5.0 AVIAN RADAR SURVEYS

The basic principles of radar ornithology are introduced in this chapter along with a description of the Mobile Avian Radar System (MARS®), the primary avian radar system GMI uses to monitor airborne targets (i.e., flight activity) in the Study Area. Survey design, methodology, and data analysis procedures are described in detail for each radar system used. Radar validation methods and results are presented and avian radar survey results are provided for offshore and onshore survey sites.

5.1 INTRODUCTION TO 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 target, the longer it takes for an echo to return to the receiver and the weaker that echo is. Almost any object reflects 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. Empirical evidence shows that the strength of echoes, or "signals", from birds is generally related to: the wavelength of the radar signal (10 centimeters [cm; 4 inches (in.)] for S-band radars); 3 cm (1 in.; for X-band radars), 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 size (reflectivity) of the return signal is smaller. The smaller the target (small reflective surface or cross-section), the more difficult it is for the radar to detect the target. Therefore, low numbers of small targets are more likely to be detected at 3 km (2 mi) from the radar than at 6 km (4 mi); larger targets (i.e., flocks or large birds) can be detected at greater distances (i.e., throughout the radar coverage area). No reliable method is known to discriminate between echoes produced by small birds and echoes produced by large birds, because several small birds in a radar pulse volume can have a combined mass similar to a single large bird and will produce a similar radar echo.

Radars work primarily along line-of-sight, and scan in a circular sweep; therefore, radars cannot detect targets behind other objects. Obstructions, such as towers or large vessels, create a shadow, which obscures objects behind them. Such obstructions, as well as the ground or sea (i.e., waves), also reflect energy back to the radar; these echoes are known as clutter echoes. Wave echoes are of similar or greater strength, than bird echoes, while tower and vessel echoes are usually much stronger than bird echoes. Combinations of topographic features (static and/or dynamic) and obstructions can block radar coverage and create "blind spots."

When the center of the beam of marine radar is horizontal, nearly half of the radar energy is directed below the horizontal and toward the sea. Sea state is directly affected by wind speed, and as the wind speed increases so does the amount of clutter from waves (**Section 5.4.1.3**). An increase in returned reflectivity from waves can obscure returned reflectivity from birds flying low above the surface of the water, because the returned signals from birds may not be distinguished from returned signals from the crest of waves. Birds flying behind and below a wave crest may not be detected, because of blockage of the radar signal.

5.2 MOBILE AVIAN RADAR SYSTEM (MARS®)

The MARS® consists of two radar systems (**Figure 5-1**):

- VerCat (X-band, 3-cm [1-in.] wavelength) determines the altitude and range of targets and is used to measure the flux of targets (the number of birds that passes through the vertical sample volume in a given unit of time).

- TracScan (S-band, 10-cm [4-in.] wavelength) determines the range, flight direction, speed, and heading of targets in a horizontal sample volume.

Figure 5-1. GMI MARS® showing both VerCat and TracScan antennae and transmitter/ receiver units.

Both VerCat and TracScan use commercially available marine-band radars to transmit radio signals and listen for echoes. **Tables 5-1** and **5-2** provide the VerCat and TracScan radar specifications for the offshore and onshore systems. These radars transmit for a very short duration (pulse length) and then listen for echoes until it is time to transmit the next pulse. The number of times per second that radar transmits a pulse and listens 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.

5.2.1 VerCat Radar (X-band)

The MARS® VerCat radar scans a vertical, circular pattern of 20° from the horizon, through zenith to the opposite horizon (**Figure 5-2**). While the antenna is pointing below horizontal (i.e., toward the ocean), no signal is transmitted; 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 in an approximate 0.5° arc below the horizon towards the water. The radar scans at 24 revolutions per minute (rpm), completing one scan (a full 360° rotation) every 2.5 s. Given a PRF of 2,200 times a second, VerCat can transmit 15.27 pulses for every degree of radar rotation. The radar signal is transmitted through a 2.4-m (8-ft) long array (T-bar) antenna (**Figure 5-1**). The antenna focuses the signals into a fan-shaped beam, which is 0.95° deep 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 antenna has been fitted with a custom-designed shield to minimize the impact of this ground-bounce clutter. **Figure 5-2** illustrates the coverage of the VerCat beam.

Table 5-1. Offshore MARS® radar parameters.

Radar Parameters	VerCat (Furuno FR-2155)	TracScan (Furuno FR-2165)
Band Type	X-band	S-band
Transmit Peak Power	50 kilowatts (kW)	60 kW
Transmit Frequency	9415 megahertz (MHz)	3040 MHz
Transmit Pulse Length	80 nanosecond (ns)	80 ns
Pulse Repetition Frequency	2200 hertz (Hz)	1900 Hz
Beamwidth	20° Horizontal	2.2° Horizontal
Beamwidth	0.95° Vertical	25° Vertical
Maximum Study Range	2.8 km downrange (1.5 NM) both directions; 5.5 km (18,200 ft; 3.0 NM) altitude	7.4 km (4 NM)
Antenna Polarization	Vertical	Horizontal
Wave Length	3 cm (1 in.)	10 cm (4 in.)

Table 5-2. Onshore MARS® radar parameters.

Radar Parameters	VerCat® (Furuno FR-2125)	TracScan® (Furuno FR-2135)
Band Type	X-band	S-band
Transmit Peak Power	25 kilowatts (kW)	30 kW
Transmit Frequency	9410 megahertz (MHz)	3050 MHz
Transmit Pulse Length	70 nanosecond (ns)	300 ns
Pulse Repetition Frequency	3000 hertz (Hz)	1100 Hz
Beamwidth	Horizontal 20°	Horizontal 1.8°
Beamwidth	Vertical 0.95°	Vertical 25°
Maximum Study Range	2.8 km (1.5 NM)	7.4 km (4 NM)
Antenna Polarization	Vertical	Horizontal
Wave Length	3 cm (1 in.)	10 cm (4 in.)

The VerCat scan pattern results in a “radar curtain,” that samples targets as they fly through the 20° by 180° scanning volume within 3 km (1.5 NM) of radar (horizontal) and up to 5.5 km (3 NM; vertical). The radar determines target altitude and downrange distance from the MARS® site. The VerCat beam depth of 0.95° provides fine angular resolution from which estimates of echo altitude can be determined. Targets flying along the axis of the VerCat scan can be tracked and accurate ground speeds measured; however, targets crossing perpendicular to the sweep of the beam appear stationary, and targets crossing the sweep at angles between parallel and perpendicular have ground speeds reduced from true ground speeds.

Because of the nature of X-band signal propagation in the atmosphere, and the generally smaller returns of targets in X-band, the operational range is limited to 3 km (1.5 NM). Furthermore, X-band is quite sensitive to precipitation (e.g., rain and high moisture content in the atmosphere) which obscures targets of interest. Wind speeds in excess of 15 to 18 m/s (49 to 59 ft/s) along the VerCat’s scan axis will trip the VerCat’s motor safety breaker. By shutting down operation, the radar protects itself from damage.

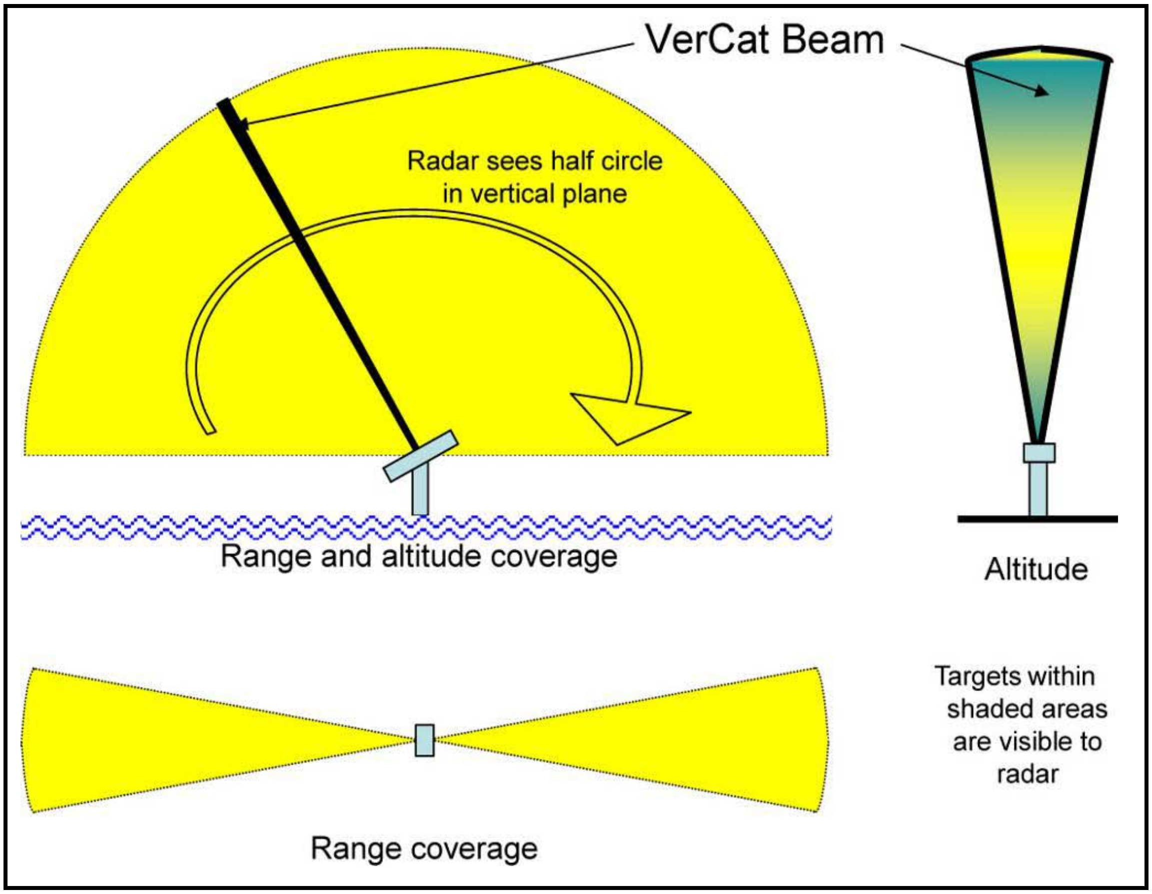


Figure 5-2. VerCat Coverage Pattern.

5.2.2 TracScan Radar (S-band)

The MARS® TracScan radar scans in the horizontal plane at 24 rpm, completing one scan (a full 360° rotation) every 2.5 s (**Figure 5-3**). Given a PRF of 1,900 pulses per second, TracScan can transmit 13.19 pulses for every degree of radar rotation. The radar signal is transmitted through an array (T-bar) antenna (**Figure 5-1**). This antenna focuses the signals into a fan-shaped beam, which is 2.2° wide in the horizontal plane and extends 12.5° above and below the horizontal plane (25° vertical beam width).

TracScan data are used to determine target position (range and bearing), speed, and heading. With its relatively wide beam width of 2.2°, TracScan is not the best radar to determine target size.

5.2.3 MARS® Surveillance Coverage

With VerCat and TracScan operating simultaneously, MARS® provides both horizontal and vertical coverage (**Figure 5-4**). The coverage for the TracScan range of 7.4 km (4 NM) is illustrated below. Concurrent radar coverage occurs only in the overlapping areas of the cross hatching of the VerCat and TracScan ranges. Therefore, targets detected by VerCat are not necessarily detected by TracScan, or the reverse.

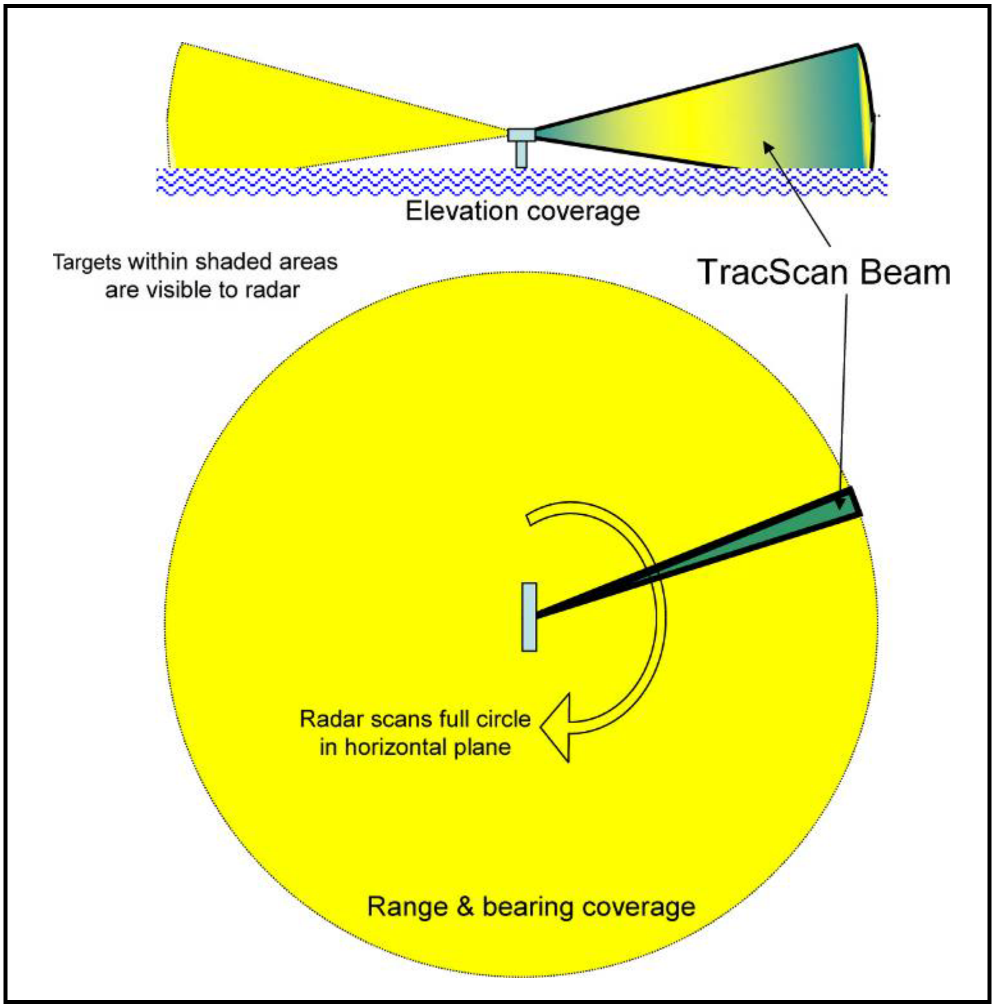
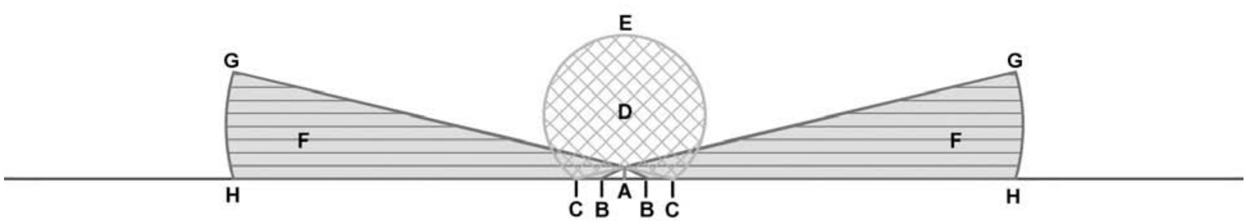


Figure 5-3. TracScan coverage pattern.



KEY TO FEATURES:

A. Radar unit
B. TracScan's horizontal beam meets ground level at approximately 61 m (200 ft) from unit
C. VerCat's vertical beam meets ground at approximately 1 km (0.5 NM) from unit
D. VerCat coverage
E. Maximum altitude of VerCat coverage at 5.5. km (18,000 ft)
F. 7.4 km (4 NM) TracScan coverage
G. Maximum altitude of 4 NM TracScan coverage at 1,629 m (5,346 ft)
H. 7.4 km (4 NM) from unit

Figure 5-4. Typical MARS® Surveillance Coverage.

5.2.4 MARS® On-Site Data Capture and 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 this high-resolution data to generate dynamic maps of background clutter and exploit the small differences between clutter and targets.

GMI proprietary algorithms attempt to exploit the distinction between background clutter (even temporary clutter like a rain cloud) and moving 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. A "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. Target echo strength depends upon the 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, bearing, size, and strength) to a database for future analysis

5.3 THERMAL IMAGING - VERTICALLY POINTING RADAR

The Thermal Imaging (TI) - Vertically Pointing Radar (VPR) was used to validate VerCat data. Recent visual studies of migration have incorporated passive infrared (IR) cameras (Buurma 1988; Winkelmann 1992; Bruderer and Liechti 1994) that detect the heat generated by a target. The passive IR cameras make it possible to distinguish between birds, insects, and foraging bats (Zehnder et al. 2001; Gauthreaux and Livingston 2006); however, IR cameras do not provide accurate information on the distance to target or altitude of flight. According to Liechti et al. (1995), the proportion of birds detected by tracking radar and IR camera did not change with distance between 0.5 and 3 km (0.31 and 1.86 mi), and the "very rough grouping of birds into three size classes by moon-watchers and IR-operators is closely related to the distances measured by the tracking radar."

5.3.1 TI-VPR System

The TI-VPR system for this study consists of two components (**Figure 5-5**):

- TI, pointed up vertically to obtain target identification, behavior, and X/Y dimensional information.

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

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, 3-cm [1-in.] wavelength) with peak power output of 25 kilowatts (kW) and a minimum range detection of 35 m (115 ft). The 463-m (0.25-NM) radar range setting was chosen to observe activity aloft within the RSZ. Additional settings were 0.07 microseconds (µs) pulse length, 3000 hertz (Hz) PRF, and 92.6-m (0.05-NM) range rings.

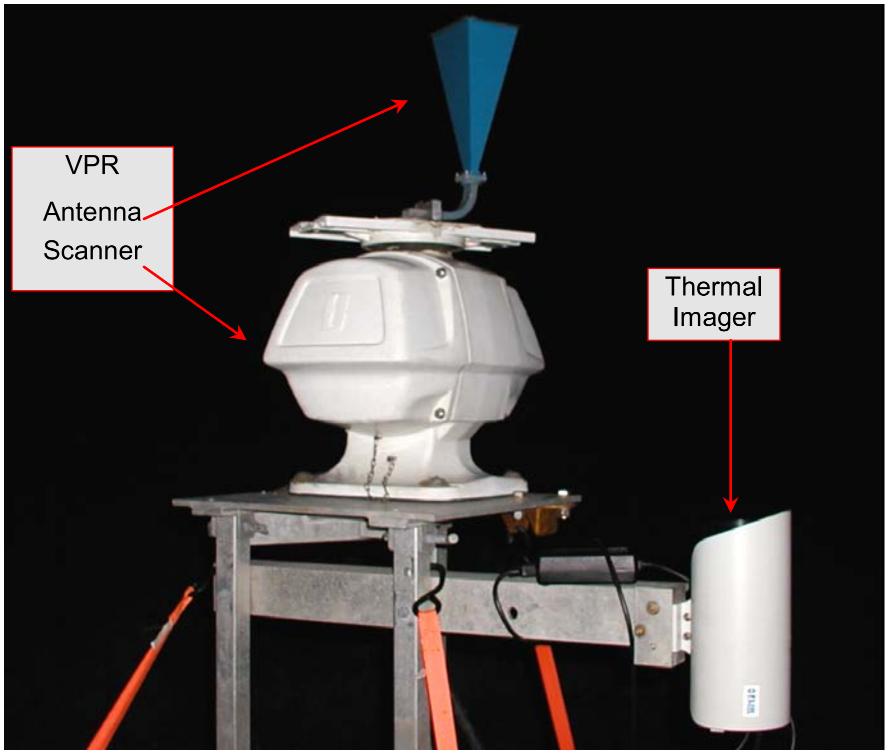


Figure 5-5. MARS® TI/VPR.

5.3.2 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. Approximately 2 hours of data were recorded per DVD for later analysis.

5.4 SURVEY METHODOLOGY

The original Scope of Work for the avian radar survey was to collect seasonal offshore radar data from a radar mounted on a jack-up barge in spring 2008, fall 2008, and spring 2009. During spring 2008, all of the scheduled survey locations could not be reached because of barge siting and/or weather constraints. In late spring 2008, NJDEP made a decision to add onshore radar surveys at three coastal sites to recover the lost sample days offshore and to ensure coverage of nearshore areas that the offshore barge could not sample.

When the surveillance radar coverage of the coastal radar sites was compared with the original survey plan there was significant overlap with the coastal radars. Modifications to the existing sampling design were evaluated. Modification of the fall offshore radar sampling locations to emphasize radar surveys in the southern section of the project area was adopted because it would enhance areal coverage of the southern and near shore region of the survey without the overlap of the coastal radar. The offshore radars would be located in proximity to, but outside the range of, the coastal radars; however, because of a May 2008 jack-up barge accident off the coast of Delaware, the barge operator implemented two new, significant operational restrictions prior to the fall sampling season: operations could not be conducted when wind speeds over 40 kts and mean low water (MLW) was greater than 37 ft. When operational restrictions and safety concerns were evaluated the decision was to conduct the fall 2008 surveys within the southern section of the Study Area. The original sampling design was then modified after collapse and loss of the barge in October 2008. The frequency of onshore radar surveys was increased to recover some of the data scheduled to be collected by the offshore barge of nearshore locations from mid-October through November.

In spring 2009, additional offshore radar surveys were scheduled; however, new U.S. Coast Guard restrictions severely limited operations and a decision was made to continue and increase the frequency of the onshore radar surveys in case the offshore barge would not be able to collect the scheduled radar data.

In summary, the offshore survey dates for the Study Area were:

- Spring 2008: 14 March – 11 May
- Fall 2008: 30 September – 19 October
- Spring 2009: 11-13 May

The onshore survey dates were:

- Spring 2008: 15 May – 19 June
  Island Beach State Park: 15-23 May
  North Brigantine Beach: 29 May – 08 June
  Corson's Inlet State Park: 09-19 June

- Fall 2008: 13 September – 15 December
  Island Beach State Park: 13 September – 02 October
  Brigantine Beach: 26 October - 16 November
  Sea Isle City: 05-26 October; 16 November – 15 December

- Spring 2009: 14 March- 2 June
  Island Beach State Park: 14 March – 05 April
  Brigantine Beach: 05 April – 05 May
  Sea Isle City: 07 May – 02 June

- Fall 2009: 15 September – 16 November
  Island Beach State Park: 15 September – 02 October
  Brigantine Beach: 05–26 October
  Sea Isle City: 26 October – 16 November

5.4.1 Offshore MARS® Radar Surveys

5.4.1.1 Survey Design

A stratified random sampling approach, with equal effort in each stratum, was used to design sampling sites for a barge-supported radar unit within the project area. To aid in the selection of radar sites, the project area was divided into three strata of variable area defined by contours paralleling the coastline and the outermost boundary of the Study Area (**Figure 5-6**). Each stratum consists of nine grid cells arranged in three rows and three columns. Each of the numbered grid cells (1 through 27) is an irregularly shaped, variable-area contoured grid. The latitude-longitude coordinates of the four corner points of the Study Area were first identified. Then the distance between the NW and SW corners (measured along the coast), and the distances between the NW and NE corners, NE and SE corners, and SE and SW corners (measured along the defined study-area boundary lines) were calculated. Tri-sector points along the coastline, outermost boundary, northernmost boundary, and southernmost boundary were then identified.

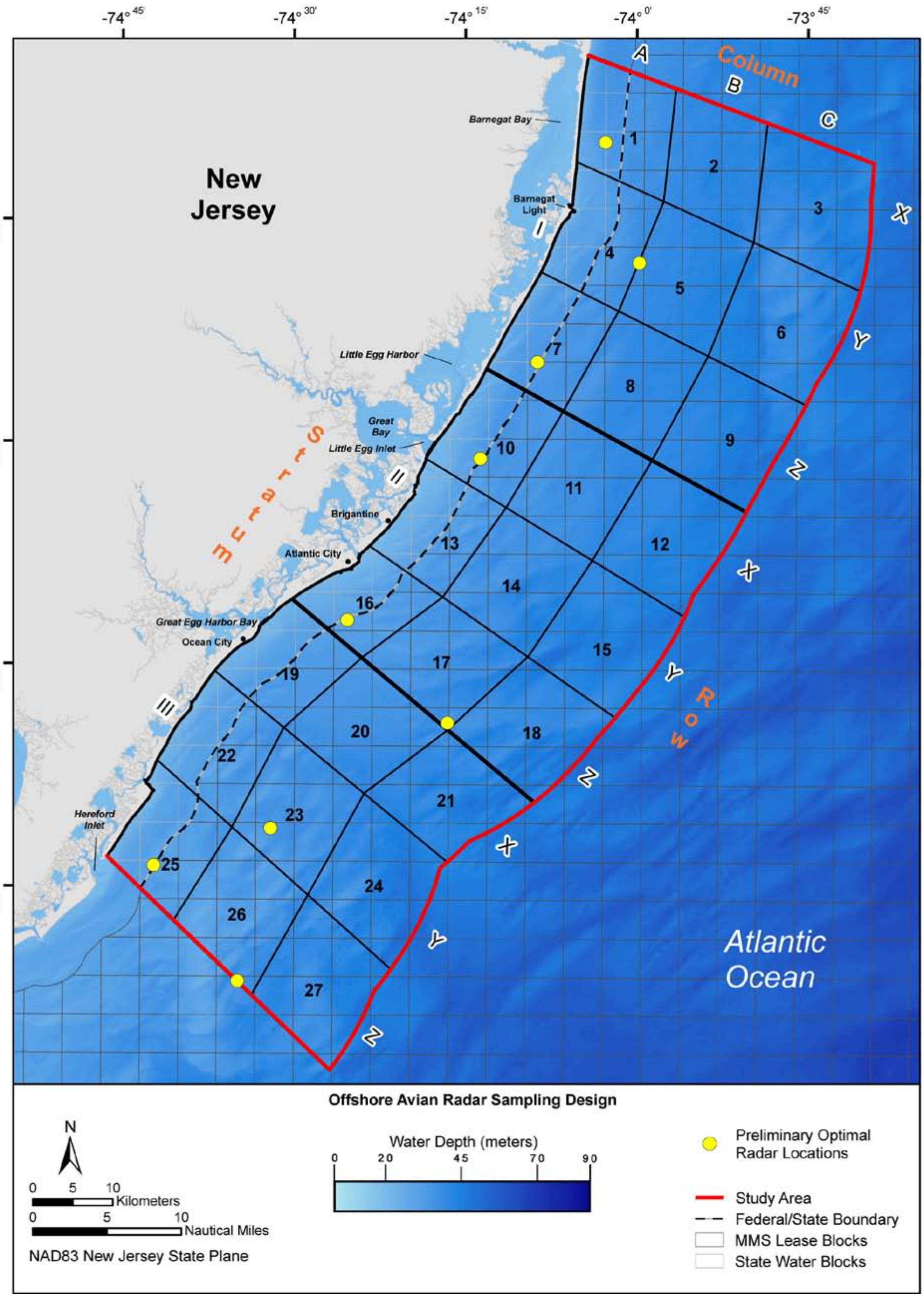


Figure 5-6. Offshore avian radar sampling design.

Straight lines were drawn between the two sets of tri-sector points between the coastline and outermost boundary, thus defining the high-latitude, mid-latitude, and low-latitude strata. Within each of these three strata, the along-coast distance between the NW and SW corners of each stratum, and the along-contour distance between the NE and SE corners (measured along the outermost boundary) were calculated, tri-sector points were located, and straight lines were drawn between each of these sets of points between the coastline and outermost boundary. Distances along each of these straight lines were then calculated, and tri-sector points for each line were identified, generating two series of points aligned roughly parallel to the coastline and outermost boundary, one-third and two-thirds of the distance between coastline and outermost boundary. Using a smoothing algorithm, these points were connected by two curves extending from the northernmost to the southernmost boundaries, defining the 27 irregularly shaped, variable-area grid cells (i.e., nine grid cells arranged 3x3 in each of the three strata). Stratum 1 is comprised of grid cells 1-9, Stratum 2 consists of grid cells 10-18, and Stratum 3 contains grid cells 19-27 (**Figure 5-6**).

The barge-supported radar was limited to a maximum operational depth of 15.24 m (50 ft), and the radar's detection range was 7.41 km (4 NM). A stratified random sampling statistical analysis was conducted to determine the radar sampling locations subject to these two constraints. The objective of this statistical analysis was to randomly select nine radar sites, with three sites in each of the three strata, off the coast of New Jersey and identify the optimal locations (latitude/longitude points) and sequential sampling of these locations that will minimize the overlapping area among the sites (i.e., maximize coverage of the radar, assuming a radar range of 7.41 km [4 NM]) while also minimizing the total travel distance and travel time of the barge among these sites (i.e., maximizing the radar's operation time for collecting data, assuming a 5.54-m/s [3-kt] barge speed). Selection of the optimal radar sites is subject to the constraint of a <15.24-m (50-ft) bottom depth, a separation distance of at least 7.41 km (4 NM; i.e., the radar's range) from the outer boundaries of the Study Area, and a separation distance of at least 14.82 km (8 NM, twice the radar's range) from adjacent neighboring radar sites, to ensure full radar coverage within the Study Area at each site as well as minimal overlapping area between adjacent sites, thus maximizing total radar coverage area. Equivalently, a 7.41 km (4-NM) wide buffer zone is defined along the inside of the Study Area's boundaries, and the point location of each radar site is excluded from this buffer zone to ensure that a 4-NM radius circle drawn around the point location

Table 5-3. Preliminary optimal locations for the offshore radar sites.

Grid Cell	Longitude (°W)	Latitude (°N)
1	-74.04709	39.83485
5	-73.99888	39.69916
7	-74.14742	39.58811
10	-74.23084	39.47996
16	-74.42404	39.29894
18	-74.27987	39.18313
23	-74.53513	39.06508
25	-74.70368	39.02345
27	-74.58290	38.89344

5.4.1.2 MARS® Survey Site Setup and Data Collection

Prior to deployment, depth data was collected from available nautical charts for all of the optimal grid locations and compared to optimal offshore barge radar sites (**Table 5-3**). If the optimal locations did not meet barge deployment criteria, alternative locations were identified in the grid. The jack-up barge proceeded to the identified location and determined whether or not the location met the jack-up barge operating requirements. If acceptable, the barge proceeded to jack-up. If the location was not acceptable, alternative locations were checked until a location met the jack-up barge requirements.

Spring 2008

The MARS® was mounted on a jack-up barge on 13 March 2008 and deployed on the morning of 14 March 2008. The barge was set-up at Grid 1 that night (**Table 5-4**; **Figure 5-8**). Initial set up and a radar validation survey occurred on 15 March 2008; avian radar surveys commenced the same day and continued until barge demobilization on 21 March 2008.

The barge was relocated to Grid 7 on 21 March 2008. Set up and a ground truth survey occurred on 22 March 2008 and radar surveys continued until 27 March 2008. On 27 March 2008 the barge moved to Grid 13 (**Table 5-3**; **Figure 5-8**), waited for 2 hrs, and then navigated to port in Atlantic City, New Jersey, as it was unable to jack up because of high sea state conditions.

