

A SURVEY OF TERN ACTIVITY WITHIN NANTUCKET SOUND,  
MASSACHUSETTS, DURING THE 2004 BREEDING PERIOD

Final Report for Massachusetts Technology Collaborative

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Giancarlo Sadoti, Taber Allison, Simon Perkins, Andrea Jones

Division of Conservation Science and Ecological Management

Massachusetts Audubon Society  
208 South Great Road  
Lincoln, MA 01773



## INTRODUCTION

A proposed wind farm on Horseshoe Shoal in Nantucket Sound, Massachusetts, would be the largest offshore wind farm in the United States and one of the largest in the world. Until recently few data have been available to assess the potential risks that offshore wind farm pose to birds. A recently completed draft Environmental Impact Statement (DEIS) has summarized data collected as part of the avian risk assessment for this project (USACE 2004). In response to the proposed wind farm, Mass Audubon has conducted bird surveys in Nantucket Sound over the past two and a half years. These surveys have contributed additional information on the avian use of Nantucket Sound and the proposed project area and, in combination with data provided in the DEIS, has resulted in three years of data on certain aspects of avian risk assessment. The focus of the current report is the second year of surveys of tern activity during the nesting season, defined as late April through July.

Several of the largest tern colonies in New England are found within 20 miles of Horseshoe Shoals. Approximately 50% of the North American population of federally endangered Roseate Terns breeds within Buzzards Bay in Massachusetts (USFWS 1998), and in 2004, approximately 10,000 pairs of Common Terns nested at Monomoy Island NWR, Chatham (Carolyn Mostello, *personal communication*). Common and Roseate terns forage within, or pass through, the Sound between early May and late September as they move to and from their nesting colonies, foraging areas, and staging sites. Prior to the data collection by the applicant and Mass Audubon during the environmental review, little was known about the abundance, dispersal, and daily movements of terns during these months. In particular, the areas where terns focus their feeding activities during spring migration and within the breeding period, was poorly known.

Between April 30 and July 29, 2004, we conducted 12 boat surveys on Horseshoe Shoal and three aerial surveys within a designated flight grid over Nantucket Sound (Figure 1). We focused our efforts on boat surveys because we wanted to assess the use of the Shoal by newly arrived migrant terns and resident terns foraging from their colonies as well the use of the Shoal by other bird species. Our three aerial surveys provided an overview of the distribution of the terns within Nantucket Sound on a given day.

Our specific objectives were to:

- 1) Estimate the abundance and distribution of Common and Roseate terns on Horseshoe Shoal within the breeding period
- 2) Observe the behaviors of the terns (i.e., traveling, actively feeding, or resting on the water's surface) on Horseshoe Shoal
- 3) Determine the heights at which the birds were flying,
- 4) Detect any temporal variation in these parameters, and
- 5) Assess annual variation in relative abundance and behavior of terns during the breeding season.

The timing of these surveys was based on the known average arrival date of terns returning to Massachusetts from their wintering quarters at the beginning of the breeding period (late April - early May), and the known dates at which both adults and juvenile birds begin to disperse from the colonies to pre-migratory staging areas at the end of the breeding period (late July- early August) (Gochfeld et. al. 1998).

## **METHODS**

In general, our methods, described below, were identical to the protocols developed for our first survey of terns during the 2003 breeding season (Perkins, et al. 2004a). Additionally, we improved our data entry system by upgrading to a new version of dLOG (v.2.0, R.G. Ford Consulting, Inc., Portland, OR). Although this had no direct bearing on survey methods, the upgrade improved the efficiency of post-survey data processing.

### **Boat surveys**

We conducted 12 boat surveys in 2004 along a series of transects oriented in two parallel tracks, one mile apart. The position of these transects was selected to sample all the waters over Horseshoe Shoal as well as the waters in the immediate vicinity of Horseshoe Shoal (Figure1). For the purposes of this study, we defined the Shoal as the area described by the 20-ft bathymetry line. Surveys were conducted from a 33 ft powerboat, cruising at an average speed of roughly 17 knots. Surveys lasted approximately 1.5 hours. The total linear length of the boat transects was 24.9 miles.

