ESS Group, Inc.

Tern Observations Near Monomoy Island August 28–31, 2006

NANTUCKET SOUND MASSACHUSETTS

PREPARED FOR

Cape Wind Associates, LLC.
75 Arlington Street
Boston, Massachusetts

PREPARED BY

ESS Group, Inc.
401 Wampanoag Trail, Suite 400
East Providence, Rhode Island 02915

In Association with

Watershed Concepts
99 High Street, 4th Floor
Boston, MA 02110

Project No. E159-502

December 8, 2006

www.essgroup.com

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ESS Group, Inc.

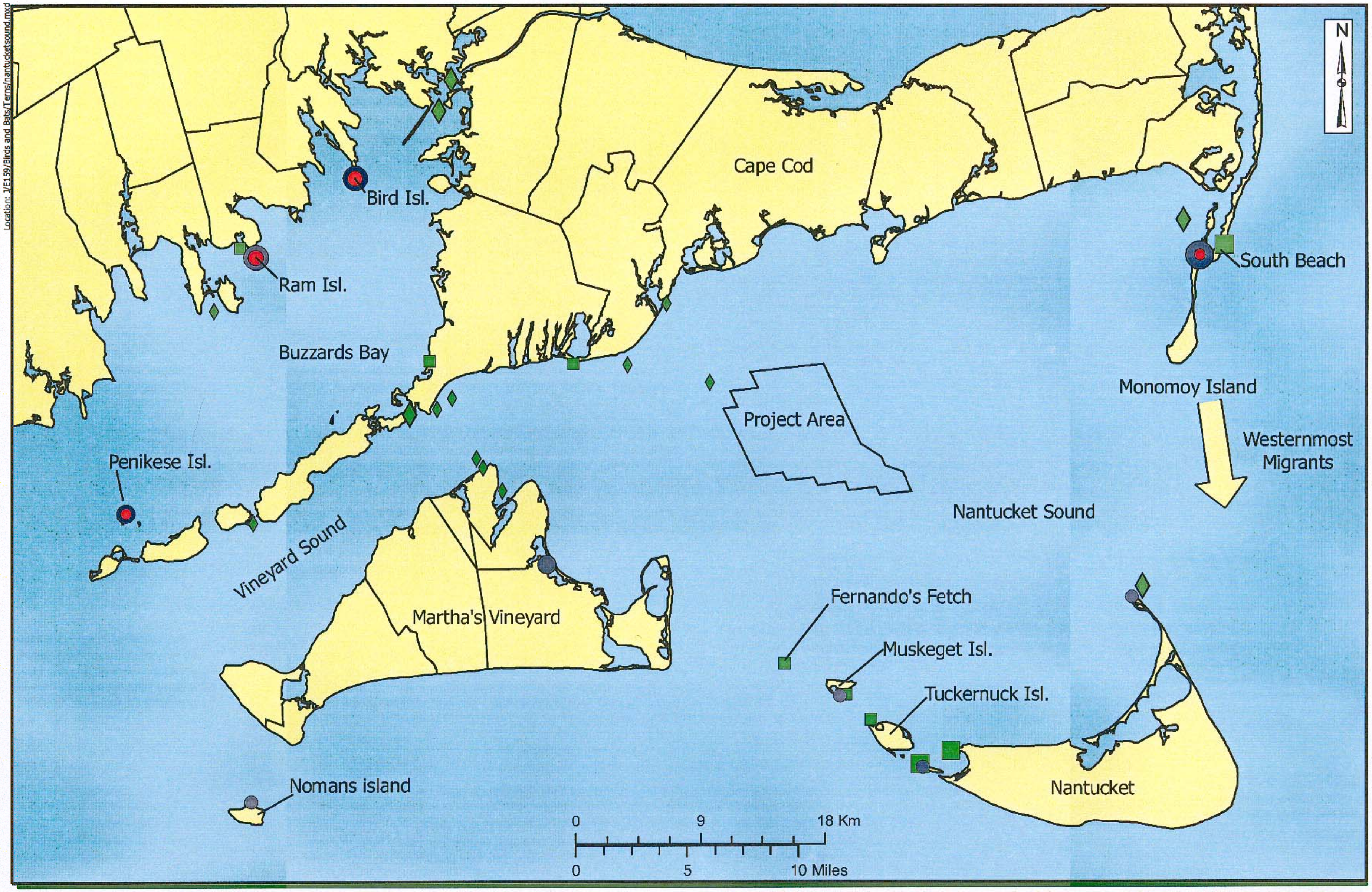
1.0 INTRODUCTION

This report summarizes the results of a study conducted from August 28 through August 31, 2006. The purpose of the study was to document commuting behavior, general flight direction, and the altitude at which terns fly. Observations occurred near a major fall staging area where high concentrations of terns are known to occur. Common (*Sterna hirundo*) and Roseate Terns (*Sterna dougallii*) are found in southeastern Massachusetts from May through September. Major breeding, feeding, and staging areas are located in and near Buzzards Bay and Nantucket Sound (Figure 1). After the breeding season, terns congregate in large numbers at staging areas prior to migrating south in late August and September. South Beach and Monomoy Island in Chatham are significant staging areas for the federally and state endangered Roseate Tern. Surveys in 1998 (Trull et al. 1999) found Roseate Terns roosted in the thousands at only two sites in Nantucket Sound, South Beach and the northern portion of Monomoy Island. Subsequent surveys performed by Cape Wind and Massachusetts Audubon confirmed the large concentration of terns at these locations (Perkins et al. 2004, Sadoti et al. 2005, and USACE 2004). The South Beach staging area includes Roseate Terns from as far away as Maine and New York (Trull et al. 1999). Cape Cod and the Islands appear to be the major staging area for much of the New England population of Roseate Terns. In addition, the area appears to be a major staging area for Common Terns, which are listed as a species of special concern by the Massachusetts Natural Heritage Program.

