.22	12.44	-	12.44
11-11-10	11.19	-	11.19	13.05	-	13.05
11-12-10	12.44	-	12.44	7.24	-	7.24
TOTAL	**6.81**	**0.95**	**6.37**	**16.0**	**5.48**	**15.48**

[1] adjusted number of bird tracks/km/hr
Note: Dashes in table boxes indicate that no data was collected (i.e., the weather condition did not occur). Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time

Table 6-2
Spring 2010 passage rate[1] data summary for the Over Land sample area in the Study Area

Date	Diurnal			Nocturnal		
	Clear	Fog	Total	Clear	Fog	Total
4/20/2011	4.67	-	4.67	-	-	-
4/21/2011	3.49	--	3.49	5.56	8.83	6.64
4/22/2011	6.08	-	6.08	7.17	-	7.17
4/23/2011	*1.21*	-	*1.21*	*2.79*	0.47	0.87
4/24/2011	4.49	5.05	4.97	-	3.42	3.42
4/25/2011	6.60	-	6.60	3.51	4.35	3.55
4/26/2011	1.74	1.13	1.31	0.31	1.29	1.10
4/27/2011	0.50	1.94	1.77	-	0.39	0.39
4/28/2011		0.20	0.20	-	1.54	1.54
4/29/2001	2.54	4.73	3.00	11.78	19.72	17.34
4/30/2011	3.62	-	3.62	5.20	-	5.20
5/1/2011	6.01	-	6.01	4.01	-	4.01
5/2/2011	2.77	-	2.77	8.37	-	*8.37*
5/3/2011	1.86	-	1.86	6.92	-	6.92
5/4/2011	0.55	0.15	0.44	9.07	*6.22*	8.71
5/5/2011	3.10	-	3.10	13.34	-	13.34
5/6/2011	2.19	-	2.19	11.48	-	11.48
5/7/2011	2.71	-	2.71	10.12	-	10.12
5/8/2011	3.77	-	3.77	8.23	-	8.23
5/9/2011	1.14	-	1.14	1.80	-	1.80
5/10/2011	0.67	-	0.67	0.18	-	0.18
5/11/2011	0.30	-	0.30	0.18	-	0.18
5/12/2011	1.75	-	1.75	4.42	-	4.42
5/13/2011	4.28	-	4.28	14.68	-	14.68
5/14/2011	3.62	-	3.62	15.09	-	15.09
5/15/2011	1.45	0.82	1.37	4.49	-	4.49
5/16/2011	0.43	-	0.43	0.20	-	0.20
5/17/2011	0.30	-	0.30	0.14	-	0.14
5/18/2011	0.24	-	0.24	-	-	
TOTAL	**2.87**	**1.69**	**2.7**	**5.83**	**4.77**	**5.60**

[1] adjusted number of bird tracks/km/hr
ND = No data collected (radar being set-up)
Note: Dashes in table boxes indicate that no data were collected (i.e., the weather condition did not occur). Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time

6.1.1.2 Passage Rates Over Water

Fall 2010

The average nocturnal passage rate Over Water was lower (14.45) than the diurnal passage rate Over Water (21.34). Daily daytime and nocturnal passage rates over the water analysis area were typically <50 (**Table 6-3**). Over Water diurnal passage rates ranged from 0.39 to 68.43 and daily nocturnal passage rates ranged from 0.27 to 44.53. Passage rates during some fog days were higher than during clear days and may contain some false tracks.

Spring 2011

The average nocturnal passage rate Over Water was lower (24.66) than the diurnal passage rate (34.98) Over Water (**Table 6-4**). Daily Over Water diurnal passage rates ranged from 0.85 to 65.18 and daily nocturnal passage rates ranged from 0.22 to 47.78. Passage rates during some fog days were higher than during clear days and may contain some false tracks.

6.1.1.3 Comparison of Land and Water Passage Rates

During fall 2010, the Over Water area had higher average diurnal passage rates than Over Land area while Over Land and Over Water average nocturnal passage rates were similar (**Table 6-5**). Over Water areas had higher diurnal and nocturnal average passage rates than Over Land areas during spring 2011.

6.1.2 Flight Direction

Flight directions in fall 2010 Over Land and Over Water were analyzed in detail because Over Water nocturnal flight directions were not similar to those Over Land. In contrast, nocturnal spring 2011 flight directions Over Water and Over Land were similar and did not require detailed analysis.

6.1.2.1 Fall 2010

Over Land during the day the majority of birds were flying to the southeast, south, and southwest (**Table 6-6**). The resultant direction was toward 208.2° (south-southwest [SSW]), but the directionality was low with a concentration of 0.56, a circular variance of 0.728, and a circular standard deviation of 92.4° (**Table 6-7**; see **Appendix D** for flight direction diagrams). More birds were migrating Over Land at night (16,072) than during the day (7,228). On most nights, the majority of birds were also traveling in a southbound direction (179.8°) Over Land, but the circular standard deviation was relatively high (82.2°) as indicated in **Table 6-7**. This is so because on a few nights, birds showed reversed migration and moved toward the north (N) and northeast (NE) in relatively low numbers with following winds.

Over Water, diurnal flight directions were frequently similar in all of the ordinal directions (**Table 6-8**) indicating that most of the birds detected were non-migratory resident and winter resident birds on local movements in the area. The resultant direction of all movements during the day was toward 168.5° or to the south-southeast (SSE), but the circular variance was very high (0.968) and the circular standard deviation was 150° (**Table 6-9**). At night, the total number of observations was less than the number during the day (**Table 6-8**). Many targets were flying Over Water toward the north-northeast (NNE; 36.2°), but the concentration was poor (0.464) and the circular variance and circular standard deviation were high 0.774 and 98.8°, respectively.

Table 6-3
Fall 2010 passage rate[1] data summary for the Over Water sample area in the Study Area

Date	Diurnal			Nocturnal		
	Clear	Fog	Total	Clear	Fog	Total
10-12-10	ND	ND	ND	*2.81*	-	*2.81*
10-13-10	23.3	-	23.30	26.12	-	26.12
10-14-10	50.13	-	50.13	44.53	-	44.53
10-15-10	0.91	-	0.91	2.63	-	2.63
10-16-10	0.39	-	0.39	1.33	-	1.33
10-17-10	16.32	-	16.32	11.26	-	11.26
10-18-10	15.39	-	15.39	9.56	-	9.56
10-19-10	49.34	-	49.34	15.81	-	15.81
10-20-10	46.30	-	46.30	43.48	-	43.48
10-21-10	19.81	-	19.81	26.52	-	26.52
10-22-10	3.46	-	3.46	4.90	-	4.90
10-23-10	15.73	-	15.73	19.48	-	19.48
10-24-10	67.65	-	67.65	13.53	-	13.53
10-25-10	36.60	-	36.60	37.67	-	37.67
10-26-10	-	-	-	3.77	-	3.77
10-27-10	4.00	7.89	7.34	4.57	6.39	5.48
10-28-10	-	36.62	36.62	0.76	17.45	12.18
10-29-10	21.1	-	21.10	2.25	-	2.25
10-30-10	11.84	-	11.84	8.99	-	8.99
10-31-10	15.18	-	15.18	19.68	-	19.68
11-01-10	17.56	-	17.56	3.03	-	3.03
11-02-10	20.49	-	20.49	15.38	-	15.38
11-03-10	53.27	-	53.27	41.91	-	41.91
11-04-10	25.32	-	25.32	32.60	-	32.60
11-05-10	10.69	32.00	15.67	40.24	*0.7*	37.49
11-06-10	38.65	-	38.65	20.15	-	20.15
11-07-10	1.49	-	1.49	1.61	-	1.61
11-08-10	0.69	-	0.69	0.27	-	0.27
11-09-10	1.08	-	1.08	1.48	-	1.48
11-10-10	0.86	-	0.86	0.56	-	0.56
11-11-10	0.94	-	0.94	2.12	-	2.12
11-12-10	5.33	-	5.33	0.72	-	0.72
TOTAL	**21.06**	**24.71**	**21.34**	**14.45**	**12.50**	**14.45**

[1] adjusted number of bird tracks/km/hr
Note: Dashes in table boxes indicate that no data were collected (i.e., the weather condition did not occur). Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time

Table 6-4
Spring 2011 passage rate[1] data summary for the Over Water sample area in the Study Area

Date	Diurnal			Nocturnal		
	Clear	Fog	Total	Clear	Fog	Total
4/20/2011	58.23	-	58.23	*21.77*	-	*21.77*
4/21/2011	12.67	-	12.67	21.37	45.89	29.42
4/22/2011	38.88	-	38.88	31.92	-	31.92
4/23/2011	*19.35*	7.93	8.80	*18.42*	4.47	6.90
4/24/2011	60.13	73.21	71.42	-	20.30	20.30
4/25/2011	62.25	-	62.25	24.46	*20.32*	24.01
4/26/2011	39.12	45.64	43.74	10.89	10.16	10.31
4/27/2011	37.28	40.75	40.32	-	4.66	4.66
4/28/2011	*4.35*	6.61	6.58	-	4.69	4.69
4/29/2001	55.80	101.64	65.18	17.87	40.72	33.85
4/30/2011	43.49	-	43.49	38.41	-	38.41
5/1/2011	31.36	-	31.36	45.88	-	45.88
5/2/2011	39.42	-	39.42	*47.45*	-	*47.45*
5/3/2011	43.20	-	43.20	45.78	-	45.78
5/4/2011	44.63	25.40	31.36	32.66	31.1	32.46
5/5/2011	16.19	-	16.19	23.75	-	23.75
5/6/2011	25.08	-	25.08	40.09	-	40.09
5/7/2011	45.65	-	45.65	37.02	-	37.02
5/8/2011	27.03	-	27.03	47.78	-	47.78
5/9/2011	9.51	-	9.51	29.01	-	29.01
5/10/2011	0.85	-	0.85	0.22	-	0.22
5/11/2011	4.05	-	4.05	0.36	-	0.36
5/12/2011	17.47	-	17.47	47.24	-	47.24
5/13/2011	68.43	-	68.43	24.30	-	24.30
5/14/2011	51.35	-	51.35	32.37	-	32.37
5/15/2011	51.64	37.38	49.80	47.45	-	47.45
5/16/2011	9.74	-	9.74	7.34	-	7.34
5/17/2011	6.79	-	6.79	4.31	-	4.31
5/18/2011	32.34	-	32.34	7.37	5.52	6.38
TOTAL	**34.33**	**38.95**	**34.98**	**26.8**	**16.61**	**24.66**

[1] adjusted number of bird tracks/km/hr
Note: Dashes in table boxes indicate that no data were collected (i.e., the weather condition did not occur). Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time

Table 6-5
Comparison of Over Land and Over Water average passage rates

Season/Year/Time	Over Land	Over Water
Fall 2010 Diurnal	**6.37**	**21.34**
Fall 2010 Nocturnal	**15.48**	**14.45**
Spring 2010 Diurnal	**2.7**	**34.98**
Spring 2010 Nocturnal	**5.6**	**24.66**

Table 6-6
Fall 2010 flight direction frequency Over Land analysis area

Date	Number of Bird Tracks by Flight Direction[1]							
	N	NE	E	SE	S	SW	W	NW
Diurnal	457	779	744	593	1392	1723	1067	473
Nocturnal	1119	1403	1062	3052	4080	3022	1388	946

[1] Direction toward

Table 6-7
Fall 2010 flight directions Over Land

Variable	Diurnal	Nocturnal
Number of Observations	7228	16072
Data Grouped?	Yes	Yes
Group Width (& Number of Groups)	45° (8)	45° (8)
Mean Vector (μ)	208.224°	179.812°
Mean Group	SSW	S
Length of Mean Vector (r)	0.272	0.357
Concentration	0.565	0.765
Circular Variance	0.728	0.643
Circular Standard Deviation	92.471°	82.21°
Rayleigh Test (Z)	534.295	2051.026

Table 6-8
Fall 2010 flight direction frequency Over Water analysis area

Date	Number of Bird Tracks by Flight Direction[1]							
	N	NE	E	SE	S	SW	W	NW
Diurnal	3175	3215	2848	3186	3614	3333	2860	2829
Nocturnal	2681	3644	2231	1581	1418	1439	1601	1682

[1] Direction toward

At night Over Water, more birds were flying in north directions (N, NE, northwest [NW] total 8007) than in south directions (4438). The nocturnal flight directions to the N and NE over the water were not expected as nocturnal migrants are generally southbound during the fall. Reverse migration in the fall is not uncommon, but in general the density of the reverse migration is much less than that for movements in seasonally appropriate directions; however, the number of targets showing northward movements Over Water was generally small when southward movements were occurring Over Land.

Table 6-9
Flight directions Over Water

Variable	Diurnal	Nocturnal
Number of Observations	25060	16277
Group Width (& Number of Groups)	45° (8)	45° (8)
Mean Vector (μ)	168.546°	36.2°
Mean Group	SSE	NE
Length of Mean Vector (r)	0.032	0.226
Concentration	0.065	0.464
Circular Variance	0.968	0.774
Circular Standard Deviation	150.075°	98.806°

A subset of MARS® nocturnal Over Water data were compared to nocturnal Next Generation Radar (NEXRAD) data collected on the same dates to determine if the northbound targets were birds in reverse migration. The directions recorded by MARS® TracScan at night Over Land agree very well with the directions of movements recorded by the NEXRAD Doppler weather surveillance radar located at Taunton/Boston, Massachusetts (**Table 6-10**). The directions of target movement recorded by MARS® TracScan Over Water at night do not agree with those recorded by NEXRAD (**Table 6-10**) and agree more with wind directions. Because of this there is the strong likelihood that wave clutter detections in the lower part of the TracScan radar beam were treated by the processing software as bird detections. When this happens the processing software can generate false tracks from these wave clutter detections that appear to be birds. This is a well acknowledged problem in radar ornithology studies Over Water, and because of this problem some radar studies have used only calm wind conditions when monitoring bird movements over water. Reverse migration in the fall is not uncommon, but in general the density of the reverse migration is much less than that for movements in seasonally appropriate directions. In this study when large numbers of tracks are recorded moving Over Water at night in seasonally inappropriate directions while movements Over Land are in seasonally appropriate directions, there is likely wave clutter contamination and the Over Water nocturnal data should not be used for the development of impact/risk assessments. Only flight direction data from Over Land should be used if flight directional is needed for modeling purposes.

6.1.2.2 Spring 2011

During the day Over Land, most birds were flying to the north and northeast (**Table 6-11**) indicating that some migration was occurring during the day. At night, most birds Over Land were flying to the northeast with slightly lower numbers to the north and east. Over the water during the day and at night, the majority of the birds were flying to the northeast (**Table 6-12**). These diurnal and night directions were expected in spring as migratory birds fly north to their breeding grounds. Birds flying in other directions were probably local resident birds on foraging flights to and from their local breeding or roosting sites. More birds were migrating in northerly directions (N, NE) Over Land during the day (19,177) than during the night (6,067). Over Water similar numbers of birds were migrating to the north during the day (1,321) and at night (1,429).