The survey teams consisted of two observers and one recorder. Data collected included numbers of birds seen by species, behavior (traveling, actively feeding, or resting on water's surface), their flight altitudes, survey starting and ending times, weather (e.g., rain, sunny, cloudy), wind speed and direction, water temperature, sea state, and visibility. The observers, positioned on each side of the boat immediately aft of the wheelhouse, verbally communicated all bird sightings. The recorder immediately entered this information onto a laptop computer; geographical location of each observation was automatically logged by the computer program (dLog). All birds observed within 0.5 mile on either side of the vessel were recorded. This distance was periodically checked with the range-finding function of the onboard radar in reference to visible objects such as buoys. Flight heights of the birds were estimated by referencing objects of known height such as the top of the wheelhouse, navigational buoys, and the Cape Wind meteorological test tower. Observers used binoculars to confirm identification to species as needed.

Common and Roseate terns were distinguished by their different flight behaviors, shapes, and plumage characteristics. We recorded all birds to species whenever possible. When we could not determine with certainty whether the bird was a Roseate or Common tern we placed the sighting in a separate category of Tern species. Any reference to 'terns' is to the combined categories of Roseate, Common, and undifferentiated Roseate/Common Terns.

## Aerial Surveys

Three aerial surveys were conducted in 2004 along sixteen fixed, parallel transects oriented north to south. The sample grid comprised approximately 70 percent of Nantucket Sound; the transects extended from points just seaward of the south shore of Cape Cod, southward to an east-west line roughly even with Great Point, Nantucket (Figure 1). Individual transects were separated at 7,500 foot intervals, and the total combined linear length of all 16 transects was 247.4 miles. The length of the longest transect was 18.2 miles, the shortest transect was 4.5 miles, and the mean length of all sixteen transects was 15.4 miles. The actual sample area, defined by the width of the transects (600 feet) times their combined length (247 miles) equaled 28 square miles comprising approximately 5 percent of the area of Nantucket Sound.

Aerial surveys were flown with a high-winged, twin-engine aircraft (Cessna Sky Master 337) cruising at an average altitude of 500 feet and at an average airspeed of 90 knots. The chosen altitude allowed us to identify birds on the sea surface but also reduced the possibility of flushing the birds from the water surface to another part of the Sound where they might have been recounted. The airspeed was the slowest at which the aircraft could safely fly. Flights were conducted only on days with light to moderate winds (not exceeding 15 knots) and on days with good atmospheric clarity (visibility >10 miles). Flights usually began mid-morning, and the average duration of each survey was roughly 3.5 hrs.

Each survey team was composed of a pilot, a recorder in the co-pilot seat, and two experienced observers. The two observers were positioned opposite one another on each side of the plane. All members of the team communicated through an onboard intercom system. The observers verbally communicated all bird sightings to the recorder. Data were recorded using dLog as described above. Recorded information included all species of birds, their abundances, and their behavior (traveling, actively feeding, or resting on the water's surface). We also recorded starting and ending times, wind direction and velocity, sea state, visibility, and cloud cover for each transect on every survey. Surveys were conducted over a wide range of tidal stages. We recorded birds seen on either side of the north-south transects out to a distance of approximately 483 feet on each side of the plane. Approximately 183 horizontal feet on either side of each transect was not visible due to the positioning of windows inside the plane. Thus, we estimated angles of viewing to approximate a "moving window" of visibility 300 feet perpendicular to the direction of travel (Figure 2).

Individual birds of all species were identified with the aid of binoculars as needed. We did not count any birds observed while we were flying the short, east-west legs between transects. Roseate and Common tern sightings were treated as described for the boat surveys. Any reference to 'terns' is to the combined total number of Roseate, Common, and undifferentiated Roseate/Common Terns. Observations of non-avian species, such as seals, were also recorded and are available from the authors by request.

## **Analysis of Aerial Survey Data**

We compared relative tern abundance on Nantucket Sound, Horseshoe Shoal, Tuckernuck Shoal, and Monomoy-Handkerchief Shoal (Figure 1). We estimated relative abundance as the proportion of the total number of birds counted in each geographic unit. Proportional tern abundance in each site was calculated first by overlaying the boundaries of the three wind farm sites over all point data collected during surveys. Percent relative abundance of a given species within a geographic unit was calculated as the number of birds observed within each project area divided by the number observed on each survey. These proportions were compared to the proportional area of each project area to determine if terns were evenly distributed across the project areas and Nantucket Sound.