The month of April began with the barge and avian radar system in port at Atlantic City because of bad weather. On 03 April 2008, the barge was able to return to sea and the avian radar was on station and collecting data at Grid 13 that afternoon. The avian radar remained at Grid 13 until the morning of 13 April 2008, at which time the barge moved to Grid 19 (**Table 5-4**; **Figure 5-8**). The avian radar collected data at Grid 19 from 13 April 2008 through 19 April 2008. A radar validation survey was conducted on 19 April 2008. After completion of the validation survey, the barge moved to Grid 26.

Table 5-4. Locations of the spring 2008 barge radar sites and VerCat azimuth(s).

Grid Cell	Longitude (°W)	Latitude (°N)	VerCat Azimuth (°)
1	-74.06454	39.82566	26
7	-74.18748	39.57974	57,35
13	-74.30098	39.38722	88
17	-74.35492	39.26475	333,320
19	-74.54988	39.2297	133
23	-74.55228	39.10084	220
26	-74.5705	38.9534	230

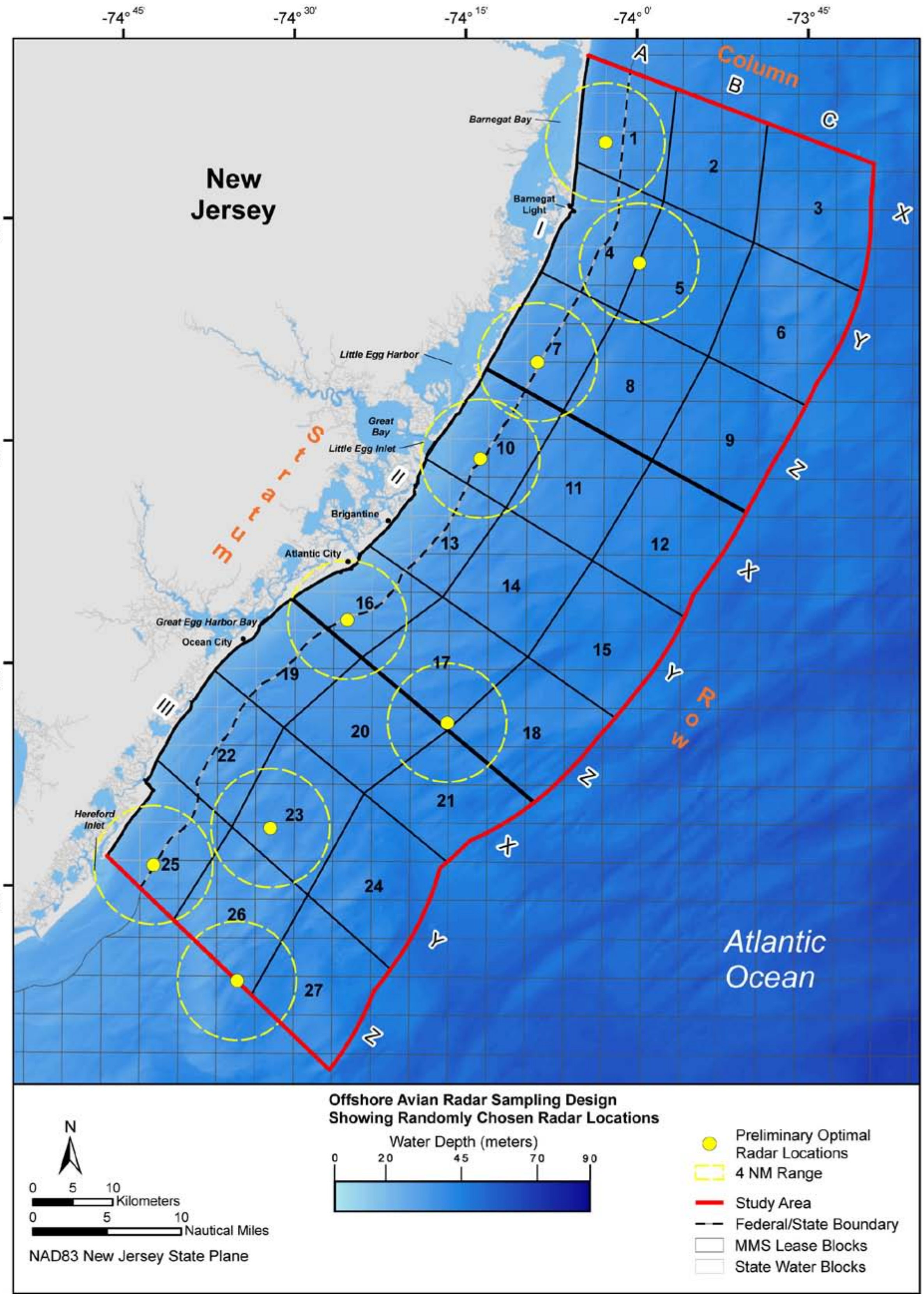


Figure 5-7. Offshore avian radar sampling design illustrating randomly chosen radar locations.

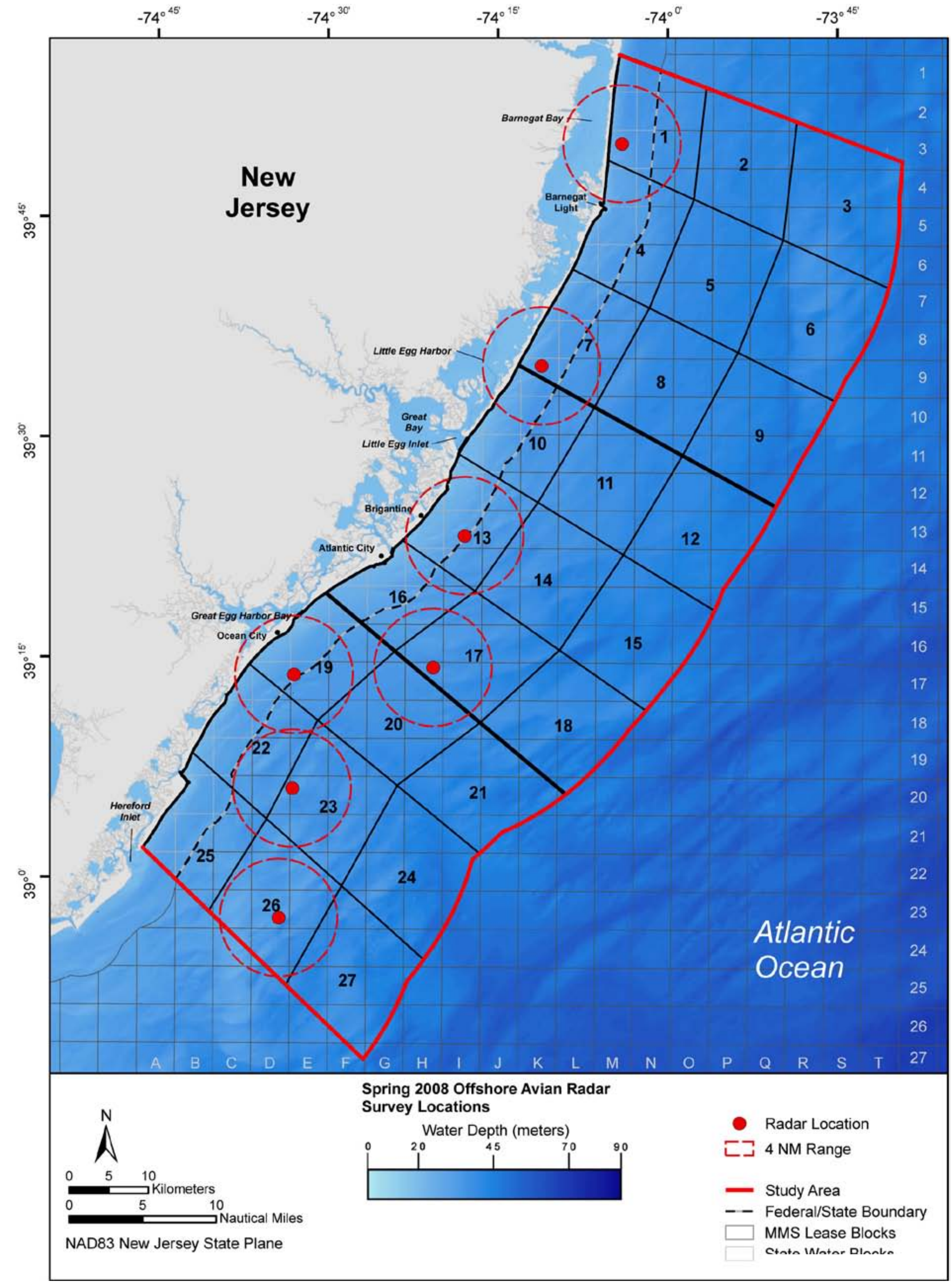


Figure 5-8. Spring 2008 offshore avian radar survey locations.

The barge attempted to jack up on station at Grid 26 on 19 April 2008, but was prevented from doing so because of rough seas at the site and had to take shelter at Cape May to await calmer seas. The barge remained at Cape May until 24 April 2008, when it was able to successfully jack up at Grid 26 (**Table 5-3**; **Figure 5-8**). The avian radar system operated at Grid 26 from 24 April 2008 through 30 April 2008.

On 30 April 2008, the barge was moved to Grid 23, and the radar began collecting data at the site (**Table 5-3**; **Figure 5-8**). The barge collected data at Grid 23 from 30 April through 07 May 2008. On 03 May 2008 a ground truth survey was conducted. On 07 May 2008 the avian radar system was turned off and the barge moved to Grid 17.

On 07 May 2008, the barge and avian radar system was moved to Grid 17 and began collecting data (**Table 5-3**; **Figure 5-8**) The avian radar remained operational at Grid 17 through 11 May 2008, at which time the barge had to return to port in Atlantic City because of an approaching weather system. The barge had to remain in port at Atlantic City until the end of the spring survey period.

Fall 2008

The original spring 2008 radar sampling locations were chosen quasi-randomly subject to the following constraints: 1) water depth less than 15.24 m (50 ft); 2) minimize overlap of the 7.41 km (4 NM) ranges of adjacent radar sites; and 3) minimize distances (travel times) from site to site.

The original sampling design was modified for the fall 2008 surveys because the coastal radar survey locations, which were added after the project was initiated, were not accounted for when the original offshore radar sites were chosen. When the surveillance radar coverage of the coastal radar sites was compared with the original survey plan there was significant overlap with the coastal radars. Modifications to the existing sampling design were evaluated.

Fall offshore radar sampling locations intended to emphasis radar surveys in the southern section of the project area because it would enhance areal coverage of the southern and near shore region of the survey without the overlap of the coastal radar. The offshore radars would be located in proximity to, but outside the range of, the coastal radars. The advantages and disadvantages of adopting this survey design were evaluated.

The statistical advantage of this modification would be the ability to scan in the offshore direction to a distance not reachable by the coastal radars. This sampling design enhances near shore areal coverage without coastal radar overlap. Under the new potential sampling design, the total number of coastal and offshore radars are more evenly distributed such that Zone A and Zone B would be more evenly sampled (**Figure 5-6**). Zone C would be poorly sampled because of water depths deeper than the new barge water depth restriction 15.24 m (50 ft). A disadvantage of the fall sampling locations is that the new design lacked true randomness because so many constraints and requirements limited the possible locations of offshore radars. With respect to offshore radars only, coverage of the southern region would be relatively over-sampled, whereas coverage of the northern region would be under-sampled. Hence, the distribution of offshore radar coverage would not be truly random, but rather clustered in mid-shore Zone B in the southern region; the northern region would not be sampled). Assessing the inter-annual variability (e.g., between spring 2008 and spring 2009) of the radar data would no longer be possible in the northern region, since the offshore radars in this region would be discontinued. It would only be possible to conduct an inter-annual variability assessment for the southern region, where the 2-3 offshore radar locations would be in operation over a sufficiently long time period to collect radar data over the same season two years in a row.

In addition, because of a May 2008 jack-up barge accident off the coast of Delaware, the barge operator implemented two new, significant operational restrictions prior to the fall sampling season: operations will not be conducted when wind speeds over 40 kts and MLW was greater than 37 ft. When operational restrictions and safety concerns were evaluated the decision was to conduct the fall 2008 surveys within the southern section of the Study Area.

On 29 September 2008, the MARS® was mounted on the jack-up barge which set sail for the Study Area that afternoon. The barge was jacked up at Grid 22 (Longitude -74.52417 W, Latitude 39.00139 N). The MARS® was set up (VerCat azimuth: 346°, 353°) and began recording on the evening of 30 September 2009 (**Figure 5-9**). Avian radar surveys continued at Grid 23 until 12 October, at which time the barge moved to Grid 26 (Longitude -74.59444 W, Latitude 39.91694 N W;) where recording began that afternoon (VerCat azimuth: 56°, 46°). Avian radar surveys continued at Grid 26 until the afternoon of 19 October 2008, at which time the barge was struck by high waves and suffered a catastrophic failure of the lifting legs, thus ending offshore avian radar sampling for the season.

Spring 2009

The jack-up barge accident which occurred during the October 2008 survey resulted in additional strict operating guidelines being imposed on the barge operator by the U.S. Coast Guard. These newly imposed restrictions included stricter wind, wave, and weather forecast guidelines. The restrictions included requiring the barge to return to port if the seas increased to 3 ft, the 24-hr forecast was for seas greater than 0.91 m (3 ft), the 24-hr forecast was for winds greater than 15 kts, and if the visibility was reduced to less than one mile (e.g., fog). The new restrictions also required the barge to return to port at least once every 24 hrs even if none of the other restrictions were applicable, and prohibited operations further than 8.05 km (5 mi) from shore.

For these reasons, no barge-based radar surveys were scheduled for April or June 2009. A total of 20 days of barge-based radar surveys were scheduled for May 2009. Based on the stated barge operational restrictions, a decision was made to concentrate the surveys on Grid 16 and Grid 22/23 (22).

The MARS® was loaded on the jack-up barge in New York harbor on 02 May 2009. The barge transited to Atlantic City on 03 May 2009, at which time the radar system was made ready for deployment at the first suitable weather window. Because weather conditions and forecasts were not compatible with the new operating guidelines, surveys were only conducted at Grid 16 (Longitude -74.37583 W, Latitude 39.29139 N; VerCat azimuth: 141°) during the night of 11–12 May 2009, and at Grid 22 (Longitude -74.55111 W, Latitude 39.19028 N; VerCat azimuth: 130°) during the night of 12–13 May 2009 (**Figure 5-9**). Two radar validation surveys were also conducted from the barge on 11 and 12 May 2009.

5.4.1.3 Data Analysis

Echoes from ground clutter on land are much more persistent and stronger than echoes from biological targets. If a biological target is flying over background clutter, then the target will be eliminated when background clutter is eliminated. 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 have been developed to minimize this possibility.

False detections, weather, and weather effects

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 2,780 m (1.5 NM). They stated that “A prerequisite for the use of

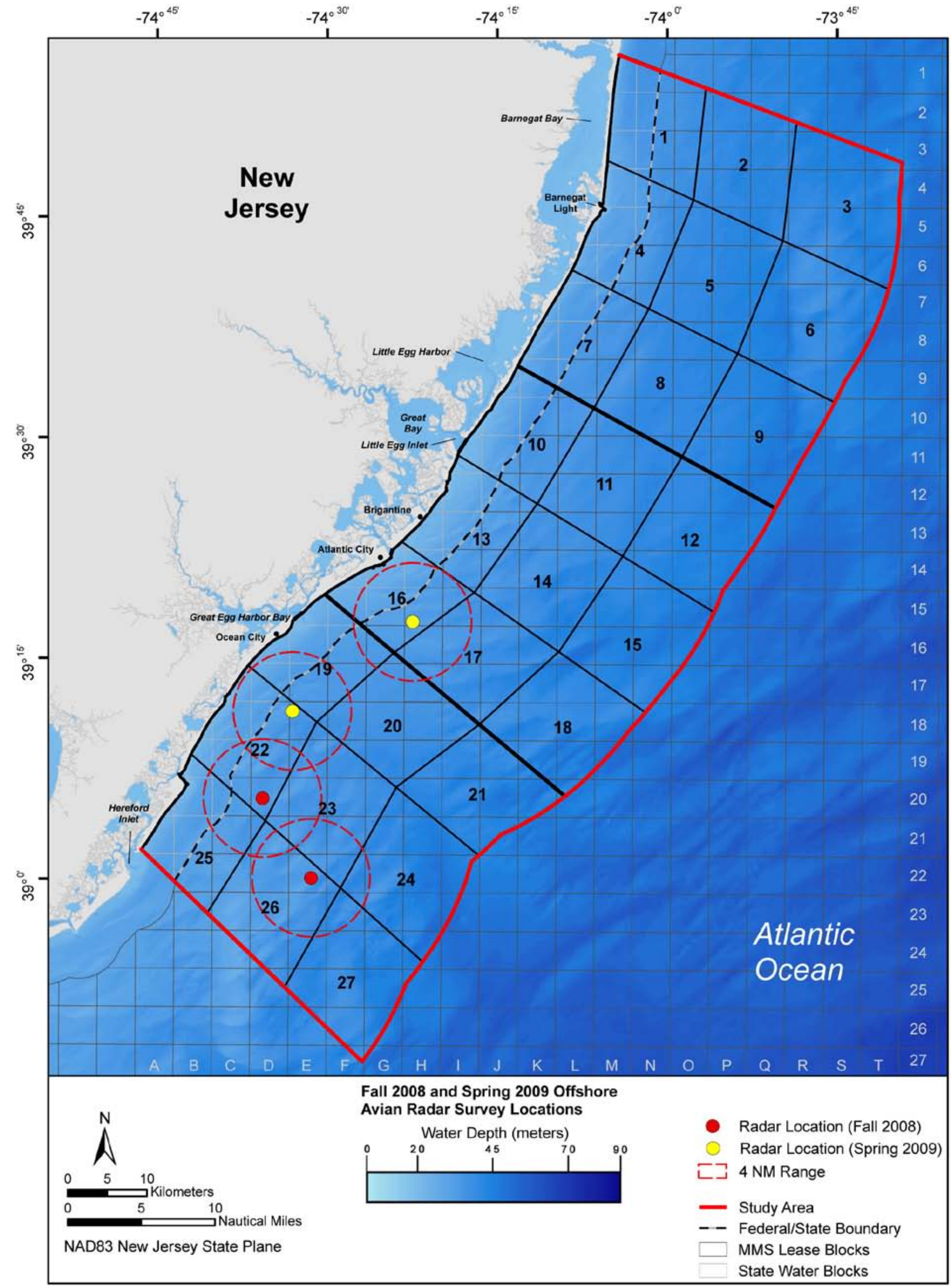


Figure 5-9. Fall 2008 and Spring 2009 offshore avian radar survey locations.

horizontal radar is a calm sea state (wind speeds less than 2 m/s [3.9 kts]). 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, 11-km [6-NM] 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. Sea clutter detections are particularly evident when the velocity measured between two detections is plotted in a histogram (**Figure 5-10**). The excessively high ground speeds (51.4 m/s; 100+ kts) are not representative of biological targets and are classified as false targets. 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 5-11**). Filtering rules have been developed to reduce detections from rain and sea clutter and false tracks that result from these detections and these rules are discussed below.

Analysis of MARS® TracScan Data

The radar data from the first nine days of radar surveillance in this study (spring 2008) have been analyzed to examine the influence of sea clutter on MARS® TracScan data. The distribution and density of processed detections have been plotted for each day. Examples are given (**Figure 5-12**). 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 5-12**). 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 91 m [300 ft] above the sea) from data posted at http://vortex.plymouth.edu/upcalc-u.html. The resulting relationship (**Figure 5-13**) indicates that about 83% of the variation in maximum range of detections can be explained by mean wind velocity. Because 85% of the recorded data from TracScan type radar can be attributed to sea clutter (Kreijgsveld et al. 2005) and sea clutter conditions are related to mean wind speed, it is possible to predict sea clutter conditions in the TracScan data from data on wind conditions. 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 targets and not to false detections.

<u>Reduction of 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 between successive detections (i.e., tracks with velocities above 51 m/s [100 kts]).

This procedure eliminated the detections with speeds greater than 185 kph (100 kts) and eliminated the mode of velocities between 51 and 162 m/s (100 and 315 kts; compare **Figures 5-14** and **5-15**).

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

This procedure changed the histogram of velocities between detections very little, suggesting that this source of false echoes was not important (compare **Figures 5-14** and **5-15**).

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

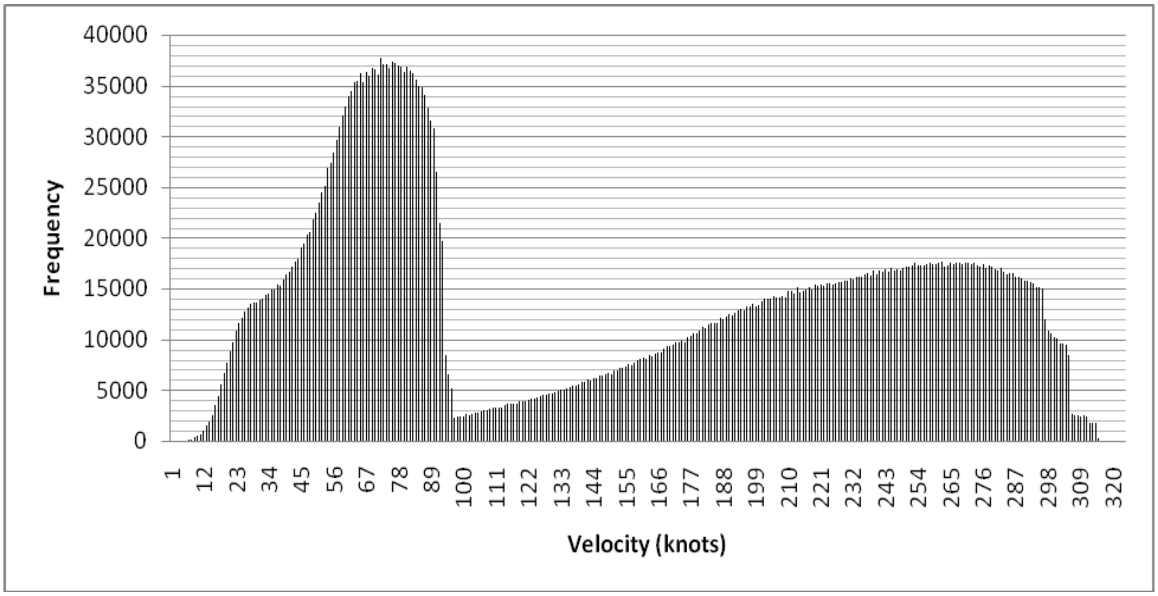


Figure 5-10. Histogram of total ground speeds between detections for 15 March 2008 from MARS® TracScan. Note the extraordinary number of detections and the extremely high velocities with no filtering.

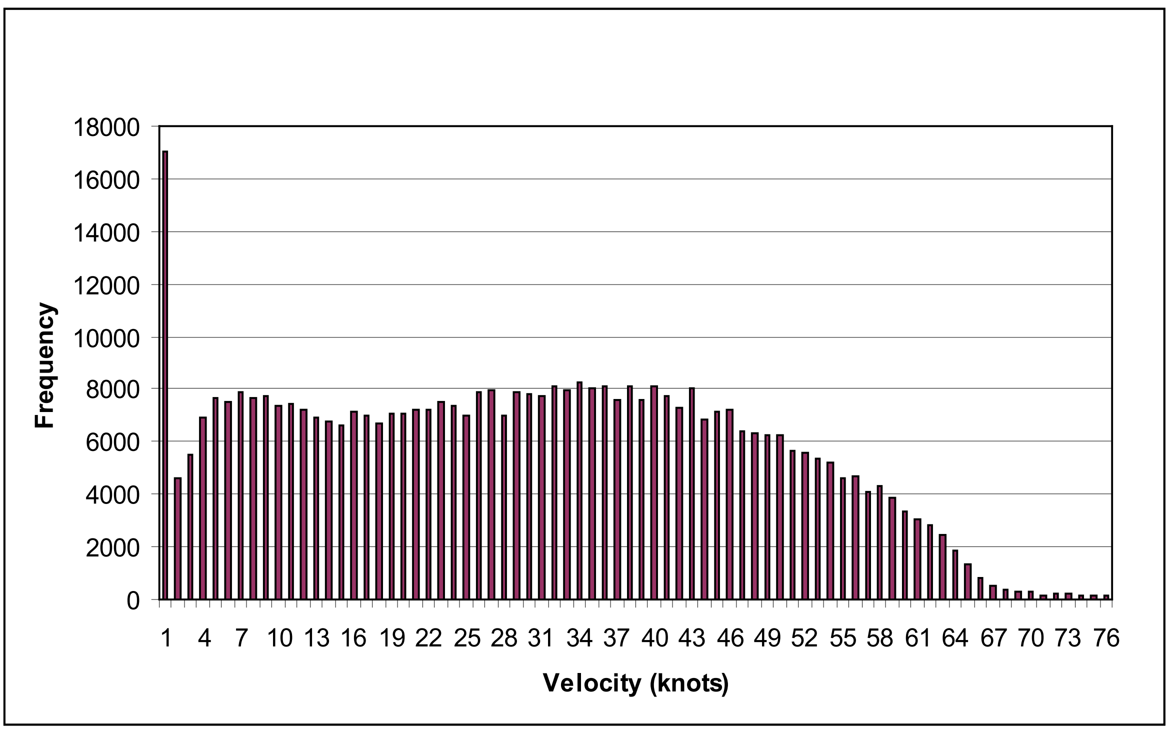


Figure 5-11. Histogram of total ground speeds between detections for 15 March 2008 from MARS® VerCat. Note the absence of a second mode of velocities and the lower frequency of velocities above 46 knots (24 m/s or 79 ft/s).

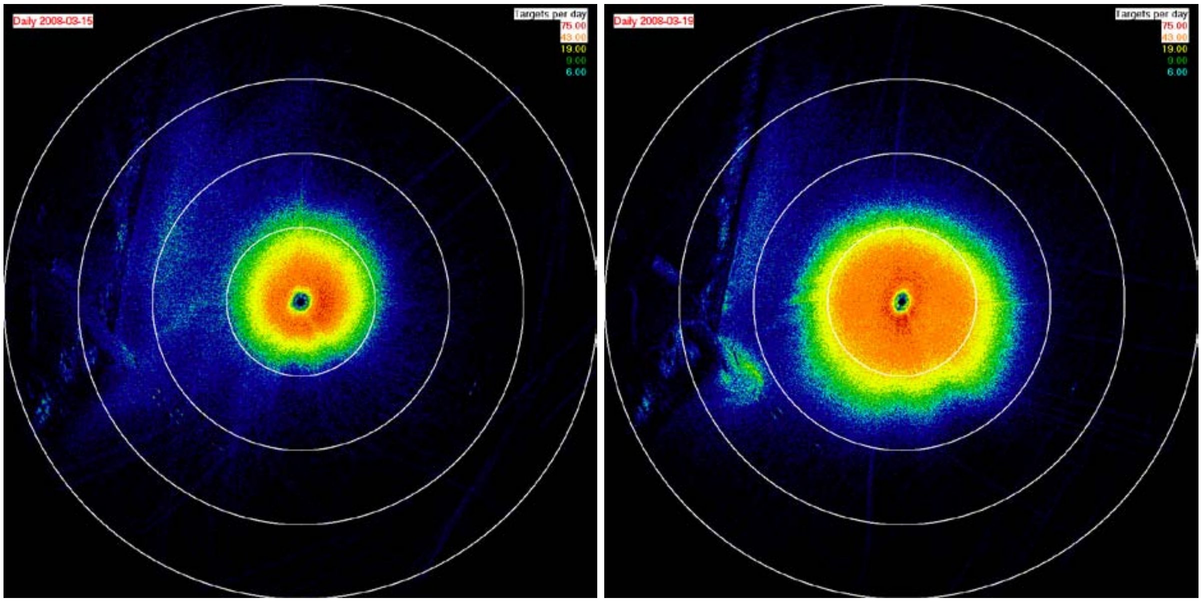


Figure 5-12. Total TracScan detections per day for 15 March 2008 (left) and 19 March 2008 (right). Maximum winds on 15 March were 7 to 8 knots and on 19 March were 18 to 19 kt.

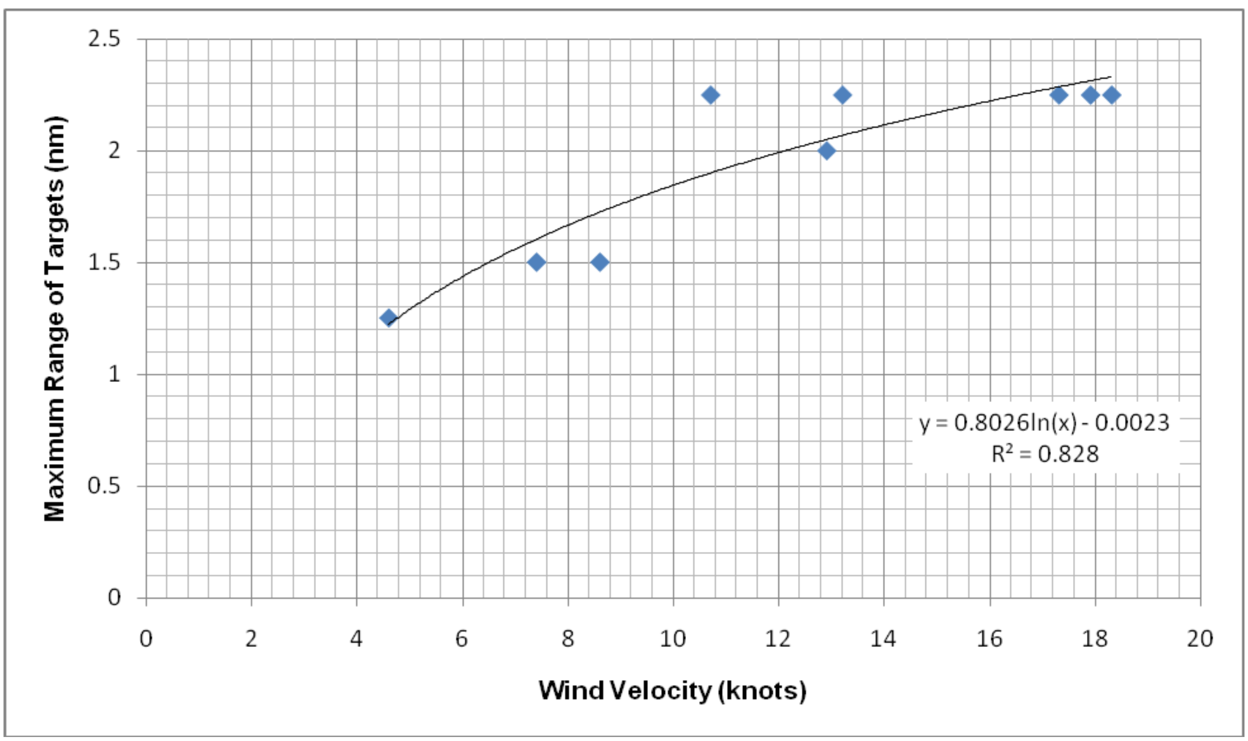


Figure 5-13. Relationship between mean wind velocity and maximum range of targets (sea clutter) in TracScan. Note that 82% of the maximum range of targets can be explained by wind velocity.