Table 6-10
Comparisons of flight directions recorded by MARS® and NEXRAD in relationship to winds for a subsample of dates

Date	PRLD	DIRLD	PRLN	DIRLN	PRWD	DIRWD	PRWN	DIRWN	NDIRN	NDENN	WIND	(m/s)	DENSITY
17-Oct-2010	2.76	ENE	30.32	SE	16.32	E	11.26	ENE	SE	0-5	265	7.7	D=N
20-Oct-2010	8.97	ENE	17.05	NE	46.3	NNE	43.48	NE	NE	0-5	170	6.2	D>N
21-Oct-2010	3.55	NE	25.71	SE	19.81	SSW	26.52	NE	SE	6-18	303	9.8	D<N
22-Oct-2010	1.98	SE	29.03	SE	3.46	SE	4.9	N	SE	6-18	300	11.8	D<N
25-Oct-2010	1.46	NE	15.24	NNE	36.6	N	37.67	NNE	NNE	0-5	215	13.4	D>N
30-Oct-2010	3.14	NE	9.75	NE	11.84	NE	8.99	NE	NE	0-5	240	13.9	D<N
5-Nov-2010	0.14	ENE	4.15	ESE	15.67	NE	37.49	NE	SE	0-5	250	9.8	D<N
6-Nov-2010	11.58	SW	9.37	SW	38.65	SSW	20.15	S	SW	58-184	9	6.2	D>N
10-Nov-2010	10.22	SW	12.44	SW	0.86	SW	0.56	SSW	SW	6-18	15	21.1	D<N
11-Nov-2010	11.19	SW	13.05	SW	0.94	SW	2.12	SSW	SW	6-18	23	13.9	D=N

PRLD=passage rate Over Land during the day
DIRLD=direction (toward) Over Land during the day
PRLN= passage rate Over Land during night;
DIRLN= direction (toward) Over Land during night;
PRWD=passage rate Over Water during the day
DIRWD=direction (toward) Over Water during the day
PRWN= passage rate Over Water during night;
DIRWN=direction (toward) Over Water during night;
NDIRN=NEXRAD direction at night;
NDENN=NEXRAD density (toward) at night;
WIND=direction from which wind is blowing;
(m/s)=wind speed in meters per second, knots (nautical miles per hour) is approximately double m/s;
DENSITY=comparison of MARS® density during day (D) and night (N).
N = North; S = South; E = East; NE = Northeast; NW = Northwest; SW = Southwest; SE = Southeast; ENE = East-Northeast; NNE = North-Northeast; ESE = East-Southeast; SSW = South-Southwest

Table 6-11
Spring 2011 flight direction frequency Over Land analysis area

Date	Number of Bird Tracks by Flight Direction[1]							
	N	NE	E	SE	S	SW	W	NW
Diurnal	8206	10971	5530	3930	5424	4949	3469	3491
Nocturnal	2036	4031	2817	1203	829	648	648	920

[1] Direction toward

Table 6-12
Spring 2011 flight direction frequency Over Water analysis area

Date	Number of Bird Tracks by Flight Direction[1]							
	N	NE	E	SE	S	SW	W	NW
Diurnal	480	841	429	283	397	498	430	369
Nocturnal	364	1065	558	173	88	76	108	153

[1] Direction toward

6.1.3 VerCat

6.1.3.1 Initial Analysis

A data screening analysis of the initial processing results was conducted by a GMI avian radar biologist to determine if the data were contaminated with false tracks. The screening process involved examining the altitude quartile data for abnormally high adjusted bird count numbers, very high flight altitudes, and very low flight altitudes.

Fall 2010

In comparison to other sample dates, abnormally high diurnal counts and median altitudes were identified on 13 and 14 October 2010 (**Table 6-13**; shaded rows). A comparison of bird counts was made between the 0.25-NM (0.5-km) samples and the 1.5-NM (2.8-km) samples. Bird counts on 29-31 October and 1-2 November were equated to the 1.5-NM sample dates (by multiplying 0.25-NM bird counts by 6). The resulting equated bird counts for 29 October to 2 November for the 0.25-NM survey dates ranged from 4,565 to 11,718. When compared to the 1.5-NM sample dates, the diurnal counts for the 0.25-NM samples were considered abnormally high. The 0.25-NM survey dates were considered contaminated with false tracks and were eliminated from the final analysis.

Nocturnal counts were also abnormally high for the 0.25-NM samples from 29-31 October and on 1 November 2010 (**Table 6-14**; shaded rows). When the 0.25-NM where equated to the 1.5-NM range, the resulting bird counts ranged from 6,204 to 35,178. These survey dates were considered contaminated with false tracks from sea clutter and were eliminated from the final analysis.

Spring 2011

The spring VerCat data was screened for abnormalities after competing processing (**Table 6-15** and **Table 6-16**). Abnormally high adjusted bird count numbers, very high flight altitudes, and very low flight altitudes are not present in the spring VerCat data.

Table 6-13
Initial diurnal altitude[1] (Alt) quartile data for fall 2010

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
10-13-10	664	959	1386	1082	10	3660
10-14-10	584	920	1335	1037	13	2537
10-15-10	142	281	504	510	44	251
10-16-10	131	201	391	373	45	112
10-19-10	199	794	1251	799	88	38
10-20-10	245	892	1625	1209	120	155
10-21-10	190	406	911	810	51	531
10-22-10	140	290	724	743	44	590
10-23-10	156	352	733	595	23	835
10-24-10	452	824	1312	1007	22	1799
10-25-10	290	746	1216	867	27	894
10-29-10	128	591	970	713	15	1508
10-30-10	39	78	121	126	5	851
10-31-10	91	471	833	520	9	1845
11-01-10	69	340	762	464	10	1836
11-02-10	52	89	258	232	6	1953
11-03-10	427	789	1232	896	22	728
11-04-10	62	128	179	130	5	220
11-05-10	39	89	279	176	10	270
11-06-10	67	180	295	225	5	1894
11-07-10	52	126	236	191	9	567
11-08-10	90	582	651	386	36	46
11-09-10	34	66	157	124	6	493
11-10-10	59	165	297	205	6	816
11-11-10	58	153	287	203	5	1047
11-12-10	47	113	228	162	5	831
TOTAL	**162**	**392**	**674**	**511**	**24**	**24508**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird count tracks
Note: VerCat sample range 0.25 NM (0.5 km) from 29 October to late afternoon of 02 November; sample range 1.5 NM (2.8 km) on all other dates. Shaded rows were considered contaminated with false biological target tracks and were eliminated from the database prior to final processing.

Table 6-14
Initial nocturnal altitude[1] (Alt) quartile data for fall 2010

Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
10-12-10	*644*	*993*	*1499*	*1111*	*36*	*283*
10-13-10	646	1020	1499	1147	12	2966
10-14-10	543	899	1401	1068	14	2776
10-15-10	388	975	1508	1051	31	572
10-16-10	340	936	1394	966	28	507
10-20-10	454	828	1413	1130	33	1198
10-21-10	361	929	1917	1228	19	2615
10-22-10	406	888	1588	1125	14	3690
10-23-10	404	1251	2106	1344	31	938
10-24-10	*496*	*785*	*1330*	*990*	*38*	*344*
10-25-10	505	1055	1564	1169	22	1928
10-26-10	504	922	1251	923	29	252
10-29-10	126	398	838	552	8	3635
10-30-10	69	124	480	322	8	1962
10-31-10	117	385	814	533	6	5863
11-01-10	79	233	691	461	8	4033
11-02-10	61	90	130	156	6	1034
11-02-10	1029	1627	2398	1781	24	1383
11-03-10	166	570	1449	932	28	972
11-04-10	57	153	291	291	22	368
11-05-10	85	226	394	282	8	701
11-06-10	119	281	537	367	7	1498
11-07-10	109	275	509	347	8	989
11-08-10	121	249	435	289	17	111
11-09-10	66	144	246	171	4	906
11-10-10	94	201	388	272	4	2117
11-11-10	118	279	559	358	5	2758
11-12-10	74	165	391	262	10	484
TOTAL	**292**	**603**	**1036**	**772**	**17**	**46883**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird tracks
Note: VerCat sample range 0.25 NM (0.5 km) from 29 October to late afternoon of 02 November; sample range 1.5 NM (2.8 km) on all other dates. Shaded rows were considered contaminated with false biological target tracks and were eliminated from the database prior to final processing. Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time.

Table 6-15
Initial diurnal altitude[1] (Alt) quartile data for spring 2011

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
4/20/2011	743	1067	1393	1119	35	390
4/21/2011	173	793	1535	1002	36	585
4/22/2011	282	778	1288	988	31	979
4/23/2011	*157*	*211*	*3506*	*1211*	*433*	*8*
4/24/2011	766	1122	1473	1152	32	366
4/25/2011	593	997	1375	1043	14	2663
4/26/2011	885	1152	1321	1035	37	261
4/27/2011	97	252	659	450	75	35
4/28/2011	-	-	-	-	-	-
4/29/2001	451	967	1389	1008	19	1117
4/30/2011	145	478	1117	913	42	829
5/1/2011	244	576	1085	1005	35	1459
5/2/2011	253	823	1263	899	23	1108
5/3/2011	317	832	1562	1068	23	1440
5/4/2011	488	1197	2023	1274	36	416
5/5/2011	111	218	572	679	59	493
5/6/2011	120	376	1090	809	44	502
5/7/2011	330	803	1546	1210	36	1199
5/8/2011	244	618	1172	1550	64	1065
5/9/2011	136	463	1092	1138	71	580
5/10/2011	106	234	656	626	84	76
5/11/2011	-	-	-	-	-	-
5/12/2011	155	346	583	509	32	378
5/13/2011	385	800	1261	943	17	2113
5/14/2011	173	422	752	706	27	1015
5/15/2011	93	287	1216	841	46	587
5/16/2011	79	187	648	618	53	263
5/17/2011	66	147	349	362	57	156
5/18/2011	84	180	447	579	58	265
5/19/2011	-	-	-	-	-	-
TOTAL	**243**	**727**	**1288**	**993**	**7**	**20347**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird tracks
Note: cells with *italics* have between 10 and 39 minutes of observation time. VerCat shutdown because of high winds on 28 April and 11 May, 2011; 19 May 2011 was not processed because of an all day rain event.

Table 6-16
Initial nocturnal altitude[1] (Alt) quartile data for spring 2011

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
4/20/2011	*556*	*802*	*1120*	*988*	*83*	*101*
4/21/2011	173	357	748	630	35	422
4/22/2011	305	654	1047	793	17	1801
4/23/2011	*285*	*741*	*1065*	*1317*	*217*	*110*
4/24/2011	-	-	-	-	-	-
4/25/2011	561	972	1421	1132	16	2169
4/26/2011	641	919	1206	1026	30	330
4/27/2011	-	-	-	-	-	-
4/28/2011	-	-	-	-	-	-
4/29/2001	428	896	1724	1192	25	1009
4/30/2011	398	823	1403	1026	18	1883
5/1/2011	463	867	1350	981	14	2663
5/2/2011	392	994	1435	1016	26	508
5/3/2011	378	684	1222	848	18	789
5/4/2011	357	647	1174	839	29	324
5/5/2011	312	593	1300	877	14	2301
5/6/2011	262	510	958	703	13	1533
5/7/2011	458	983	1576	1139	27	891
5/8/2011	431	857	1407	1042	16	3021
5/9/2011	285	609	1190	835	17	1823
5/10/2011	148	449	951	638	33	214
5/11/2011	-	-	-	-	-	
5/12/2011	380	700	1172	835	12	1922
5/13/2011	387	839	1430	965	12	2229
5/14/2011	609	1065	1743	1248	19	1640
5/15/2011	344	796	1505	1076	27	1036
5/16/2011	202	371	1106	787	45	267
5/17/2011	200	584	1223	922	64	173
5/18/2011	150	252	520	512	30	332
5/19/2011	-	-		-	-	-
TOTAL	**362**	**770**	**1337**	**960**	**4**	**29474**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird count (tracks)
Note: cells with *italics* have between 10 and 39 minutes of observation time. VerCat shutdown because of high winds on 28 April and 11 May, 2011; 24 April and 19 May 2011 was not processed because of an all day rain events.

6.1.3.2 Final Analysis

Fall 2010

For the final analysis, flight altitudes were adjusted to flight altitude above sea level (asl). The median diurnal flight altitude was 247 ft (75 m) asl for the fall study period (**Table 6-17**). The diurnal median altitude ranged from 66 to 892 ft (20-272 m) asl. Daily altitudes varied during the study period; higher diurnal median altitudes occurred in October than November. The median diurnal flight altitude was within the RSZ on 13 days during fall.

The median nocturnal flight altitude was 452 ft (138 m) asl during fall (**Table 6-18**). The nocturnal median altitude ranged from 144 to 1,251 ft (42-381 m) asl. Daily altitudes varied during the study period. Median flight altitudes were higher in October than November. Nocturnal median flight altitudes in October ranged from 785 to 1,251 ft (239- 381 m) and after 02 November from 144 to 281 ft (44-86 m) asl. The nocturnal flight altitude was within the RSZ on 10 days during fall.

Bird altitude distribution for the study was summarized by sorting all of the VerCat study data into three altitude bands (**Table 6-19**). A RSZ of 50 to 450 ft (15-137 m) agl, which covers a wide range of small to large turbine types, was selected for presentation of the cumulative altitude distribution data.

Table 6-17
Final diurnal altitude[1] (Alt) quartile data for fall 2010

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
10-15-10	158	231	512	670	133	53
10-16-10	131	201	391	373	45	112
10-19-10	*199*	*794*	*1251*	*799*	*88*	*38*
10-20-10	245	892	1625	1209	120	155
10-21-10	190	406	911	810	51	531
10-22-10	140	290	724	743	44	590
10-23-10	156	352	733	595	23	835
10-24-10	452	824	1312	1007	22	1799
10-25-10	290	746	1216	867	27	894
11-03-10	385	742	1173	860	27	527
11-04-10	62	128	179	130	5	220
11-05-10	39	89	279	176	10	270
11-06-10	67	180	295	225	5	1894
11-07-10	52	126	236	191	9	567
11-08-10	*90*	*582*	*651*	*386*	*36*	*46*
11-09-10	34	66	157	124	6	493
11-10-10	59	165	297	205	6	816
11-11-10	58	153	287	203	5	1047
11-12-10	47	113	228	162	5	831
TOTAL	**99**	**247**	**621**	**504**	**7**	**11719**

[1] Altitude asl
[2] STE = Standard Error
[3] adjusted bird count
Note: Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time. VerCat sample range was 1.5 NM (2.8 km).

Table 6-18
Final nocturnal altitude[1] (Alt) quartile data for fall 2010

Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
10-15-10	386	972	1486	1047	32	545
10-16-10	340	936	1394	966	28	507
10-20-10	454	828	1413	1130	33	1198
10-21-10	361	929	1917	1228	19	2615
10-22-10	406	888	1588	1125	14	3690
10-23-10	404	1251	2106	1344	31	938
10-24-10	*496*	*785*	*1330*	*990*	*38*	*344*
10-25-10	505	1055	1564	1169	22	1928
10-26-10	584	922	1251	923	29	252
11-03-10	86	205	410	419	24	534
11-04-10	57	153	291	291	22	368
11-05-10	85	226	394	282	8	701
11-06-10	119	281	537	367	7	1498
11-07-10	109	275	509	347	8	989
11-08-10	121	249	435	289	17	111
11-09-10	66	144	246	171	4	906
11-10-10	94	201	388	272	4	2117
11-11-10	118	279	559	358	5	2758
11-12-10	74	165	391	262	10	484
TOTAL	**188**	**452**	**1067**	**763**	**5**	**22473**

[1] Altitude asl
[2] STE = Standard Error
[3] adjusted bird count
Note: Cells with normal text have >40 minutes of observation time; cells with *italics* have 10-39 minutes of observation time. VerCat sample range was 1.5 NM (2.8 km).

For the study period, the percentage of adjusted bird tracks was higher at night (64.48%) than during the day (35.52%). Fifty-three percent of the birds were within the potential turbine during the day and 44% were within the RSZ at night (**Table 6-19**).

Table 6-19
Altitude distributional summary for fall 2010

Altitude Band (asl)	Total Number	Percent Total
Count	37916	-
Diurnal		
Subtotal	13467	35.52
Below RSZ (1-49 ft)	2263	16.80
RSZ (50-450 ft)	7114	52.83
Above RSZ (>450 ft)	4090	30.37
Nocturnal		
Subtotal	24449	64.48
Below RSZ (1-49 ft)	1954	00.80
RSZ (50-450 ft)	10854	44.39
Above RSZ (>450 ft)	11641	47.61

Spring 2011

The median diurnal flight altitude was 727 ft (222 m) asl for the spring study period (**Table 6-20**). The diurnal median altitude ranged from 147 to 1197 ft (45 to 365 m) asl. Daily altitudes varied during the study period; higher diurnal median altitudes occurred in April than May. The median diurnal flight altitude was within the RSZ on 11 days during spring.