Terns congregate at their staging areas during the late evening and continue to arrive after dark (Trull et al. 1999). Terns presumably begin leaving the roosting colonies before dawn through early morning to feed. This survey was conducted in part to document observations of the altitude that terns fly near a staging area. The flight altitude of terns and their general flight directions in relation to their staging area will help document the behavior of terns as a means to assess the potential effect of the proposed Cape Wind Project on Horseshoe Shoal in Nantucket Sound. The overall height of the proposed wind turbines at the Cape Wind Farm is 134 meters (440 feet). The rotor swept zone is 23 to 134 meters (75 to 440 feet).

2.0 METHODOLOGY

The field study employed boat surveys to examine and observe movements of terns near their major staging area on South Beach and Monomoy Island in Chatham, Massachusetts. The boat was stationed at Chatham Harbor overnight in order to be at the study areas prior to sunrise. Field staff was housed onboard. Two observations areas (northern and southern, see Figure 2) were used to observe tern behavior during the periods immediately before and after sunrise and sunset. Observations also occurred during the middle part of the day on August 30. The locations were positioned on the western side of South Beach and Monomoy Island (Figure 2). The boat was positioned at the northern location for 420 minutes (7 hours) over four days (August 28 to August 31). The boat was positioned for 656 minutes (10.9 hours) at the southern location over three days (August 29 to August 31).



CAPE WIND
Nantucket Sound, Massachusetts

Scale: 1" = 6 miles

Source: 1) MassGIS, Town Boundary 2) MassGIS, Bathymetry 1:250,000, 1999
3) Monomoy shoreline digitized from MassGIS ortho, 2005 4) Colony Information from Mostello, 2006