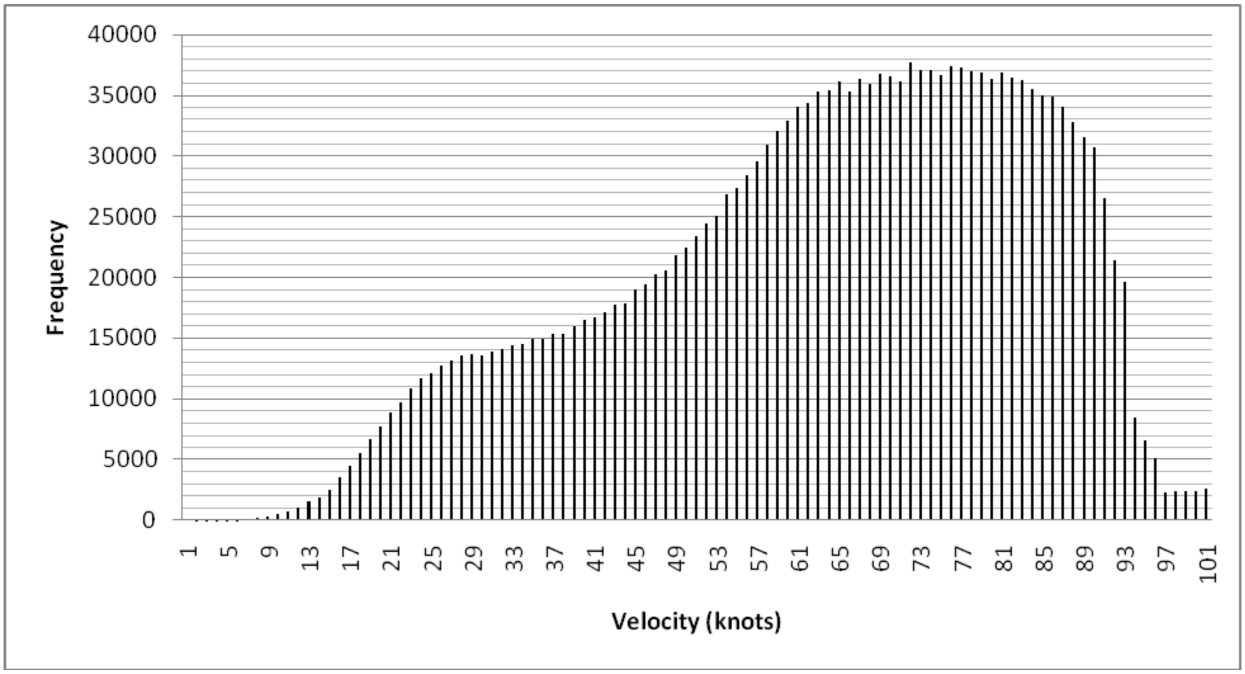


Figure 5-14. Histogram of total ground speeds between detections for 15 March 2008 with velocities greater than 100 knots (kts) removed for MARS® TracScan.

Figure 5-15. Histogram of total ground speeds between detections for 15 March 2008 after treating tracks with gaps (missing detections) as separate tracks for MARS® TracScan.

This procedure had a tremendous effect on the frequency of velocities. The highest velocity counts dropped from nearly 37,000 to approximately 3,000 and the histogram showed a bimodal distribution (compare **Figures 5-15** and **5-16**).

4) Sea clutter filter

This filter was developed to eliminate false tracks that resulted from detections of sea clutter within 3 km (1.5 NM) of the radar. When applied the second mode of the ground speed histogram was greatly reduced (**Figure 5-17**) and the speeds were comparable to those measured with VerCat (**Figure 5-11**) during the same time period.

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 were processed using all four procedures.

Rain Clutter Elimination

The following procedures were completed during the analysis of TracScan data to eliminate echoes from rain within the surveillance area:

1) Weather Surveillance Radar-1988, Doppler (WSR-88D) rain contamination analysis

This procedure involved analyzing WSR-88D data from the Fort Dix (KDIX), New Jersey radar station. Polygons were drawn over the TracScan surveillance areas, and a biologist examined each radar image file to determine if echoes from precipitation or biological targets were within the polygons. WSR-88D radar files were generated every five minutes when precipitation was present in the surveillance area and every 10 min when the surveillance area was clear of precipitation. The following data were entered into a database: time of the file, condition (clear, biological, or rain). Time periods with rain within the polygon were eliminated from radar processing.

2) Rain filter

This filtering algorithm is identical to that for sea clutter. The filter greatly reduces false tracks based on detections from rain and clouds of small insects.

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 (**Appendix J-1**) 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.

Presentation of Analysis Results

The results of the TracScan data analysis are presented as flux directions. Flux is the adjusted number of birds that pass through a sample volume per hour and direction is compass direction to which a bird is moving. These results are presented in tabular form for each sample location where flux values are entered into eight cardinal directions (e.g., N = 338° to 22°, NE = 23° to 67°; E = 68° to 112°; SE = 113° to 157°; S = 158° to 202°; SW = 203° to 247°; W = 248° to 292°, NW = 293° to 337°) for diurnal and nocturnal time periods for each of three classes of wind velocity (0 to 12.87 kph [0 to 8 mph]; 14.48 to 24.14 kph [9 to 15 mph]; and greater than 25.75 kph [16 mph]).

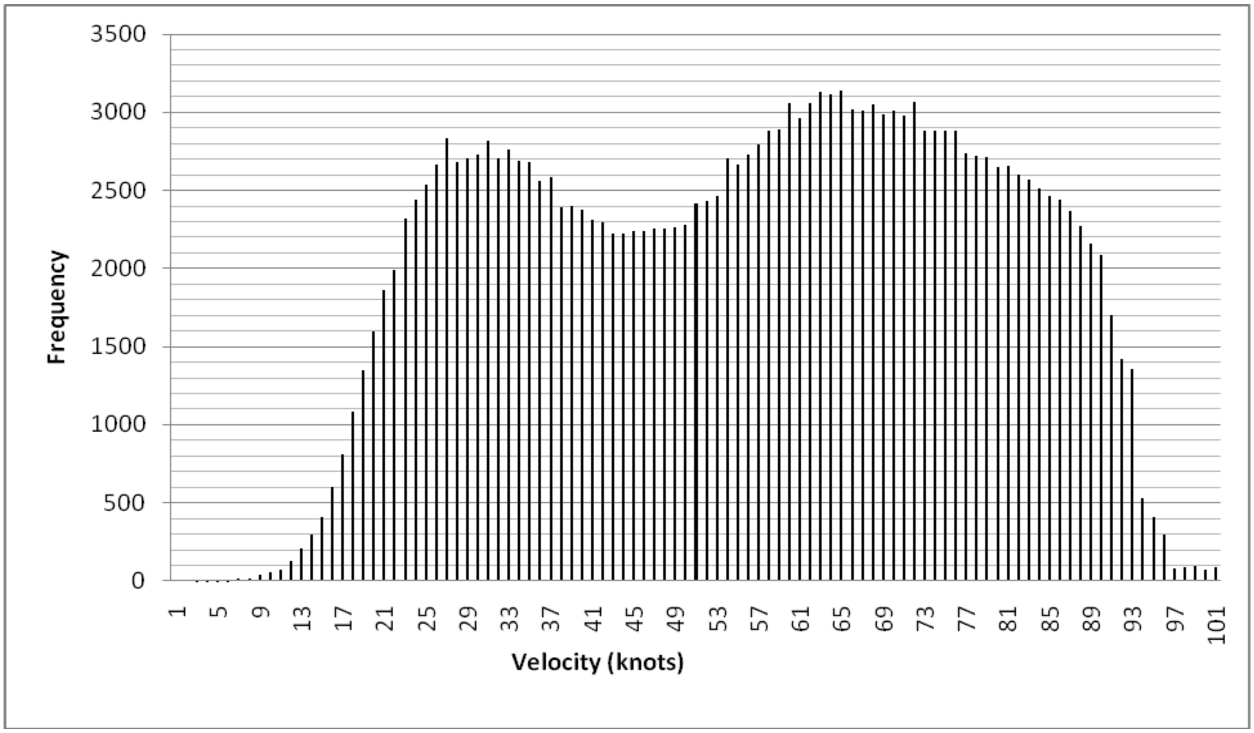


Figure 5-16. Histogram of total ground speeds between detections for 15 March 2008 after eliminating tracks that did not have nine continuous detections in a track for MARS® TracScan.

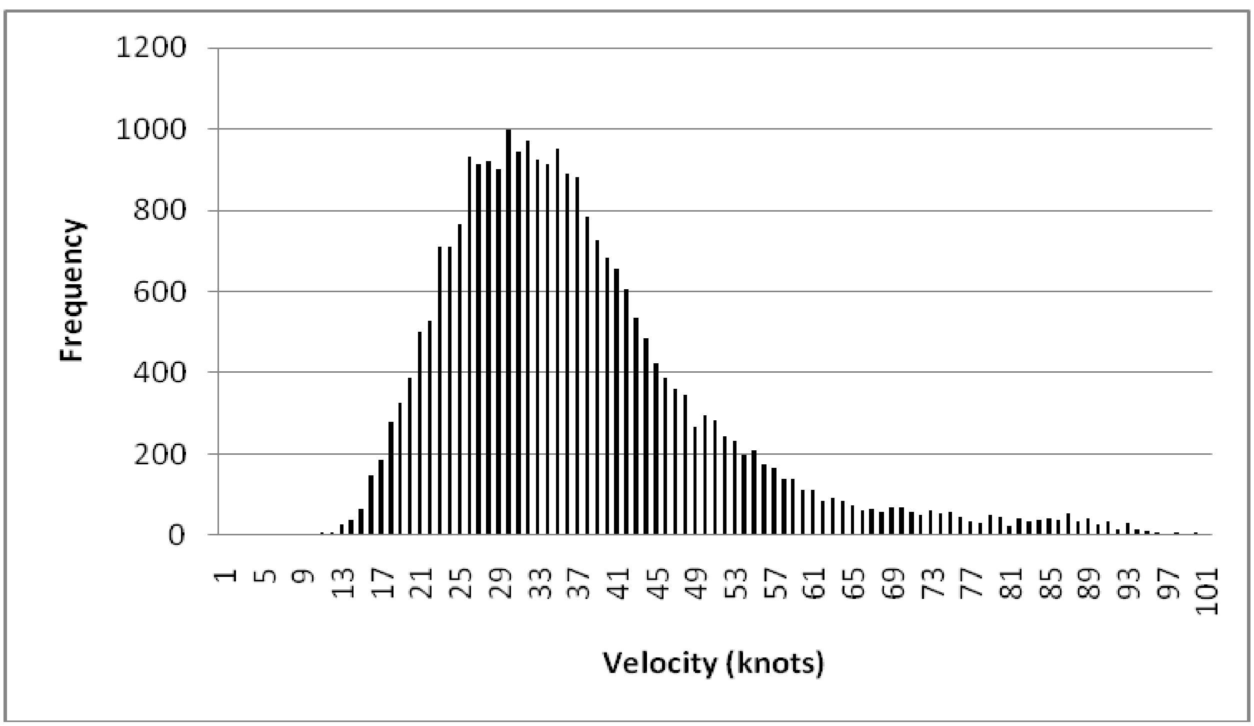


Figure 5-17. Histogram of total ground speeds between detections for 15 March 2008 after applying clutter reduction protocols and the sea clutter filter to the data from MARS® TracScan in all weather conditions.

Analysis of MARS® VerCat Data

VerCat data are used for calculating the altitudinal distribution of targets, migration traffic rate (MTR; the number of biological targets crossing a given line in a given unit of time [e.g., birds per kph]), and flux (i.e., the number of targets passing through a sample volume per unit of time). After the auto capture and on-site processing of the data were completed, the data were removed from the host computer for further analysis. Because VerCat can detect precipitation (i.e., rain, sleet, snow), the detections can be processed and generate false tracks and greatly increase the median altitude of targets aloft. It is important to remove false tracks that result from detections of sea clutter and rain to assure that the results of the analyses relate to biological targets and not to false tracks.

Rain Contamination

The following procedures were completed during the analyses of VerCat data to eliminate the number of detections from rain:

1) To eliminate rain contamination, to the extent possible, the WSR-88D inspection protocol discussed in the TracScan analysis section above was utilized. Rain contaminated data were not processed.

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 51.4 m/s (100 kts).

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.

5) Applied Rain/insect filter to eliminate false tracks resulting from detections of precipitation that may have been undetected in the WSR-88D inspection protocol and of clouds of small insects.

Zero Target Velocities

When the velocity between two detections is plotted in a histogram for VerCat data, a large number of velocities are classified as zero knots (**Figure 5-11**). 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.

The resulting datasets contained information on the number of tracks within three altitudinal zones: below 30 m (100 ft), between 30 to 213.4 m (100 to 700 ft), and above 213.4 m to 5,556 m (above 700 ft to 18,228 ft) and were expressed as tracks per hour by altitude in relation to the MARS® site and MTR (tracks/hour/km of front by altitude [in relation to the MARS® unit]). Analysis of the filtered target data depended on the normality of distribution of the data. The volumes sampled by the VerCat for the three altitudinal zones listed above were computed to measure the flux of targets (the number of birds passing through a sample volume in a given amount of time).

Adjustment for Insect Contamination

The TI-VPR validation of VerCat data showed that VerCat detected a considerable number of insect targets during the offshore and onshore surveys. During the spring of 2008 the ratio of birds to insects in the TI-VPR samples was 83:248 and during the fall of 2009 the ratio of birds to insects was 61:156. The average of the two seasons showed a ratio of 363:1000 indicating that approximately 1/3 (36.06%) of the VerCat targets were birds. This figure was used to make adjustments for insect contamination in the VerCat data.

Adjusted Migration Traffic Rate

The adjusted migration traffic rate (AMTR) was calculated by applying the average bird to insect ratio of 0.363 to the MTR.

Flux

To compute flux (the number of tracks passing through a sample volume per unit time) the volumes sampled by the VerCat for the three altitudinal zones listed above was computed and the numbers of tracks passing through the sample volumes were adjusted to correct for insect contamination and ultimately expressed as adjusted tracks per cubic km per hour.

After processing the VerCat data, a biologist examined the results to see if in any samples the number of tracks and their altitudinal distribution were abnormally high. Whenever this occurred, the biologist replayed the radar data to determine if precipitation (e.g., virga) had been missed in the WSR-88D data. Whenever contaminated data were found they were removed and the remaining data reprocessed.

Data Analysis Presentation

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.

Relevant descriptive statistics for the analyzed data include the observed diurnal and nocturnal altitude distributions include 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 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.

A further, more conclusive statistical test for normality is the K-S GOF test (Kolmogorov 1933; Smirnov 1939a,b; Zar 1999). According to this test, a cumulative frequency distribution (CFD) is calculated from the observed (altitude) distribution; and the GOF of this observed CFD to an expected CFD (i.e., the normal CFD) is assessed. A test statistic for each sample “i” (for i=1 to sample size n) is calculated as the absolute magnitude of the difference between the cumulative observed frequency and the cumulative expected (i.e., normal) frequency. The maximum test statistic calculated is compared to the critical value (tabulated in published statistical tables) for the given sample size (n) and desired confidence level (e.g., a=0.05). If the test statistic is less than the critical value, then the H_o that the given distribution is normal is accepted. Otherwise, H_o is rejected.

To assess whether the observed altitude data follow a normal distribution, the K-S test can be used. If the tested data were not normal, the data were placed into a linear transformation model (logarithmic) to determine if the data could be normalized. If the data cannot be normalized, the only remaining alternative was to use a quartile system for reporting the altitudinal distribution data. Non-transformed datasets can be subject to non-parametric statistical tests, such as the Mann-Whitney test, or Kruskal-Wallis (K-W) test, which are the non-parametric equivalents of the 2-sample test t-test, paired-sample t-test, and the Analysis of Variance (ANOVA) test, respectively, to test for and the differences in diurnal and nocturnal altitude distributions.

The K-S test was run for the diurnal and nocturnal altitude distributions of all spring 2008 radar offshore and radar onshore data. The data were not normally distributed. A logarithmic linear transformation model was then run to determine if the datasets could be normalized; the datasets could not be transformed to normal. Therefore, a quartile data reporting system (cumulative and daily median with 25% and 75% quartiles) was selected to report altitudinal data.

A two-way ANOVA or K-W analysis was conducted on the avian density radar dataset, with the two factors being time of day (two levels: day and night) and wind speed (three levels: 0-8, 9-15, and >15 mph), resulting in a total of 2*3 = 6 samples, and sample size (n) for each sample is equal to the number of locations (for the onshore data) or number of grid cells (for offshore data).

For the application of a two-way ANOVA/K-W Test, the avian density radar dataset was structured into the following parameters and criteria:

1) Only the VerCat data were examined.
2) Only the altitude band within the RSZ was examined (not above or below the RSZ).
3) 2 shore types: Onshore and offshore:
   a) Onshore: 3 locations (Island Beach, Brigantine/Brigantine Beach, and Corson's Inlet/Sea Isle City) and 4 seasons (spring and autumn 2008, and spring and autumn 2009).
   b) Offshore: 3 seasons (spring/autumn 2008, spring 2009); 7 grid cells for spring 2008 (Grids 1, 7, 13, 19, 26, 23, 17), 2 grid cells for autumn 2008 (Grids 23 and 26), and 2 grid cells for spring 2009 (Grids 16 and 22).
4) Three or four seasons (depending on shore type as discussed above).
5) Two time of day periods (Day and Night).
6) Three wind speed ranges (0-8, 9-15, and >15 mph).

In initial testing for normality (K-S test) and homoscedacity (Bartlett test), if it was determined that the six-sample dataset is normal and homoscedastic, then the parametric ANOVA test was applied to the six samples (each with sample size = # locations or # grid cells). In contrast, if it was determined that the six-sample dataset was non-normal or non-homoscedastic, then the non-parametric two-way K-W test was applied. In the K-W test, the avian densities are ranked from lowest to highest, and an ANOVA-type test is conducted on the ranks (rather than on the values) of the densities to assess differences between the two time of day periods (Factor 1), among the three wind speed ranges (Factor 2), and any significance in the two-way interaction (time of day x wind speed). In the event that the ANOVA or K-W test detects a significant difference (indicated by rejection of the null hypothesis H_o of no difference), a subsequent Tukey test examined each pair-wise comparison (i.e., N*(N-1)/2 pairs for N samples) to determine the sources of variance (i.e., which specific sample pairs were significantly different from each other). Results of the two-way ANOVA/K-W tests for the 95% confidence level (CL) are given in the Radar Statistical Analyses on the Appendix CD.

5.4.2 Onshore Radar Surveys

5.4.2.1 Survey Design

Three sample sites were initially chosen in spring 2008 based on location relative to the coastline, availability, and radar line of sight coverage of the coastline and ocean from the location (**Figure 5-18**). The first site (northern most) was located at Island Beach State Park (IBSP). The second was originally located behind an observation tower in North Brigantine Beach (NBB). The third, southernmost location was at Corson's Inlet State Park. After the first survey season, the radar was re-located from Corson's Inlet State Park to Sea Isle City (SIC). In fall 2008, the North Brigantine site was moved about 137 m (449 ft) south of the original site because of access issues.

5.4.2.2 MARS® Survey Site Setup and Data Collection Schedule

Seasonal surveys were scheduled for the term of the project. The number of surveys conducted was variable between years because of different funding levels for the task (spring 2008 [37 days]; fall 2008 [67 days]; spring 2009 [63 days]; fall 2009 [59 days]).

Spring/Summer 2008

The onshore MARS® was stationed at IBSP on 13 May 2008 (**Table 5-5**). Set up occurred on 15 May 2008 and avian radar surveys commenced the same day and continued through 23 May 2008. The onshore MARS® was deployed to NBB and operated from 29 May through June 2008. The onshore MARS® was moved to Corson's Inlet and collected data from 09 June through 19 June 2008.

Fall 2008

An avian radar unit was setup at IBSP on 13 September 2008 (**Table 5-6**). Operation began the same day and continued through 05 October 2008. The radar was moved to SIC and then to Brigantine Beach (BB) where the radar operated from 05-26 October 2008 and from 26 October through 15 November 2008, respectively. The radar unit was then returned to IBSP where it operated from 15 November through 15 December 2008.

Spring 2009

Avian radar surveys were initiated at IBSP on 14 March 2009 and completed on 08 April 2009 (**Table 5-7**). The onshore MARS® was then moved to BB where the unit collected data from 09 April through 06 May 2009. The radar unit was relocated to SIC where it collected data from 07 May through 06 June 2009.

Fall 2009

The onshore MARS® was deployed to IBSP where it operated from 15 September through 02 October 2009 (**Table 5-8**). The radar unit was moved to BB on 02 October 2009; radar surveys were conducted at BB from 05 through 26 October 2009. The onshore MARS® was then relocated to SIC where it operated from 26 through 16 November 2009.

5.4.2.3 Data Analysis

Data analysis protocols for the TracScan and VerCat onshore radar data were identical to the protocols established or the offshore radar data (**Section 5.4.1.3**).

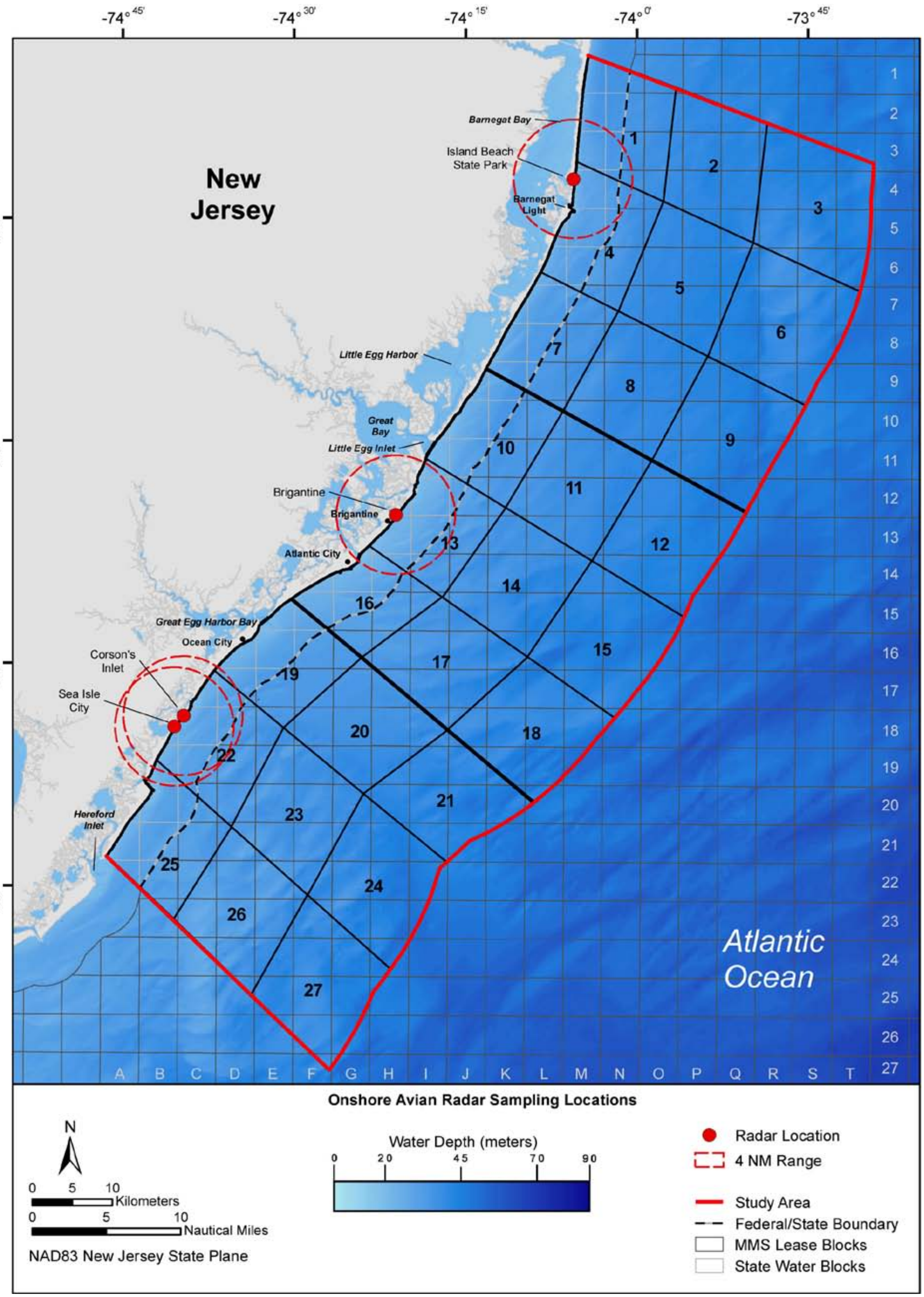


Figure 5-18. Onshore avian radar sampling locations.

Table 5-5. Locations of the spring 2008 onshore radar sites and VerCat azimuth(s).

Location	Longitude (°W)	Latitude (°N)	VerCat Azimuth (°)
Island Beach SP	-74.09139	39.79306	224
North Brigantine Beach	-74.35194	39.41806	247, 250
Corson's Inlet SP	-74.64889	39.21472	96

Table 5-6. Locations of the fall 2008 onshore radar sites and VerCat azimuth(s).

Location	Longitude (°W)	Latitude (°N)	VerCat Azimuth (°)
Island Beach SP	-74.09420	39.79330	218
Sea Isle City	-74.67306	39.17917	100
Brigantine Beach	-74.35361	39.41667	102
Sea Isle City	-74.67611	39.18028	118

Table 5-7. Locations of the spring 2009 onshore radar sites and VerCat azimuth(s).

Location	Longitude (°W)	Latitude (°N)	VerCat Azimuth (°)
Island Beach SP	-74.09417	39.79306	217
Brigantine Beach	-74.35417	39.41667	112
Brigantine Beach	-74.35361	39.41667	109
Sea Isle City	-74.67577	39.18037	87
Sea Isle City	-74.67580	39.18040	87

Table 5-8. Locations of the fall 2009 onshore radar sites and VerCat azimuth(s).

Location	Longitude (°W)	Latitude (°N)	VerCat Azimuth (°)
Island Beach SP	-74.09420	39.79310	43
Brigantine Beach	-74.35361	39.41667	8, 0
Sea Isle City	-74.67583	39.18028	92

5.4.3 Radar Validation Surveys

The results of TI-VPR surveys are used to validate VerCat radar data. The survey design, survey methods, and data analysis for radar validation are discussed in this section. All TI-VPR survey data are fully evaluated in **Chapter 6.0**.

5.4.3.1 Sample Design

Offshore Spring 2008

The proposed TI-VPR sampling scheme was chosen to enable every hour of the day to be sampled twice during a seven-day period at the site. Each sampling session was conducted over a 4-hr period, and data were recorded onto two DVDs during that sampling period. Dr. Sidney Gauthreaux, Jr., set up and tested the TI-VPR during the first deployment of the system to the project site, and determined that a modification of the TI-VPR methodology was necessary to reduce radar operator fatigue. Per Dr.

Gauthreaux's recommendations, the methodology was amended to: record 4 hrs, off 4 hrs, record 4 hrs, off 16 hrs, and repeat. This schedule was adequate to record hourly data at least once for each hour in a day at each site. Sampling was not conducted during periods of rain, drizzle, or heavy fog, and the sampling schedule was adjusted as required for changing weather conditions.

Offshore Fall 2008

The spring 2008 sample design was revised prior to the fall 2008 surveys. This was achieved by changing the recorded-to-media from DVDs to a local hard drive. This modification enabled a new sampling scheme to sample every hour of the day twice during a 5-day period (record 8 hrs, off 12 hrs, and repeat).

Offshore Spring 2009

With the new operating guidelines imposed on the barge operator by the U.S. Coast Guard (**see section 5.4.1.2: Spring 2009**) sampling efforts were limited offshore. Given these new guidelines an effort was made to collect multiple 2-hr segments (single DVD) of data throughout each evening (00:00 Coordinated Universal Time [UTC] – 12:00 UTC). This sampling scheme was adjusted as required for adverse weather conditions for TI-VPR data collection. These conditions included precipitation and fog.

Onshore Fall 2008

Sample design is identical to that discussed previously in **Section 5.2.3.1: Offshore**, **Fall 2008**.

Onshore Spring 2009 & Fall 2009

In 2009, surveys were conducted during evening hours to document activity aloft. These surveys began 30 to 45 min after sunset and lasted from two to four hrs. Because cloud cover obscured the majority of the duller heat signatures in the TI (e.g., high-flying birds (304.8 m [1,000+ ft]) or insects) we only sampled on clear nights to maximize target detections.

5.4.3.2 Survey Site Setup and Data Collection Schedule

Offshore Spring 2008

After validation surveys were completed at Grid 1 on 15 March 2008, DVD recording of the TI-VPR began. Equipment problems with the multiplexer prevented simultaneous recording of both camera and radar systems, preventing the intended functionality of the system. A new multiplexer was ordered and arrived in New Jersey approximately one week later; however, weather conditions prevented transport of the new multiplexer to the radar. The new multiplexer was installed in the radar system when the barge returned to port (because of sea conditions) on 27 March 2009.

Only TI images could be recorded at Grids 1 and 7, not VPR images. Because of bad weather and the inability to record TI and VPR images simultaneously, TI images were recorded to DVD only at times of high target activity in the VerCat radar. Ten DVDs (20 hrs) of TI images were recorded at Grids 1 and 7.

The offshore conditions during the months of April and May included large periods of heavy fog and/or rain at each site. This prevented following the proposed TI-VPR recording schedule of 4 hrs recording, 4 hrs off, 4 hrs recording, 16 hrs off, and repeat. During April, recording at Grid 13 was conducted for approximately 26.5 hrs, at Grid 19 for approximately 36 hrs, and at Grid 26 for approximately 28 hrs. In May, recording was conducted at Grid 23 for approximately 51 hrs and at Grid 17 for approximately 21.5 hrs.

Offshore Fall 2008

On 29 September 2008, the TI-VPR was mounted on the jack-up barge which left for the Study Area that afternoon. The barge was jacked up at the first study site, Grid 22, that evening. The TI-VPR was set up and began recording on 01 October 2008 and continued at Grid 22 until 12 October (approximately 99 hrs total), at which time the barge moved to Grid 26. TI-VPR surveys began on the morning of 13 October and continued until the afternoon of 19 October 2008 (approximately 62 hrs total), at which time the barge was struck by high waves and suffered a catastrophic failure of the lifting legs, thus ending offshore TI-VPR sampling for the season.

Offshore Spring 2009

The TI-VPR system was loaded on the jack-up barge in New York harbor on 02 May 2009. The barge transited to Atlantic City on 03 May 2009, at which time the TI-VPR system was made ready for deployment at the first suitable weather window. Because weather conditions and forecasts did not meet the new range of operating guidelines mandated by the U.S. Coast Guard, surveys were only able to be conducted at Grid 16 during the night of 11–12 May 2009 (approximately 11 hrs total), and at Grid 22 during the night of 12–13 May 2009 (approximately 4 hrs total).