Table 6-20
Diurnal altitude[1] (Alt) quartile data for spring 2011

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
4/20/2011	743	1067	1393	1119	35	390
4/21/2011	173	793	1535	1002	36	585
4/22/2011	282	778	1288	988	31	979
4/23/2011	*157*	*211*	*3506*	*1211*	*433*	*8*
4/24/2011	766	1122	1473	1152	32	366
4/25/2011	593	997	1375	1043	14	2663
4/26/2011	885	1152	1321	1035	37	261
4/27/2011	97	252	659	450	75	35
4/29/2001	451	967	1389	1008	19	1117
4/30/2011	145	478	1117	913	42	829
5/1/2011	244	576	1085	1005	35	1459
5/2/2011	253	823	1263	899	23	1108
5/3/2011	317	832	1562	1068	23	1440
5/4/2011	488	1197	2023	1274	36	416
5/5/2011	111	218	572	679	59	493
5/6/2011	120	376	1090	809	44	502
5/7/2011	330	803	1546	1210	36	1199
5/8/2011	244	618	1172	1550	64	1065
5/9/2011	136	463	1092	1138	71	580
5/10/2011	106	234	656	626	84	76
5/12/2011	155	346	583	509	32	378
5/13/2011	385	800	1261	943	17	2113
5/14/2011	173	422	752	706	27	1015
5/15/2011	93	287	1216	841	46	587
5/16/2011	79	187	648	618	53	263
5/17/2011	66	147	349	362	57	156
5/18/2011	84	180	447	579	58	265
TOTAL	**243**	**727**	**1288**	**993**	**7**	**20347**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird tracks
Note: cells with *italics* have between 10 and 39 minutes of observation time. VerCat shutdown because of high winds on 28 April and 11 May, 2011; 19 May 2011 was not processed because of an all day rain event.

The median nocturnal flight altitude was 770 ft (235 m) asl for the spring study period (**Table 6-21**). The diurnal median altitude ranged from 252 to 1065 ft (77 to 325 m) asl. Nocturnal attitudes varied during the study period; higher nocturnal median altitudes occurred in April than May. The median nocturnal attitude was within the RSZ on four nights.

For the study period, the percentage of adjusted bird tracks was higher at night (58.61%) than during the day (41.39%). The percentage of birds within the potential turbine RSZ was similar during the day (33.20%) during the day and at night (29.63%; **Table 6-22**).

Table 6-21
Nocturnal altitude[1] (Alt) quartile data for spring 2011

Survey Date	25% Alt	Median Alt	75% Alt	Mean Alt	Mean STE[2] Alt	Bird Count[3]
4/20/2011	*556*	*802*	*1120*	*988*	*83*	*101*
4/21/2011	173	357	748	630	35	422
4/22/2011	305	654	1047	793	17	1801
4/23/2011	*285*	*741*	*1065*	*1317*	*217*	*110*
4/25/2011	561	972	1421	1132	16	2169
4/26/2011	641	919	1206	1026	30	330
4/29/2001	428	896	1724	1192	25	1009
4/30/2011	398	823	1403	1026	18	1883
5/1/2011	463	867	1350	981	14	2663
5/2/2011	392	994	1435	1016	26	508
5/3/2011	378	684	1222	848	18	789
5/4/2011	357	647	1174	839	29	324
5/5/2011	312	593	1300	877	14	2301
5/6/2011	262	510	958	703	13	1533
5/7/2011	458	983	1576	1139	27	891
5/8/2011	431	857	1407	1042	16	3021
5/9/2011	285	609	1190	835	17	1823
5/10/2011	148	449	951	638	33	214
5/12/2011	380	700	1172	835	12	1922
5/13/2011	387	839	1430	965	12	2229
5/14/2011	609	1065	1743	1248	19	1640
5/15/2011	344	796	1505	1076	27	1036
5/16/2011	202	371	1106	787	45	267
5/17/2011	200	584	1223	922	64	173
5/18/2011	150	252	520	512	30	332
TOTAL	**362**	**770**	**1337**	**960**	**4**	**29474**

[1] Altitude in feet above MARS® site
[2] STE = Standard Error
[3] adjusted bird count (tracks)
Note: cells with *italics* have between 10 and 39 minutes of observation time. VerCat shutdown because of high winds on 24 and 28 April and 11 May, 2011; 27 April and 19 May 2011 was not processed because of rain.

Table 6-22
Altitude distributional summary for spring 2011

Altitude Band (asl)	Total Number	Percent Total
Count	55907	-
Diurnal		
Subtotal	23138	-41.39
Below RSZ (1-49 ft)	2022	8.74
RSZ (50-450 ft)	7681	33.20
Above RSZ (>450 ft)	13435	58.06
Nocturnal		
Subtotal	32769	-58.61
Below RSZ (1-49 ft)	1254	3.83
RSZ (50-450 ft)	9711	29.63
Above RSZ (>450 ft)	21804	66.54

6.2 QUALITY CONTROL

6.2.1 Ground Truth (Radar Validation) Surveys

The ground truth (radar validation) survey determines if the radar is detecting birds based on its performance requirements. In addition to validating radar sightings, ground truth surveys allow for the identification of the species being detected within the Study Area.

6.2.1.1 Validation Surveys

During the surveys it was determined that the radar was performing to its performance capabilities.

6.2.1.2 Bird Species Occurrence

Forty-three bird species were observed during the ground truth (radar validation) surveys (**Table 6-23**). No federally-listed threatened and endangered bird species (USFWS 2010) were observed during this study. One state listed species, Peregrine Falcon (*Falco peregrines*), was observed on two of the four survey days during fall and none of the survey days in spring. One state candidate species, Black-crowned Night-Heron (*Nycticorax nycticorax*) was observed during the spring validation surveys. Two federal avian species of conservation concern (USFWS 2008), the Horned Grebe (*Podiceps auritus*) and Peregrine Falcon, were sighted during the surveys.

6.2.2 TI-VPR

The principal goal of the TI-VPR surveys was to collect data on the number of insects being detected by the VerCat and to subsequently develop a correction factor to eliminate insect detections in the database. The development of the correction factor was previously addressed in **Section 5.3.3**.

The data collected also provides additional data on occurrence of birds and bats and bird flight altitudes. TI-VPR surveys were conducted 15 times during the fall surveys and 8 times during spring. Total survey effort was 15.0 hrs in fall and 11 hrs in spring. Although quantitative results are reported, the data should be considered as qualitative in nature because of the low survey effort.

Table 6-23
Birds observed during ground truth (radar validation) surveys

Family/Common Name	Scientific Name	Fall 2010	Spring 2011
Geese and Ducks			
Brant	*Branta bernicla*		X
Canada Goose	*Branta canadensis*	X	X
Gadwall	*Anas strepera*		X
Common Eider	*Somateria mollissima*	X	
Surf Scoter	*Melanitta perspicillata*		X
Red-breasted Merganser	*Mergus serrator*	X	X
Loons			
Common Loon	*Gavia immer*	X	X
Grebes			
Horned Grebe	*Podiceps auritus*		
Cormorants			
Double-crested Cormorant	*Phalacrocorax auritus*	X	X
Herons			
Great Blue Heron	*Ardea herodias*	X	
Black-crowned Night-Heron	*Nycticorax nycticorax*		X
Raptors			
Osprey	*Pandion haliaetus*		X
Cooper's Hawk	*Accipiter cooperii*	X	
Red-tailed Hawk	*Buteo jamaicensis*	X	
American Kestrel	*Falco sparverius*		X
Peregrine Falcon	*Falco peregrines*	X	
Sandpipers			
Spotted Sandpiper	*Actitis macularius*		X
Gulls			
Laughing Gull	*Leucophaeus atricapilla*		X
Ring-billed Gull	*Larus delewarensis*		X
Herring Gull	*Larus argentatus*	X	X
Great Black-backed Gull	*Larus marinus*	X	X
Pigeons and Doves			
Mourning Dove	*Zenaida macroura*		X
Swifts			
Chimney Swift	*Chaetura pelagica*		X
Kingfishers			
Belted Kingfisher	*Megaceryle alcyon*		X
Crows and Jays			
Blue Jay	*Cyanocittacristata*		X
American Crow	*Corvus brachyrhynchos*	X	X
Swallows			
Tree Swallow	*Tachycineta bicolor*		X
N. Rough-winged Swallow	*Steigidoptera rufucollis*		X
Barn Swallow	*Hirundo rustica*		X
Chickadees and Titmice			
Black-capped Chickadee	*Poecile atricapillus*		X

Table 6-23 (*continued*)
Birds observed during ground truth (radar validation) surveys

Family/Common Name	Scientific Name	Fall 2010	Spring 2011
Wrens			
Carolina Wren	*Thryothorus ludovicianus*	X	X
House Wren	*Troglodytes aedon*		X
Thrushes			
American Robin	*Turdus migratorius*	X	
Mimic Thrushes			
Northern Mockingbird	*Mimus polyglottos*		X
Starlings			
European Starling	*Sturnus vulgaris*		X
Sparrows			
Song Sparrow	*Melospiza melodia*	X	X
White-throated Sparrow	*Zonotrichia albicollis*	X	
Snow Bunting	*Plectrophenax nivalis*	X	
Cardinals			
Northern Cardinal	*Cardinalis cardinalis*		X
Blackbirds			
Red-winged Blackbird	*Agelaius phoeniceus*		X
Common Grackle	*Quiscalus quiscula*		X
Finches			
House Finch	*Carpodacus mexicanus*	X	
American Goldfinch	*Carduelis tristis*		X
Old World Sparrows			
House Sparrow	*Passer domesticus*	X	

6.2.2.1 Bird and Bat Species Occurrence

Fall 2010

Birds were detected during all TI-VPR surveys dates (**Table 6-24**). The total TCC of birds ranged from 3 to 177 per survey hour. Foraging bats were detected by the thermal imager on three of the 10 survey nights (**Table 6-24**). The TCC for foraging bats on 21, 28, and 29 October 2010 was three on each day and 12 on 10 November 2010. Bat occurrence was not always coincidental with the occurrence or abundance of insects in the survey area (**Table 6-24**).

Spring 2011

Birds were detected during all TI-VPR surveys dates (**Table 6-25**). The total TCC of birds ranged from 0 to 45 per survey hour. Foraging bats were detected by the thermal imager on two of the eight survey nights (**Table 6-25**). The TCC for foraging bats was three on 29 April and 12 May 2011. Bat occurrence was not always coincidental with the occurrence or abundance of insects in the survey area (**Table 6-25**).

Table 6-24
Total time corrected counts (TCC)[1] of birds, bats, and insects during fall 2010 nocturnal TI-VPR surveys

Survey Date	Total Number of Targets	Number of Birds	Number of Foraging Bats	Number of Insects
10-14-10	54	48	0	6
10-14-10	63	57	0	6
10-16-10	3	3	0	0
10-21-10	24	21	3	0
10-21-10	18	18	0	0
10-22-10	72	72	0	0
10-28-10	108	36	3	69
10-29-20	231	177	0	54
10-29-10	63	60	0	3
10-29-10	105	102	3	0
11-03-10	21	3	0	18
11-10-10	30	18	12	0
11-10-10	39	39	0	0
11-11-10	27	27	0	0
11-11-10	18	18	0	0

[1] TCC = actual count x 3 to account for the hour of data

Table 6-25
Total time corrected counts (TCC)[1] of birds, bats, and insects during spring 2011 nocturnal TI-VPR surveys

Survey Date	Total Number of Targets	Number of Birds	Number of Foraging Bats	Number of Insects
04-21-11	0	0	0	0
04-29-11	45	36	3	6
04-29-11	54	42	3	9
05-06-11	9	9	0	0
05-07-11	63	45	0	18
05-11-11	9	3	0	6
05-12-11	45	12	3	30
05-12-11	42	27	3	12

[1] TCC = actual count x 3 to account for the hour of data

6.2.2.2 Bird Altitude Distribution

Fall 2010

On the dates and time sampled most birds were flying at altitudes between 150 and 900 ft (46-274 m) agl (**Figure 6-1**; **Table 6-26**). Nearly 29% of the birds were flying from 200 to 500 ft (61-274 m) agl (**Table 6-27**). The TI-VPR did not detect any low flying birds (<150 ft [46 m] agl) therefore a direct comparison between the VerCat and TI-VPR is not possible.

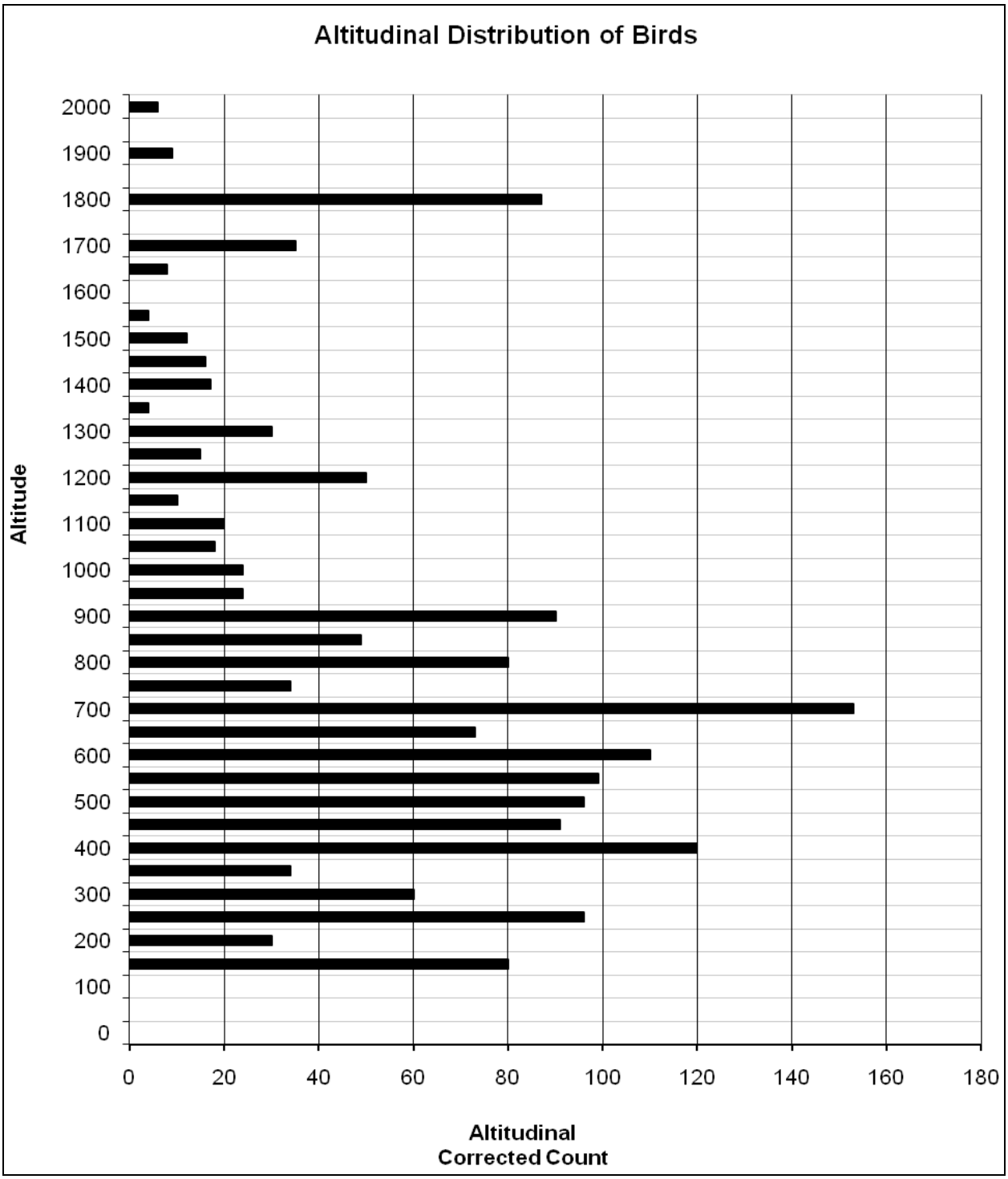


Figure 6-1. Nocturnal bird flight altitudes during the fall 2010 TI surveys in the Study Area. The corrected altitudinal count (CAC) = corrected count for birds for time sampled multiplied by the sample size correction factor.