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Tern Behavior

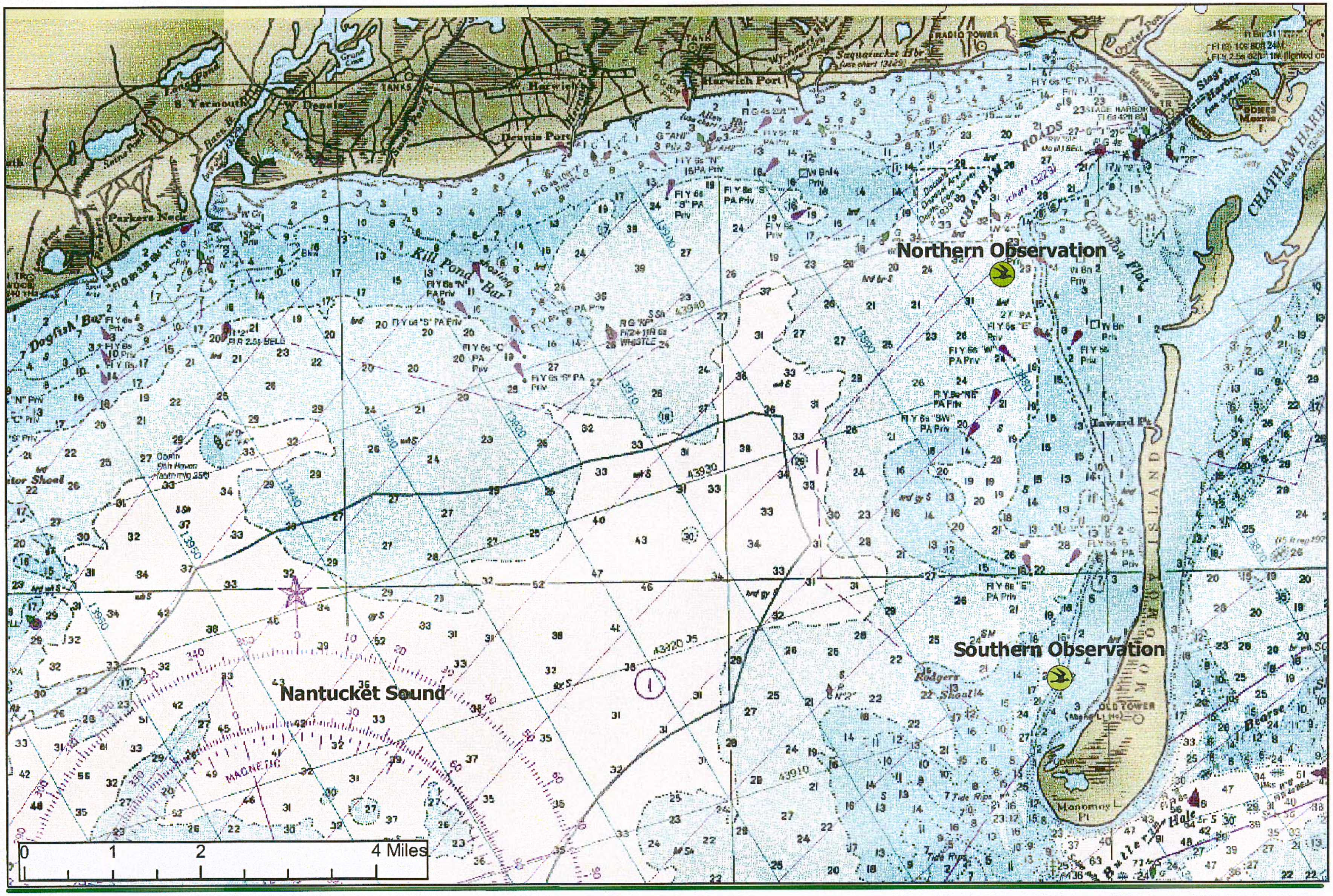
Roosting	Fixed Foraging
Major	Major
Minor	Minor

Colony Location and Density

Roseate Tern	Common Tern	
R1	C1	C3
R2	C2	C4

Terns in Nantucket Sound and Buzzards Bay

Figure 1



CAPE WIND
Nantucket Sound Near Monomoy Island

Tern Survey Observation Locations
August 28-31, 2006

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Scale: 1:100,000
Source: 1) NOAA Chart #13229 2) ESS, Observation Locations, 2006
3) NOAA Fisheries Data 2000-2004

Figure 2

Location: J:/E159-000/Birds and Bats 2005/Tern Observations/GPS

The morning surveys began at first light or when terns could first be seen. The evening flights continued until darkness or when tern activity could no longer be observed. The majority of the survey hours occurred in the early morning and late afternoon to early evening. Two observers and a data collector positioned themselves on the bridge or aft deck of the boat. A buoy, landform, or fishing weir was used as a point of reference to determine tern passage rates. Terns flying between the boat and the point of reference were tallied. The observers noted the direction of travel and estimated distance and altitude.