Onshore Fall 2008

The TI-VPR system was set up at SIC, New Jersey, on the morning of 08 December 2008. TI-VPR surveys began that evening and continued until 15 December 2008 (approximately 48 hrs total). Surveys were not conducted from 10 through 12 December 2008 because of poor weather conditions.

Onshore Spring 2009

The TI-VPR system was setup at IBSP, New Jersey, on 14 March 2009. TI-VPR surveys were conducted on the evenings of 21, 22 and 27 March (approximately 10 hrs total). The system was then transported to BB, New Jersey, on 08 April 2009. No surveys were conducted at BB as the TI-VPR system was relocated to accompany the offshore MARS®.

Onshore Fall 2009

The TI-VPR system was set up at IBSP, New Jersey, on 15 September 2009. TI-VPR surveys were conducted on the evening of 19 September 2009 for 3 hrs. The system remained at IBSP until 02 October 2009, when it was taken down and brought back to GMI's Millville, New Jersey office. The system was then transported to BB, New Jersey, on 05 October 2009 and a TI-VPR survey was conducted on the evening of 20 October 2009 for 2 hrs. The TI-VPR system remained there until 26 October at which time it was removed and transported to SIC, New Jersey. TI-VPR surveys were conducted on 03, 06 and 08 November 2009 for a total of 12 hrs. The TI-VPR system was removed from SIC on 16 November and transported back to GMI's Millville, New Jersey office, ending the surveys for the fall season.

5.4.3.3 Data Analysis

To analyze the data, the combined (multiplexed) TI and VPR recorded image was separated using a model 497-2C demultiplexer (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 (**Figure 5-19**). 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.

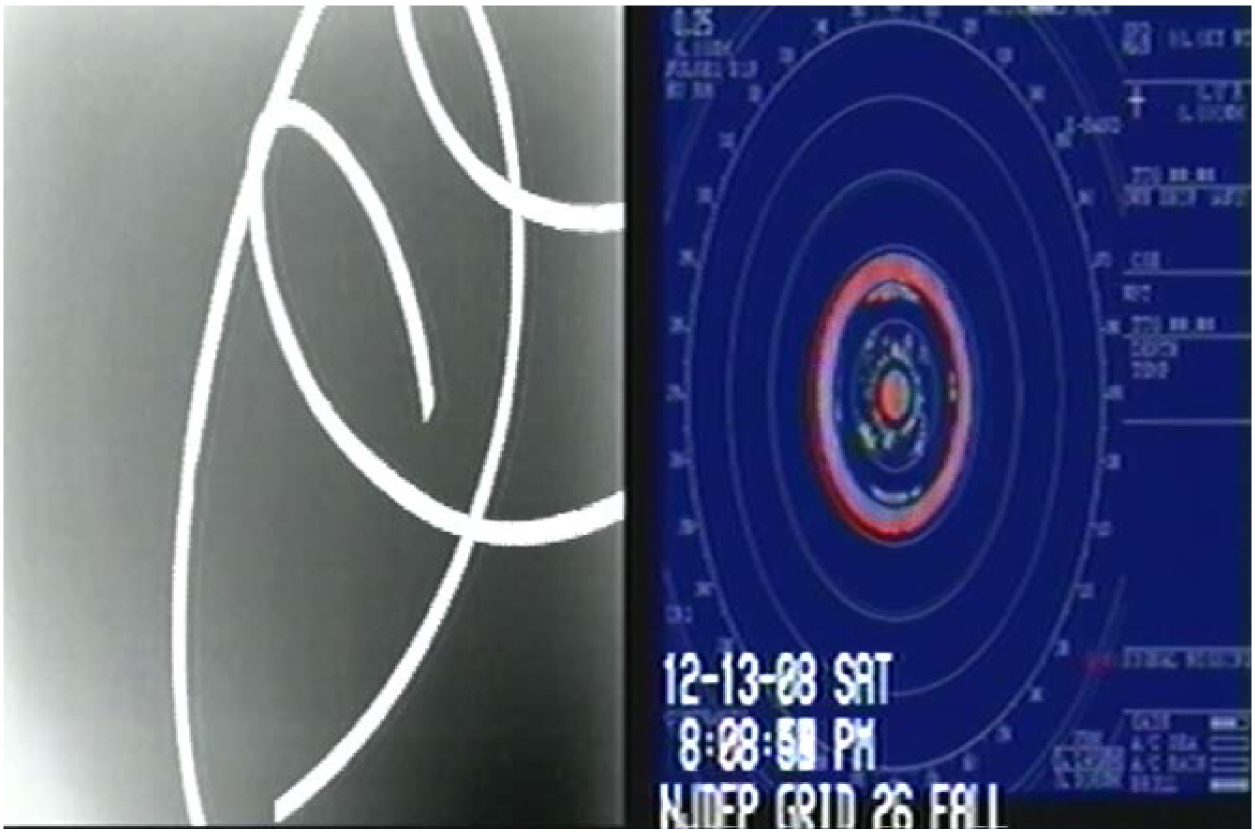


Figure 5-19. Multiplexed VPS TI-VPR image of soaring birds from 13 December 2009 over Sea Isle City, New Jersey, at 8:08 PM (UTC; 3:08 PM Eastern Standard Time [EST]). Thermal image is on the left and display of vertically pointing radar is on the right (shows birds at 550 ft [168 m]).

GMI analyzed 5-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 a preliminary analysis of four hrs of data.

In a preliminary analysis all targets were counted for the entire duration and two sampling protocols were tested against the total count (10 hrs from 00:00 UTC to 10:00 UTC, on the night of 11 May 2008, Grid 17). The first method used a 5-min sample for each 10-min (5/10) time block for each hour and the second method used a 5-min sample within each 15-min (5/15) time block for each hour. The results of the preliminary analysis showed the first method (5/10) had a count of 98 in comparison to the total count of 94; the second method (5/15) had a count of 93 that was closer to the total count of 94. Since the 5/10 method is more exact this sampling scheme was selected. 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, see **Appendix K**).

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 3 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 15.24-m (50-ft) bands of elevation up to 671 m (2,200 ft). 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]). This enables a comparison of the amounts of migration below, in, and above the RSZ. Directional analyses were conducted using circular statistics (Oriana 2, Kovach Computing Services, Pentraeth, Wales, United Kingdom [U.K.]) to analyze straight track data to determine mean direction of movement. The CAC for each direction was used when analyzing the directional data. In the directional analyses irregular flight tracks were not used because of the unknown heading.

5.5 RADAR VALIDATION

5.5.1 Methods

The purpose of the avian radar validation surveys was to determine MARS® performance related to target detection (i.e., number of targets present to the number of targets detected by the radar). Radar target detection is affected by many variables including the size of the target, the location of the target within the beam, flight direction of the target with reference to the radar, flight behaviors (e.g., flapping, gliding, soaring), and weather conditions. Detection of all targets decreases with increasing distance from the radar because of a decrease in target reflectivity; therefore smaller targets are more difficult to detect at increasing distances from the radar than larger targets. Large flocks are easier to detect than single individuals throughout the radar's range because of the higher reflectivity of a large flock. The upper and lower sections of the radar beam have less power than the central portion of the beam; targets in the upper and lower sections of the beam may or may not be detected at increasing distances from the radar. A small target in the center of the radar beam at 4.6 km (2.5 NM) from TracScan may be detected while the same target near the lower or upper edge of the beam at the same distance may not be detected.

Each flight profile (e.g., flapping, gliding, diving) produces a different reflectivity which may have an effect on its detection. Flight direction with reference to the radar also affects a target's reflectivity. A target flying toward or away from the radar is more likely to have a lower reflectivity than a target flying tangential (broadside) to the sweep of the radar beam. Weather conditions (e.g., wind speed) may increase sea state and sea clutter and limit detection capabilities of the radar. Even with these limitations, radar provides the best available data on flying targets in the vicinity of the radar site at night. Three validation methods were used during the study: boat-based, line transect, and TI-VPR (**Section 5.4.3**). Spring and fall 2008 validation survey methods differed from spring and fall 2009 validation methods.

5.5.1.1 Spring and Fall 2008

The validation protocol utilized communication between the avian radar operator (ARO) and the visual observer (VO). The ARO observed a track on the radar screen and communicated this to the VO, or the VO communicated an observation to the ARO. Field team members were comprised of at least two GMI biologists; one observer and a radio communicator/recorder. Validation surveys consisted of multiple observation periods scheduled over the radar season at each radar site.

The field team navigated to multiple oceanic sites at varying distances within the barge-based MARS® coverage area. In addition, radar validation surveys were conducted at onshore avian radar sites. Prior to and during each validation event, field observers requested, from the ARO, distances to nearby vessels to establish distance estimation with the MARS®; passing and stationary ships were used to orient field observers.

The first offshore survey site was assigned to the team during the pre-event briefing. The ARO reviewed the radar clutter image at varying distances from MARS® and determined an area where both the ARO and field team could detect/observe birds. The ARO then directed the field team to traverse to the first validation location (e.g., navigate northwest 5 km [2.5 NM] from the barge).

At the arrival of each survey site, the field team recorded pertinent data on the "Ground Truth Data Sheet" (**Figure 5-20**). Data recorded included: date, time, team number, event number, observer name(s), recorder name, and location information (latitude, longitude). After the initial data were recorded, the field team reported "ready" on-station status via radio. The ARO subsequently radioed to the field team when the event would begin, which was recorded on the datasheet by the field recorder. The ARO in the MARS® began observing the radar displays surrounding the designated survey site, which encompassed a 2- to 4-km (1- to 2-NM) radius from the boat.

GROUND TRUTH VALIDATION SURVEY DATA SHEET
Date:___________
Team No: ________ Event No: ________ Observer: ___________ Recorder: ___________
Lat.______________ Long.____________ Location:_____________________
Time on Station: Begin: _____________End: _____________
Weather conditions/visibility/comments:
____
____
____

Time	C/U	By Radar or Observer	Bearing from observer	Range/m	Flight heading	Altitude/ft	Count	Species

Figure 5-20. Radar validation survey data sheet.

When the ARO saw a tracked target on the radar screen (or when the field team saw a bird/flock) within the survey site, the following detection/observation information was reported: the approximate range and bearing of the detection/observation relative to the field team location, bird/target heading (using eight cardinal compass points), and the location of bird/target as it moved across the landscape/radar display. A typical radio call during each event was: "Target East (bearing 90°), range 2 km (1 NM), heading west (i.e., towards you)". The field team recorded time, detection bearing (or quadrant), and confirmed (C) or unconfirmed (U). The following data were recorded for all confirmed tracks: estimated range (m), heading, flight altitude (ft), number of birds in the tracked target/flock, species/group (e.g., Northern Gannet), and any other comments.

As workload permitted, field observers recorded observations of bird activity that were not called out by the ARO since the MARS® (or ARO) may not have been able to see all the visual observations. All bird species/groups of varying sizes, flight altitudes, and behaviors were relevant to qualifying MARS® (TracScan and VerCat) performance. Therefore, resident and migratory bird activities were recorded during avian radar validation events. In addition, visual observations were limited to areas without radar clutter and within the boundaries of the observer's vision (aided by binoculars). For each of the non-cued observations, the field team recorded observation time, observation bearing, estimated range (m), heading, flight altitude (ft), count, and species/group. Events ended when the field team was notified by the ARO, and the event end time was recorded on the field data sheet by the recorder. The validation events were approximately 1 to 2 hrs in duration. After each validation event, the field data recorder verified that all field event data sheets were completed. The field team members and the ARO discussed validation event methods and made improvements if necessary. Significant observations were discussed and locations of successive field events were determined.

Radar validation survey data were analyzed to determine the number of confirmed and unconfirmed birds by flight altitude category (e.g., 1-25, 26-50 ft AMSL). Survey results were summarized for each season by species (e.g., Northern Gannet) or guild (ducks, loons, cormorants, and gulls), flight altitude, and location with reference to distance from the radar site. Survey data are presented in **Appendix J-2**.

5.5.1.2 Spring and Fall 2009

The radar validation survey protocol used in 2008 was evaluated at the end of the first survey season. This evaluation revealed that the radar operator may bias the surveillance of the onshore observer and the observations of the onshore observer may bias the radar operator. In addition, the quadrant validation method covers a relatively large area. When a target is called in/out by the avian observer or the radar operator the position of the target in the quadrant is difficult to describe accurately. Therefore, specific birds called in/out may be confused with other nearby birds. In addition, there is a communication time lag between the radar operator and avian observer. By the time the communication was received and understood the bird observed may have changed direction or disappeared behind a wave. Boat-based validations were also limited to times when sea states allowed small boats to safely operate and conduct the survey. Based on this evaluation a new validation protocol was developed.

The 2009 radar validation protocol 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 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; Fonseca et al. 2007). 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 and behavior (e.g., flight altitude/direction) are recorded along with a GPS time. The protocol is 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 observer and the observations of the observer do not bias the radar operator.

The observer was positioned looking over an azimuth nearly perpendicular to the shore or at a set azimuth from the offshore platform or ship. The GPS position of the observer and the azimuth of their observation "line" were recorded so that the location of the observer and azimuth line could be added to the radar display for post survey analysis. Before the beginning of a validation session the GPS time on the field observer personal digital assistant (PDA) was synchronized so that the time stamp was the same as that for the radar. Sea-state and visibility conditions were recorded at the beginning of each survey. Additional weather data were recorded by the weather station at the radar site.

An observer using 10 x 50 binoculars looked for birds flying over the imaginary azimuth line (survey line). A telescope pointed down the survey line was also used to identify birds crossing too far away to be identified with 10 x 50 binoculars. When a bird crossed the vertical plane above the survey line, the bird's identity, distance, height, direction of flight, and flight behavior were recorded (along with a GPS time). In the PDA Survey Program, the "bearing" entry was the azimuth of the survey line chosen for monitoring. The altitude bins were 1 (skimming), 25 ft, 50 ft, 100 ft, 200 ft, 300 ft, 500 ft, 1,000 ft, and >1,000 ft. The distance bins were 100 m, 200 m, 300 m, 1,000 m, and >1,000 m. If a boat passed offshore the observer checked the radar to determine the distance from the observers to the boat. Flight directions were recorded in the following eight cardinal direction codes: N, S, E, W, NE, SE, SW, and NW. Flight behavior (e.g., directional flight, circling, feeding) was noted in the comment section.

Post survey GMI's radar software was used to replay the stored TracScan radar data at the same time of observers sighting to determine if the observer-recorded bird was or was not detected passing over the azimuth line. Results (confirmed or unconfirmed) were recorded on a datasheet (Fonseca et al. 2007) and analyzed to determine percentages of radar confirmed bird targets by flight altitude.

In spring 2009 the line-intercept protocol was used from the offshore barge on Grid 16. The azimuth was set looking towards shore. In fall 2009 the line intercept protocol was conducted at IBSP, BB, and SIC. It was also conducted from an anchored boat along an azimuth aimed at the radar at BB to supplement the onshore ground truth data collection. Because the radar validation exercises were designed in part to determine the extent of missed tracks obscured by sea clutter, samples were collected in different sea-state conditions because increasing sea states increases clutter distance in the radar surveillance area.

5.5.2 Radar Validation Survey Results

Validation of TracScan and VerCat radars were conducted during the radar surveys. Boat-based validation surveys were conducted during the first year of the study. Line-transect surveys, both offshore and onshore, were used during the second year of the study and TI-VPR data were used for validation of VerCat data throughout the study. Validation results for TI-VPR data have been presented previously in **Section 5.4.1.3**.

5.5.2.1 Spring and Fall 2008

Offshore

Six boat-based validation surveys, four in spring 2008 and two in fall 2008, were conducted for offshore radar sites. The total onsite survey effort was 6.6 hrs in spring and 4.0 hrs in fall.

No general trends were identified for VerCat offshore boat-based validation data during the spring surveys because adverse weather and associated sea state conditions limited the collection of validation survey data. TracScan offshore validation survey data were also limited and only general trends regarding TracScan detection of Northern Gannet were determined. Insufficient survey data were available to identify any general trends in radar detections of other birds at varying altitudes and distances from the radar site (**Appendix J: Tables J-2** through **J-11**).

TracScan target confirmation of Northern Gannets decreased with increasing distance from the radar site. At 2 km (1.00 NM) from the radar 88.23% of the Northern Gannet observations (n=17) were confirmed, and at 4 km (2.00 NM), 63.64% of the Northern Gannet observations (n=33) were confirmed (**Table 5-9**). At 6 km (3.00 NM), 28.57% of the Northern Gannet observations (n=7) were confirmed. The decrease in Northern Gannet detections resulted from decreased detection when birds were flying at lower flight altitudes (<31 m [101 ft] ASL) at increasing distances from the radar.

Survey results are summarized for the spring 2009 season are limited for TracScan (**Appendix J: Tables J-12** through **J-14**); insufficient data are available to identify any general trends in radar detections of these species/guilds at varying altitudes and distances from the radar site.

Onshore

One boat-based TracScan validation survey was conducted at each of the three onshore sites: IBSP, North Brigantine Beach, and Corson's Inlet during spring 2008. VerCat validation surveys were not conducted. Total survey effort was 3.8 hrs. No general trends were identified except for gulls. Although data were limited, gulls were confirmed at all altitudinal bands (**Table 5-10**). Data for the other guilds were analyzed; however, insufficient validation data were available to identify any general trends in radar detections of these guilds at varying altitudes and distances from the radar site (**Appendix J: Tables J-14** through **J-21**).

Table 5-9. Validation of Northern Gannet targets tracked by TracScan radar. Observations grouped by flight altitude during spring 2008 boat-based offshore validation surveys.

Grid #	Distance to Radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
07	1.00	0	2	3	0	4	0	4	0	2	0	13	2
19	1.00	-	-	1	0	1	0	-	-	-	-	2	0
Subtotal	**1.00**	**0**	**2**	**4**	**0**	**5**	**0**	**4**	**0**	**2**	**0**	**15**	**2**
23	1.75	2	1	1	0	-	-	-	-	-	-	3	1
01	2.00	-	-	-	-	-	-	2	3	2	0	4	3
07	2.00	2	1	0	2	3	0	2	0	2	1	9	4
19	2.00	1	0	1	1	2	3	-	-	1	0	5	4
Subtotal	**2.00**	**5**	**2**	**2**	**3**	**5**	**3**	**4**	**3**	**5**	**1**	**21**	**12**
23	**3.00**	**1**	**4**	**0**	**1**	**1**	**0**	**-**	**-**	**-**	**-**	**2**	**5**
Total		**6**	**8**	**6**	**4**	**11**	**3**	**8**	**3**	**7**	**1**	**38**	**19**

NM = nautical miles; ft AMSL = feet mean above sea level; C = Confirmed; U = Unconfirmed

Table 5-10. Validation of gull targets tracked by TracScan radar onshore. Observations grouped by flight altitude during spring 2008 boat-based validation surveys.

Location	Distance to Radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	1	-	-	2	0	2	0	0	1	2	0	6	1
North Brigantine Beach	1	-	-	5	0	2	0	3	0	-	-	10	0
Corson's Inlet	1	2	0	4	0	3	0	4	0	3	0	16	0
Total		**2**	**0**	**11**	**0**	**7**	**0**	**7**	**1**	**5**	**0**	**32**	**1**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Validation surveys were conducted at three sites: IBSP, SIC, and BB during fall 2008. At BB ground truth observations were conducted both onshore and offshore. Total survey effort was 36.26 hrs. Only TracScan validation surveys were conducted; VerCat validation surveys were not conducted. Survey results are summarized for the land-based observation sites by species (Northern Gannet) or guild (ducks, cormorants, gulls, and terns), flight altitude, and location with reference to the radar site. At all three sites surveying was constrained by access and limited field of view, and as a result, all of the observations were conducted at 2 km (1.00 NM) or less from the radar. Survey data are provided in **Appendix J: Tables J-22** through **J-25.**

The number of confirmed and unconfirmed sightings by radar was determined by guild or species (**Tables 5-11** through **5-15**). The confirmation percentages were 95.52% for Northern Gannet (n=67), 97.8 for ducks (n=182), 97.2 for cormorants (n=96), and 100% for tern sightings (n=49).

Table 5-11. Confirmation status of Northern Gannet observations by flight altitude during fall 2008 land-based TracScan radar onshore validation surveys.

Location	Distance to Radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	0.03	4	0	2	1	1	0	3	1	3	0	13	2
Sea Isle City	0.03 to 0.20	0	1	8	0	5	0	-	-	1	0	14	1
Brigantine Beach	0.10	5	0	21	0	7	0	3	0	1	0	37	0
Total		**9**	**1**	**31**	**1**	**13**	**0**	**6**	**1**	**5**	**0**	**64**	**3**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Table 5-12. Confirmation status of duck (Anatidae) observations by flight altitude during fall 2008 land-based TracScan radar onshore validation surveys.

Location	Distance to Radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	0.03	6	0	1	0	-	-	-	-	1	0	8	0
Sea Isle City	0.03 to 0.40	105	0	22	1	2	0	8	0	14	2	151	3
Brigantine Beach	0.10	8	0	2	0	-	-	0	1	9	0	19	1
Total		**119**	**0**	**25**	**1**	**2**	**0**	**8**	**1**	**24**	**2**	**178**	**4**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Table 5-13. Confirmation status of cormorant observations by flight altitude during fall 2008 land-based TracScan radar onshore validation surveys.

Location	Distance to Radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	0.03	3	0	2	0	-	-	-	-	-	-	5	0
Sea Isle City	0.03 to 0.40	2	0	2	1	1	0	5	0	70	0	80	1
Brigantine Beach	0.10	1	0	2	0	-	-	1	1	5	0	9	1
Total		**6**	**0**	**6**	**1**	**1**	**0**	**6**	**1**	**75**	**0**	**94**	**2**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

The observations taken offshore from BB during boat-based surveys were conducted at 3, 4, and 5 km (1.67, 2.00, and 2.75 NM). Total survey effort was 3.6 hrs. Data are summarized by species (Northern Gannet) or guild (gulls, ducks, and cormorants). At all distances from the radar 100% of the Northern Gannet (n=70) and gull (n=26) sightings were confirmed (**Tables 5-16** and **5-17**). Insufficient data for ducks and cormorants prevent any generalizations in radar detection trends. .

Table 5-14. Confirmation status of gull observations by flight altitude during fall 2008 land-based TracScan radar onshore validation surveys.

Location	Distance to radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	0.03 to 1.00	22	0	53	1	11	1	21	0	37	0	144	2
Sea Isle City	0.03 to 0.40	3	0	4	0	3	0	5	0	4	0	19	0
Brigantine Beach	0.10	1	0	8	0	4	0	2	0	2	0	17	0
Total		**26**	**0**	**65**	**1**	**18**	**1**	**28**	**0**	**43**	**0**	**180**	**2**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Table 5-15. Confirmation status of tern observations by flight altitude during fall 2008 land-based TracScan radar onshore validation surveys.

Location	Distance to radar (NM)	Altitude (ft AMSL)											
		1-25		26-50		51-75		76-100		101+		Total	
		C	U	C	U	C	U	C	U	C	U	C	U
Island Beach State Park	0.03	6	0	9	0	3	0	13	0	13	0	44	0
Sea Isle City	0.03	-	-	4	0	-	-	-	-	-	-	4	0
Brigantine Beach	0.10	-	-	1	0	-	-	-	-	-	-	1	0
Total		**6**	**0**	**14**	**0**	**3**	**0**	**13**	**0**	**13**	**0**	**49**	**0**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Table 5-16. Confirmation status of Northern Gannet observations by flight altitude during fall 2008 boat-based TracScan radar validation surveys off Brigantine Beach.

Distance to Radar (NM)	Altitude (ft AMSL)											
	1-25		26-50		51-75		76-100		101+		Total	
	C	U	C	U	C	U	C	U	C	U	C	U
1.67	-	-	7	0	4	0	5	0	2	0	18	0
2.00	4	0	12	0	3	0	2	0	-	-	21	0
2.75	15	0	16	0	-	-	-	-	-	-	31	0
Total	**19**	**0**	**35**	**0**	**7**	**0**	**7**	**0**	**2**	**0**	**70**	**0**

NM = nautical miles; ft AMSL = feet above sea level; C = Confirmed; U = Unconfirmed

5.5.2.2 Spring and Fall 2009

Offshore

Radar validation data were collected from the barge at Grid 16 on 11 May 2009. The survey effort totaled 2 hrs. The sample size was too small to make any general conclusions except that bird radar confirmation percentage mostly increased with increasing flight altitude (**Table 5-18**).

Table 5-17. Confirmation status of gull observations by flight altitude during fall 2008 offshore boat-based TracScan radar validation surveys off of Brigantine Beach.

Distance to Radar (NM)	Altitude (ft AMSL)											
	1-25		26-50		51-75		76-100		101+		Total	
	C	U	C	U	C	U	C	U	C	U	C	U
1.67	4	0	5	0	1	0	3	0	1	0	14	0
2.00	2	0	6	0	1	0	-	-	-	-	9	0
2.75	1	0	2	0	-	-	-	-	-	-	3	0
Total	**7**	**0**	**13**	**0**	**2**	**0**	**3**	**0**	**1**	**0**	**26**	**0**

NM = nautical miles; ft AMSL = feet above mean sea level; C = Confirmed; U = Unconfirmed

Table 5-18. Bird observations confirmed by radar for Grid 16 in the New Jersey Study Area, 11 May 2009.

Radar Sea Clutter Distance (NM)	Altitude (ft ASL)											
	1-5		6-25		26-50		51-100		101-200		201-300	
	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C
0.7 to 1.2	9	11.1	11	18.2	16	37.5	12	58.3	1	0.0	1	0.0

No. = number of observations; ft ASL = feet above sea level; %C = percent confirmed

Onshore

Radar validation surveys were collected from 17 September to 02 October 2009 at IBSP (**Appendix J: Table J-26**). Survey effort totaled 23.25 hrs. For sea clutter distances from 0.9 km to 2.8 km (0.5 NM to 1.50 NM), the percentage of bird radar confirmations increased with increasing flight altitude (**Table 5-19**). Except for the skimming 0.3-1.5 m (1-5 ft) ASL altitude, the greatest bird radar confirmation percentages occurred when the sea clutter distance was 0.9 km (0.50 NM). No birds were confirmed when the sea clutter distance was 4.6 km (2.50 NM).

At BB onshore radar validation surveys were conducted from 06 to 23 October 2009 (**Appendix J: Table J-27**). The total onshore survey effort was 24.25 hrs. The sea clutter distance of 0.9 km (0.5 NM) had too few observations to make any generalizations, but for sea clutter distances of 1.9 km (1.00 NM) and 2.8 km (1.5 NM) bird radar confirmation percentage generally increased with flight altitude (**Table 5-20**). No birds were confirmed for sea clutter distances of 4.5 km (2.50 NM) and 5.6 km (3.00 NM).

Boat-based data were also conducted offshore of BB on 22 October 2009 (survey effort: 5 hrs; **Appendix J: Table J-28**). The boat-based observations were all conducted when the sea clutter distance from the radar was 1.9 km (1.0 NM; **Table 5–21**). No bird radar confirmations were made when the sea clutter distance was 3.7 km (2.00 NM); however, many of the observations were of birds that were skimming 0.3-1.5 m (1-5 ft) ASL. Based on the low percentage in the 0.3-1.5 m (1-5 ft) altitude band these birds were most likely obscured from radar by waves; however, a very small percentage of birds were confirmed flying just above the waves at 1.8-7.6 m (6-25) ft AMSL when the sea clutter distance was 4.6 km (2.5 NM).

Onshore radar validation surveys were conducted at SIC from 26 October to 15 November 2009 (**Appendix J: Table J-29**). Survey effort totaled 34 hrs. For distances of 0.9 km (0.5 NM) to 2.8 km (1.50 NM) sea clutter, bird radar confirmations generally increased with increasing flight altitude (**Table 5-22**).

Table 5-19. Bird observations confirmed by radar for Island Beach State Park, New Jersey, in fall 2009.

Radar Sea Clutter Distance (NM)	Altitude (ft ASL)															
	1-5		6-25		26-50		51-100		101-200		201-300		301-500		501-1000	
	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C
0.50	68	14.7	49	24.5	41	34.2	53	43.4	19	73.7	4	100.0				
1.00	24	20.8	36	8.3	20	25.0	29	34.5	17	47.1	7	85.7	1	0.0	1	0.0
1.50	15	0.0	27	0.0	34	5.9	26	15.4	4	50.0						
2.50	14	0.0	101	0.0	42	0.0	15	0.0	3	0.0	1	0.0				

No. = number of observations; ft ASL = feet above sea level; %C = percent confirmed

Table 5-20. Radar validation survey observations on 22 October 2009 confirmed by radar for Brigantine Beach, New Jersey.

Distance to Radar (NM)	Altitude (ft ASL)							
	1-5		6-25		26-50		51-100	
	No.	%C	No.	%C	No.	%C	No.	%C
1.50	43	9.3	21	14.3	1	0.0		
2.00	50	0.0	14	0.0	1	0.0		
2.50	35	0.0	38	2.6	3	0.0	2	0.0

No. = number of observations; ft ASL = feet above sea level; %C = percent confirmed

Table 5-21. Bird observations confirmed by radar for Brigantine Beach, New Jersey, in fall 2009.

Radar Sea Clutter Distance (NM)	Altitude (ft ASL)															
	1-5		6-25		26-50		51-100		101-200		201-300		301-500		501-1000	
	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C
0.50	25	16.0	8	37.5	5	80.0	2	0.0								
1.00	81	19.8	64	18.8	59	18.6	47	25.5	8	37.5	3	33.3	1	0.0		
1.50	21	23.8	20	20.0	32	31.3	14	14.3	7	57.1	3	33.3	3	66.7		
2.00	27	0.0	42	7.1	16	6.3	10	40.0	6	16.7	7	0.0	10	0.1	3	0.0
2.50	44	0.0	76	0.0	17	0.0	2	0.0								
3.00	1	0.0	7	0.0	2	0.0	1	0.0								

No. = number of observations; ft ASL = feet above sea level; %C = percent confirmed

Table 5-22. Radar validation survey observations confirmed by radar for Sea Isle City, New Jersey, in fall 2009.

Radar Sea Clutter Distance (NM)	Altitude (ft ASL)																	
	1-5		6-25		26-50		51-100		101-200		201-300		301-500		501-1000		>1,000	
	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C	No.	%C
0.50	52	5.8	34	17.7	16	6.3	10	20.0	4	0.0							1	0.0
1.00	32	12.5	54	27.8	20	45.0	4	50.0	1	100.0								
1.50	59	18.6	152	29.6	127	32.3	38	29.0	4	50.0	2	50.0						
2.00	112	11.6	253	25.7	163	34.4	46	6.5	2	50.0	1	100.0						
2.50	28	0.0	91	3.3	100	1.0	59	0.0	27	11.1	11	18.2	1	0.0				

No. = number of observations; ft ASL = feet above sea level; %C = percent confirmed

5.5.3 Discussion

The radar validation survey protocol used in 2008 was evaluated at the end of the first survey season. This evaluation revealed that the radar operator may bias the surveillance of the onshore observer and the observations of the onshore observer may bias the radar operator. A new protocol method (line transect survey) was developed and implemented in 2009.