Table 6-26
Nocturnal corrected altitude counts for flight altitudes during fall 2010 TI-VPR surveys in the Study Area

Altitude[1]	CAC[2]	Altitude[1]	CAC[2]
200	80	1150	20
250	30	1200	10
300	96	1250	50
350	60	1300	15
400	34	1350	30
450	120	1400	4
500	91	1450	17
550	96	1500	16
600	99	1550	12
650	110	1600	4
700	73	1650	0
750	153	1700	8
800	34	1750	35
850	80	1800	0
900	49	1850	87
950	90	1900	0
1000	24	1950	9
1050	24	2000	0
1100	18	2050	6
TOTAL	1,361	**TOTAL**	404

[1] ft asl
[2] Corrected Altitudinal Count

Table 6-27
Fall 2010 TI-VPR altitude distribution summary

Altitude Band	Total Number	Percent Total
Count	1765	-
RSZ (200-500 ft)	511	28.95
Above RSZ (>500 ft)	1254	71.05

Note. Based on CACs; Altitude asl.
Total Survey effort was 15 hours.

Spring 2011

On the dates and times sampled most birds were flying at altitudes between 200 and 900 ft (46-274 m) agl (**Figure 6-2**; **Table 6-28**). Overall, half of the birds were flying at altitudes >500 ft (152 m) agl (**Table 6-27**), while the remaining birds were flying from 200 to 500 ft (61-274 m) agl (**Table 6-29**).

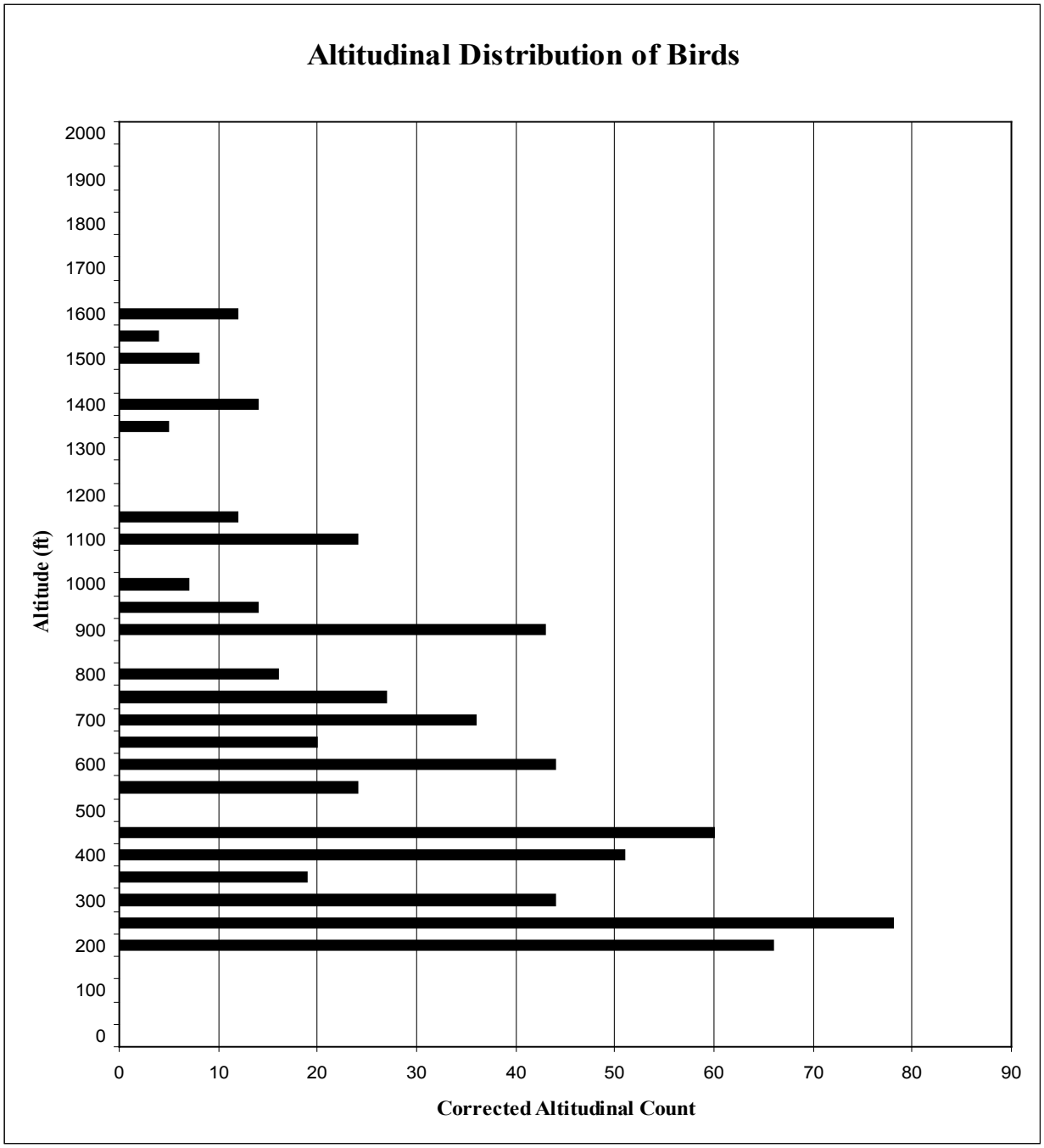


Figure 6-2. Nocturnal bird flight altitudes during the spring 2011 TI surveys in the Study Area. The corrected altitudinal count (CAC) = corrected count for birds for time sampled multiplied by the sample size correction factor.

Table 6-28
Nocturnal corrected altitude counts for flight altitudes during spring 2011 TI-VPR surveys in the Study Area

Altitude[1]	CAC[2]	Altitude[1]	CAC[2]
200	66	950	14
250	78	1000	7
300	44	1050	0
350	19	1100	24
400	51	1150	12
450	60	1200	0
500	0	1250	0
550	24	1300	0
600	44	1350	5
650	20	1400	14
700	36	1450	0
750	27	1500	8
800	16	1550	4
850	0	1600	12
900	43		
TOTAL	528	**TOTAL**	100

[1] ft asl
[2] Corrected Altitudinal Count

Table 6-29
TI-VPR altitude corrected nocturnal altitude distribution summary for the spring 2011 study period

Altitude Band	Total Number	Percent Total
Count	628	-
RSZ (200-500 ft)	318	50.64
Above RSZ (>500 ft)	310	49.36

Note. Altitude asl.
Total Survey effort was 11 hours.

7.0 DISCUSSION/SUMMARY OF RESULTS

7.1 AVIAN RADAR

7.1.1 TracScan

7.1.1.1 Passage Rate

Over Water Passage rates were slightly higher in spring than fall. Over Land and Over Water average passage rates were below 35 during all seasons. During fall 2010, most of the daily diurnal passage rates Over Land were <10 while most of the nocturnal passage rates were <30. During spring 2011, most of the diurnal passage rates Over Land were <5 while most of the daily nocturnal passage rates Over Land were <30. Over Land diurnal and nocturnal passage rates were lower than the Over Water Passage rates in all seasons with the exception of fall 2010 (**Table 6-30**).

Table 6-30
Comparison of Over Land and Over Water average passage rates

Season/Year/Time	Over Land	Over Water
Fall 2010 Diurnal	6.37	21.34
Fall 2010 Nocturnal	15.48	14.45
Spring 2010 Diurnal	2.7	34.98
Spring 2010 Nocturnal	5.6	24.66

The diurnal and nocturnal passage rates of birds at the only other coastal site (Cape May) for which passage rate data were available are listed in **Table 6-31**. Although not directly comparable because of the difference in metrics (birds/hr for Cape May and bird tracks [a single track may be comprised of one or more birds/km/hr]), passage rates are generally low at NAVSTA Newport when compared to Cape May. The radar passage rates (targets/km/hr) at NAVSTA Newport were also lower than the radar passage rates at inland locations in New York State where the mean passage rates in spring ranged from 41 to 509 (overall mean of 254) and in fall from 112 to 535 (overall mean 324.7) (New York State Department of Environmental Conservation 2008).

Table 6-31
Passage rate at Cape May

Bird Guild	Passage Rate[1]
Waterbirds	57.56
Raptors	3.70
Landbirds	421.46
TOTAL	**482.72**

[1] birds/hr
Source: Weston Solutions 2010

7.1.1.2 Flight Direction

Fall 2010

Over Land and during the day and at night the majority of birds were flying in southbound directions (i.e., to the southeast, south, and southwest; **Table 6-6**). This movement indicates that southbound migration was occurring Over Land during the day and at night. More birds were migrating in southerly directions at night (10,154) than during the day (3,708).

Over Water, diurnal flight direction frequency was similar in all of the ordinal directions indicating that most of the birds detected were non-migratory resident and winter resident birds on local movements in the area (**Table 6-8**). At night Over Water, more birds were flying in northerly directions (primarily north, northeast; total 8,007) than in south directions (4,438). When large numbers of tracks are recorded moving Over Water at night in seasonally inappropriate directions (north) while movements Over Land are in seasonally appropriate directions (south), there is likely wave clutter contamination An analysis of NEXRAD data during selected survey days revealed that birds were flying in southerly directions. Fall 2010 nocturnal Over Water data has an unknown quantity of wave clutter contamination and should not be used for impact/risk assessment.

Spring 2011

During the day Over Land, most birds were flying to the north and northeast (**Table 6-11**). At night Over Land, most birds were flying to the northeast with slightly lower numbers to the north and east. Over the water during the day and at night, the majority of the birds were flying to the northeast (**Table 6-12**). These diurnal and night directions were expected in spring as migratory birds fly north and northeast to their breeding grounds. More birds were migrating in northerly directions (N, NE) Over Land during the day (19,177) than during the night (6,067). Over Water, similar numbers of birds were migrating to the north during the day (1,321) and at night (1,429).

7.1.2 VerCat

7.1.2.1 Fall 2010

The median diurnal flight altitude was 247 ft (75 m) asl for the study period. Daily altitudes varied during the study period; higher diurnal median flight altitudes occurred in October than November. The median diurnal flight altitude was within the RSZ on 13 days during fall. The median nocturnal flight was within the RSZ on 10 nights during the study period.

The median nocturnal flight altitude was 452 ft (138 m) asl during the study period. Median flight altitudes were higher in October than November. For the study period, the percentage of adjusted bird tracks was higher at night (64.38%) than during the day (35.52). Fifty-three percent of the bird tracks were within the potential RSZ during the day and 44% were within the RSZ at night.

7.1.2.2 Spring 2011

The median diurnal flight altitude was 727 ft (222 m) asl for the spring study period. Daily altitudes varied during the study period; higher diurnal median altitudes occurred in April than May. The median diurnal flight altitude was within the RSZ on 11 days during spring. The median nocturnal flight altitude was 770 ft (235 m) asl for the spring study period. Nocturnal attitudes varied during the study period; higher nocturnal median altitudes occurred in April than May. The median nocturnal attitude was within the RSZ on four nights.

For the study period, the percentage of adjusted bird tracks was higher at night (58.61%) than during the day (41.39%). The percentage of birds within the potential turbine RSZ was similar during the day (33.20%) during the day and at night (29.63%).

7.2 QUALITY CONTROL

7.2.1 Ground Truth (Radar Validation) Surveys

The radar performed to GMI standards during the study.

7.2.2 TI-VPR

Fall 2010

The total corrected count of birds ranged from 3 to 177/hr and, based on the corrected altitude count, the majority of detected birds were flying between 150 and 900 ft (46-274 m) agl. Based on the low survey

effort no formal conclusions can be made regarding the number of birds and bats and flight altitudes recorded during the TI-VPR surveys.

Spring 2011

The total corrected count of birds ranged from 0 to 45 birds/hr. On the dates and times sampled most birds were flying at altitudes between 200 and 900 ft (46-274 m) agl. Overall, half of the birds were flying at altitudes >500 ft (152 m) agl, while the remaining birds were flying from 200 to 500 ft (61-274 m) agl.

7.3 SUMMARY OF ANTICIPATED BIRD-TURBINE COLLISION IMPACTS

Based on the results presented in this report, the Naval Undersea Warfare Center (NUWC) Study Area is not within a major migratory flight corridor. The number of birds in the Study Area is relatively low in comparison to bird passage rates for other proposed wind development sites for which public data were available. Most of these sites have passage rates over 100 targets/km/hr (New York State Department of Environmental Conservation 2008; Weston Solutions 2010) while passage rates in the Study Area for the proposed wind development project at NAVSTA Newport on most days during spring and fall is <50 bird adjusted bird tracks/km/hr. The lower the overall number of birds the lower bird-turbine collision potential; however, the percentage of birds in the potential turbine RSZ is in the moderate range (34-66%) during both the day (53%) and at night (43%) during fall and in the low range (0 to 33%) during the day (33.20%) and night (29.63%) at night during spring

Avoidance would be expected to occur during diurnal hours because the single to multiple turbine locations would be visible and would be avoided by most birds. Nocturnal avoidance may also occur; however, visibility is lower at night and may result in some bird-turbine collisions because of the moderate percentage of birds in the RSZ during fall. Based on the data analyzed, some bird-wind turbine collisions would likely occur during operation. However, the number of individuals present is low. No adverse impacts would occur to migratory and resident bird populations because of the low diurnal and nocturnal passage rates over the Study Area. A three year post construction monitoring study will be conducted as part of the proposed action to document bird -turbine collision impacts and determine appropriate mitigation, if necessary.

8.0 LITERATURE CITED

AWS Truewind. 2008. Basic Resource and Energy Assessment of the Newport Naval Base Area. AWS Truewind, Albany NY.

Blew, J., A. Diederichs, T. Grünkorn, M. Hoffmann, and G. Nehls. 2006. Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark. Status report 2005: Draft version, 27.2.2006. Prepared by Universität Hamburg, Hamburg, Germany, and BioConsult SH, Husum, Germany.

Christensen, T.K., J.P. Hounisen, I. Clausager, and I.K. Petersen. 2004. Visual and radar observations of birds in relation to collision risk at the Horns Rev offshore wind farm. Annual status report 2003. NERI Report. Prepared for Elsam Engineering A/S, Kraftværksvej, Denmark, by National Environmental Research Institute, Roskilde, Denmark.

Coastal Resources Management Council. 2008. Rhode Island Coastal and Estuarine Land Conservation Plan. University of Rhode Island Coastal Resources Center/Rhode Island Sea Grant. National Oceanic and Atmospheric Association Award No. NA 03 NOS 4190100.

DNV Global Energy Concepts. Inc. 2010. Preliminary Survey of Potential Wind Development on Naval Station Newport. DNV Global Energy Concepts. Inc., Seattle. 45 p.

Louis Berger & Associates. 1997. Integrated Natural Resources Management Plan: Main Site, Middleton, Rhode Island. Prepared for Naval Undersea Warfare Center, NUWCDIV Newport.

National Renewable Energy Laboratory. 2010. Renewable Energy Optimization Report for Naval Station Newport.: A Study Prepared in Cooperation with the Environmental Protection Agency for RE-Powering America's Lands Initiative: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites. Technical Report NREL/TP-48852. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy.

New Jersey Department of Environmental Protection (NJDEP). 2010. Final Interim Ocean Wind Power Environmental Baseline Survey Report. Prepared for the New Jersey Department of Environmental Protection by Geo-Marine, Inc. Plano, Texas.

New York State Department of Environmental Conservation. 2008. Publicly available radar results for proposed wind sites in New York. New York State Department of Environmental Conservation, Albany, New York. Spring: 5/29/2008; Fall 10/7/2008.

Rhode Island Natural History Survey. 2005. Natural Resources Inventory and Assessment of Naval Station, Newport, Newport County, Rhode Island. Rhode Island Natural History Survey, Kingston, Rhode Island.

Tulp, I., H. Schekkerman, J.K. Larsen, J. van der Winden, R.J.W. van de Haterd, P. van Horssen, S. Dirksen, and A.L. Spaans. 1999. Nocturnal flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat. Report Number 99.64. Prepared for Novem, Utrecht, The Netherlands, by Bureau Waardenburg bv, Culemborg, The Netherlands.

United States Fish and Wildlife Service (USFWS). 2008. Birds of Conservation Concern. U.S. Fish and Wildlife Service, Division of Migratory Bird Management. Arlington, Virginia.

United States Fish and Wildlife Service (USFWS). 2010. USFWS Endangered and threatened species listings and occurrences for Rhode Island http://ecos.fws.gov/tess_public/pub/stateListingand OccurrencesIndividual.jsp?state.

Weston Solutions, Inc. 2010. Final environmental assessment. 2-MW wind turbine generators. U.S. Coast Guard Training Center (TRACEN), Cape May, New Jersey. Edison, New Jersey: Weston Solutions, Inc.