Data presented from 2003 breeding period surveys may include slight corrections or adjustments to 2003 data previously reported in Perkins et al. (2004a)

## **RESULTS**

### **Boat surveys**

Twelve boat surveys were conducted on Horseshoe Shoals between April 30 and July 29. A cumulative total of 317 terns were observed on Horseshoe Shoal, and terns were recorded on all but two boat surveys (July 1 and July 8) (Table 1). Of the terns seen on all surveys, 163 (51.4%) were traveling, 130 (41.0%) were actively feeding, and 24 (7.6%) were resting on the sea surface (Table 2). Tern numbers increased from April 30 to May 13 then declined through the end of July (Figure 3). The altitude range of all traveling terns was between 5 and 100 feet with an average height of 24 ft (SD=22, median = 20) (Table 3). As flight height increased number of birds generally decreased (Figure 4).

Over the course of the entire survey period, terns were generally distributed throughout the entire Shoal area, although slightly more terns were observed in the southern portions (Figure 5). Fifteen additional bird species were recorded during the boat surveys (Table 4).

Wind speed during all boat surveys did not exceed 15 knots except on April 30, when it gusted occasionally to 20 knots. Sea states (Beaufort Scale) ranged between 1 and 4.

### **Aerial Surveys**

Three aerial surveys were conducted on May 20, June 3, and July 7. Terns were recorded on all three surveys. We observed 641 terns including one Common Tern and 640 undifferentiated Common-Roseate-type terns (Table 5). Ninety-seven terns were recorded on May 20, 488 terns were recorded on June 3, and on July 7, the last aerial survey, only 56 terns were observed. During the survey period, sea state conditions never exceeded 3 on the Beaufort scale. The May 20 survey was incomplete (47% missing

from the western half of the study area) due to deteriorating weather conditions. Thirteen other bird species or groups were observed during aerial surveys (Table 6).

In 2004, 83.2% of all terns were recorded along transects 14-16, near Monomoy Island, and 63.2% of all terns were seen along transect 16 alone. Approximately 17% of the terns were counted within transects 1-13. No terns were observed during aerial surveys in the Horseshoe Shoal proposed project area (Figure 6). To examine the distribution of terns on alternative sites, we eliminated transects 14-16 to avoid overwhelming the comparisons by the high numbers of terns near Monomoy. Using the modified survey area, 6.5% and 4.6% of terns were observed in the Monomoy-Handkerchief project area and Tuckernuck project area, respectively.

Of all 641 terns counted during the three aerial surveys, 53.5% of were actively feeding, 45.4% were traveling, 0.8% were resting on the water, and 0.3% were associated with vessels (Table 2).

Of the few birds traveling high enough to estimate flight altitude, one tern and two gulls were observed in the proposed “sweep zone” of the rotors of the proposed turbines. The one tern was estimated to be traveling at 400 feet, while one Great Black-backed Gull and one Bonaparte’s Gull were estimated to be traveling at 300 feet.

## **DISCUSSION**

### **Boat Surveys**

Both Common and Roseate terns were observed within the area described by Horseshoe Shoal. Terns observed on boat surveys increased from 12 terns on April 30, to a peak of 134 terns on May 13. Tern counts gradually decreased through late July. Data from 2003 show a similar pattern of decline after mid-May. Undoubtedly, if we had started the 2003 season earlier, we would have seen a similar trend of rising abundance between April and May.

Most of the birds observed on the Shoal were traveling versus actively feeding or resting. Although the data are limited, we continue to hypothesize (e.g., Perkins, et al. 2004a) that the majority of terns observed on the Horseshoe Shoal were either passage migrants moving through these waters to breeding colonies farther north and east, and/or recently returned Massachusetts breeding residents. Though data from 2003 boat surveys showed similar patterns of abundance early in the breeding period, this hypothesis cannot be tested fully without marking and tracking individual terns.