In order to obtain a more accurate flight altitude, distance to terns and the angle of the terns above the horizon was collected. When possible, the distance of the terns was determined using a combination binocular and range finder (Bushnell laser rangefinder binocular, 8x36). The angle of flight above the horizon was determined using a clinometer. When terns flew above the horizontal view of the observer, the angle of the tern in relation to the boat was collected. When terns flew below the horizontal view of the observers, the terns were characterized as flying at or below 3 meters (the height of the observers above the water). When the observers were able to collect the distance of the terns and the angle of flight in relation to the observer, a flight altitude was determined using trigonometry. Wind speed and direction data for the survey periods were collected using the Cape Wind meteorological (met) tower on Horseshoe Shoal. The met tower collects wind speed 20 meters above mean sea level every 10 minutes.

Tern behavior was characterized as flying (i.e. commuting - coming or going to or from the staging areas), foraging, or kettling. Kettling is believed to be a tern pre-migratory behavior (see Section 4.0). Foraging terns that fly near the water surface were not the focus of the study. Data analysis was completed on terns believed to be flying to and from the staging areas. Data analysis included passage rates and flight altitude, direction in relation to wind speed and actual flight direction. Terns flying outside the passage rate study area were included when accessing flight altitudes in order to increase the number of terns in the data set. Results of these analyses are presented in the sections below.

3.0 RESULTS

The boat was positioned at the northern location for 420 minutes (7 hours) over four days (August 28 to August 31). The boat was positioned for 656 minutes (10.9 hours) at the southern location over three days (August 29 to August 31). The cumulative amount of time of the survey over the four days was approximately 17.9 hours. The average wind speed during the survey was 6 knots out of the northeast (38°). Wind speed and wind direction were not very variable during the study period. Northeast winds were predominant.

One thousand one hundred seventy six (1176) terns were observed during the four-day survey. This tally included commuting, foraging, and kettling terns. The number of terns by species was Common Tern–932, Roseate Tern–63, Black Tern–52, Forster's Tern–1, and tern species–128. Common and Roseate Terns appear very similar in the distance and sometimes cannot be positively identified. The designation of "tern species" is used when terns cannot be identified to species.

The passage rates of commuting terns from the two survey locations are listed in Table A. The passage rates do not include terns that were foraging, kettling or terns flying outside of the passage rate study area. Terns generally appeared shortly after sunrise and before sunset. On each of the surveys, fewer terns were observed before sunrise and after sunset even though there was sufficient light to see any tern movements.

Table A. Passage Rates of Commuting Terns Near Staging Areas on South Beach and Monomoy Island (August 28–31, 2006).

Location	Number of Terns	Survey Time (minutes)	Terns/Minute	Terns/10 Minutes	Terns/Hour
North	135	420	0.3	3	19
South	809	656	1.2	12	74
Totals	944	1076	0.9	9	53