APPENDIX A

MARS® OPERATIONAL HOURS

Appendix A-1

TracScan Fall 2010 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
10/12/10	-	-	-	-	-	0.5	-	2.1	-	2.6	2.6
10/13/10	11.2	-	4.5	-	11.2	8.2	-	3.4	-	11.6	22.7
10/14/10	7.4	-	1.1	-	11.9	5.5	-	6.4	-	11.9	23.8
10/15/10	10.8	-	-	-	11.9	5.8	-	6.1	-	11.9	23.8
10/16/10	12.0	-	-	-	12.0	12.0	-	-	-	12.0	24.0
10/17/10	12.0	-	-	-	12.0	12.0	-	-	-	12.0	24.0
10/18/10	11.9	-	-	-	11.9	12.1	-	-	-	12.1	24.0
10/19/10	11.9	-	-	-	11.9	12.1	-	-	-	12.1	24.0
10/20/10	11.9	-	-	-	11.9	12.2	-	-	-	12.2	24.0
10/21/10	10.0	-	1.8	-	11.8	11.2	-	1.1	-	12.2	24.0
10/22/10	8.1	-	-	-	8.1	11.4	-	0.8	-	12.2	20.3
11/23/10	11.7	-	-	-	11.7	6.3	-	6.0	-	12.3	24.0
10/24/10	8.7	-	3.0	-	11.7	0.6	-	11.7	-	12.3	24.0
10/25/10	11.7	-	-	-	11.7	9.5	-	2.9	-	12.4	24.0
10/26/10		-	-	-		8.4	-	0.4	-	8.8	8.8
10/27/10	1.5	8.8	-	1.0	11.2	5.7	5.7	-	1.0	12.5	23.7
10/28/10		11.4	-	-	11.4	3.8	8.3	-	-	12.2	23.5
10/29/10	7.1	-	-	-	7.1	10.8	-	-	-	10.8	17.9
10/30/10	11.4	-	-	-	11.4	12.5	-	-	-	12.5	23.9
10/31/10	11.4	-	-	-	11.4	12.0	-	0.6	-	12.6	24.0
11/01/10	11.4	-	-	-	11.4	12.5	-	0.2	-	12.6	24.0
11/02/10	11.0	-	0.3	-	11.3	10.0	-	2.7	-	12.7	24.0
11/03/10	11.3	-	-	-	11.3	12.7	-	-	-	12.7	24.0
11/04/10	1.5	-	9.7	-	11.3	3.4	-	8.4	1.0	12.8	24.0
11/05/10	5.5	1.7	0.1	4 .0	11.2	6.9	-	0.2	5.2	12.8	24.0
11/06/10	9.7	-	1.5	-	11.2	7.4	-	5.4	-	12.8	24.0
11/07/10	3.7	-	7.5	-	11.1	6.9	0.5	6.3	-	12.9	24.0
11/08/10	9.0	-	2.1	-	11.1	6.7	-	6.3	-	12.9	24.0
11/09/10	9.8	-	0.7	-	10.5	8.3	-	4.6	-	12.9	23.4
11/10/10	9.3	-	1.7	-	11.0	12.4	-	0.6	-	13.0	24.0
11/11/10	10.9	-	0.2	-	11.0	13.0	-	-	-	13.0	24.0
11/12/10	7.9	-	-	-	7.9	6.0	-	-	-	6.0	13.9
TOTAL	**271.7**	**21.9**	**34.2**		**332.5**	**278.5**	**14. 5**	**76.5**	**7.2**	**376.3**	**708.3**

[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
Hrs = hours

Appendix A-2

VerCat Fall 2010 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
10/12/10	-	-	-	--		0.5	-	2.5	-	3.0	3.0
10/13/10	11.5	-	-	-	11.5	8.0	-	3.3	-	11.3	22.8
10/14/10	7.4	-	4.5	-	11.9	5.4	-	6.3	-	11.8	23.6
10/15/10	10.8	-	1.1	-	11.9	5.8	-	6.1	-	11.9	23.8
10/16/10	2.6	-	-	-	2.6	5.5	-	-	-	5.5	8.1
10/17/10	-	-	-	-	-	-	-	-	-	-	-
10/18/10	-	-	-	-	-	-	-	-	-	-	-
10/19/10	0.3	-	-	-	0.3		-	-	-	-	0.3
10/20/10	3.4	-	-	-	3.4	6.6	-	-	-	6.6	9.9
10/21/10	10.0	-	1.8	-	11.8	11.1	-	1.1	-	12.2	24.0
10/22/10	10.4	-	-	-	10.4	11.4	-	0.8	-	12.2	22.6
11/23/10	11.7	--	-	-	11.7	6.3	-	6.0	-	12.3	24.0
10/24/10	8.7	-	3.0	-	11.7	0.6	-	11.7	-	12.3	24.0
10/25/10	11.7	-	-	-	11.7	9.5	-	2.9	-	12.4	24.0
10/26/10	-	-	-	-	--	4.8	-	0.4	-	5.2	5.2
10/27/10	-	-	-	-	-	-	-	-	-	-	-
10/28/10	-	-	-	-	-	-	-	-	-	-	-
10/29/10	8.6	-	-	-	8.6	5.9	-	0.9	-	6.8	15.4
10/30/10	11.5	-	-	-	11.5	12.5	-	-	-	12.5	23.9
10/31/10	11.4	-	-	-	11.4	12.0	-	0.6	-	12.6	24.0
11/01/10	11.4	-	-	-	11.4	12.5	-	0.2	-	12.6	24.0
11/02/10	10.9	-	0.3	-	11.2	10.0	-	2.7	-	12.7	23.9
11/03/10	11.2	-	-	-	11.2	12.2	-	-	-	12.2	23.4
11/04/10	1.5	-	9.7	-	11.3	3.4	-	8.4	1.0	12.8	24.0
11/05/10	5.5	1.7	0.1	4.0	11.2	6.9	0.5	0.2	5.2	12.8	24.0
11/06/10	9.6	-	1.5	-	11.1	7.4	-	5.4	-	12.8	23.9
11/07/10	3.7	-	7.5	-	11.1	5.1	-	6.3	-	11.4	22.5
11/08/10	0.6	-	1.8	-	2.3	1.6	-	5.4	-	7.0	9.3
11/09/10	9.7	-	0.7	-	10.5	8.3	-	4.6	-	12.9	23.4
11/10/10	9.2	-	1.7	-	10.9	12.4	-	0.6	-	13.0	23.9
11/11/10	10.8	-	0.2	-	11.0	13.0	-	-	-	13.0	24.0
11/12/10	8.2	-	-	-	8.2	6.0	-	-	-	6.0	14.2
TOTAL	**212.3**	**1.7**	**34.2**	**4.0**	**252.4**	**204.7**	**0.5**	**76.4**	**6.2**	**287.8**	**540.2**

Note: No data collected 17-18 and most of 19 October 2010 because of a computer failure. Shaded rows indicate days when the radar was set at range of 0.25 NM (0.5 km); range 1.5 NM (2.8 KM) on all other survey dates.
[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
Hrs=hours

Appendix A-3

TracScan Spring 2011 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
4/20/2011	2.1	-	-	-	2.1	0.2	-	1.0	3.8	5.0	7.1
4/21/2011	13.3	-	-	-	13.3	6.3	3.1	-	0.1	9.4	22.8
4/22/2011	13.6	-	1.0	-	14.7	9.4	-	-	-	9.4	24.0
4/23/2011	0.3	3.6	9.6	1.1	14.7	0.7	3.1	3.8	1.8	9.3	24.0
4/24/2011	1.1	6.6	6.7	0.3	14.7		1.5	4.9	2.9	9.3	24.0
4/25/2011	14.0	-	0.6	-	14.6	4.5	0.3	4.3	0.3	9.2	23.8
4/26/2011	4.2	10.6		0.1	14.8	1.2	4.8	0.2	3.1	9.2	24.0
4/27/2011	1.5	11.1	.01	2.3	14.9		5.5	-	3.6	9.2	24.0
4/28/2011	0.2	10.9	0.2	3.7	14.9		4.5	-	4.6	9.1	24.0
4/29/2001	11.0	2.9	0.1	-	14.0	1.8	4.3	2.8	-	8.9	22.9
4/30/2011	14.9	-	0.1	-	15.0	5.6	-	3.4	-	9.0	24.0
5/1/2011	15.0	-	0.1	-	15.0	5.4	-	3.5	-	9.0	24.0
5/2/2011	15.1	-	-	-	15.1	1.3	-	7.6	-	8.9	24.0
5/3/2011	15.0	-	0.1	-	15.1	1.8	-	7.1	-	8.9	24.0
5/4/2011	6.6	2.5	5.7	0.3	15.2	0.8	0.1	7.4	0.6	8.8	24.0
5/5/2011	12.4	-	2.8	-	15.2	8.4	-	0.4	-	8.8	24.0
5/6/2011	15.3	-	-	-	15.3	5.5	-	3.3	-	8.8	24.0
5/7/2011	15.3	-	-	-	15.3	2.6	-	6.1	-	8.7	24.0
5/8/2011	15.3	-	-	-	15.3	5.7	-	3.0	-	8.7	24.0
5/9/2011	13.1	-	0.4	-	13.4	7.9	-	0.8	-	8.7	22.1
5/10/2011	8.2	-	7.3	-	15.4	8.2	-	0.4	-	8.6	24.0
5/11/2011	2.4	-	-	-	2.4	4.0	-	-	-	4.0	6.4
5/12/2011	15.0	-	-	-	15.0	3.5	-	1.0	-	4.6	19.5
5/13/2011	15.4	-	0.2	-	15.5	3.6	-	4.9	-	8.5	24.0
5/14/2011	14.9	-	0.6	-	15.6	3.2	-	5.3	-	8.5	24.0
5/15/2011	12.6	1.8	1.0	0.2	15.6	3.7	-	4.0	0.7	8.4	24.0
5/16/2011	12.7	-	2.9	-	15.6	5.5	-	2.9	-	8.4	23.9
5/17/2011	11.0	-	4.7	-	15.7	5.1	-	2.6	0.7	8.4	24.0
5/18/2011	7.5	-	2.7	-	10.1	1.0	1.2	0.5	1.2	3.9	14.0
5/19/2011[4]		-	-	-	-	-	-	-	-	-	-
TOTAL	**299.0**	**50.0**	**46.9**	**8.0**	**403.5**	**106.9**	**28.4**	**81.2**	**23.4**	**239.6**	**642.5**

[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
[4] Weather Station Off-line – rain most of day
Hrs = hours

Appendix A-4

VerCat Spring 2011 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
4/20/2011	2.2	-	0.1	-	2.2	0.2	-	1.0	3.8	5.0	7.2
4/21/2011	9.1	-	-	-	9.1	6.1	3.1	-	0.1	9.3	18.4
4/22/2011	13.6	-	1.0	-	14.6	9.4	-	-	-	9.4	24.0
4/23/2011	0.3	3.6	9.6	1.1	14.7	0.7	3.1	3.8	1.8	9.3	24.0
4/24/2011	1.1	6.6	6.7	0.3	14.7	-	1.5	4.9	2.9	9.3	24.0
4/25/2011	14.0	-	0.6	-	14.6	4.5	0.3	4.3	0.3	9.2	23.8
4/26/2011	14.2	10.6	-	0.1	14.8	1.2	4.8	0.2	3.1	9.2	24.0
4/27/2011	1.5	11.1	0.1	2.3	14.9	-	5.5	-	3.6	9.2	24.0
4/28/2011	-	5.8	0.2	3.7	9.7	-	2.0	-	2.3	4.3	14.0
4/29/2001	10.8	-	0.1	-	10.9	1.7	-	2.8	-	1.5	15.4
4/30/2011	15.0	-	0.1	-	15.0	5.6	-	3.4	-	9.0	24.0
5/1/2011	15.0	-	0.1	-	15.0	5.4	-	3.5	-	9.0	24.0
5/2/2011	15.0	-	-	-	15.1	1.3	-	7.6	-	8.9	23.9
5/3/2011	15.0	-	0.1	-	15.2	1.8	-	7.1	-	8.9	24.0
5/4/2011	6.6	2.5	5.7	0.3	15.2	0.8	0.1	7.4	0.6	8.8	24.0
5/5/2011	12.4	-	2.8	-	15.2	8.4	-	0.4	-	8.8	24.0
5/6/2011	15.0	-	-	-	15.0	5.5	-	3.3	-	8.7	23.8
5/7/2011	15.3	-	-	-	15.3	2.6	-	6.1	-	8.7	24.0
5/8/2011	15.2	-	-	-	15.2	5.7	-	3.0	-	8.7	23.9
5/9/2011	14.0	-	0.4	-	14.4	7.8	-	0.8	-	8.6	23.0
5/10/2011	2.7	-	7.3	-	10.0	3.6	-	0.4	-	4.0	14.0
5/11/2011	-	-	-	-	-	-	-	-	-	-	--
5/12/2011	5.4	-	-	-	5.4	3.5	-	1.0	-	4.6	9.9
5/13/2011	15.2	-	0.2	-	15.4	3.6	-	4.9	-	8.5	23.9
5/14/2011	14.9	-	0.6	-	15.6	3.2	-	5.3	-	8.4	24.0
5/15/2011	12.6	1.8	1.0	0.2	15.6	3.7	-	4.0	0.7	8.4	24.0
5/16/2011	12.7	-	2.8	-	15.5	5.5	-	2.9	-	8.4	23.9
5/17/2011	10.9	-	4.7	-	15.7	5.1	-	2.6	0.7	8.2	24.0
5/18/2011	11.2	-	4.5	-	15.7	4.6	1.2	1.3	1.2	1.6	23.9
5/19/2011[4]	-	-	-	-	-	-	-	1.6	-	-	1.6
TOTAL	**280.7**	**41.9**	**48/7**	**8.1**	**379.4**	**101.3**	**21.5**	**83.4**	**20.9**	**227.2**	**606.6**

Note: No data collected 17-18 and most of 19 October 2010 because of a computer failure. Shaded rows indicate days when the radar was set at range of 0.25 NM (0.5 km); range 1.5 NM (2.8 KM) on all other survey dates. Hrs=hours

[1] Diurnal occurs from Civil Sunrise to Civil Sunset

[2] Nocturnal occurs from Civil Sunset to Civil Sunrise

[3] Totals are rounded to the nearest 0.1 hour (columns may not total)

[4] Weather Station Off-line – rain most of day

APPENDIX B

GROUND TRUTH (RADAR VALIDATION) SURVEY METHODOLOGY

Line-Intercept Method of Identifying Sources of TracScan Radar Tracks

Introduction

The identification of the sources of radar echoes is of great importance with respect to quality assurance/quality control (QA/QC) of the data gathered during radar studies of bird movements. This is particularly important in circumstances when automatic data processing (tracking algorithms) may produce false tracks from radar detections of waves (sea clutter). Validation of tracks is necessary if the number of false tracks is to be assessed accurately. Validation is also necessary to determine the effectiveness of filtering rules that eliminate false tracks produced by sea clutter. The protocol that follows represents a straight-forward way to identify the sources of radar echoes when mobile radar is in a horizontal surveillance mode and monitoring the near-shore ocean from the shore. The protocol can also be used to monitor bird movements from a stationary ship, boat, or platform offshore. By using this approach, the radar operator does not bias the surveillance of the onshore observer and the observations of the onshore observer do not bias the radar operator. There is no need to have the radar monitored during the validation exercises except when a passing boat can be used to verify distance estimates.

Protocol

The protocol for validating sources of radar tracks is a variation of the line-intercept sampling protocol used by ecologists to count animal tracks crossing a line or count the stems of plants touching a line of a fixed length (Sutherland 2006:153; Fonseca et al. 2007). Although the line in this protocol is imaginary, when a bird crosses the vertical plane above the line, the bird's identity, distance, height, direction of flight, and flight behavior are recorded along with a global positioning system (GPS) time.

Setup

An onshore observer should be positioned so that the observer is looking at an azimuth nearly perpendicular to the shore. Their GPS position and the azimuth of their observation "line" should be recorded so that the location of the observer and azimuth line can be added to the radar display. Before the beginning of a validation session the GPS time on the field observer personal digital assistant (PDA) should be synchronized so that the time stamp is the same as that for the radar. Sea-state and visibility conditions should be recorded at the beginning of each watch. Additional weather data will be recorded at the radar trailer.