Radar validation survey results from 2009 were:

- Bird radar confirmations generally increased with increasing flight altitude.
- The highest percentage of bird radar confirmations occurred when the sea clutter was less than or equal to 2.8 km (1.50 NM).

The low percentage of birds detected by the radar at low flight altitudes was understandable based on operational constraints of the radar, operational capabilities of the radar, and the extent of sea clutter. At the offshore sites, the VerCat radar on the barge was, on average, approximately 9.1 m (30 ft) above the water. The VerCat radar ceased operation when it became horizontal with the sea surface. When the VerCat radar was horizontal 50% of the radar beam spreads below the horizontal and travels towards the water surface reaching it at 1 km (0.50 NM) from the barge. When sea clutter (wave height) increases the capability of detecting a bird flying at low altitudes over the water was reduced.

In contrast, the lower portion of the offshore TracScan radar contacted the water surface at 61 m (200 ft) from the radar. Because of the TracScan's operational height requirement the lower portion of the radar beam contacted the water surface at a sharper angle. This resulted in greater sea clutter returns at greater ranges and this negatively affected the detection of birds flying at low altitudes above the water.

The onshore radar sites were located only a few feet above the water and were affected by operational site requirements. The lower portion of the VerCat beam was blocked during days with high waves and/or by an obstruction (sand dunes) at one location thereby decreasing detection capability of low flying birds. In contrast, the TracScan beam angles were lower at the lower onshore operational heights thereby increasing detection of low flying birds when the wave heights were low.

As previously discussed in the radar analysis section, the effects of sea clutter were reduced during processing (**Section 5.4.3**); however, operational constraints and radar capability negatively affected the radar detection of low flying birds.

5.6 OFFSHORE SURVEY RESULTS

This section summarizes the results of the offshore and onshore radar studies. Three VerCat radar metrics, median altitude quartile, flux, and AMTR, were used to identify the altitudinal relationship of bird flight activity in the potential RSZ (100-700 ft AMSL). 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. This metric allows for identification of bird altitude distribution with respect to the RSZ. Cumulative diurnal and nocturnal flux data (adjusted bird tracks per cub kilometer (km^3) per hour) were sorted into three altitude bands with reference to the potential RSZ: (1) below the RSZ (low altitude band, 1 to 99 ft AMSL), (2) within the RSZ (middle altitude, 100 to 700 ft AMSL), and (3) above the RSZ (high altitude band, 701+ ft AMSL). This metric allows identification of time periods (e.g., weeks, daytime, nighttime) where a majority of birds may be within the RSZ and the flux or density of bird tracks moving through the low, middle, and high altitude bands (below, within and above the RSZ). The flux value is the primary metric used to estimate bird-turbine collision mortality. The number of bird tracks crossing over a km per hour (AMTR) was calculated to provide a quantitative passage rate. Although many variables affect the possibility of bird-turbine collision risk, in general the greater the AMTR value the greater the potential for bird-turbine collision.

As discussed in the radar validation section (**Section 5.5.2**), only 10-20% of the birds flying at very low altitudes were detected with the radar. This is because of constraints of the marine radar detecting wave clutter that obscures return from low flying birds. Consequently, bird numbers reported within the 25% altitude quartile by the radar were thought to be lower than what was present in the study area.

The results of the offshore and onshore avian radar surveys during the study are summarized below. A detailed analysis of the radar survey results is provided in **Appendix J-3**.

5.6.1 Offshore

5.6.1.1 Spring 2008

With the exception the diurnal time period during early spring at the nearshore grids 1 and 7, most of the diurnal and nocturnal offshore median altitude quartiles were within the potential RSZ band (100-700 ft AMSL; **Figure 5-21**).

VerCat cumulative diurnal flux values over nearshore grids (1, 7, 13, 19) were concentrated within the low altitude band (**Figure 5-22**). Over the offshore grids, diurnal flux values were similar within the low and middle altitude bands over grids 26 and 23. Over Grid 17 flux was greater within the middle (RSZ) band than within the low altitude band. Cumulative nocturnal flux values within the middle altitude band increased over both the nearshore and offshore grids and became greater than low altitude flux values by the end of the nearshore and offshore sampling periods. The overall diurnal nearshore and offshore trend during spring 2008 was for gradually decreasing diurnal flux values within the low altitude band and gradually increasing flux values within the middle altitude band. The overall nocturnal trend for both nearshore and offshore grids was for greater flux values within the middle (RSZ) band than the low altitude band as the spring season advanced (**Figure 5-22**).

Diurnal AMTR increased over the nearshore grids while nocturnal AMTR remained constant (**Figure 5-23**). Over the offshore grids, diurnal AMTR steadily increased; cumulative nocturnal AMTR decreased from Grid 26 to Grid 23 before increasing over Grid 17. Diurnal AMTR was greater than nocturnal AMTR over most grids. The peak diurnal AMTR occurred offshore on Grid 26 (137.0 adjusted number of bird tracks [abt]/kph) from 24-30 April and on Grid 17 (113.0 abt/kph) from 07-11 May 2008. Peak nocturnal AMTR occurred 30 April - 07 May (320.3 abt/kph) on Grid 26 and from 07-11 May 2008 (333.5 abt/kph) on Grid 17. The dominant diurnal and nocturnal nearshore and offshore flux directions during most of the survey weeks was from the south and southwest to the north and northeast.

5.6.1.2 Fall 2008

The fall 2008 radar surveys were limited to two offshore sampling grids in the southern section of the Study Area. The data are limited and insufficient to make any conclusions.

All cumulative diurnal and nocturnal median altitudes were within the RSZ (100-700 ft AMSL; **Figure 5-24**). The VerCat cumulative diurnal and nocturnal flux was greater in the mid-altitude (RSZ) band than the low altitude band (**Figure 5-25**). Cumulative diurnal and nocturnal AMTR decreased from Grid 22/23 to Grid 26 (**Figure 5-26**) Peak diurnal AMTR was 104.3 abt/kph and peak nocturnal AMTR was 134.3 abt/kph from 30 September through 12 October 2008. Directional flux occurred only from 20 September to 12 October 2008. As expected the directional movement was from the north to the south.

5.6.1.3 Spring 2009

The survey effort was limited to three days and therefore no general trends were identified from the survey results. The data presented for spring 2009 may be used as a qualitative measure of the avian activity for the days that the data were collected (11-13 May).

5.6.2 Onshore

5.6.2.1 Spring/Early Summer 2008

The majority of the median altitude quartiles were within the middle (RSZ) altitude band at all of the onshore sites (**Figure 5-27**). The cumulative diurnal flux values varied within and between the onshore sites (**Figure 5-28**). At IBSP and Corson's low altitude and middle altitude (RSZ) band flux values were generally similar. At Brigantine, cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ) band. This difference may be the result of the different migratory species passing the site or the behavior of resident species at the site. The cumulative nocturnal flux values were greater within the low altitude band than with the middle (RSZ) altitude band at all onshore sites.

The cumulative diurnal AMTR values were similar between the onshore sites (**Figure 5-29**). Nocturnal AMTR values were greater than cumulative diurnal AMTRs indicating that some nocturnal migration was probably still in progress from mid-May into mid-June. The cumulative peak diurnal AMTR (17.6 abt/kph) occurred at Brigantine from 29 May through 01 June 2008. The cumulative nocturnal AMTR decreased from IBSP to SIC indicating a decline in nocturnal migration. The cumulative peak nocturnal AMTR (66.2 abt/kph) was at IBSP from 15-18 May 2008. Overall, as expected during spring migration, the dominant movement of birds was from the south and southwest to the north and northeast.

5.6.2.2 Fall/Early Winter 2008

Cumulative diurnal median altitude quartiles varied between the onshore sites (**Figure 5-30**). Most of the cumulative median diurnal altitude quartiles were within the middle (RSZ) altitude band at IBSP in early fall 2008. In contrast, the majority of the cumulative median altitude quartiles were within the low altitude band at Brigantine, SIC, and at IBSP from mid-fall into early winter 2008. Most of the cumulative nocturnal altitude quartiles were within the middle (RSZ) altitude band.

The majority of the cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ) altitude band (**Figure 5-31**). Cumulative nocturnal flux varied at several sites. For most of the survey dates, the cumulative nocturnal flux values at the onshore sites were generally similar between the low and middle (RSZ) altitude bands. The cumulative diurnal flux values were greater within the low altitude band at IBSP from 28 September through 05 October 2008, at SIC from 20 through 26 October 2008.

Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal AMTRs were less than 30 abt/kph at all of the onshore sites (**Figure 5-32**). At each onshore site, peak cumulative AMTR occurred at night (IBSP: 19.1 abt/kph from 31-21 September 2008; SIC: 25.0 abt/kph from 05-12 October 2008; BB: 26.4 abt/kph from 26 October to 02 November 2008. Overall, as expected during fall migration, the dominant direction of movement during most weeks was from the north and northeast to the south and southwest.

5.6.2.3 Spring/Early Summer 2009

Cumulative weekly median altitude diurnal and nocturnal altitude distribution varied between sites. At IBSP, all of the cumulative weekly median diurnal altitude quartiles were within the low altitude band (**Figure 5-33**). In contrast, at BB, cumulative weekly altitude quartiles were nearly split equally between the low altitude band and the middle (RSZ) altitude band. At SIC, the cumulative weekly median diurnal altitudes were all within the low altitude band. Most of the cumulative weekly median nocturnal altitude quartiles at IBSP were within the middle (RSZ) band. At BB, most of the cumulative weekly median nocturnal altitude quartiles were in the high altitude band (above the RSZ) and at SIC all of the cumulative weekly median nocturnal altitude quartiles were within the middle (RSZ) band.

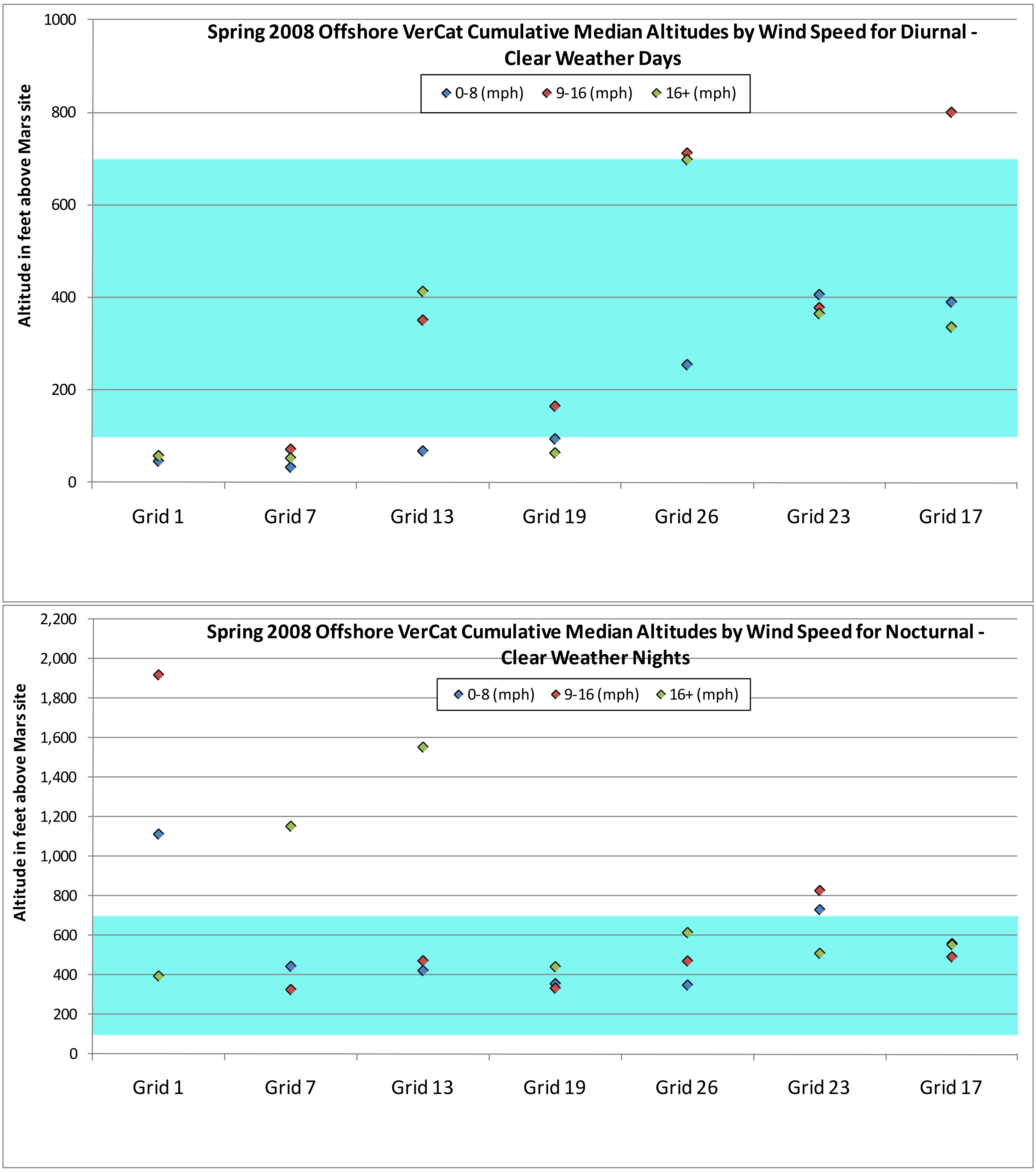
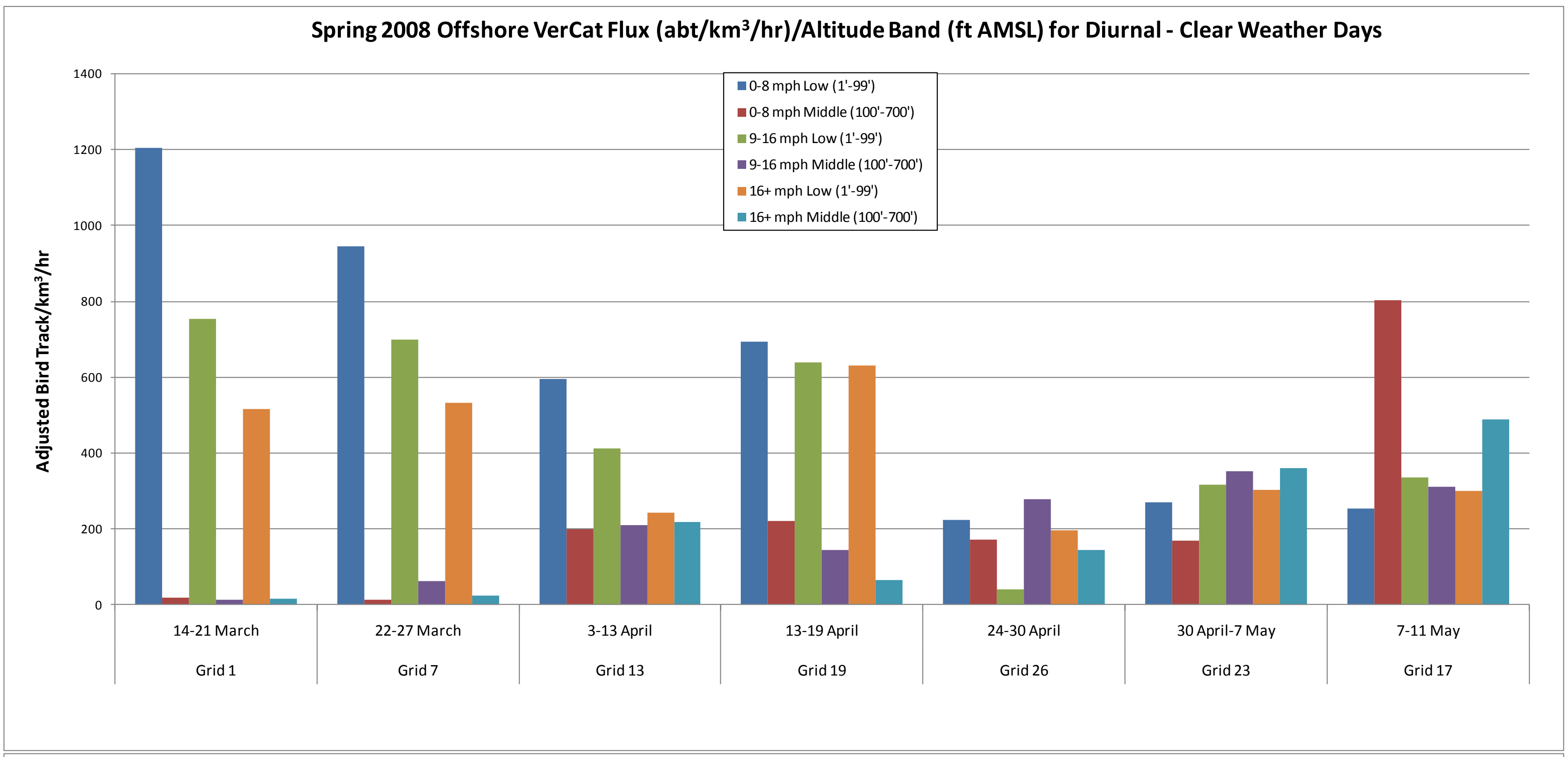


Figure 5-21. Spring 2008 Offshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).



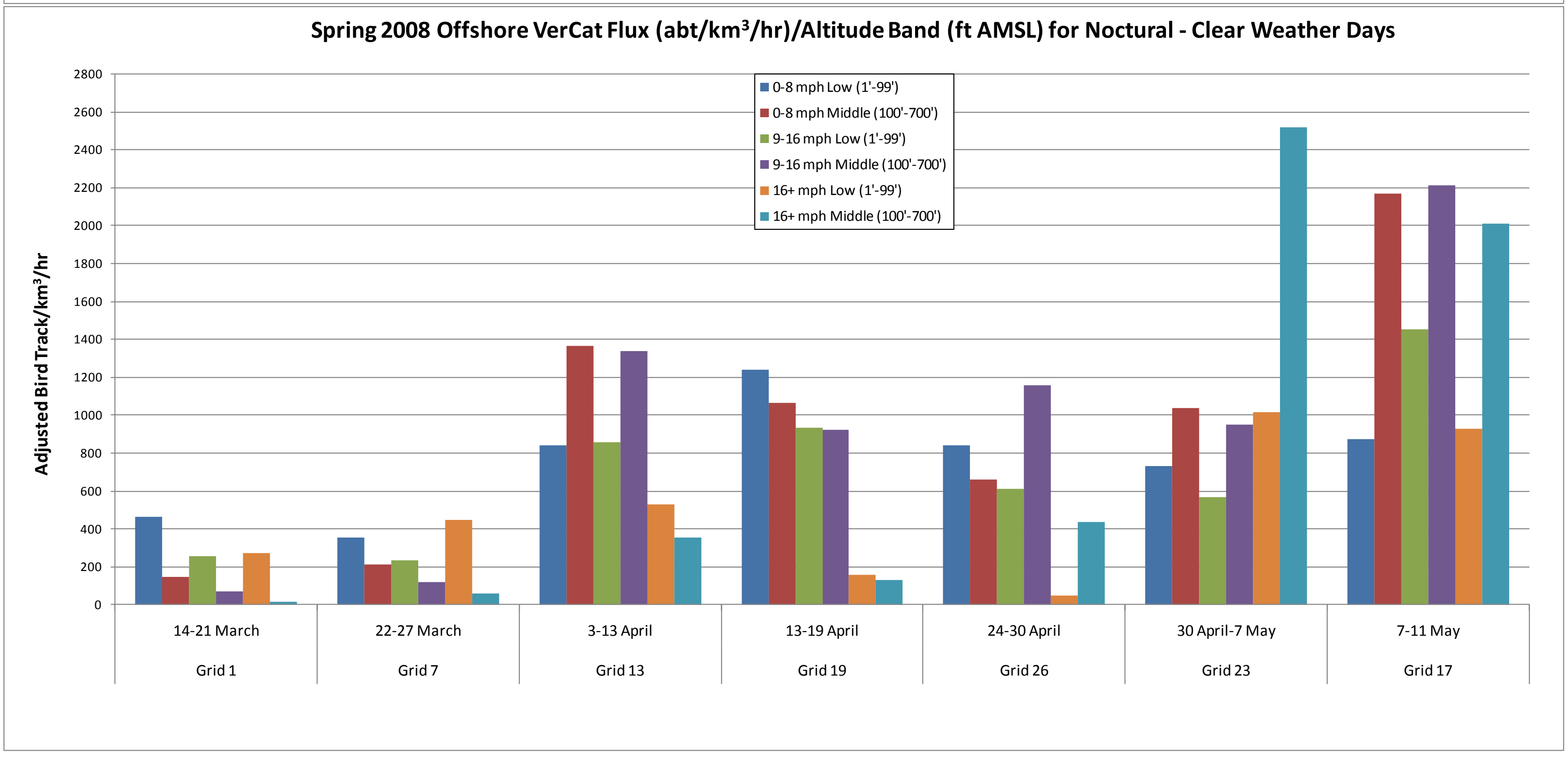
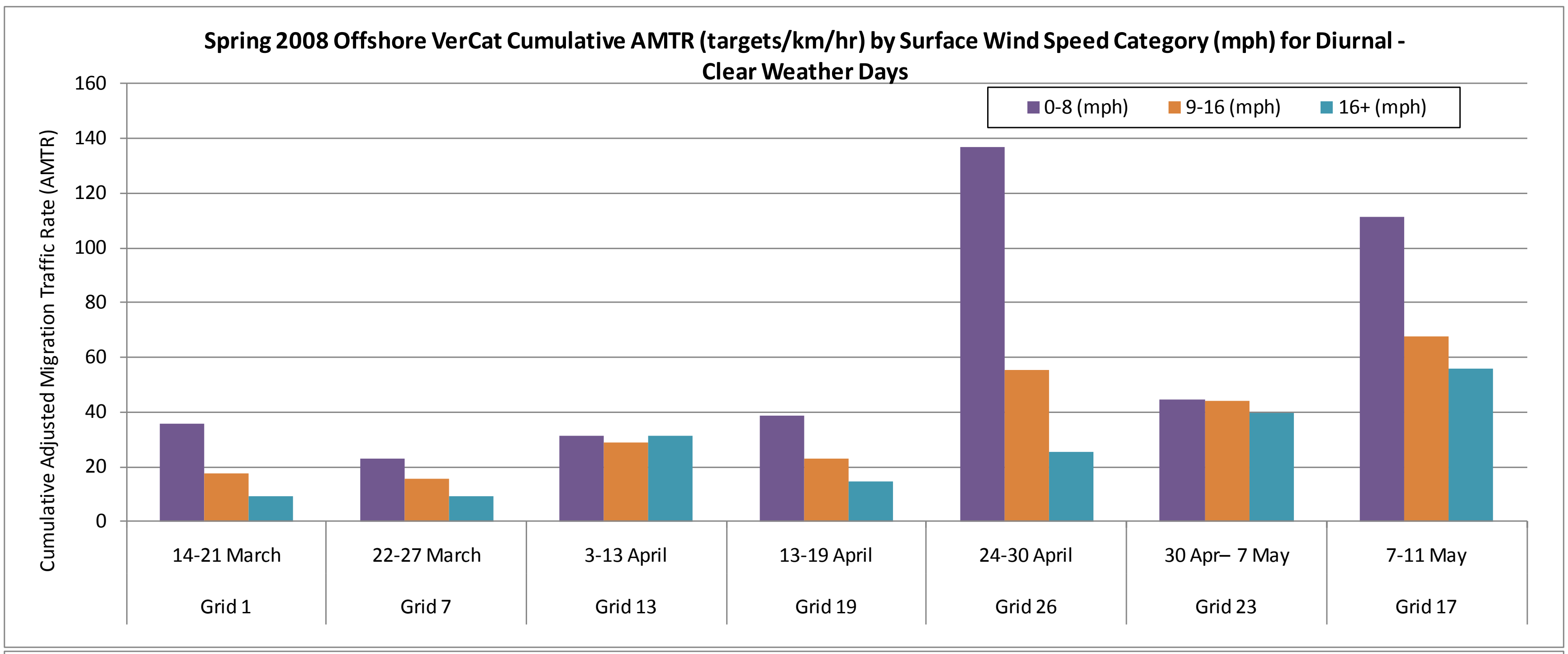


Figure 5-22. Spring 2008 Offshore VerCat Cumulative Flux.



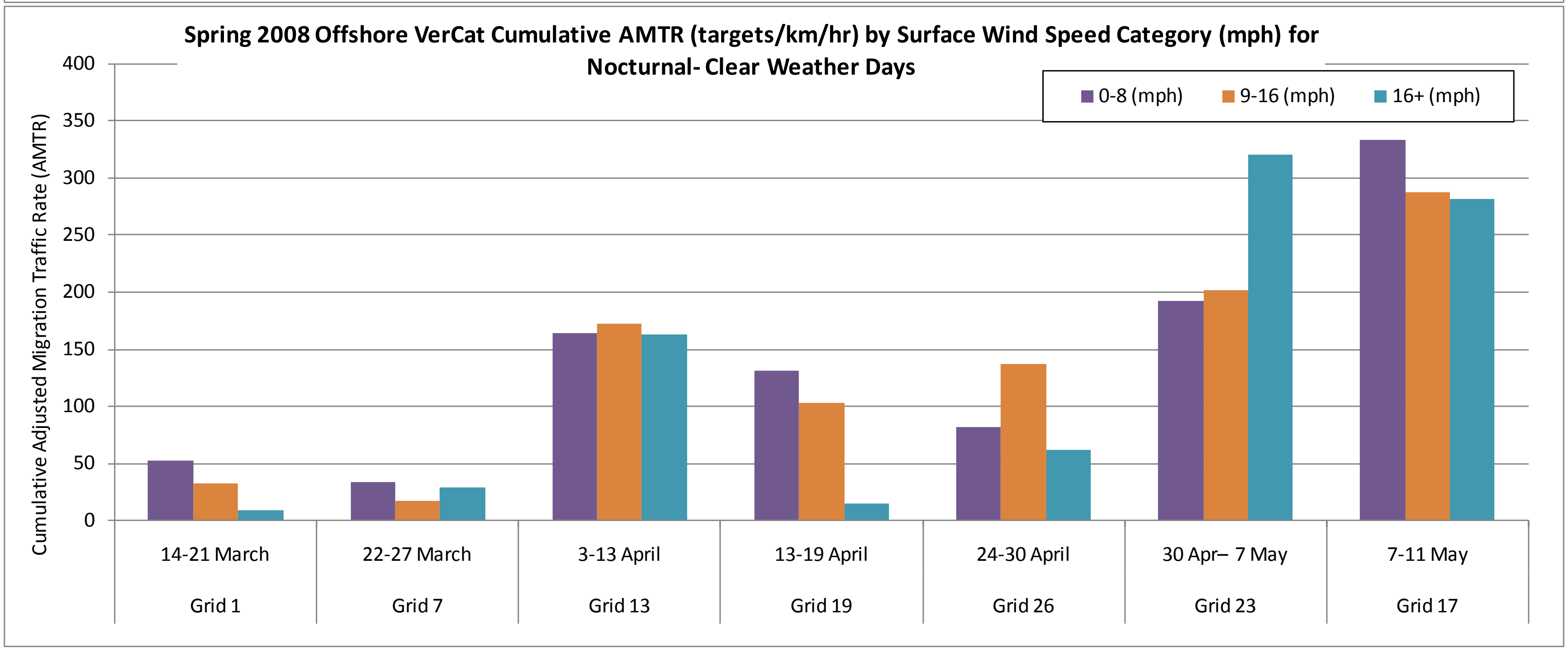


Figure 5-23. Spring 2008 Offshore Cumulative AMTR.