Again we observed terns occasionally resting (“rafting”) on the water over Horseshoe Shoal during the boat surveys. As we described in our previous breeding season report (Perkins, et al. 2004a), when terns are within close proximity to their colonies in Massachusetts, they rarely alight on the water (Ian Nisbet, *personal communication*). Rafting behavior was most prevalent early in the breeding period, at a time when many terns were just arriving back into local waters.

Boat surveys of Nantucket Sound were also conducted by consultants for Cape Wind Associates between April 2002 and September 2003 (USACE 2004). Out of 15 surveys conducted during what we have defined as the “tern breeding period” (April – July), only two were conducted on a standardized route within our boat survey area. Nineteen terns were observed on the one standardized survey with a known survey length (April 17-18, 2002, 13 miles, Hatch and Kerlinger, 2003). Assuming the same survey width as our own (0.5 miles), an average 0.7 terns per mile were observed on this survey. This is in the range of tern densities observed on our boat surveys in April–May 2003 and 2004 (n=7, range=0.5-5.4 terns/sq. mi).

Out of the total 1,461 birds observed on all 2004 breeding period boat surveys, 955 were traveling. Of these, 86, or 5.8% of the total 1,461 birds observed, were observed within the rotor-swept zone of 75 – 417 feet above mean sea level. Of these 86 birds, nine terns (or 2.9% of all 317 terns) and 77 birds of eight other species or species groups were observed in the “sweep zone” of the turbine rotors. These results were similar to those of 2003, when 3.2% of terns were observed in the rotor-swept zone (n=9) out of a total 130 terns traveling (250 terns total in 2003 boat surveys).

Similar results were found by consultants for Cape Wind Associates during tern surveys from Spring 2002 to Fall 2003, where, out of 8,515 Common, Roseate, and unknown terns observed, 100 (or 1.7%) were flying at 75 ft above sea level or higher (USACE 2004; Section 5.7.2.3.1). None of these birds were seen on Horseshoe Shoal, and it is not always clear where, when with respect to the breeding vs. staging period, or from what perspective (from boat or plane) these observations were made. As such, direct comparison of our findings to data provided by Cape Wind Associates is not possible.

## **Aerial Surveys**

Ninety percent and 93% of terns were observed on transects 14-16 (within 4 miles of South Monomoy Island) on June 30 and July 7, respectively. This result is not surprising given that, in 2004, the South Monomoy colony contained approximately 63 percent of the over 32,000 breeding Common Terns in Massachusetts (Carolyn Mostello, *personal communication*). As in 2003, the higher abundances of terns in proximity to South Monomoy Island suggest that the majority of terns observed within Nantucket Sound during the breeding period were feeding in near-shore areas close to breeding colonies or were en route to or from these areas.

As with data from boat surveys, aerial survey data suggest the hypothesis that Horseshoe Shoal is more important as a migratory stopover point or “refueling” area for terns than as a feeding area for locally nesting resident terns. A third year of surveys could help us determine whether our observations this past breeding period are consistent from year to year, or if there is a shift in local distribution or abundance of terns based on availability of food or other factors.

Calculations of proportional abundance of terns in the Horseshoe Shoal project area show similar patterns to data presented by Cape Wind Associates (USACE 2004, Table 5.7-7), with the exception of the greater abundance of terns observed on Monomoy-Handkerchief Shoal and Tuckernuck Shoal in 2003 during our surveys. Caution should be exercised, however, in any interpretation of such a small survey sample size ( $n = 3$ ). Overall, tern numbers per unit area during our 2003 – 2004 breeding period surveys were in a similar density range to those observed by Cape Wind Associates in 2002 – 2003 (0.1 – 3.2 terns/sq. km) (USACE 2004, Figure 5.7-13). However, due to the slightly different extent of study areas used in the two studies, some caution should be exercised in direct comparisons of MAS and Cape Wind abundance data.

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Table 1. Terns observed during the 2003 and 2004 breeding period boat surveys on Horseshoe Shoals by date. Birds in the Common/Roseate Tern spp. column are undifferentiated.