An observer using 10 x 50 binoculars should look for birds flying over the line. A telescope pointed down the survey line can be used to identify birds crossing too far away to be identified with 10 x 50 binoculars. An observer should try to limit surveillance above the horizontal to the radar coverage pattern, and keep in mind that the vertical sample volume is small close to the radar and increases with distance. Observers should not record birds too close to the radar, because the radar cannot detect bird targets within 30 m of the antenna. The lower portion of the radar beam should not be blocked by sand dunes or other obstructions. Altitude estimates of birds crossing the surveillance line will help determine the altitudinal zone where the radar is missing low-flying or high-flying birds.

Data Recording

The pertinent data on a crossing will be entered into a GMI PDA Survey Program (version 2008-07-24) by a second observer when available. When a bird crosses the vertical plane above the line, the bird's identity, distance, height, direction of flight, and flight behavior are recorded (along with a GPS time). In the PDA Survey Program, the "bearing" entry will be the azimuth of the line chosen for monitoring. The

maximum distance sampled will be 3,281 (1 km), and the distance bin size, and number of distance bins will follow the design used on typical boat surveys of birds (e.g., 82 ft [25 m], 164 ft [50 m], 328 ft [100 m], 492 ft [150 m], 984 ft [300 m], 3281 [1000 m], and >1000 m). Estimating the distance of the crossing can be difficult, and observers should have practiced distance estimation before doing validation exercises. If at all possible a reference distance should be used such as a buoy offshore at a fixed distance. If a boat passes offshore an observer should check the radar to determine the distance from the observers to the boat. If the observer thinks that the bird is possibly too low or too high to be detected by the radar, this can be noted for the entry, but the altitudinal zone where birds are missed will be determined by post-processing of the visual and radar data. Recording the data for several isolated birds crossing the line at different distances at nearly the same time and flying in different directions is difficult and should be avoided during validation exercises. When this happens, it is very difficult to relate correctly individual direct visual crossings to the appropriate radar tracks, and the chance of mismatching increases.

Because flight directions are hard to determine in horizontal observations, directions should be entered with respect to the movement toward the line of observation. If the surveillance line is oriented toward the west then a bird moving toward the line from the left would be moving toward the north (N), and if a bird is moving toward the line from the right it would be moving toward the south (S). If a bird target is approaching the shore flying down the surveillance line it would be flying east (E) and if it is flying away from the shore down the line it would be flying west (W). The PDA has the following eight cardinal direction codes: N, S, E, W, NE, SE, SW, NW. Flight behavior (e.g., circling) can be noted in the comment section. When only a single observer is available the data can be voice recorded for a 15-minute sample period and then transcribed to data sheets. If this is done, some practice is required so that GPS time and other required data on bird targets are recorded efficiently.

The line-intercept procedure can also be used from a fixed platform offshore or from a boat or ship offshore looking back toward the onshore radar. GPS positions of the boat and the azimuth of the surveillance line need to be recorded regularly so they can be put on the radar display during post-processing.

Because the validation exercises are designed in part to determine the extent of false tracks produced by sea clutter, it is important to gather samples in different sea-state conditions. When the observer is looking into the sun, identification of the birds will be difficult and late afternoon watches should be avoided unless the late afternoon is overcast or the sun is obscured by cloud cover.

Discussion

The line-intercept method of identifying sources of TracScan radar tracks is a straight-forward approach to gathering the data required for validation of the radar processing algorithms. When sea clutter is present false tracks are generated by digital processing algorithms, and validation data sets can be used to measure the effectiveness of filtering rules that eliminate false tracks from sea clutter. The line-intercept validation procedure is also necessary for determining the maximum distance that certain species can be detected by the TracScan radar.

Literature Cited

Fonseca, C., K. Mateusz, M. Dorota, and B. Boguslaw. 2007. Use of line intercept track index and plot sampling for estimating wild boar, *Sus scrofa* (Suidae), densities in Poland. Folia Zool. 56(4): 389–398.

Sutherland, William J. 2006. Ecological Census Techniques: A Handbook. 2d Ed. Cambridge University Press. 432 pages.

APPENDIX C

DROPPED TRACK ANALYSIS

Methods for Dropped Target Analysis

Undetected Track Analysis Method

- Ten, five-minute samples were taken from a calm day.
- Ten, five-minute samples were taken from a windy day.
- Replay was used to watch the filtered data.
- Each track was monitored during the five minute sample period.
- Radar tracks were examined visually. Based on overall heading and speed, the tracks that were dropped and then detected again, were given a Target # to represent a single target comprised of multiple tracks.
- An Undetected Obs. #. was assigned to a target that was observed on the screen, lost, and then redetected.
- The amount of Time Undetected between tracks was determined by subtracting the time the target dropped from the time the target was redetected.
- An average Time Undetected was determined by adding up all time undetected between all tracks of a target and divided by the total number of Undetected Observations for all sample periods.

To ensure that dropped target was the same target and not a new target, heading and speed of the target was checked.

Heading and Speed Verification Method

- Two targets from each five-minute period were sampled for heading and speed verification.
- One of the targets selected was the target with the most number of dropped tracks during that period.
- The other target was selected by a random number generator using the =rand (i.e., the random number selection function) in Excel.
- For each track of a target, the heading and speed were recorded.
- The difference in heading was determined by subtracting the heading of where the track stopped from the heading of where the track was redetected.
- An average difference in heading was then determined by adding up all differences in heading for each recounted track and dividing by the total number of tracks observed for the heading and speed verification sample.
- The difference in speed was determined by subtracting the speed of where the track stopped from the speed of where the track was redetected.
- An average difference in speed was then determined by adding up all differences in speed for each recounted track and divided by the total number of tracks observed for the heading and speed verification sample.
- Average difference in heading and speed were analyzed for a windy day, a calm day, and both days combined.

Data Analysis

The data were analyzed and the recount percentage was determined. Recounts are the number of times additional tracks of a single target were counted after the initial track of a target was dropped. This number is the same as the Undetected Obs. #.

- Percent recount was determined by dividing the total number of recounts by the total number of tracks observed during the sample period.

- Percent recounts and average time undetected were determined for the windy day, calm day, and both days combined.

Data Analysis Results

Results of the analysis are presented in **Table C-1**.

The data were analyzed and the recount percentage was determined. Recounts are the number of times additional tracks of a single target were counted after the initial track of a target was dropped. This number is the same as the Undetected Obs. #.

- Percent recount was determined by dividing the total number of recounts by the total number of tracks observed during the sample period.
- Percent recounts and average time undetected were determined for the windy day, calm day, and both days combined.

Table C-1
Results of Dropped Target Analyses

Sample Period	Tracks Recorded	Recounts	% Recounts	Average Time Undetected (seconds)
Calm Day				
12:00:00-12:05:00	156	34	21.79%	0:00:13
2:00:00-2:05:00 AM	97	39	40.21%	0:00:16
4:00:00-4:04:00 AM	22	8	36.36%	0:00:22
6:00:00-6:05:00 AM	82	25	30.49%	0:00:11
8:00:00-8:05:00 AM	94	25	26.60%	0:00:15
10:00:00-10:05:00	89	26	29.21%	0:00:15
12:00:00-12:05:00	64	22	34.38%	0:00:12
2:00:00-2:05:00 PM	32	3	9.38%	0:00:17
4:00:00-4:05:00 PM	41	4	9.76%	0:00:08
6:00:00-6:05:00 PM	52	10	19.23%	0:00:13
Subtotal	**729 (14.58 per minute)**	**196 (3.92 per minute)**	**26.89%**	**0:00:14**
Windy Day				
12:00:00-12:05:00	49	16	32.65%	0:00:21
2:00:00-2:05:00 AM	13	3	23.08%	0:00:24
4:00:00-4:04:00 AM	7	2	28.57%	0:00:13
6:00:00-6:05:00 AM	18	1	5.56%	0:00:08
8:00:00-8:05:00 AM	13	1	7.69%	0:00:08
10:00:00-10:05:00	15	0	0.00%	0:00:00
12:00:00-12:05:00	5	1	20.00%	0:00:24
2:00:00-2:05:00 PM	21	0	0.00%	0:00:00
4:00:00-4:05:00 PM	48	2	4.17%	0:00:17
6:00:00-6:05:00 PM	47	18	38.30%	0:00:19
Subtotal	**236 (4.72 per minute)**	**44 (0.88 per minute)**	**18.64%**	**0:00:20**
TOTAL	**965 (9.65 per minute)**	**240 (2.4 per minute)**	**24.87%**	**0:00:15**

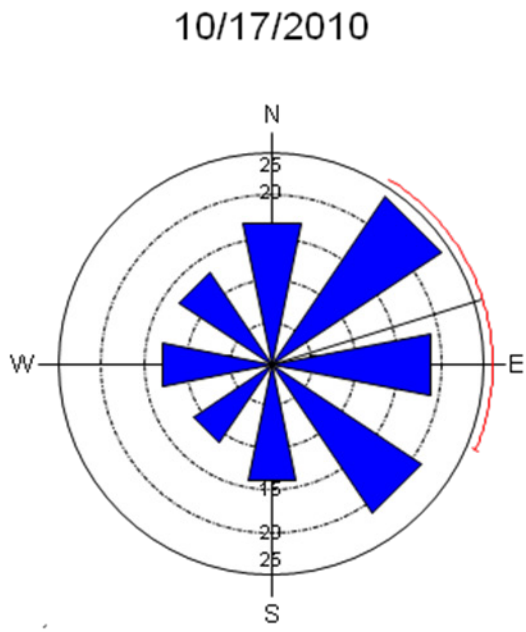
APPENDIX D

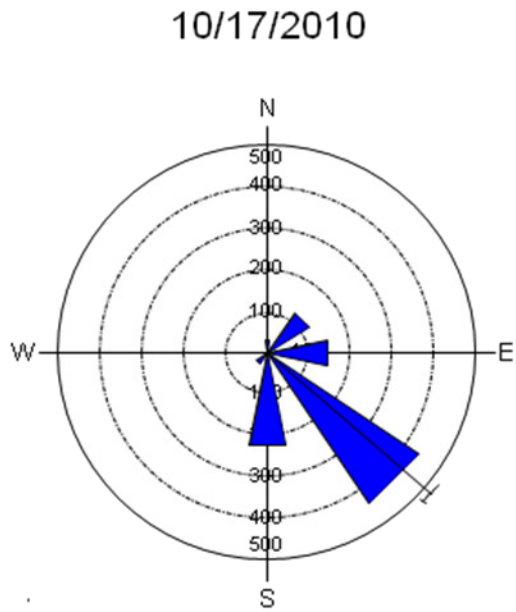
FALL 2010 FLIGHT DIRECTION DIAGRAMS

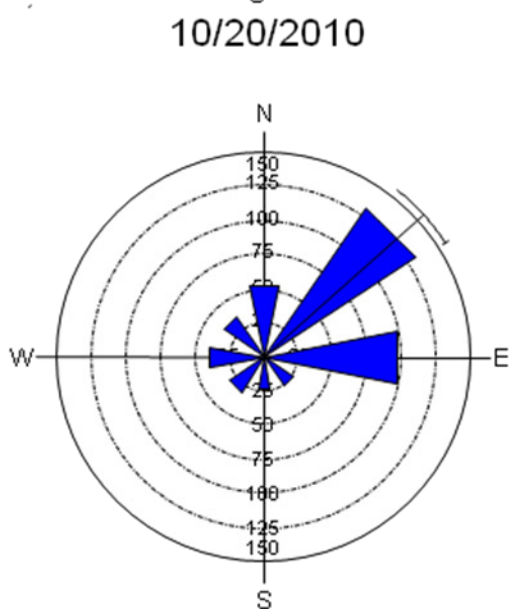
Appendix D-1

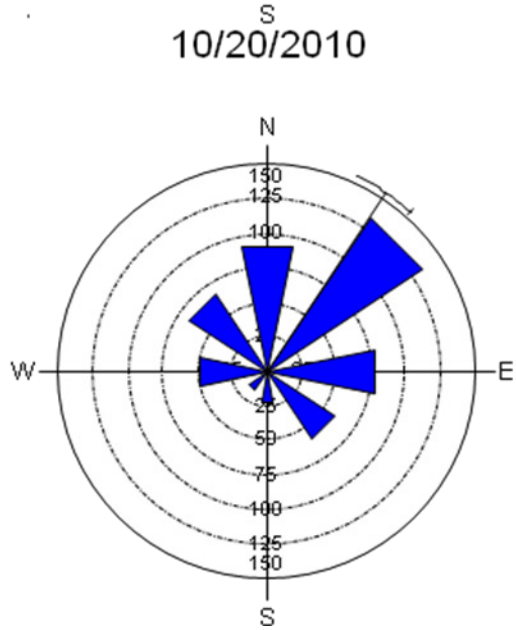
East Over Land

East Diurnal (left) and Nocturnal (right)