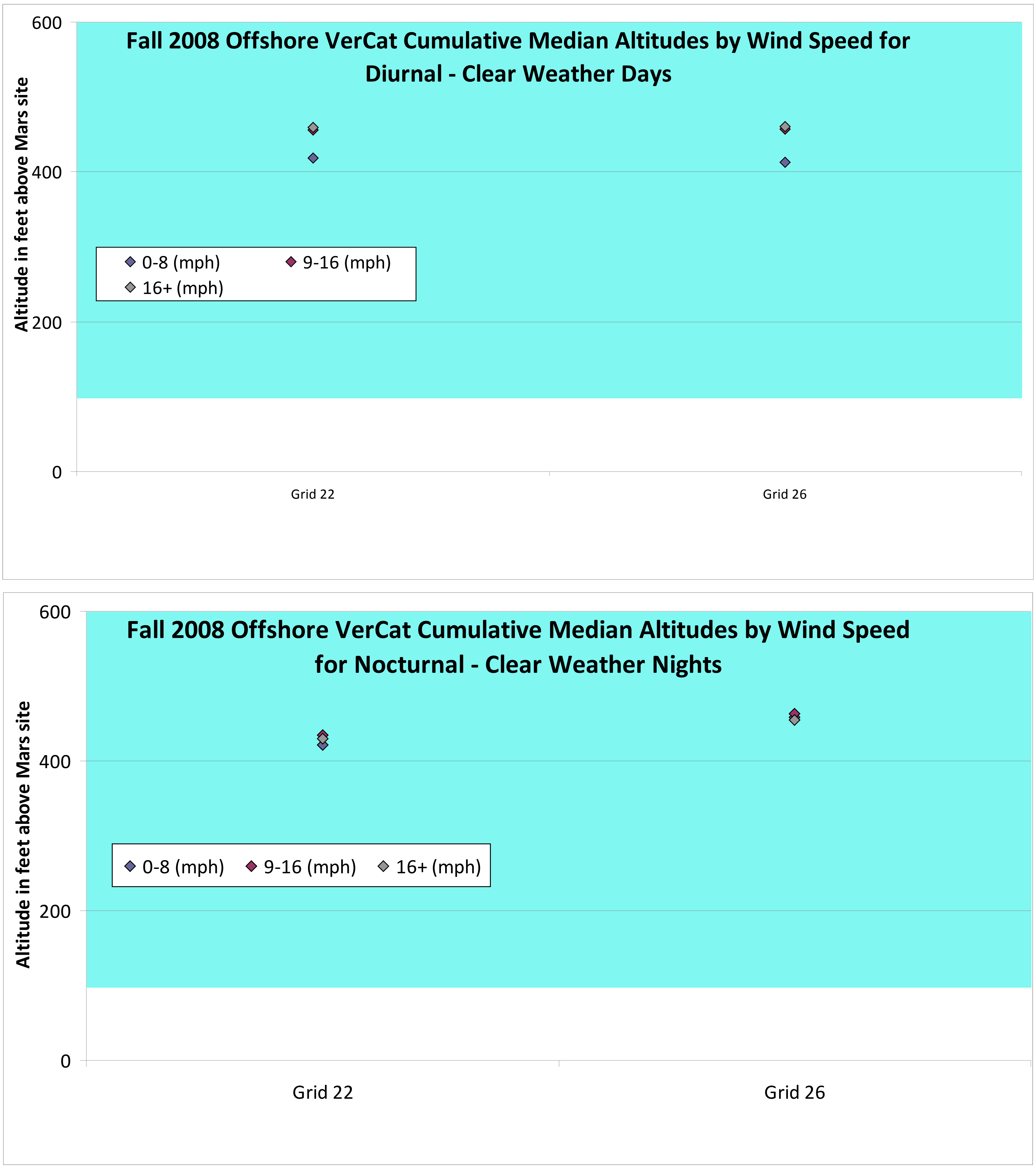
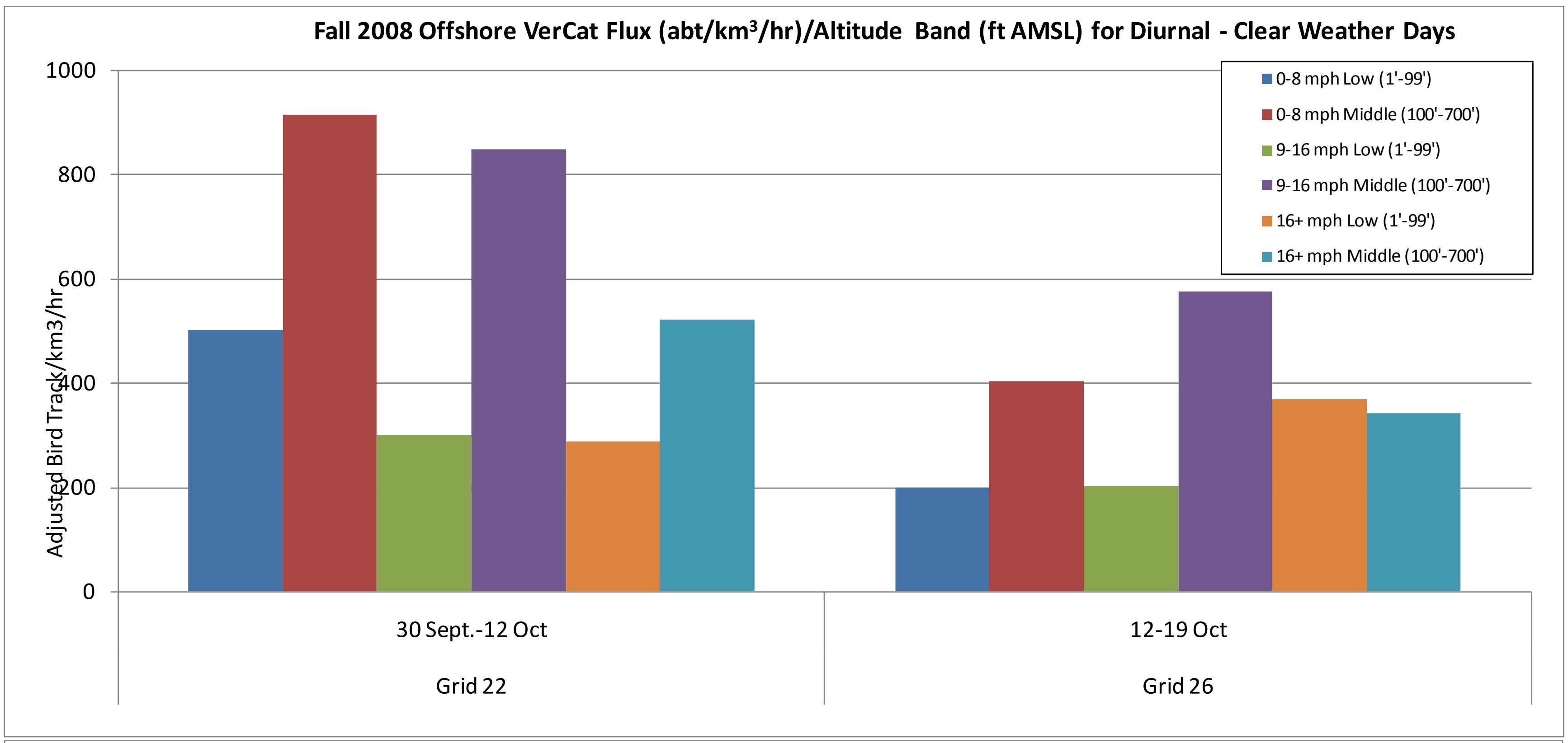


Figure 5-24. Fall 2008 Offshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).



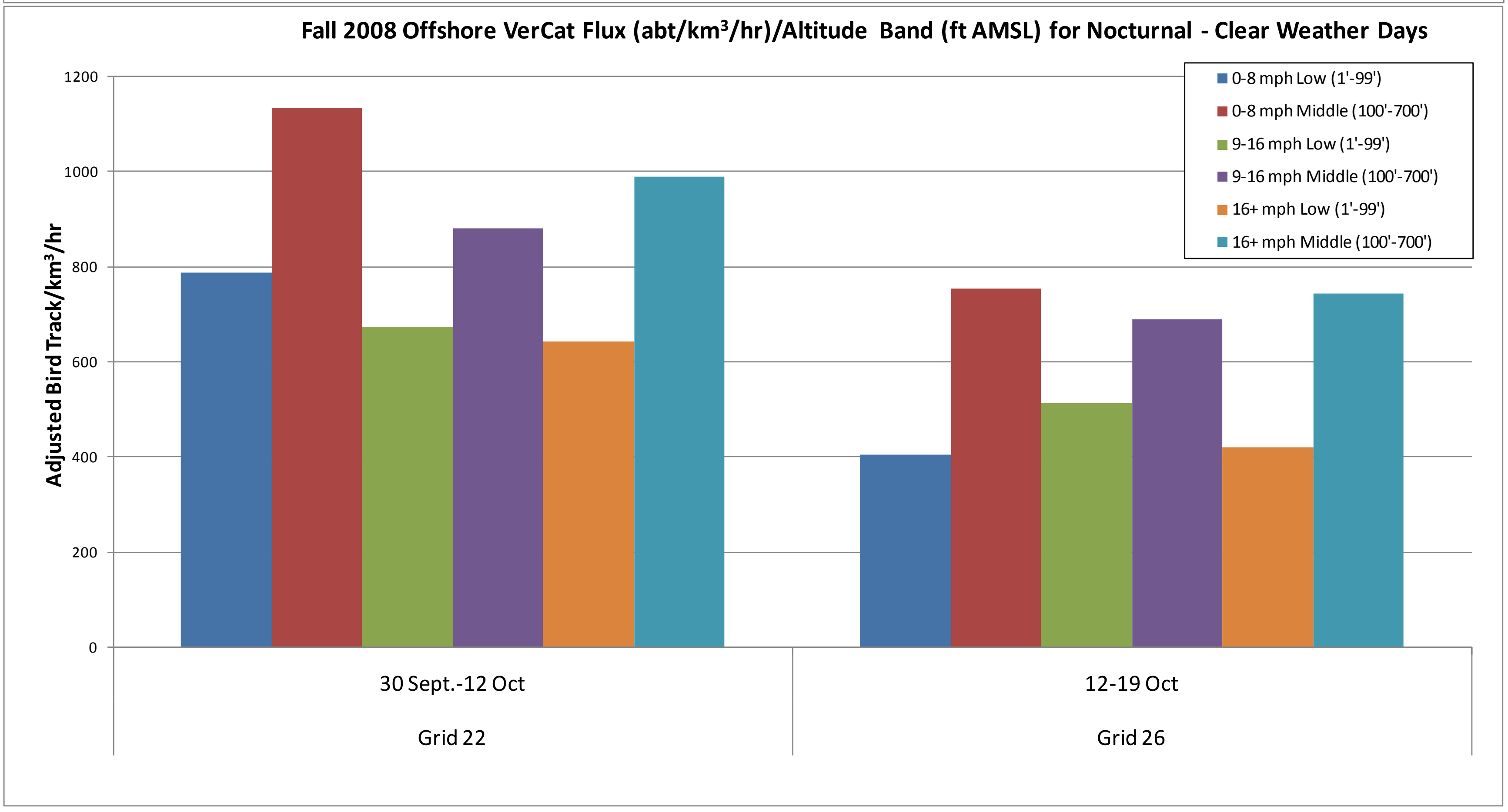
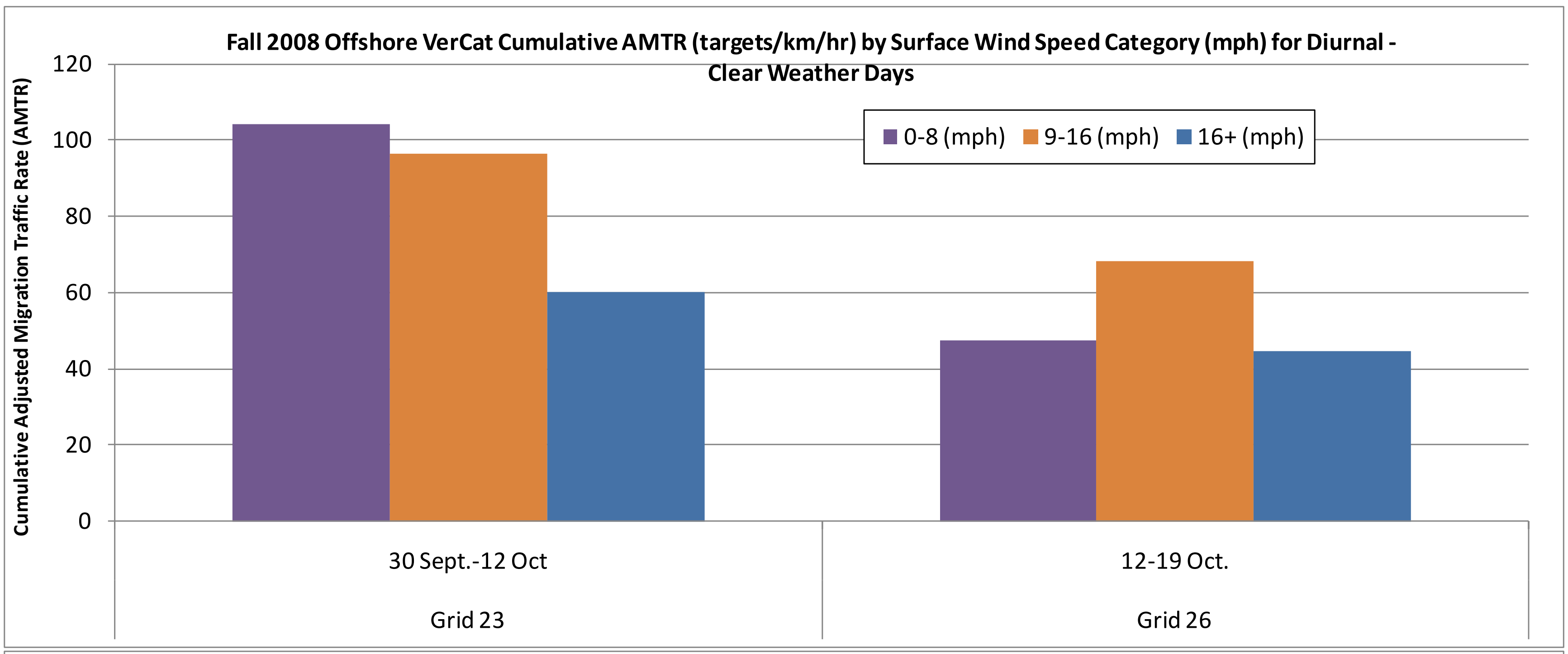


Figure 5-25. Fall 2008 Offshore VerCat Cumulative Flux.



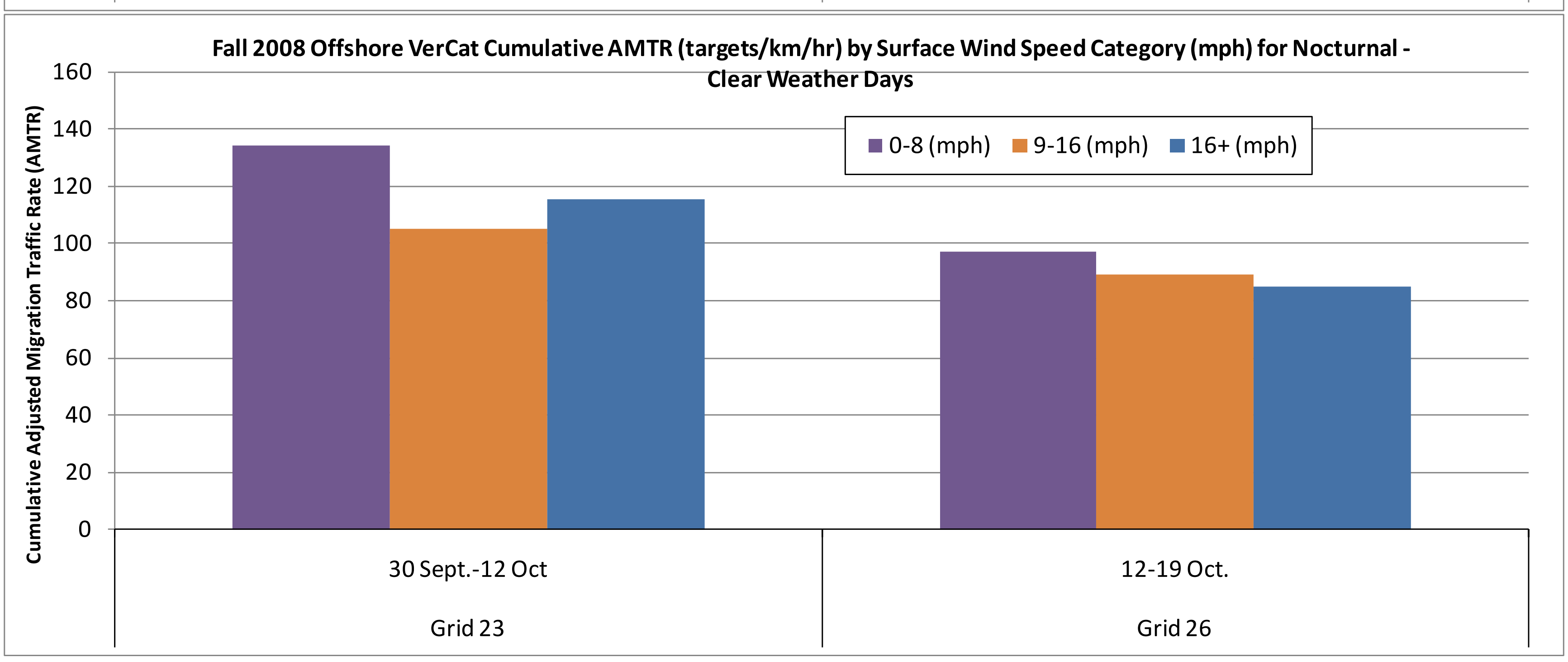
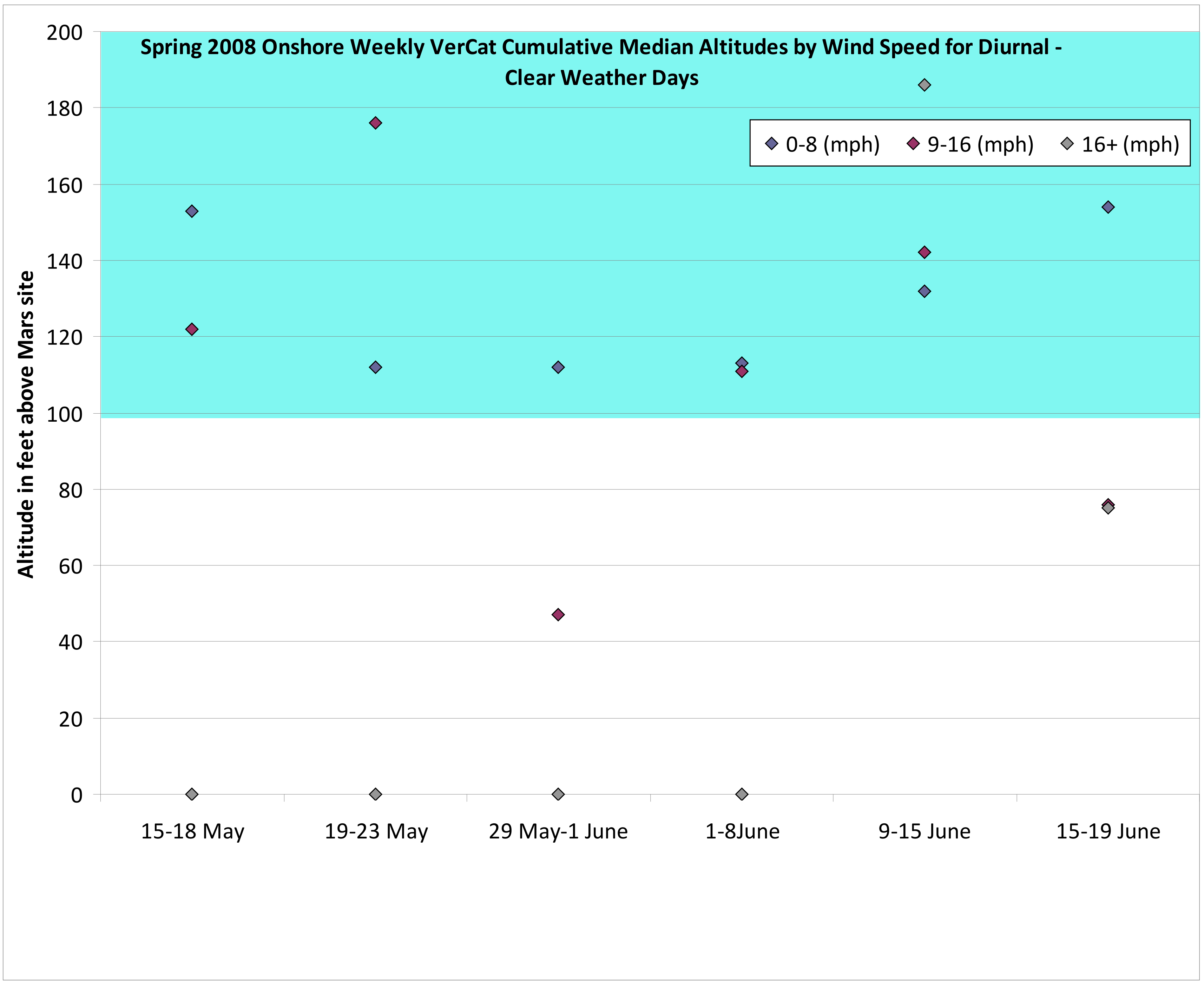


Figure 5-26. Fall 2008 Offshore Cumulative AMTR.



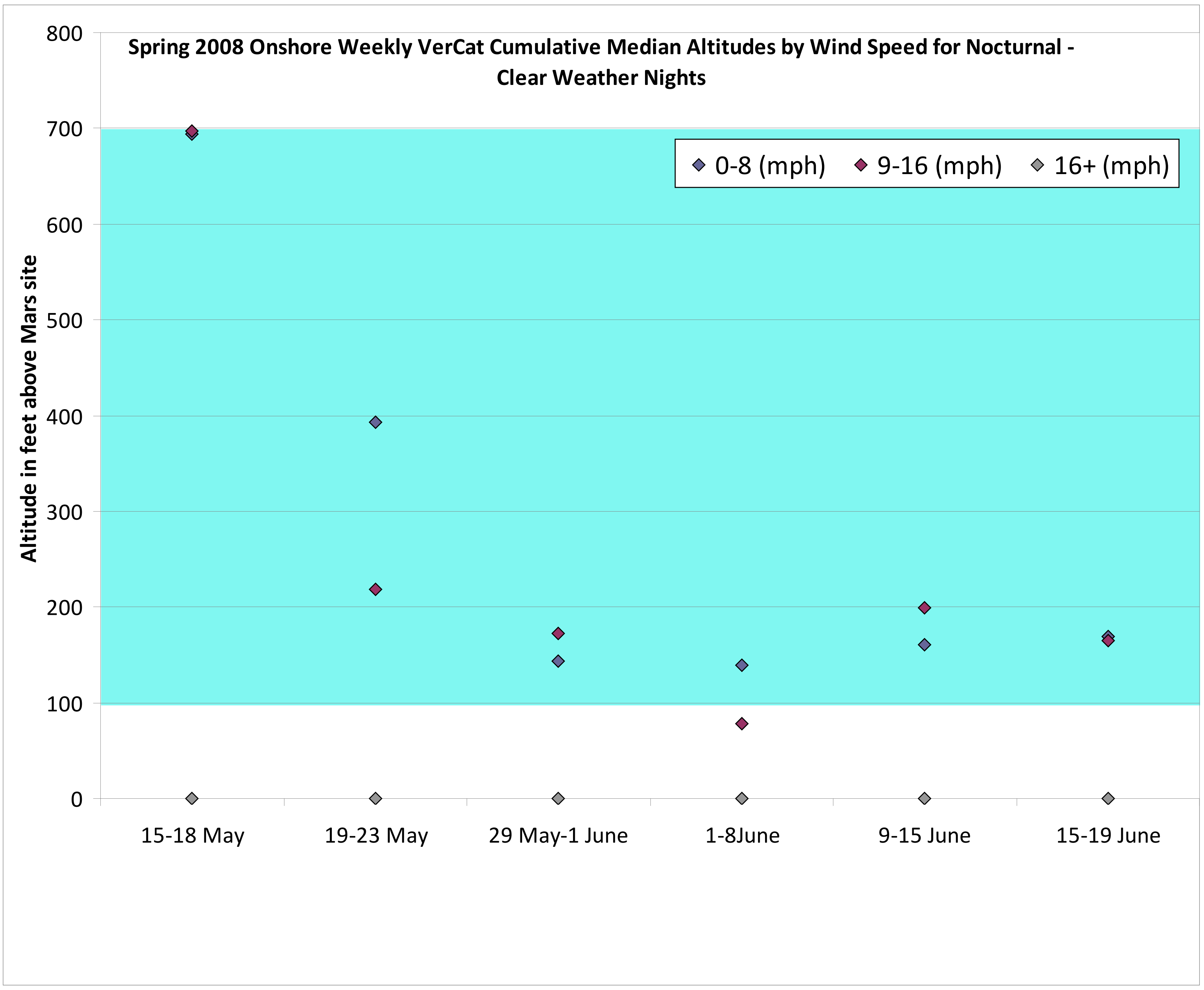


Figure 5-27. Spring 2008 Onshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).

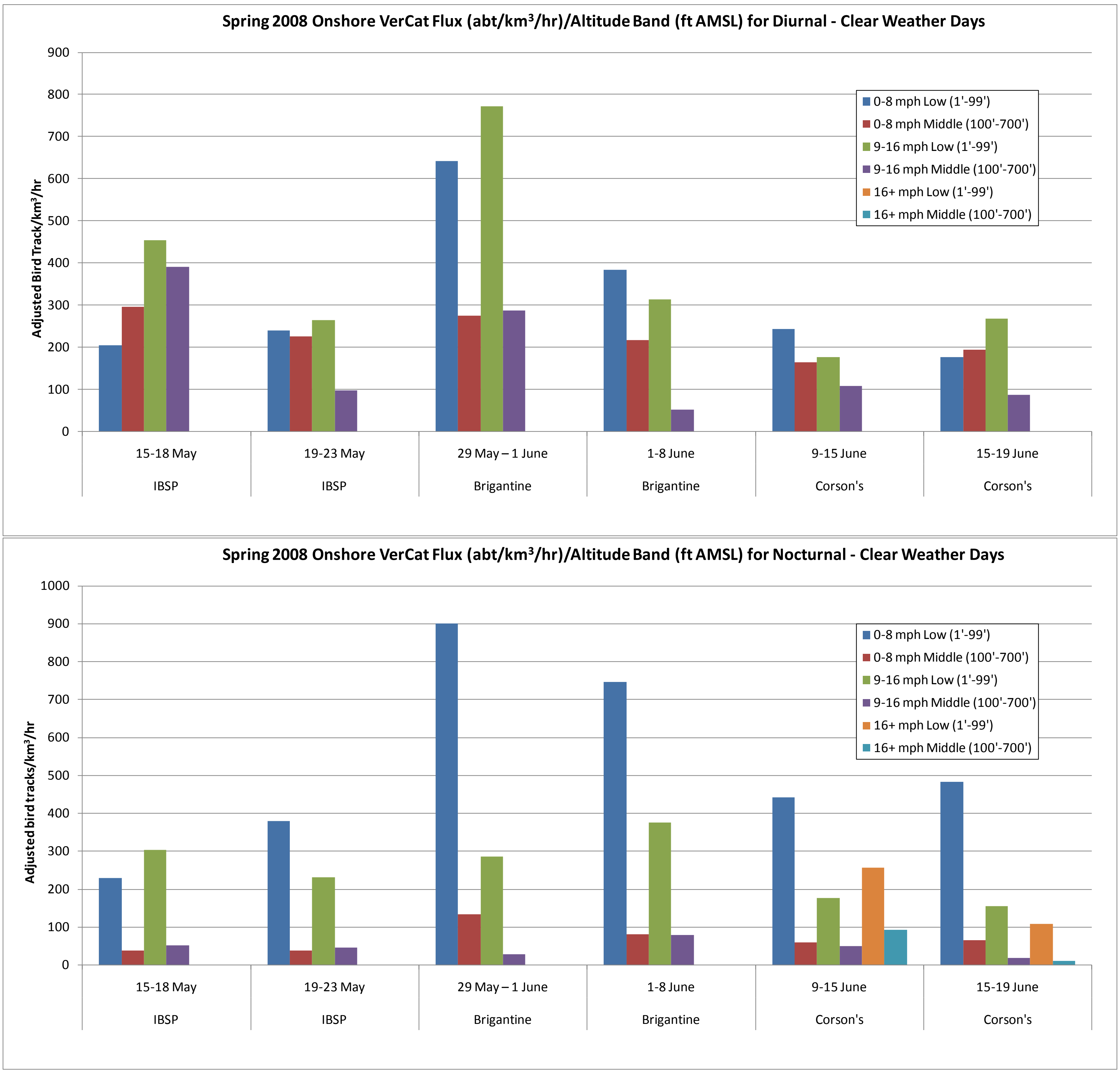
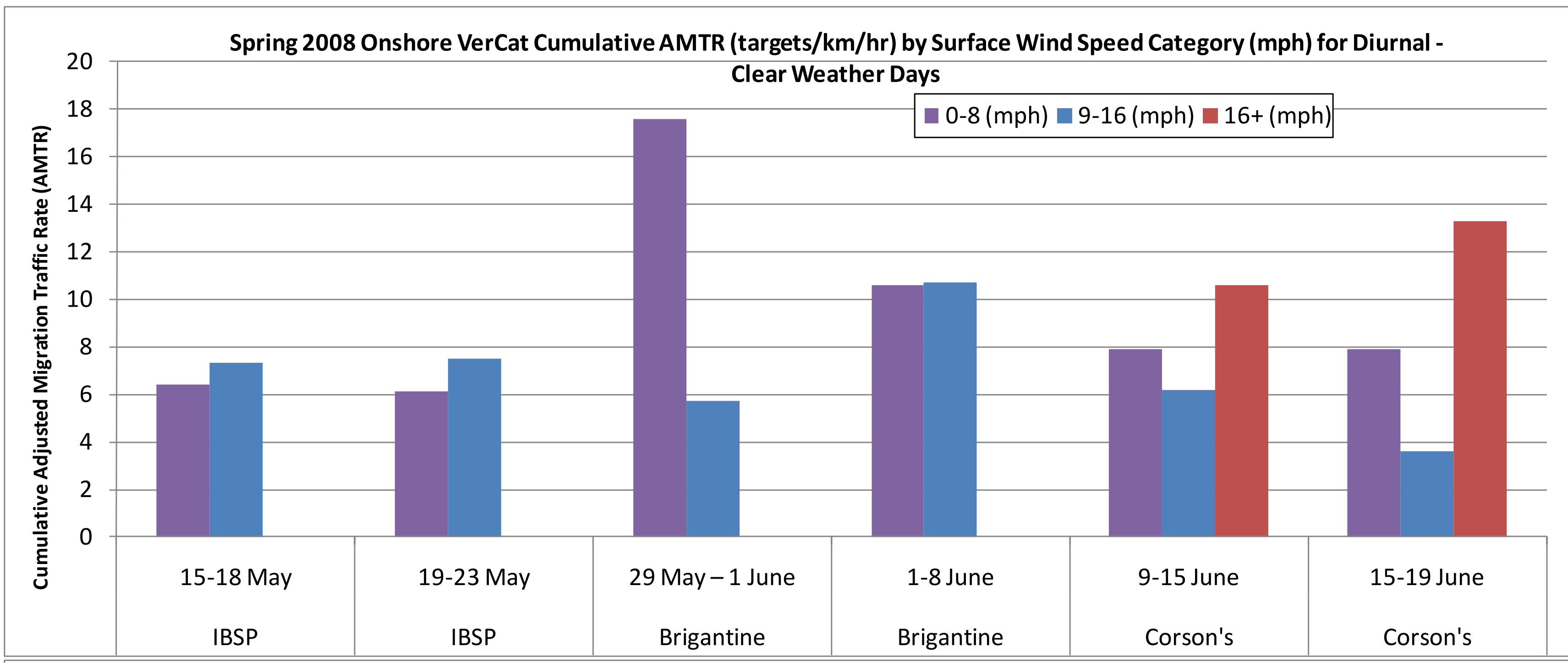


Figure 5-28. Spring 2008 Onshore VerCat Cumulative Flux.



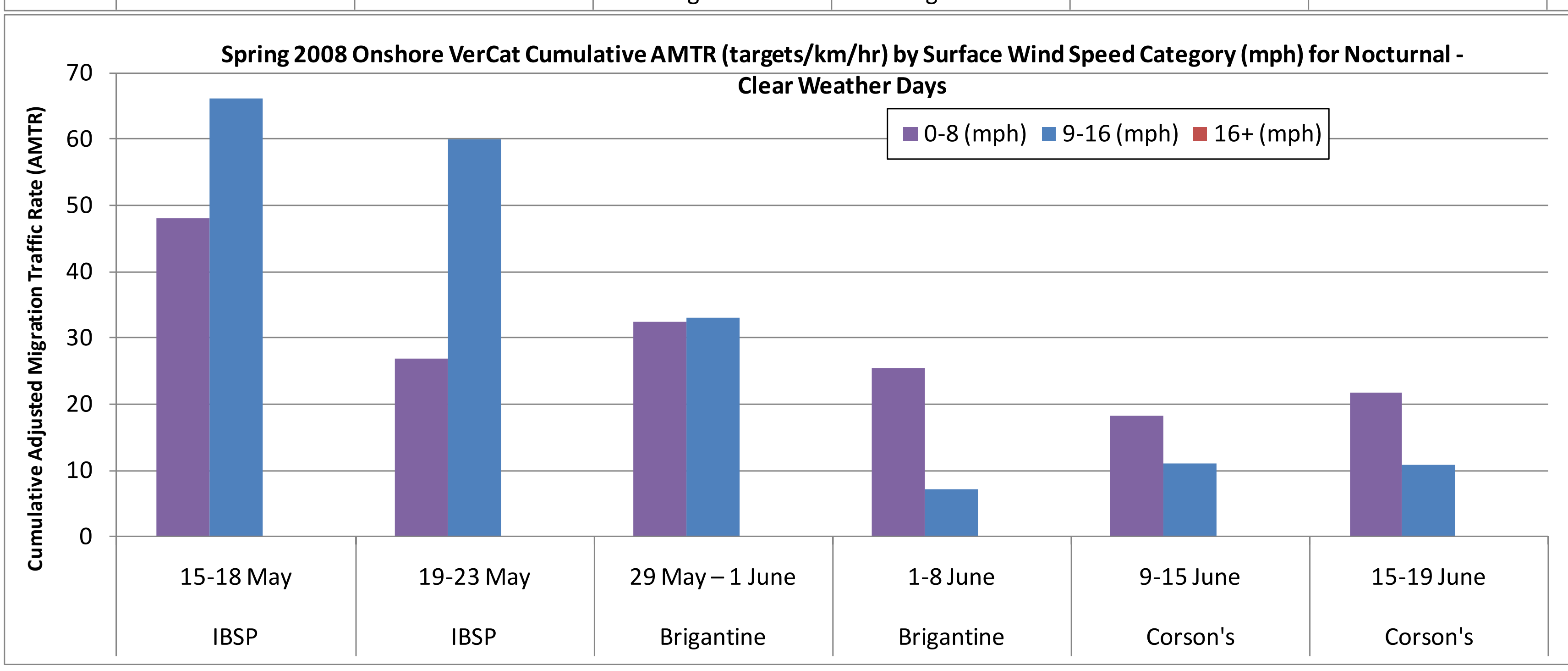


Figure 5-29. Spring 2008 Onshore Cumulative AMTR.