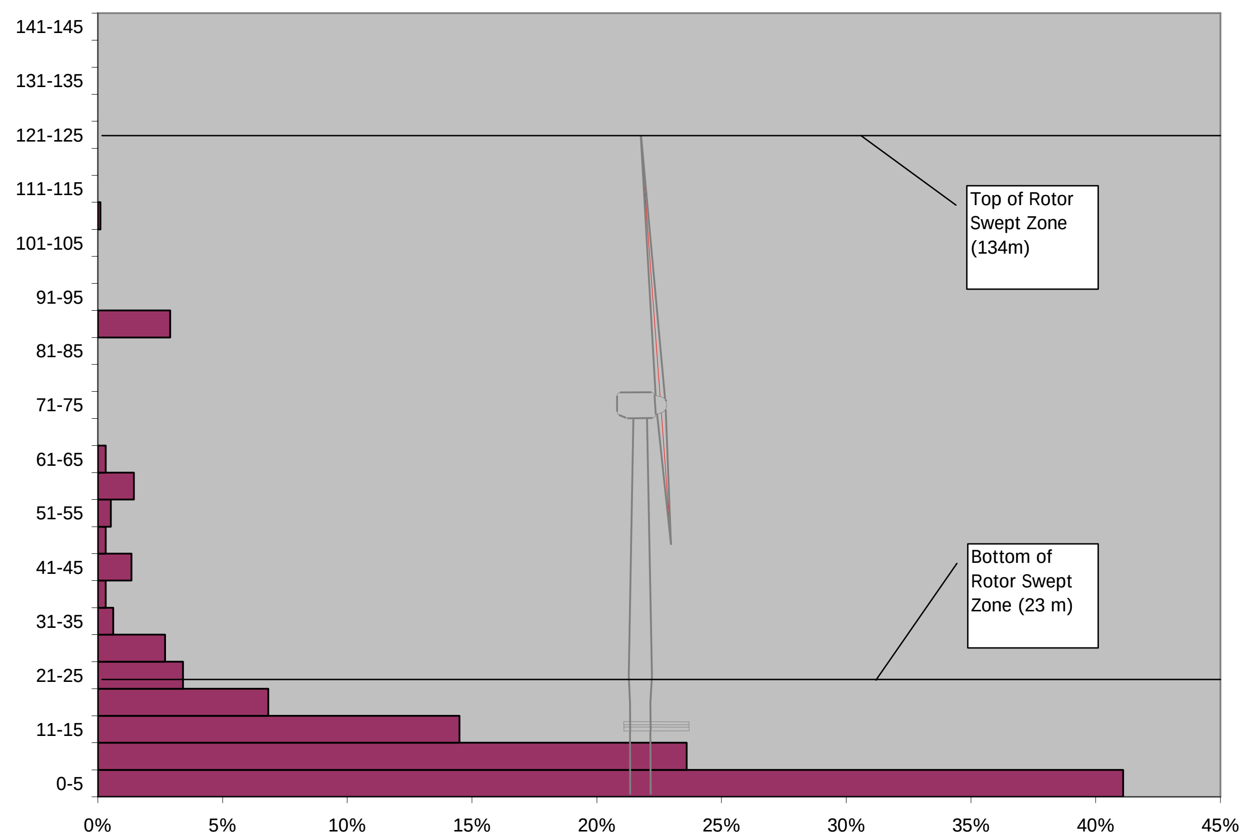
Two hundred ninety (250) terns were observed where a range and angle were able to be determined. A range was not able to be determined for all terns due to human and rangefinder limitations. The effectiveness of the range finder is discussed in Section 4.0. Birds flying below the horizontal view of the observers were characterized as flying at three meters or below. Three hundred eighty (380) terns were estimated to be flying 3 meters or below. For terns where flight altitude was unable to be calculated, flight altitudes were estimated (n=716). Fifty three (53) percent of the estimated flight altitudes were 3 meters or below. Thirty-four (34) percent of the estimated flight altitudes were 4 to 20 meters. The remaining 13 percent ranged from 21 to 100 meters. Estimated tern flight altitudes are listed in Table B. Because tern flight altitudes were relatively low, estimating altitude is likely to result in accurate altitude estimates.

Table B. Breakdown of Estimated Tern Flight Altitudes

Altitude	Number of Terns at Estimated Altitude	Percentage of Terns with Estimated Altitude
3 meters or less	380	53
4 to 20 meters	243	34
21 to 50 meters	43	6
51 to 100 meters	50	7

Nine hundred sixty-six (966) commuting tern flight altitudes were examined in relation to the rotor swept zone for a proposed Cape Wind turbine. This data set consisted of 250 terns with calculated altitudes and 716 with estimated altitudes. Three hundred eighty (380) of terns were flying at 3 meters or less. The majority (89%) of the terns in this data set would be below the rotor swept zone (see Figure 3).

Figure 3. Percentage of Commuting Terns by Altitude in Relation to the Rotor Swept Zone during the August 2006 Survey



Nine hundred fifty-eight (958) commuting terns had sufficient data collected that allowed for analysis of impacts of wind speed and direction on tern flight altitude. Terns were characterized as flying downwind, upwind, or into a crosswind. The flight altitude distribution of the different wind/flight scenarios is listed in Table C.

Table C. Number of Commuting Terns in the Rotor Swept Zone for Downwind, Upwind, Crosswind, and all Wind/Flight Conditions.