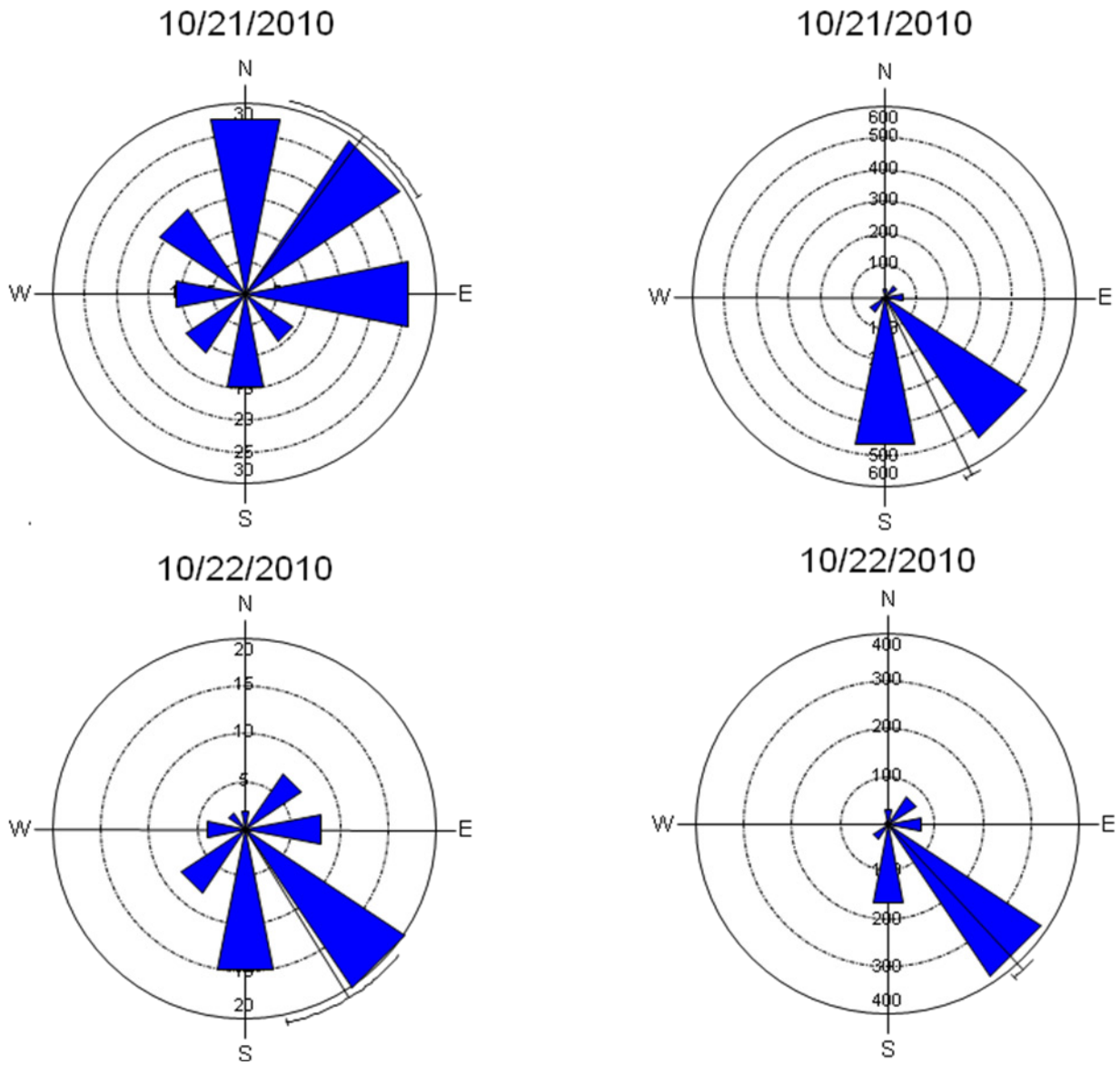




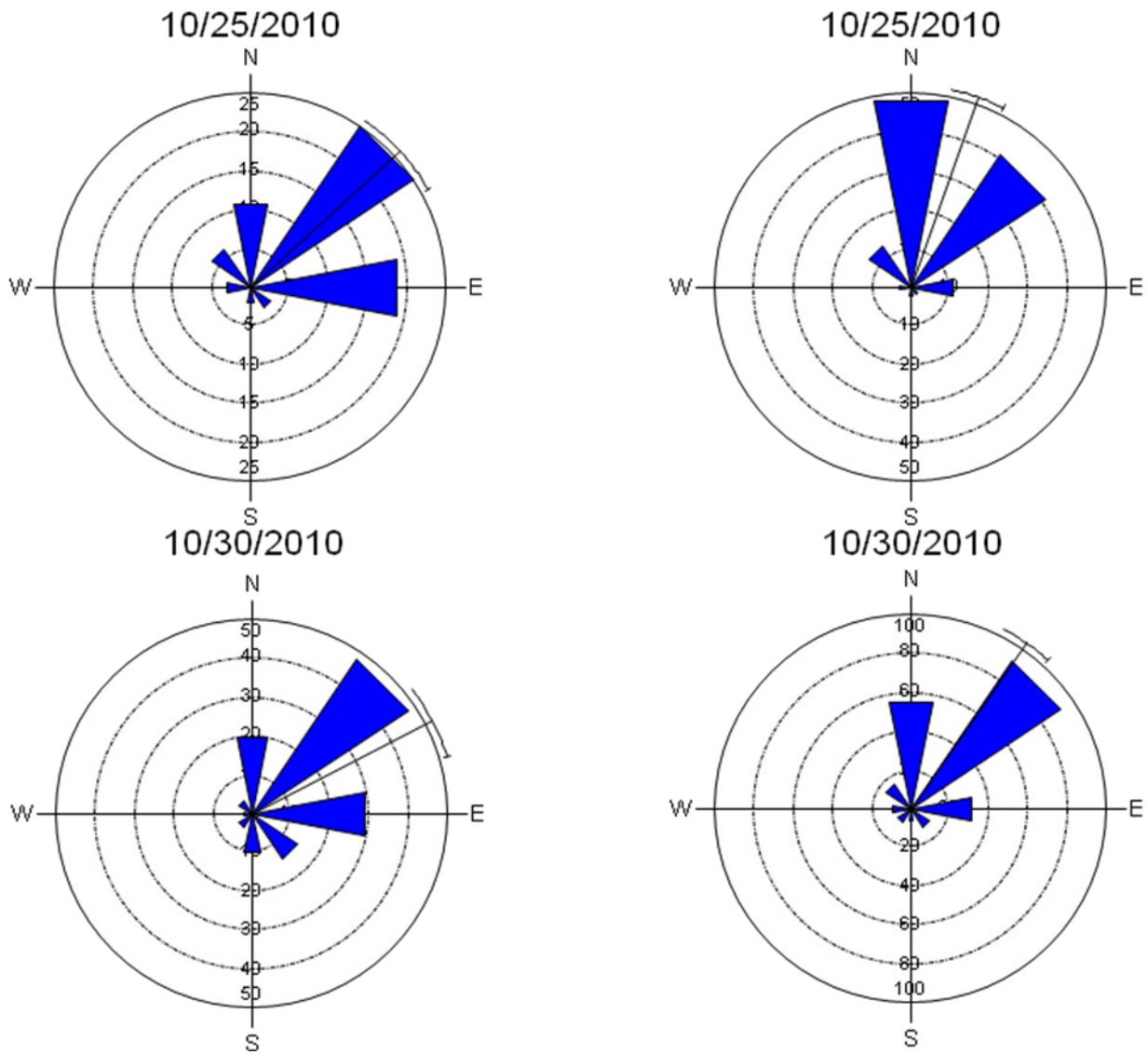




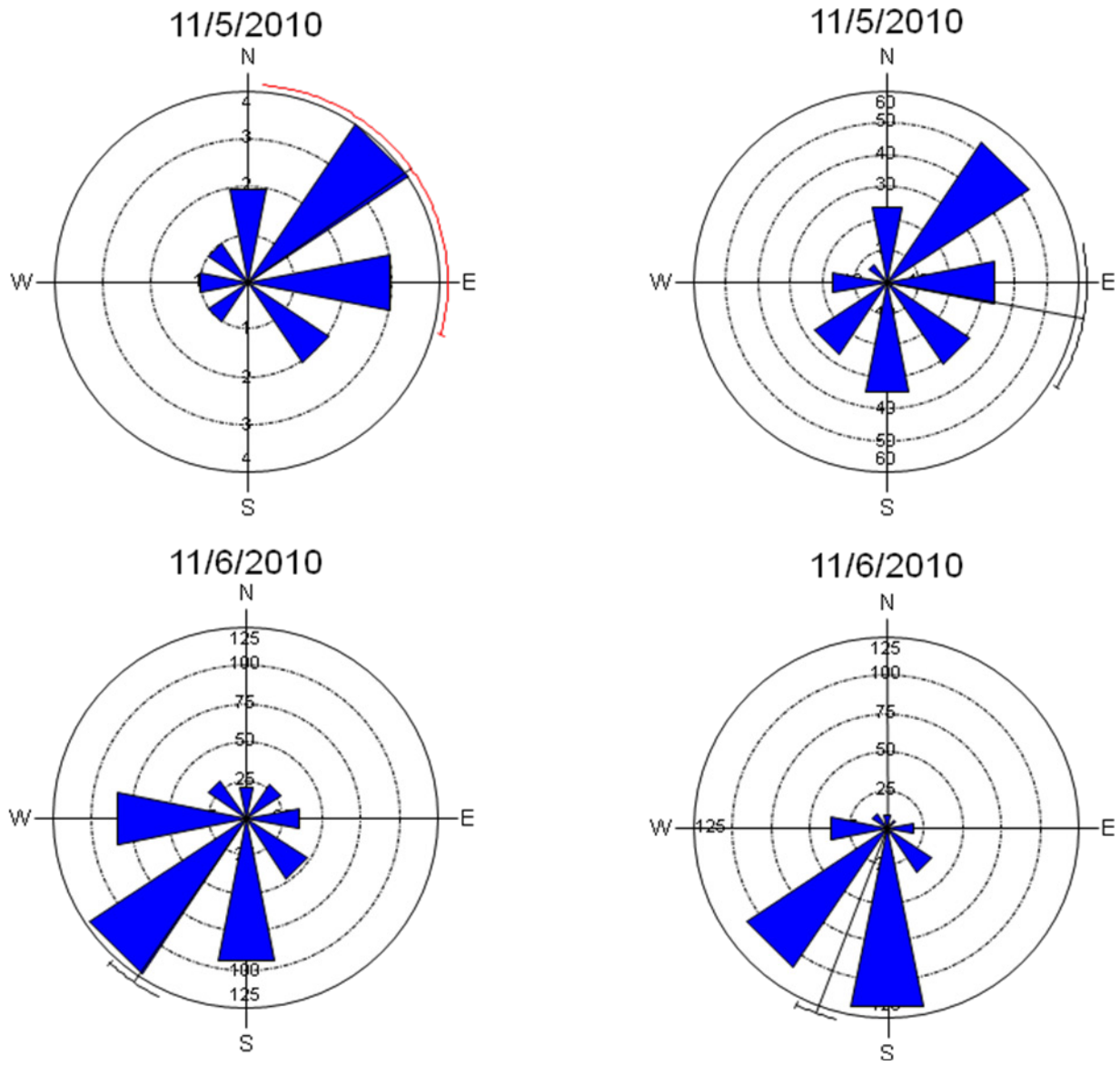
East Diurnal (left) and Nocturnal (right)



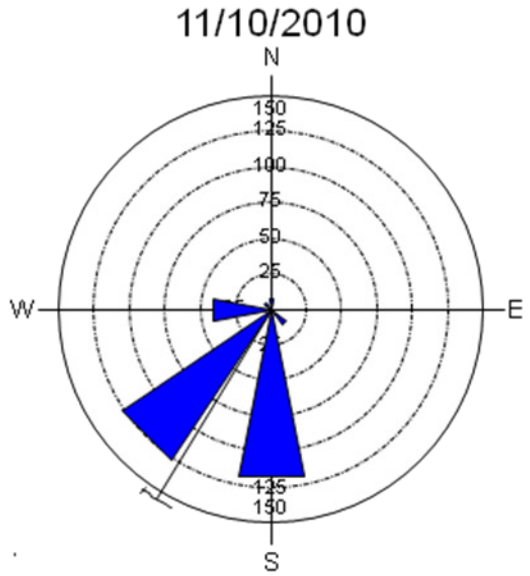
East Diurnal (left) and Nocturnal (right)

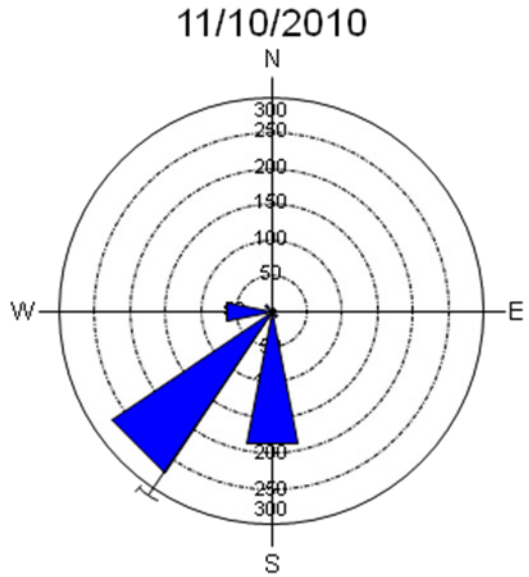


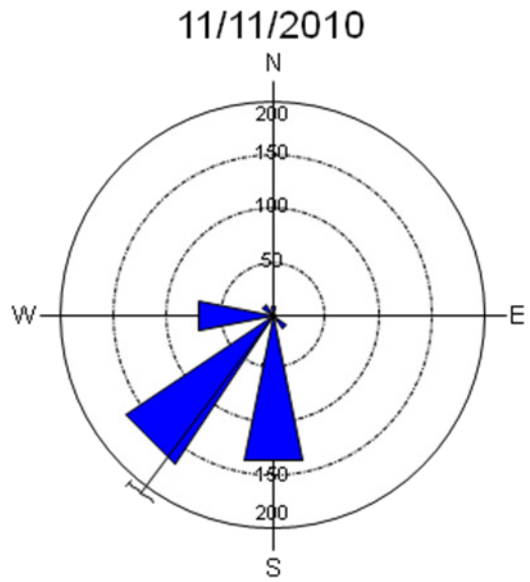
East Diurnal (left) and Nocturnal (right)

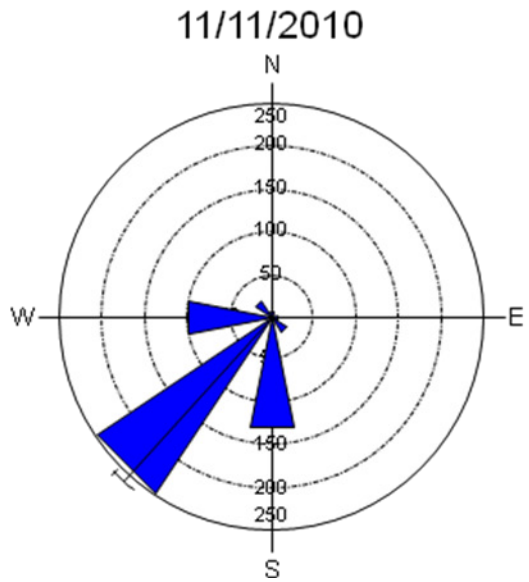


East Diurnal (left) and Nocturnal (right)