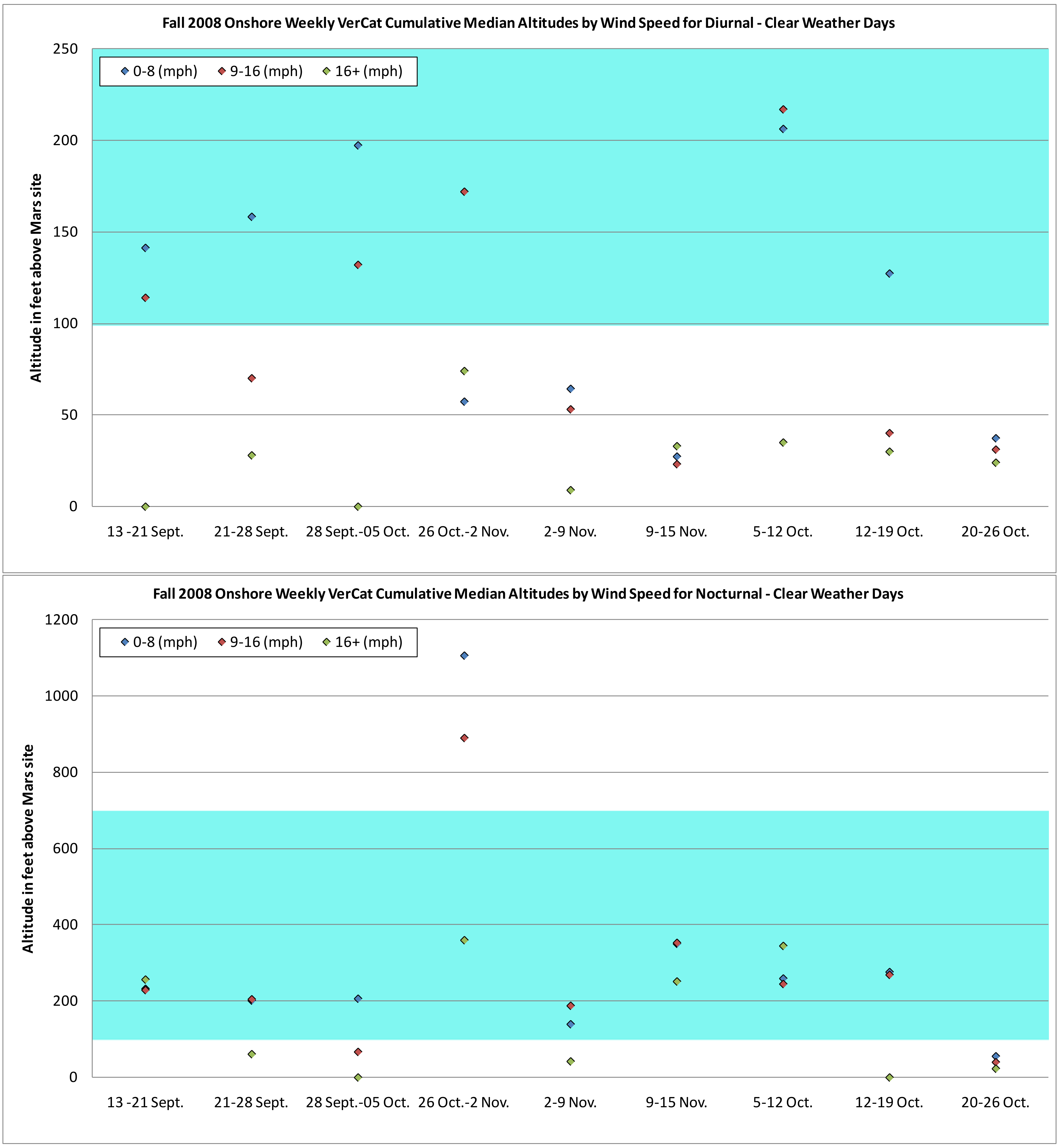


Figure 5-30. Fall 2008 Onshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).

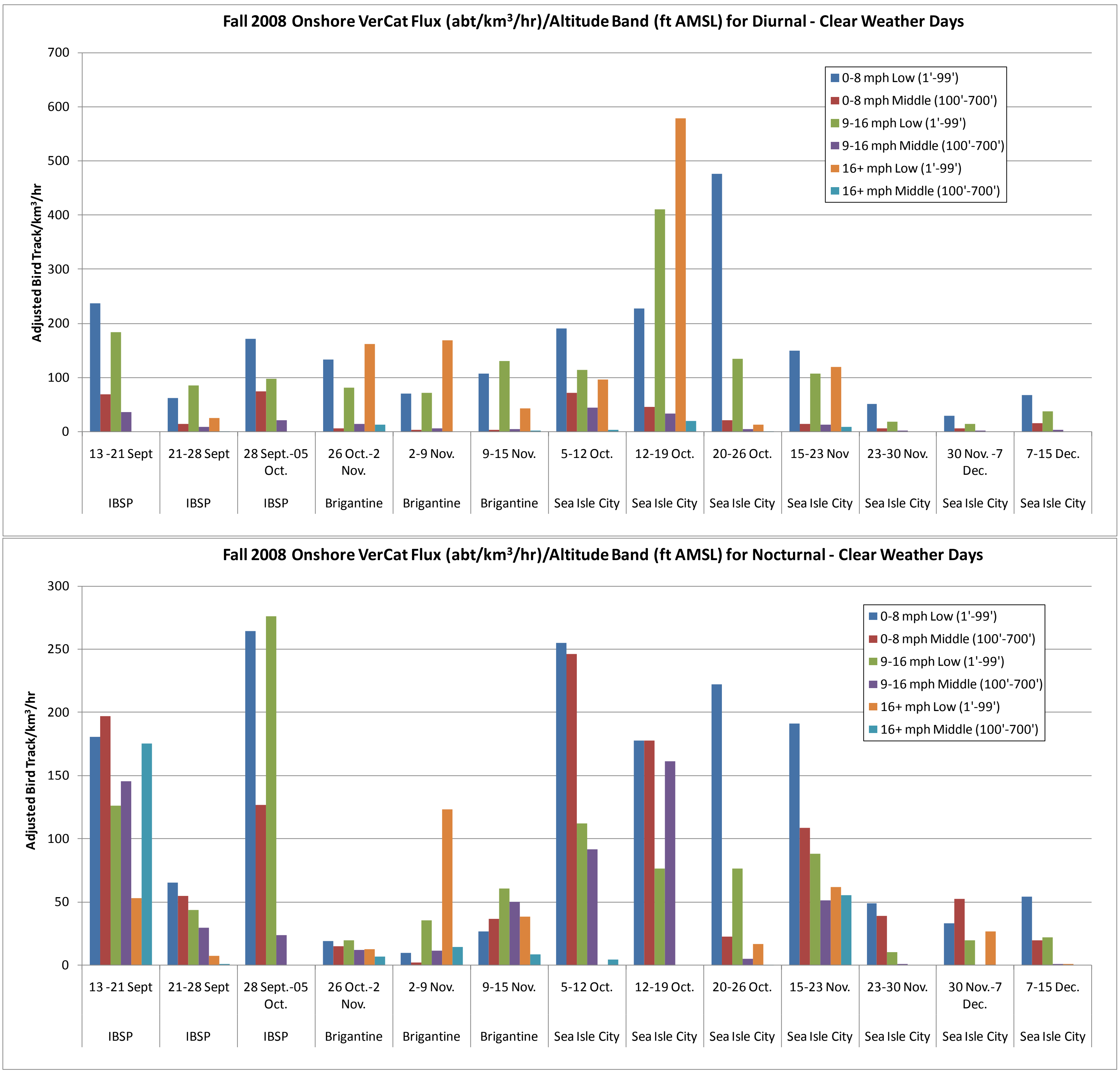
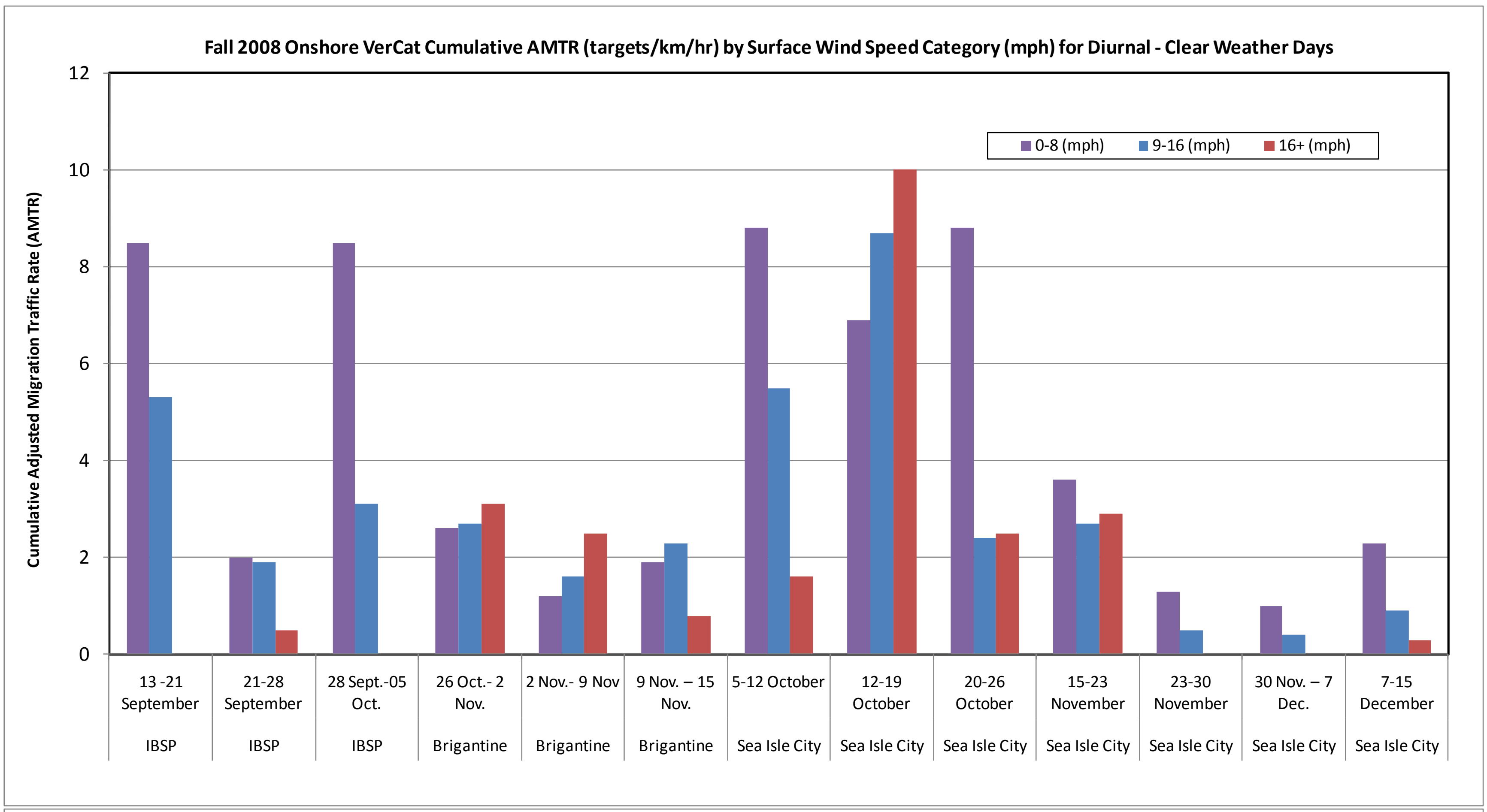


Figure 5-31. Fall 2008 Onshore VerCat Cumulative Flux.



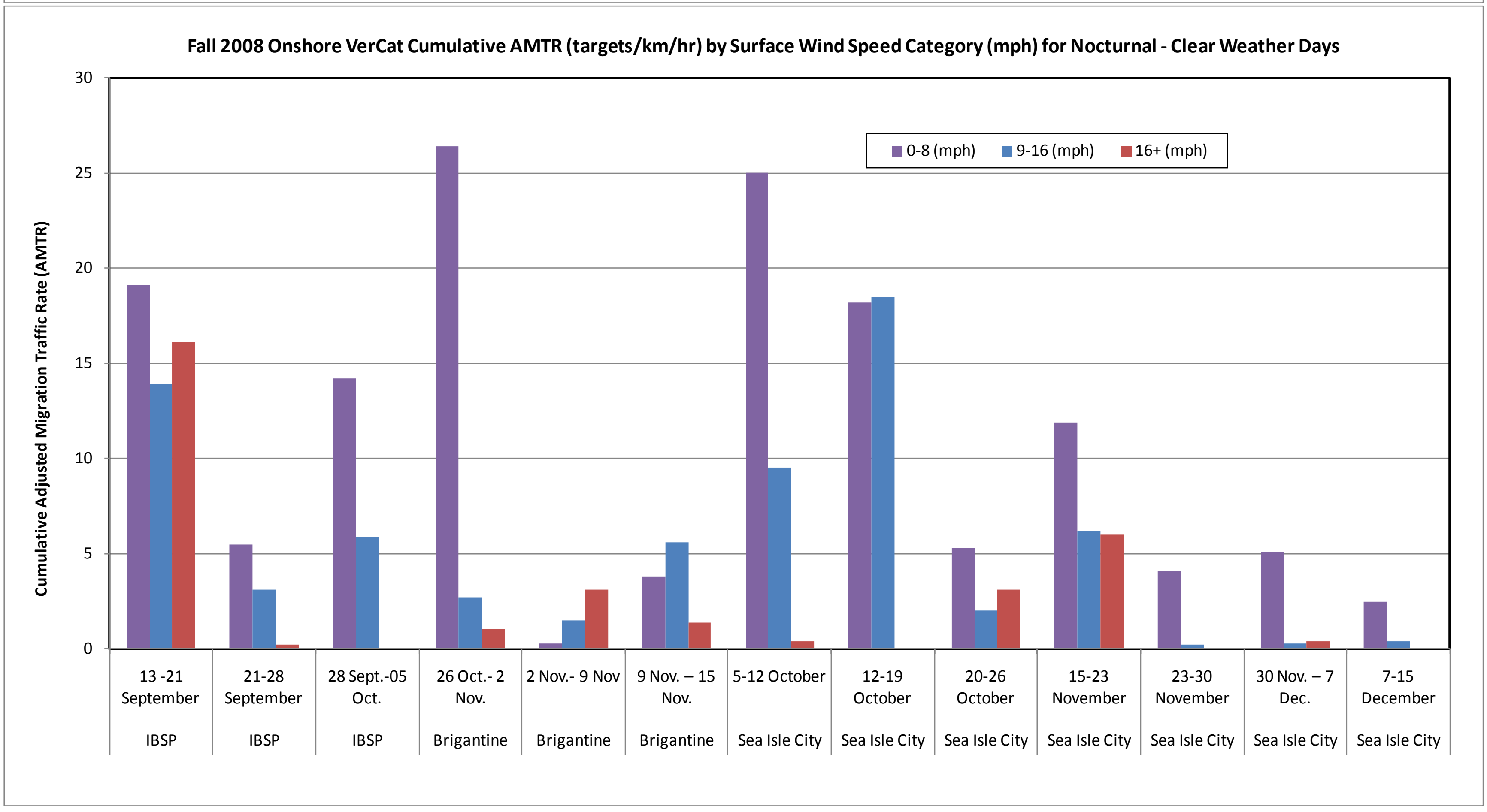


Figure 5-32. Fall 2008 Onshore Cumulative AMTR.

Cumulative weekly diurnal flux values were greater within the low altitude band than within the middle (RSZ) band (**Figure 5-34**). Cumulative weekly nocturnal flux values varied at sites and throughout the fall season. Cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ) altitude band at IBSP from 29 March - 05 April, at Brigantine from 12-19 April 2009, and at SIC on 06-10 May 2009. Cumulative weekly nocturnal flux values within the low and middle altitude bands were similar during the other sampling dates.

Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal AMTRs were less than 80 abt/kph at all of the onshore sites (**Figure 5-35**). At each onshore site, peak cumulative AMTR occurred at night (IBSP: 17.4 abt/kph from 29 March – 05 April 2009; BB: 28.6 abt/kph from 26 April - 03 May 2009; SIC: 76.0 abt/kph from 06-10 May 2009.

The dominant flux movement was from the south and southwest to the north and northeast. Some of these movements occurred even though winds were unfavorable (from north to south) for northerly movement. One small scale reverse migration was recorded.

5.6.2.4 Fall 2009

The majority of cumulative weekly diurnal and nocturnal median altitude quartiles were within the middle (RSZ) band (**Figure 5-36**). Most all of the cumulative weekly diurnal and nocturnal altitude quartiles were greater within the low altitude band than the middle (RSZ) band (**Figure 5-37**). The high flux value for the 16+ mph surface wind speed category from 08-16 November 2009 was not expected based on the steady trend in cumulative weekly diurnal flux values prior to this date. The data was replayed through the MARS® software analysis system and examined for possible contaminants that may not have been processed correctly by the radar filters. The examination revealed a large group of birds were present during the time when the surface wind speed was above 16+ mph. The duration of the 16+ mph surface wind was only 22 min. The short time duration was responsible for the high diurnal and nocturnal cumulative flux values in the 16+ surface wind speed category.

Cumulative diurnal AMTR values were <20 abt/kph during the majority of the study. The only exception was during the week of 08-16 November at SIC when the AMTR increased dramatically but only in the 16+ mph wind category (**Figure 5-38**). As previously discussed above, this is an accurate representation of the activity that occurred in the 16+ surface wind speed category. Except for peak cumulative nocturnal migration period from 05-11 October 2009, the cumulative weekly nocturnal AMTR was <50 abt/kph.

Overall, as expected during fall migration, the dominant flux direction during most weeks were from the north and northeast to the south and southwest. Many of these southerly movements occurred despite frequent unfavorable winds from the south to the north.

5.6.3 Summary

5.6.3.1 Offshore Spring 2008

Results for the spring 2008 nearshore and offshore radar sample grids were:

- Most of the offshore cumulative diurnal and nocturnal median altitude quartiles were within the potential RSZ band (100-700 ft AMSL).
- VerCat diurnal and nocturnal flux values at nearshore stations early in the season were concentrated in the low-altitude (1-99 ft AMSL) band. By mid-spring diurnal flux values at nearshore sample grids were similar in the low and middle altitude bands. Cumulative nocturnal flux values within the middle altitude band increased over both the nearshore and offshore grids and became greater than low altitude flux values by the end of the nearshore and offshore sampling periods.
- Diurnal AMTR increased over the nearshore grids while nocturnal AMTR remained constant over the offshore grids, diurnal AMTR steadily increased; cumulative nocturnal AMTR decreased from

Grid 26 to Grid 23 before increasing over Grid 17. Diurnal AMTR was greater than nocturnal AMTR over most grids.
- Peak diurnal AMTRs occurred offshore on Grid 26 (137.0 adt/kph) from 24-30 April and on Grid 17 (113.0 abt/kph) from 07-11 May 2008. Peak nocturnal AMTR occurred 30 April - 07 May (320.3 abt/kph) and from 07-11 May 2008 (333.5 abt/kph) on Grid 26 and Grid 17, respectively.
- The dominant diurnal and nocturnal nearshore and offshore flux directions during most of the survey weeks was from the south and southwest to the north and northeast.

5.6.3.2 Offshore Fall 2008

The fall 2008 radar surveys were limited to two offshore sampling grids in the southern section of the Study Area. The data are limited and insufficient to make any conclusions. The results of the fall study were:

- All cumulative diurnal and nocturnal median altitudes were within the RSZ (100-700 ft AMSL).
- The VerCat cumulative diurnal and nocturnal flux was concentrated in the mid-altitude (RSZ) band.
- Cumulative diurnal and nocturnal AMTR was greater over Grid 22 than Grid 25. The cumulative nocturnal AMTR was greater than the diurnal AMTR over both sample grids.
- Peak diurnal AMTR was 104.3 abt/kph and peak nocturnal AMTR was 134.3 abt/kph and occurred from 30 September through 12 October 2008.
- Directional flux occurred only from 20 September to 12 October 2008. As expected the directional movement was to the south.

5.6.3.3 Offshore Spring 2009

The survey effort was limited to three days and therefore no general trends were identified from the survey results. The data presented for spring 2009 may be used as a qualitative measure of the avian activity for the days that the data were collected.

5.6.3.4 Onshore Spring 2008

The results of the spring/early summer onshore radar survey were:

- The majority of weekly cumulative diurnal and nocturnal median altitude quartiles were within the potential RSZ (middle altitude band: 100-700 ft AMSL).
- At IBSP and Corson's Inlet low altitude and middle altitude (RSZ) band flux values were generally similar. At Brigantine, cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ) altitude band. This difference may be the result of the different migratory species passing the site or the behavior of resident species at the site. The cumulative nocturnal flux values were greater within the low altitude band than with the middle (RSZ) altitude band at all onshore sites.
- The cumulative diurnal AMTR values were similar between the onshore sites. Nocturnal AMTR values were greater than cumulative diurnal AMTRs indicating that some nocturnal migration was probably still in progress from mid-May into mid-June.
- The cumulative peak diurnal AMTR (17.6 abt/kph) occurred at Brigantine from 29 May-01 June 2008. The cumulative nocturnal AMTR decreased from IBSP to SIC indicating a decline in nocturnal migration. The cumulative peak nocturnal AMTR (66.2 abt/kph) was at IBSP from 15-18 May 2008.Peak AMTR occurred from 15-23 May 2009 (60-66 abt/kph).
- The cumulative diurnal AMTR for all survey sites ranged from 3.6 to 17.6 abt/kph; the cumulative nocturnal AMTR ranged from 7.1-66.2 abt/kph. Most weekly nocturnal AMTRs were greater than weekly diurnal AMTRs.
- Overall, as expected during spring migration, the dominant directions of flux were from the south and southwest to the north and/or northeast, respectively.

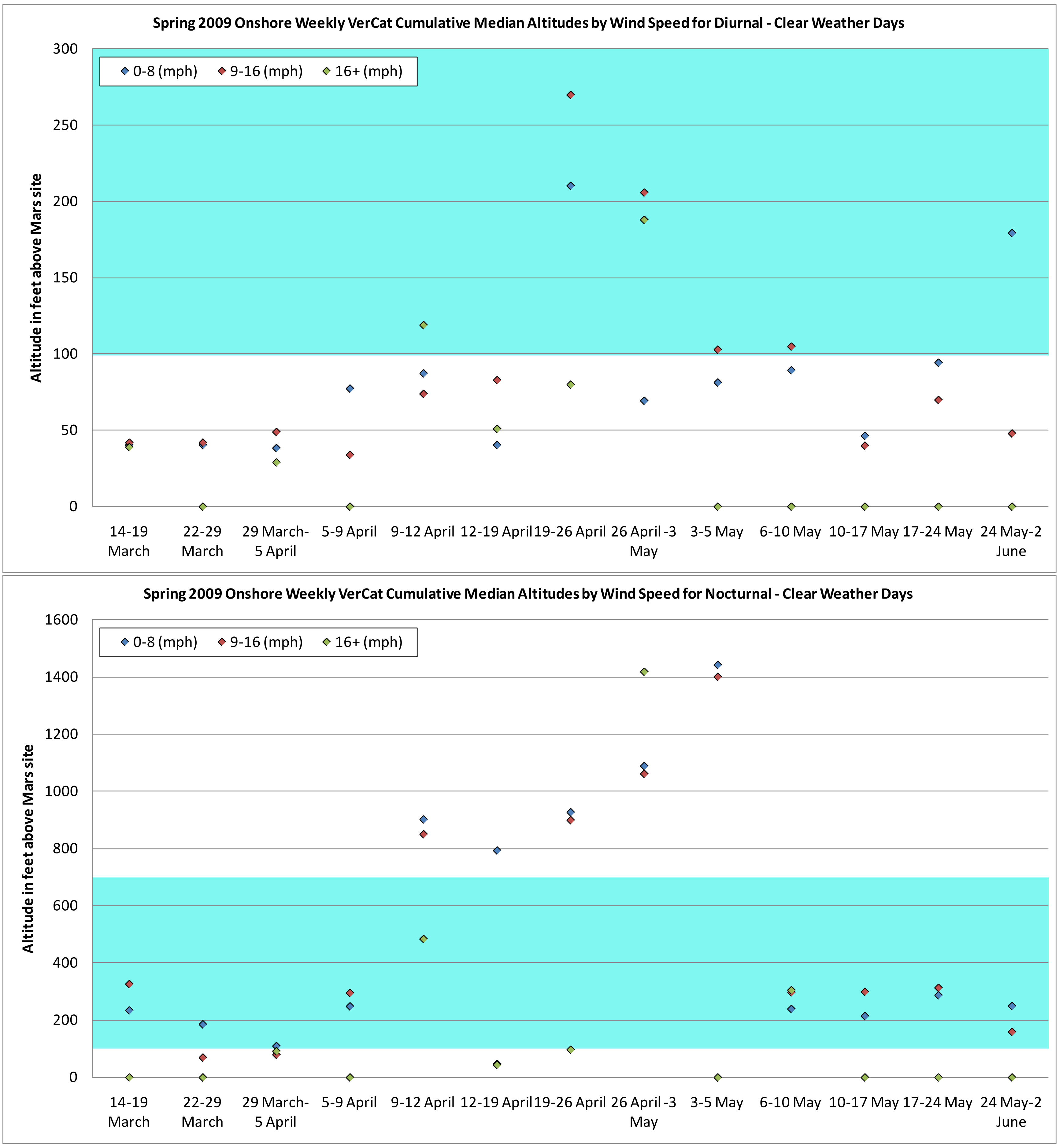
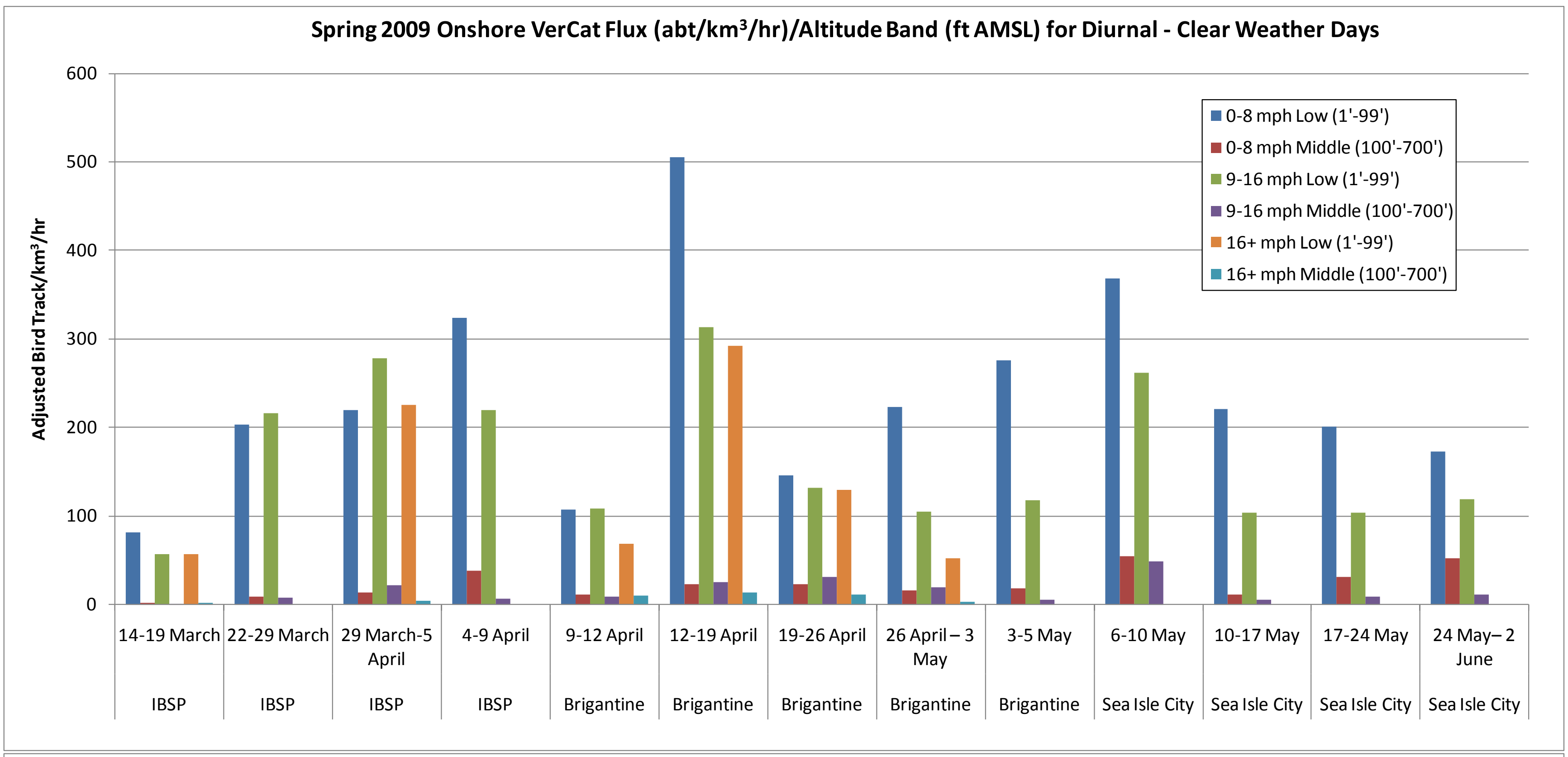


Figure 5-33. Spring 2009 Onshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).