	Number of Terns in Sample	Number of Terns Below Rotor Swept Zone (23 meters)	Number of Terns Within Rotor Swept Zone (23-134 meters)	Percentage of Terns Within Rotor Swept Zone
Downwind	177	107	70	40%
Upwind	357	356	1	0%
Crosswind	424	385	39	9%
Combined Winds	958	848	110	11%

For the 110 terns within the rotor swept zone, the 90th percentile is 90 meters. Seventy-three (73) percent of the 110 terns were below the nacelle hub height of 78.5 meters and 37percent were above the nacelle hub height. The mean flight altitudes for terns flying under the three wind scenarios are listed in Table D. In general, terns flying downwind flew at higher altitudes than birds flying upwind or into a crosswind.

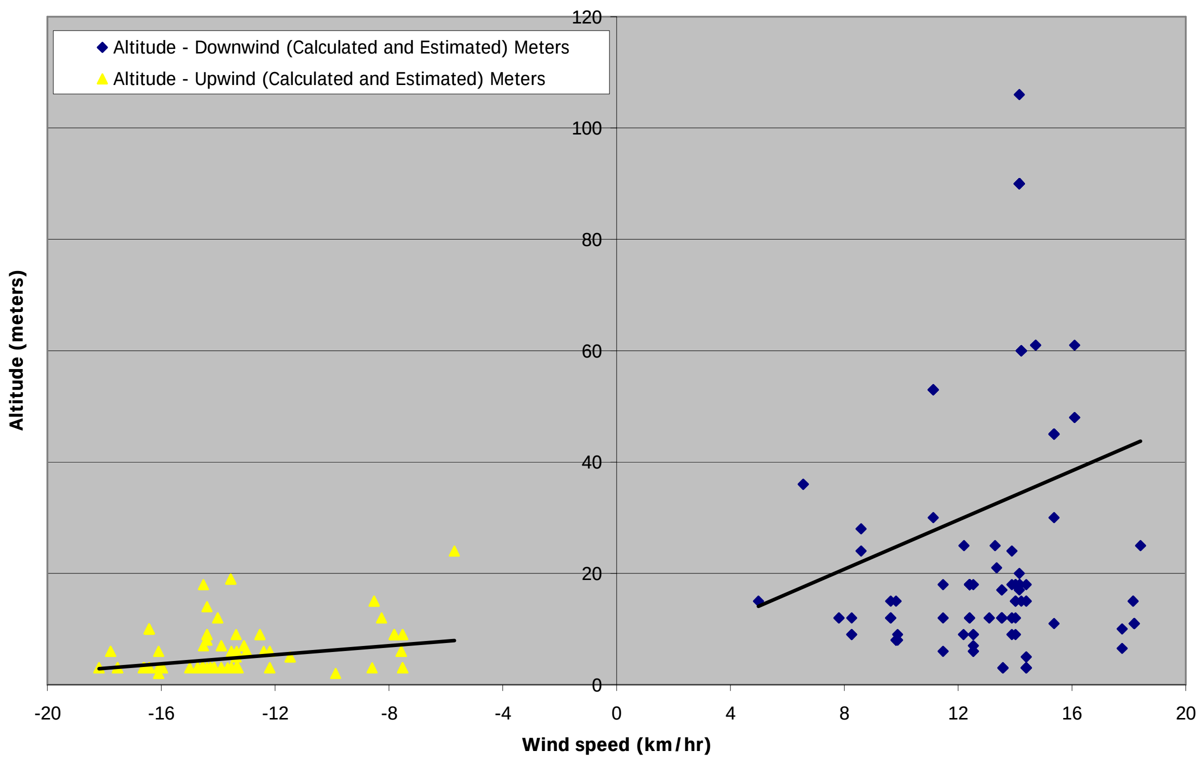
Table D. Mean Flight Altitude for Terns Commuting Downwind, Upwind, and into a Crosswind.

Wind Condition in Relation to Flight	Mean Altitude (m)[1]	Standard Deviation	Minimum (m)	Maximum (m)	Number of Terns in Sample
Downwind	33	31	3	106	177
Upwind	4	3	2	24	357
Crosswind	12	9	1	55	424

Notes and initialism: [1] 95% confidence level m–meters

The relationship between wind speed and altitude was plotted on a scatter plot for terns commuting downwind and upwind (n=534) (Figure 4). Terns flying downwind tended to fly at higher altitudes. The trendline on the downwind scatter plot shows an increase in altitude for terns flying downwind as wind speed increases. Conversely, the trendline shows that altitude decreases for terns flying upwind as wind speed increases. Figure 4 shows the marked difference in flight altitude between terns traveling upwind (mean=4±3 meters) and those traveling downwind (mean=33±31 meters). Only one of the 110 terns (flying upwind, downwind and into a crosswind) within the rotor swept zone flew upwind.