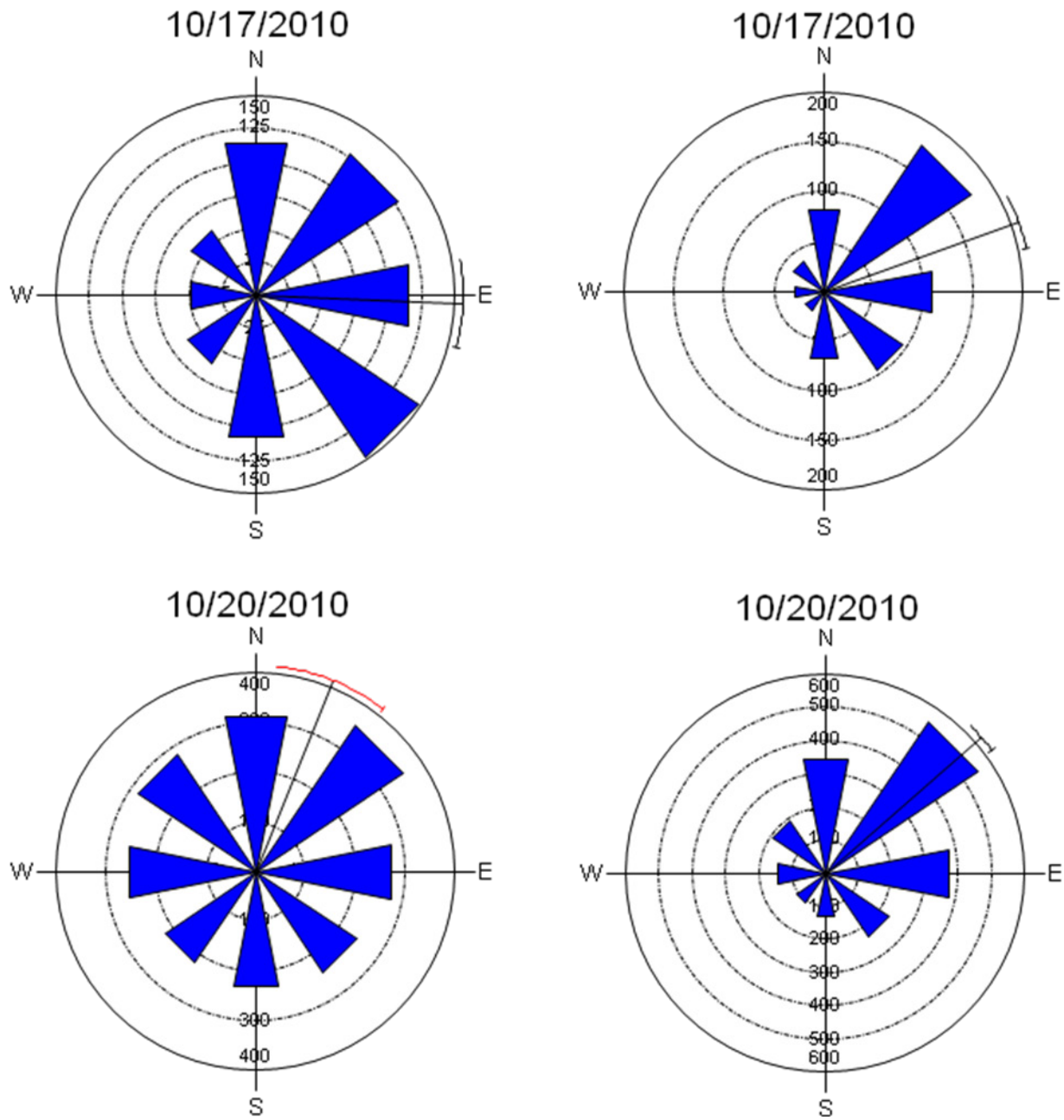




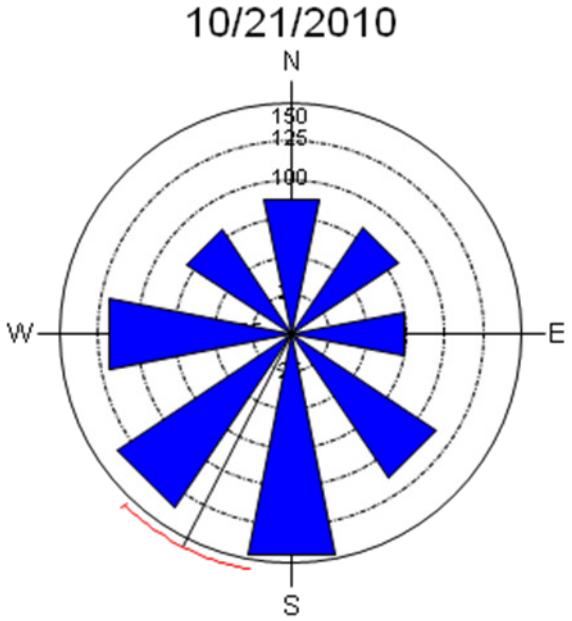
Appendix D-2

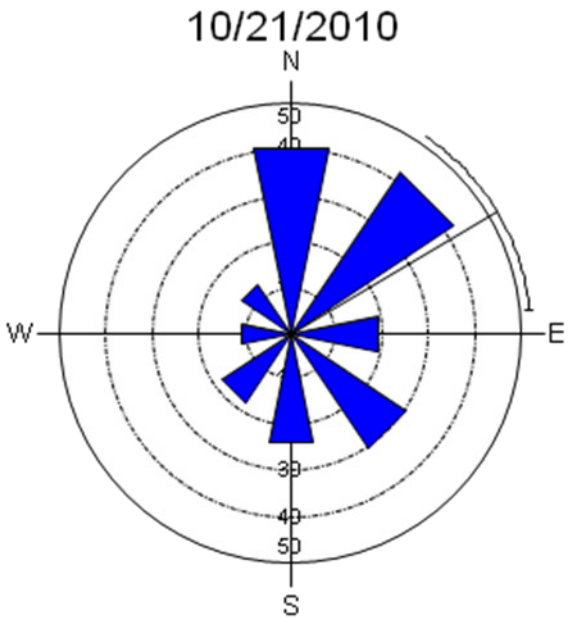
West Over Water

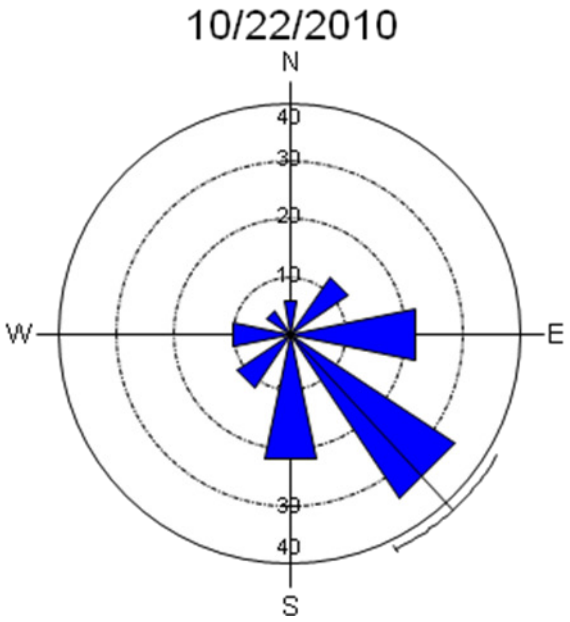
West Diurnal (left) and Nocturnal (right)

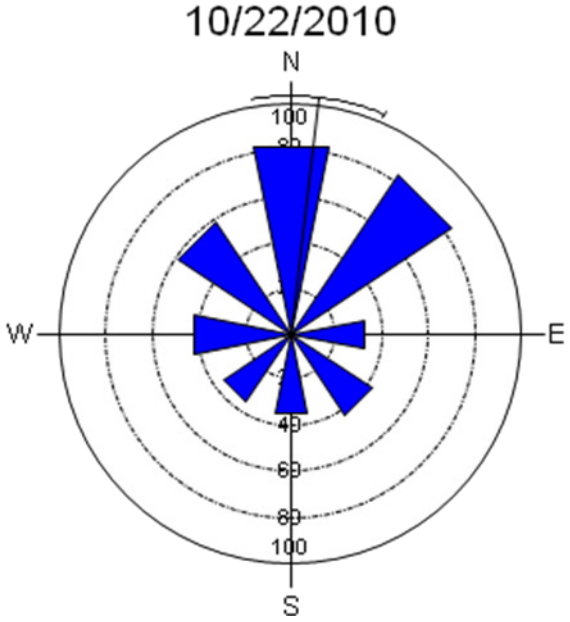


West Diurnal (left) and Nocturnal (right)

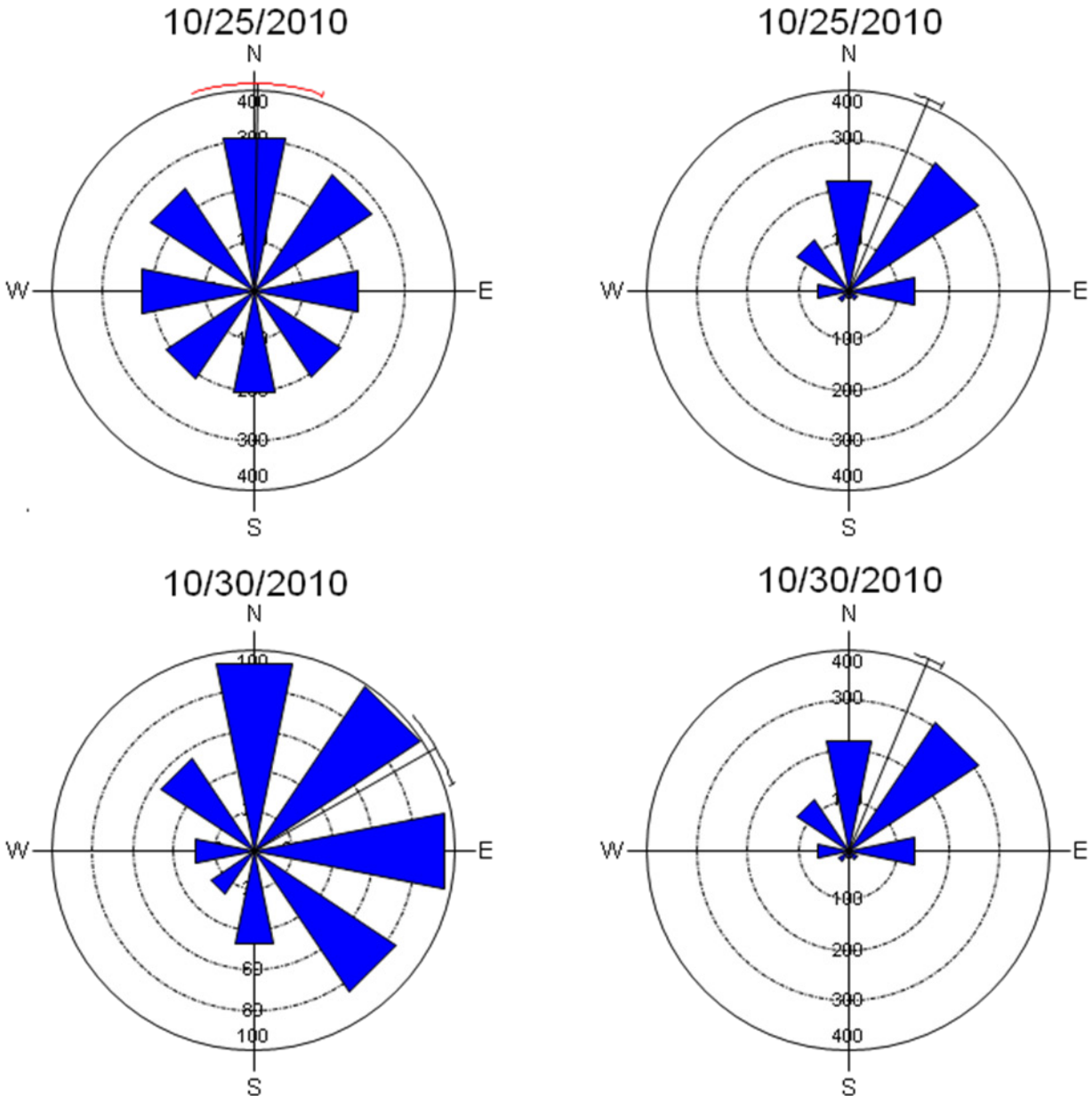




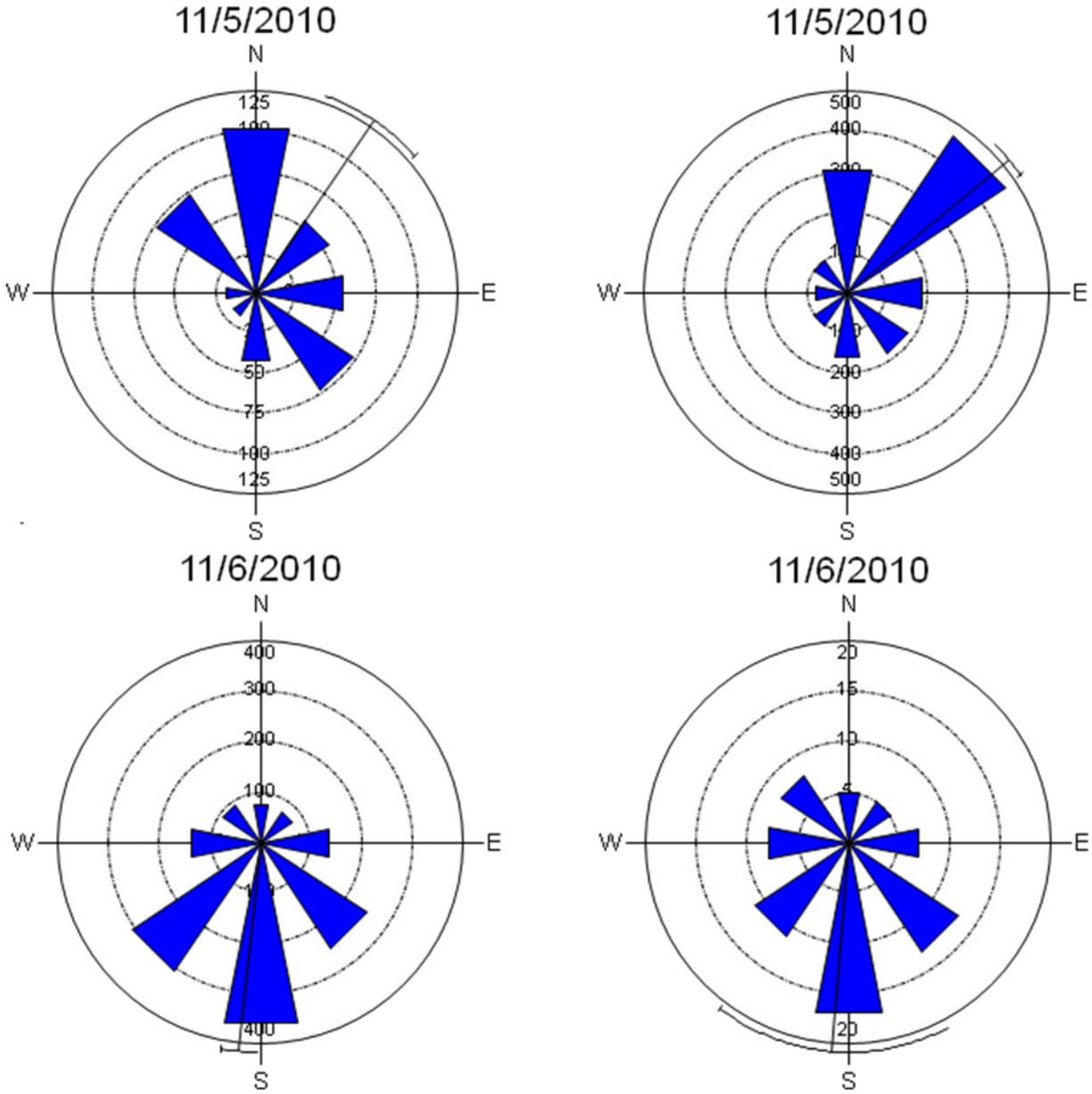
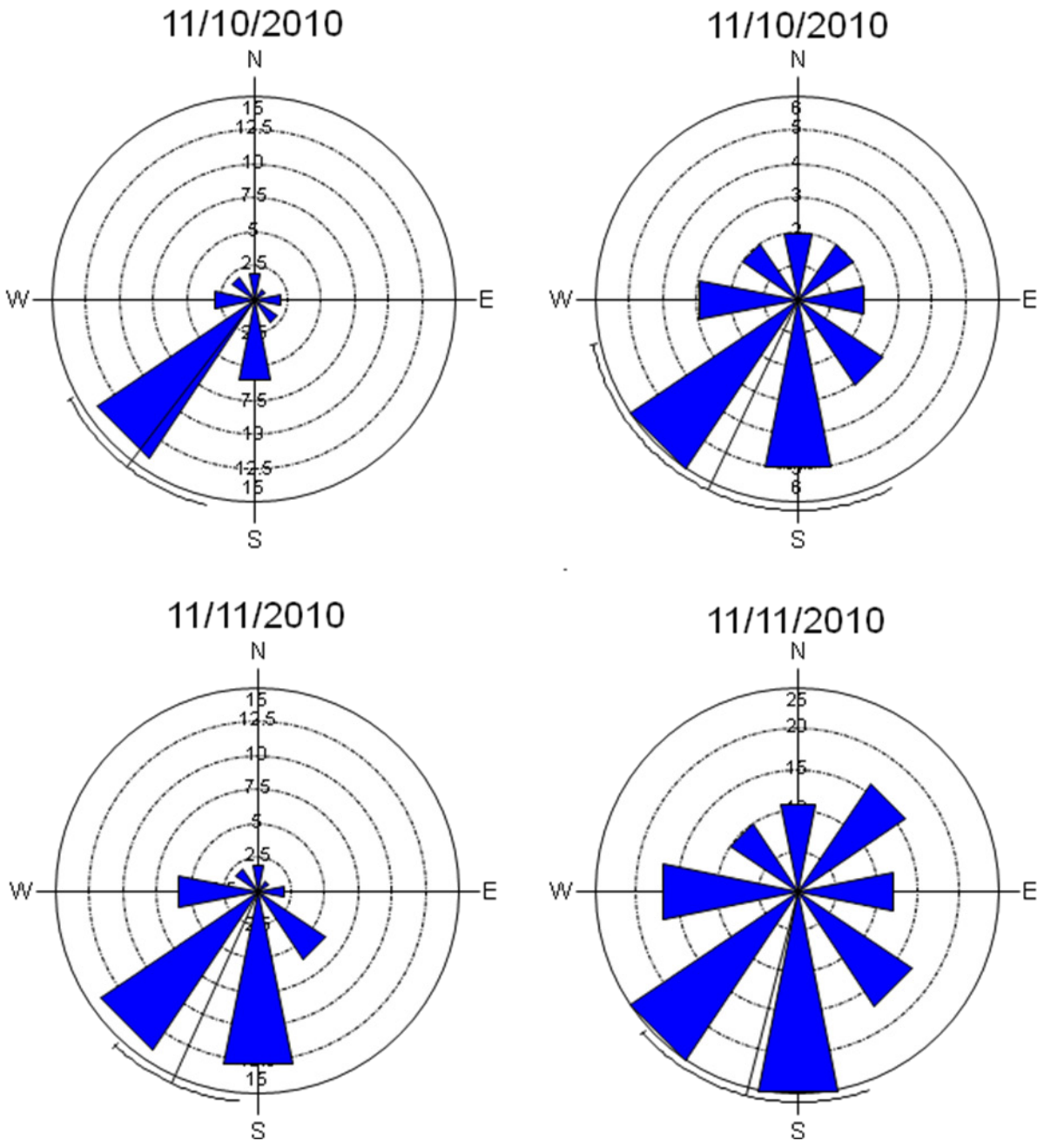




West Diurnal (left) and Nocturnal (right)



West Diurnal (left) and Nocturnal (right)



West Diurnal (left) and Nocturnal (right)