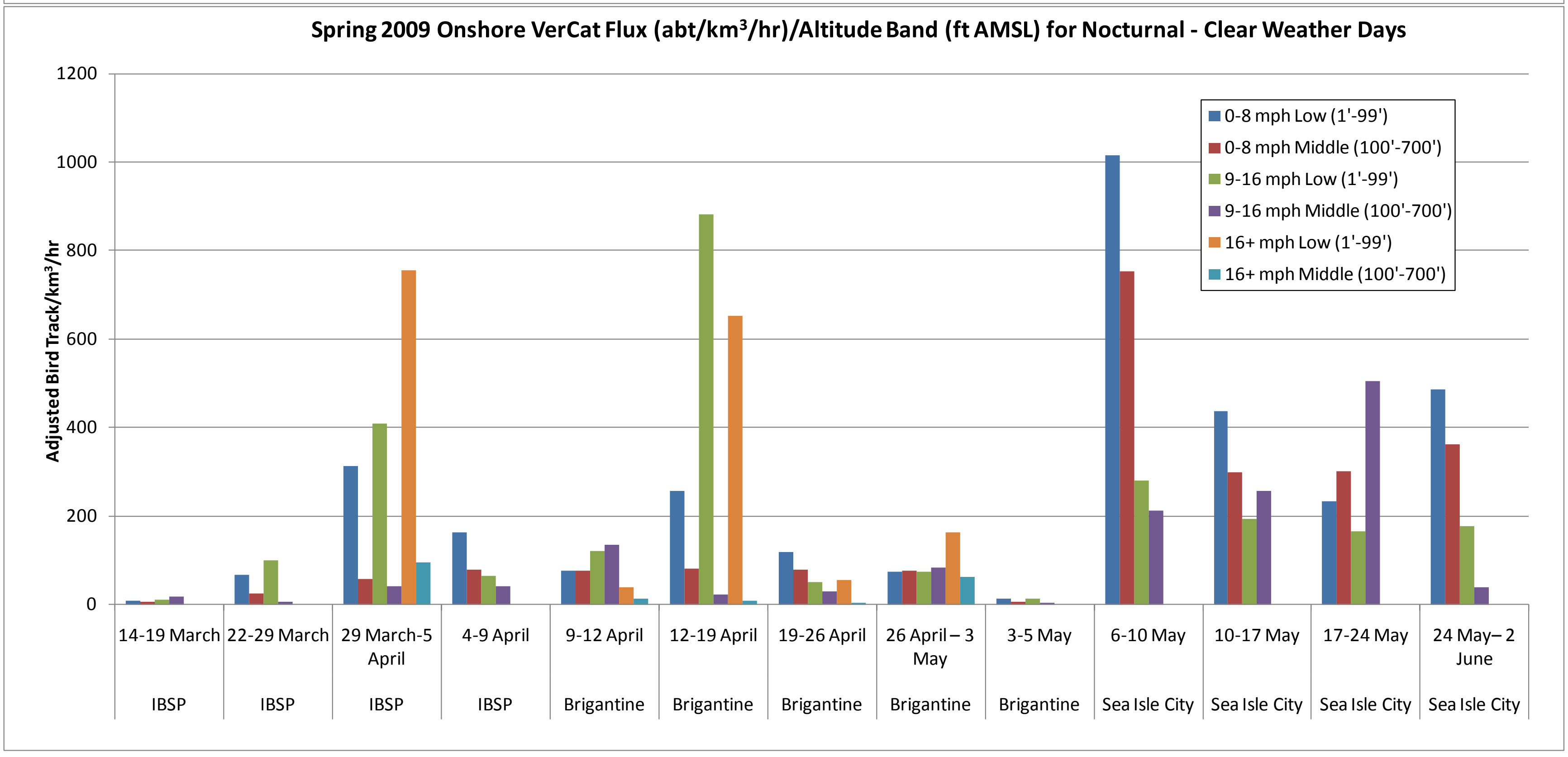
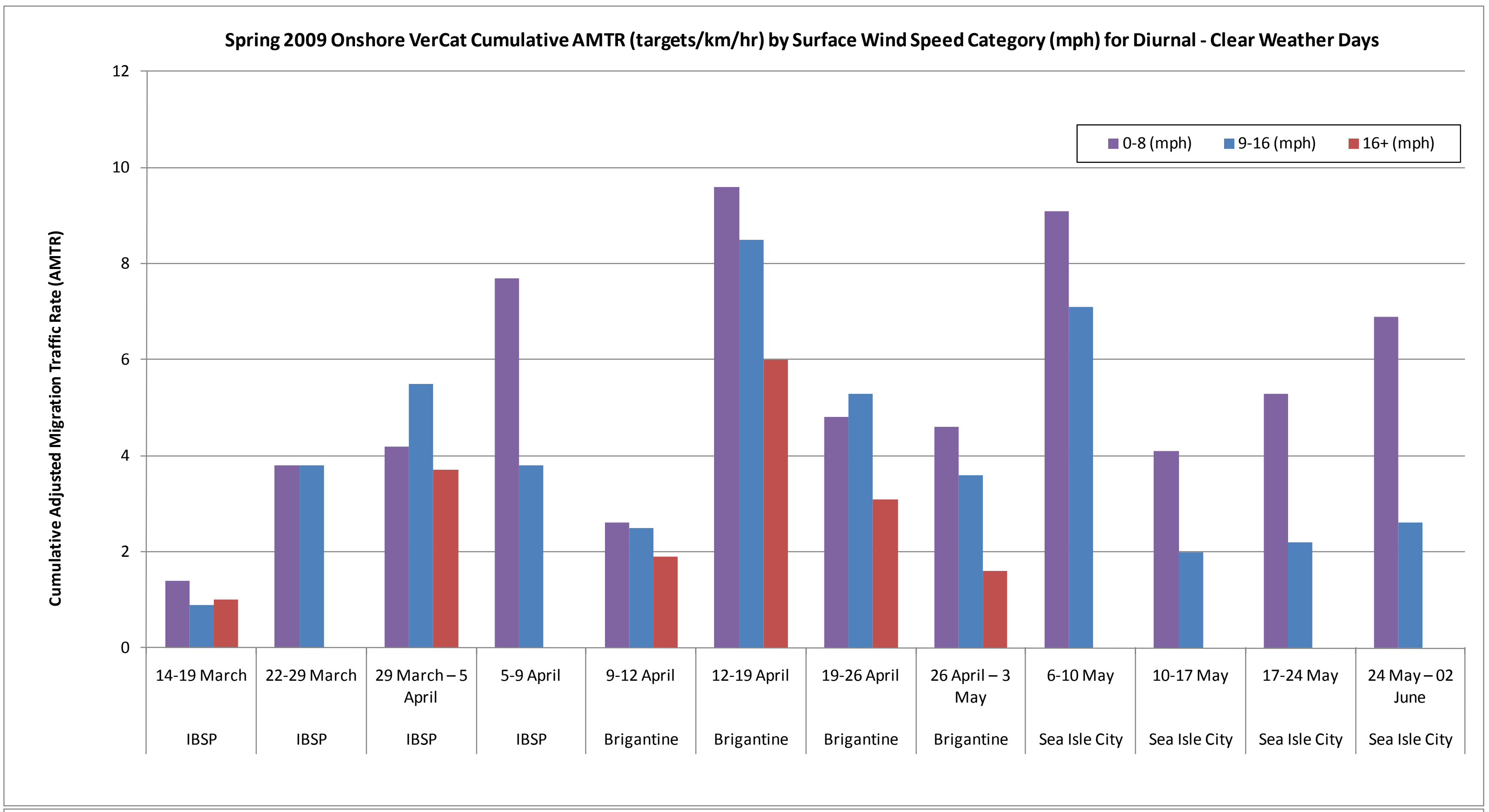


Figure 5-34. Spring 2009 Onshore VerCat Cumulative Flux.



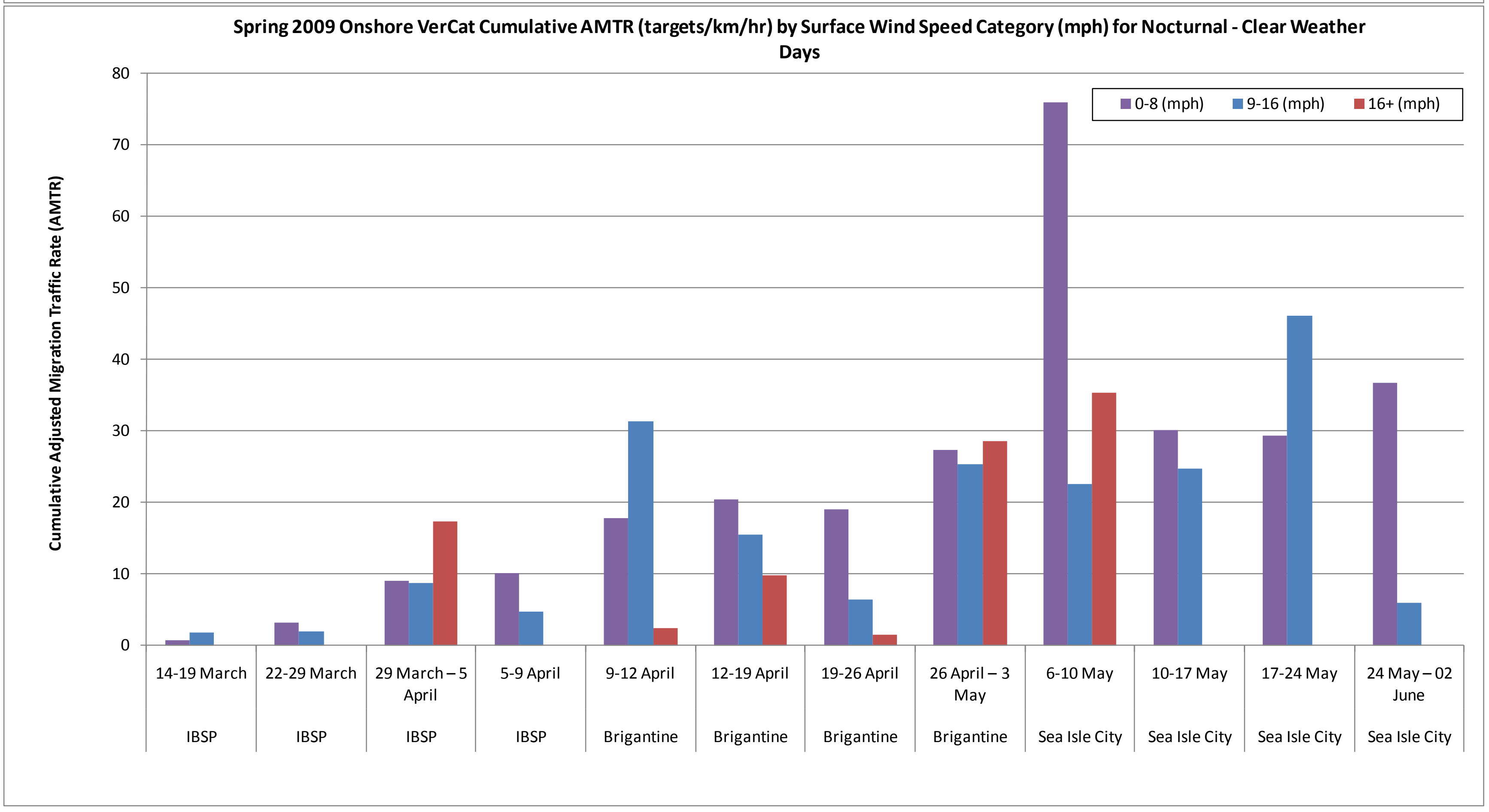
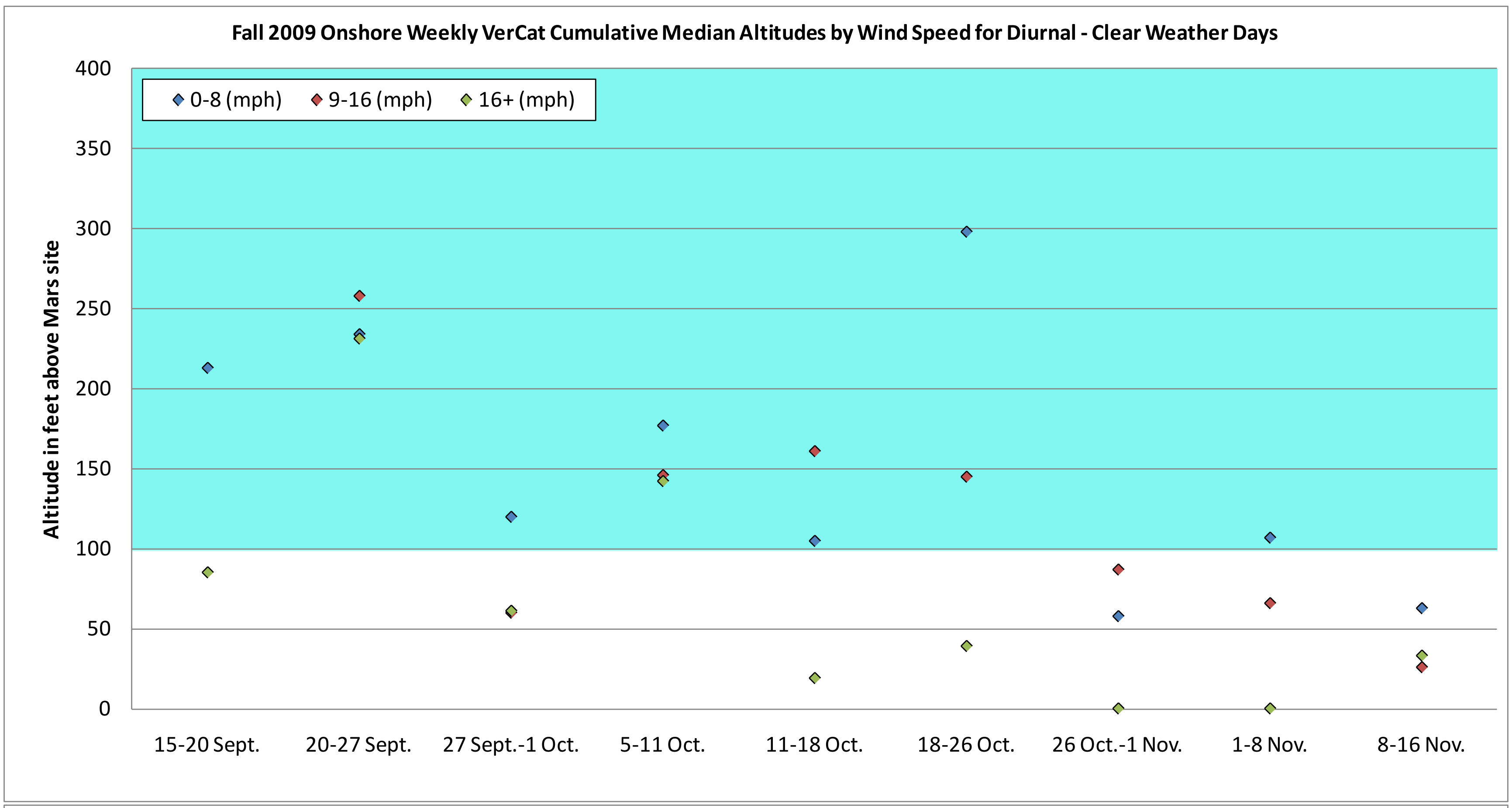


Figure 5-35. Spring 2009 Onshore Cumulative AMTR.



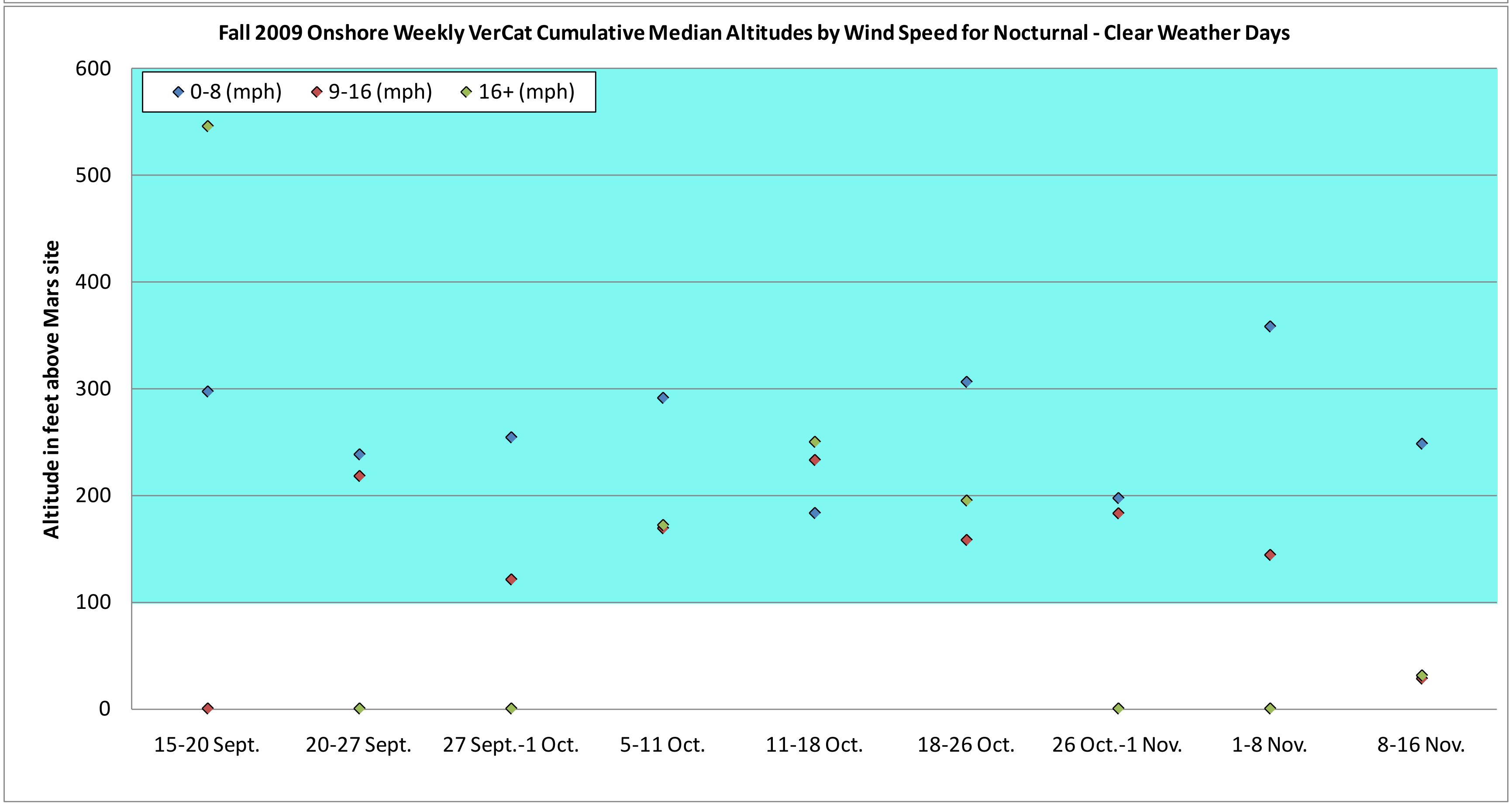


Figure 5-36. Fall 2009 Onshore Cumulative Median Altitude Quartiles (blue band is the potential RSZ).

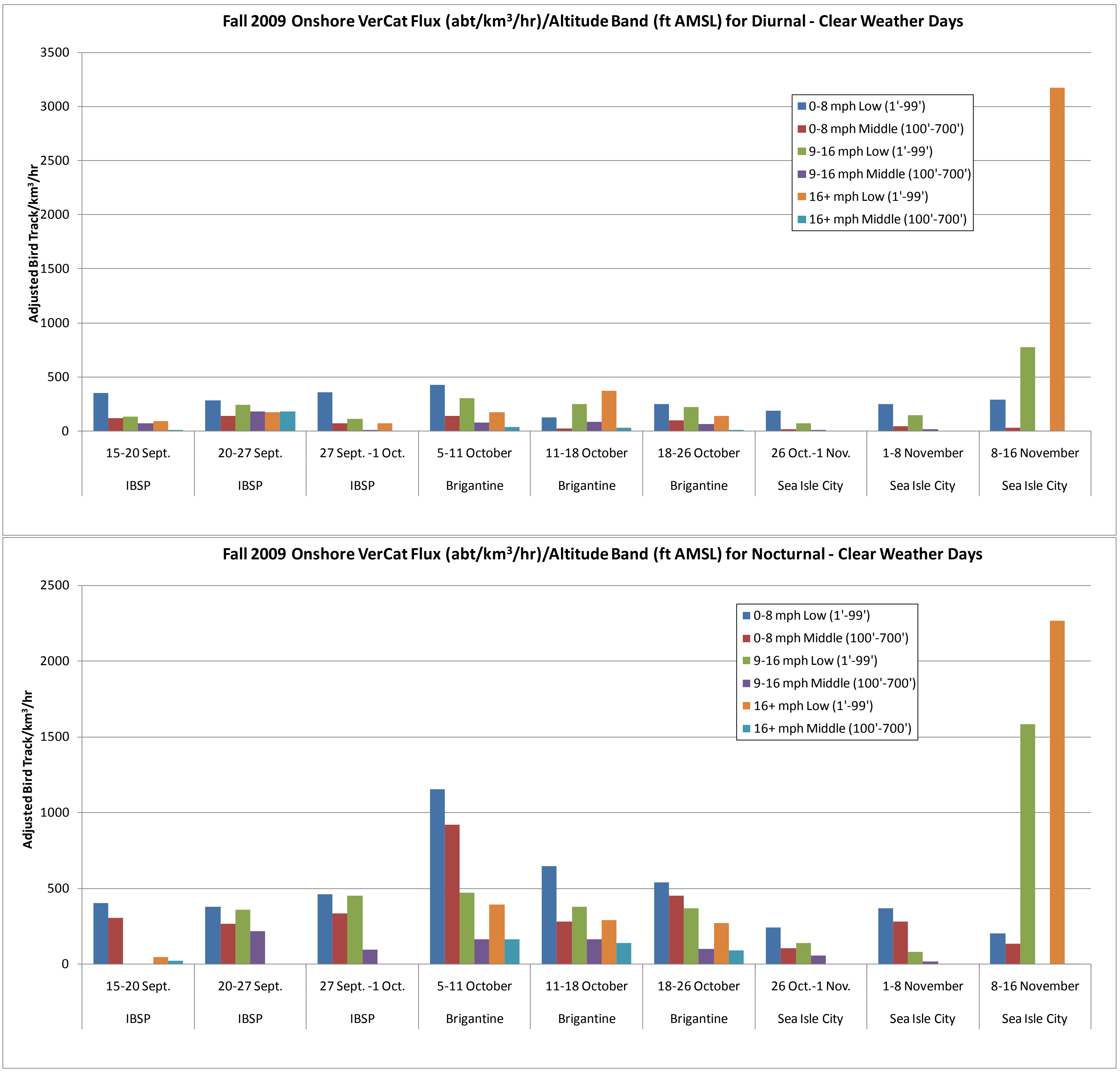


Figure 5-37. Fall 2009 Onshore VerCat Cumulative Flux.

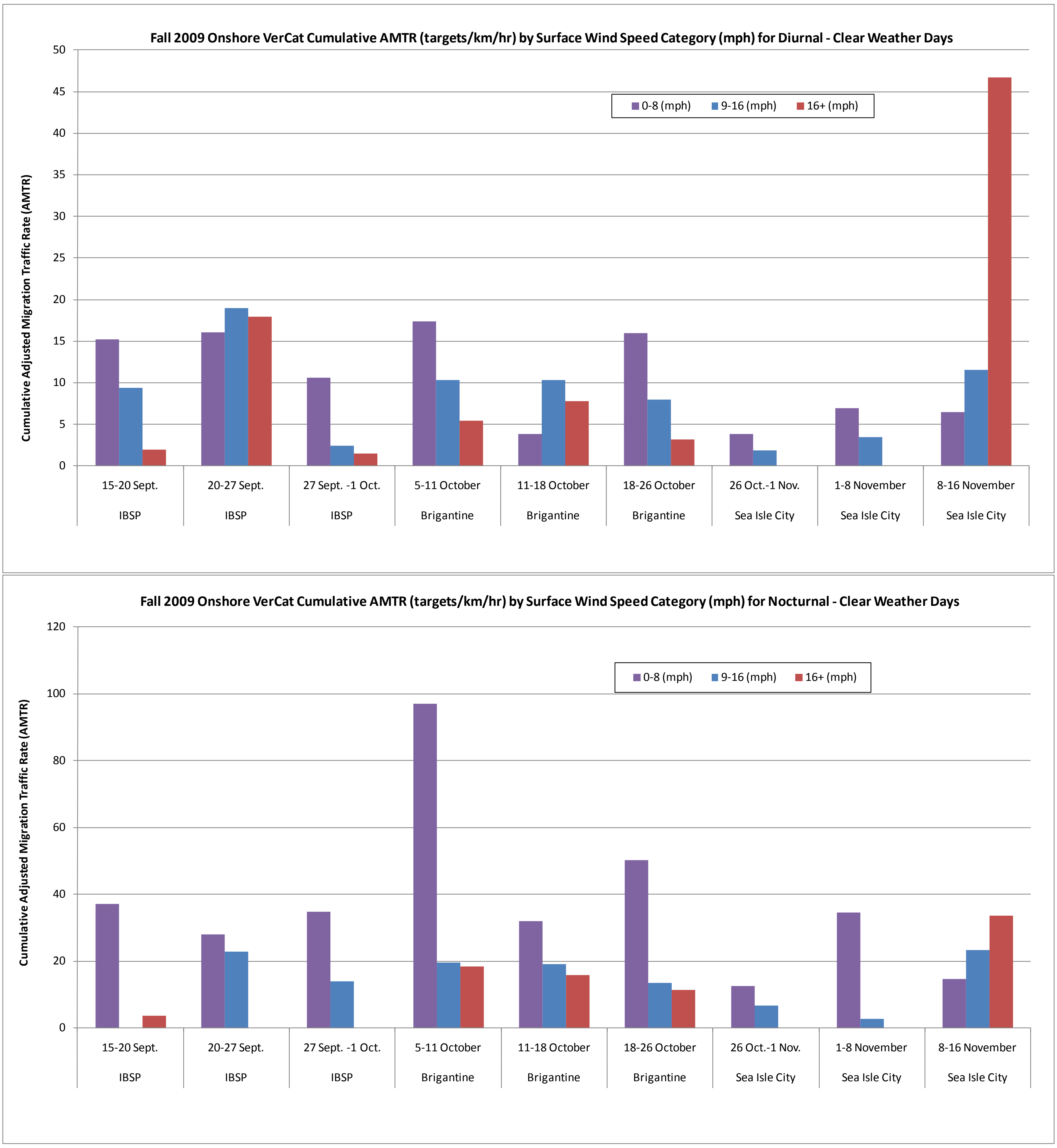


Figure 5-38. Fall 2009 Onshore Cumulative AMTR.

5.6.3.5 Onshore Fall 2008

The results of the fall/early winter 2008 onshore radar surveys were:

- Most of the cumulative median diurnal altitude quartiles were within the middle (RSZ) altitude band at IBSP in early fall 2008. In contrast, the majority of the cumulative median altitude quartiles were within the low altitude band at Brigantine, SIC, and at IBSP from mid-fall into early winter 2008. Most of the cumulative nocturnal altitude quartiles were within the middle (RSZ) altitude band.
- The majority of the cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ altitude band. Cumulative nocturnal flux varied at several sites. For most of the survey dates, the cumulative nocturnal flux values at the onshore sites were generally similar between the low and middle (RSZ) altitude bands.
- Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal AMTRs were less than 30 abt/kph at all of the onshore sites.
- Peak cumulative AMTR occurred at night at each onshore site (IBSP: 19.1 abt/kph. from 13-21 September; BB: 26.4 abt/kph from 26 October to 02 November; Sea Isle City: 25.0 abt/kph from 05 to 12 October)
- Most weekly nocturnal AMTRs were greater than diurnal AMTRs.
- Overall, as expected during fall migration, the dominant direction of movement during most weeks was from the north and northeast to the south and southwest.

5.6.3.6 Onshore Spring 2009

The results of the spring/early summer 2009 onshore radar survey varied by onshore survey site:

- At Island Beach SP, all of weekly cumulative diurnal median altitude quartiles were within the low altitude band (1-99 ft AMSL) and most of the weekly cumulative nocturnal altitudes were within the middle (RSZ) band (100-700 ft AMSL). At BB, the weekly number of cumulative diurnal median altitudes in the low altitude band and in the middle (RSZ) band was similar. Most of the cumulative nocturnal median altitudes were in the high altitude band (701+ ft AMSL). At SIC, all of the weekly cumulative diurnal median altitudes were within the low altitude band and all of the weekly cumulative nocturnal median altitudes were within the middle (RSZ) band.
- Cumulative weekly diurnal flux values were greater within the low altitude band than within the middle (RSZ) band. Cumulative weekly nocturnal flux values varied at sites and throughout the fall season. Cumulative diurnal flux values were greater within the low altitude band than within the middle (RSZ) altitude band at IBSP from 29 March - 05 April, at Brigantine from 12-19 April 2009, and at SIC on 06-10 May 2009. Cumulative weekly nocturnal flux values within the low and middle altitude bands were similar during the other sampling dates.
- Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal AMTRs were less than 80 abt/kph at all of the onshore sites. At each onshore site, peak cumulative AMTR occurred at night (IBSP: 17.4 abt/kph from 29 March – 05 April 2009; BB: 28.6 abt/kph from 26 April - 03 May 2009; SIC: 76.0 abt/kph from 06-10 May 2009.
- The dominant flux movement was from the south and southwest to the north and northeast. Some of these movements occurred even though winds were unfavorable (from north to south) for northerly movement. One small-scale reverse migration was recorded.

5.6.3.7 Onshore Fall 2009

The results of the fall 2009 onshore surveys were:

- The majority of cumulative weekly diurnal and nocturnal median altitude quartiles were within the middle (RSZ) band.
- Most to all of the cumulative weekly diurnal and nocturnal flux values were greater within the low altitude band than the middle (RSZ) band. The high flux value for the 16+ mph surface wind

speed category from 08-16 November 2009 was not expected based on the steady trend in cumulative weekly diurnal flux values prior to this date. The data was replayed on GMI's software analysis system and examined for possible contaminants that may not have been processed correctly by the radar filters. The examination revealed a large group of birds were present during the time when the surface wind speed was above 16+ mph. The duration of the 16+ mph surface wind was only 22 min. The short time duration was responsible for the high diurnal and nocturnal cumulative flux values in the 16+ surface wind speed category.

- Cumulative diurnal AMTR values were <20 abt/kph during the majority of the study. The only exception was during the week of 08-16 November at SIC when the AMTR increased dramatically but only in the 16+ mph wind category. As previously discussed above, this is an accurate representation of the activity that occurred in the 16+ surface wind speed category. Except for peak cumulative nocturnal migration period from 05-11 October 2009, the cumulative weekly nocturnal AMTR was below 50 abt/kph
- Overall, as expected during fall migration, the dominant flux direction during most weeks were from the north and northeast to the south and southwest despite frequent unfavorable winds from the south to the north.