Figure 4. Wind Speed versus Altitude for Terns Commuting Upwind and Downwind



4.0 DISCUSSION

The range finder effectiveness was variable. At times, it was able to lock on to targets and calculate the range. Other times the range finder would not lock on target. During testing of the range finder, we found that the color of the target may affect the effectiveness of the range finder. We continually noticed that the range finder did not recognize dark birds such as cormorants. It is possible that some of the missed terns were darker or that the angle of the terns displayed darker portions of their body so that the range finder was unable to lock on. We intended to compare altitude results using the range finder/clinometer with the altitude estimations. The limitations of the instrumentation did not allow enough data to be collected in order to provide any comparison.

The tern observations occurred away from the proposed Cape Wind Project Area. The study location was chosen in an area where high concentrations of terns occur during the fall staging period. Directly comparing tern-commuting altitudes near the fall staging area and terns commuting over Horseshoe Shoal is not feasible in the data set. However, the tern-commuting altitudes near the fall staging area may indicate altitudes at which terns commute over Horseshoe Shoal. Based on the dataset, 89 percent of the terns would be flying below the rotor swept zone (23 meters).

Selection of flight altitude is likely to result from combination of several costs and benefits: birds flying upwind can lower travel costs by not climbing and by flying in weaker headwinds close to the water surface. Benefits of flying high downwind include stronger tailwinds and better opportunities for locating feeding flocks to join. Conditions during the observations reported here varied too little to allow further investigation of these matters.

During the evening survey on August 29, we observed interesting tern behavior that has been documented by Massachusetts Audubon (Perkins et al. 2004 and Perkins et al. 2003). Approximately three flocks containing a combined 75 terns appeared to be kettling near the southern observation area at flight altitudes ranging between 30 and 130 meters (estimated). Kettling is a term normally used in ornithology to describe the flights of birds as they circle upon thermal updrafts. The tern flocks continued flying south while kettling and climbing to altitudes estimated up to 130 meters. It is unknown why terns conduct this behavior, but it is thought that this behavior precedes migration (Dr. Jeremy Hatch personal comm. and Perkins et al. 2004). The kettling terns are not included in altitude and passage rate analyses since the behavior is not comparable to the commuting terns.

5.0 CONCLUSIONS

One thousand one hundred seventy six (1176) terns were observed during the four-day survey. This tally includes commuting, foraging, and kettling terns. The number of terns by species was Common Tern–932, Roseate Tern–63, Black Tern–52, Forster's Tern–1, and tern species–128. The majority of the tern activity occurred near the southern location and the majority of the observations occurred at that location.

Nine hundred sixty-six (966) commuting tern altitudes were examined in relation to the rotor swept zone for a proposed Cape Wind turbine. Three hundred eighty (380) of terns were flying at 3 meters or less. The majority (89%) of the terns in this data set would be below the rotor swept zone. For terns within the rotor swept zone, 73 percent would be in the lower half of the rotor swept zone (i.e. below 78.5 meters).

The altitude of terns commuting near their staging area varied for different wind conditions in relation to flight during the study period. The mean flight altitude for birds flying downwind, crosswind, and upwind were 33, 12, and 4 meters respectively. The standard deviation of terns flying downwind was greatest, whereas the standard deviation of terns flying upwind was much lower.

Wind speed versus altitude was plotted on a scatter plot for terns commuting downwind and upwind. The trendline on the downwind scatter plot shows an increase in altitude for terns flying downwind as wind speed increases. Conversely, the trendline shows that altitude decreases for terns flying upwind as wind speed increases. The scatterplot shows the marked difference in flight altitude between terns traveling upwind (mean=4±3 meters) and those traveling downwind (mean=33±31 meters). Only one of the 110 terns (flying upwind, downwind and into a crosswind) within the rotor swept zone flew upwind.

6.0 REFERENCES

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