**2003**

| Date          | Common Tern | Roseate Tern | Common/Roseate Tern spp. | Grand Total |
|---------------|-------------|--------------|--------------------------|-------------|
| 15-May-03     | 37          | 0            | 53                       | 90          |
| 22-May-03     | 49          | 0            | 6                        | 55          |
| 29-May-03     | 45          | 1            | 6                        | 52          |
| 5-Jun-03      | 15          | 0            | 2                        | 17          |
| 11-Jun-03     | 3           | 0            | 0                        | 3           |
| 18-Jun-03     | 0           | 0            | 0                        | 0           |
| 25-Jun-03     | 0           | 0            | 0                        | 0           |
| 2-Jul-03      | 0           | 2            | 0                        | 2           |
| 10-Jul-03     | 2           | 0            | 2                        | 4           |
| 17-Jul-03     | 1           | 0            | 0                        | 1           |
| 28-Jul-03     | 20          | 5            | 1                        | 26          |
| 29-Jul-03     | 0           | 0            | 0                        | 0           |
| 31-Jul-03     | 0           | 0            | 0                        | 0           |
| <b>Totals</b> | <b>172</b>  | <b>8</b>     | <b>70</b>                | <b>250</b>  |

**2004**

| Date          | Common Tern | Roseate Tern | Common/Roseate Tern spp. | Grand Total |
|---------------|-------------|--------------|--------------------------|-------------|
| 30-Apr-04     | 12          | 0            | 0                        | 12          |
| 06-May-04     | 27          | 2            | 40                       | 69          |
| 13-May-04     | 100         | 2            | 32                       | 134         |
| 21-May-04     | 13          | 0            | 20                       | 33          |
| 28-May-04     | 13          | 0            | 32                       | 45          |
| 04-Jun-04     | 7           | 0            | 3                        | 10          |
| 11-Jun-04     | 0           | 0            | 1                        | 1           |
| 18-Jun-04     | 3           | 0            | 0                        | 3           |
| 24-Jun-04     | 2           | 0            | 0                        | 2           |
| 01-Jul-04     | 0           | 0            | 0                        | 0           |
| 08-Jul-04     | 0           | 0            | 0                        | 0           |
| 29-Jul-04     | 7           | 0            | 1                        | 8           |
| <b>Totals</b> | <b>184</b>  | <b>4</b>     | <b>129</b>               | <b>317</b>  |

Table 2. Frequency of behavior of terns observed during 2003 and 2004 breeding period boat surveys on Horseshoe Shoal within Nantucket Sound, Massachusetts (1) and during aerial surveys of Nantucket Sound (2). Vessel refers to birds observed following a fishing boat.

1. Boat surveys

| <b>Year</b> | <b>Surveys</b> | <b>Traveling</b> | <b>Feeding</b> | <b>Resting</b> | <b>Vessel</b> |
|-------------|----------------|------------------|----------------|----------------|---------------|
| 2003        | 13             | 53.6%            | 34.8%          | 11.2%          | 0.4%          |
| 2004        | 12             | 51.4%            | 41.0%          | 7.6%           | -             |

2. Aerial surveys

| <b>Year</b> | <b>Surveys</b> | <b>Traveling</b> | <b>Feeding</b> | <b>Resting</b> | <b>Vessel</b> |
|-------------|----------------|------------------|----------------|----------------|---------------|
| 2003        | 3              | 34.6%            | 64.4%          | 1.0%           | -             |
| 2004        | 3              | 45.2%            | 53.5%          | 0.8%           | 0.3%          |

Table 3. Flight heights of all species observed traveling during 2003 and 2004 breeding period boat surveys of Horseshoe Shoal, Nantucket Sound, Massachusetts. Rotor-swept zone is defined as an altitude range of 75 to 417 ft above mean sea level. Percentage of birds in the rotor-swept zone is calculated from all birds observed of a given species in a given year. Flight heights are not included for birds observed actively feeding.

| Species                    | 2003 (n = 13 surveys) |               |                              |             |          |            |                                  |                                 | 2004 (n = 12 surveys) |               |                              |             |          |            |                                  |                                  |
|----------------------------|-----------------------|---------------|------------------------------|-------------|----------|------------|----------------------------------|---------------------------------|-----------------------|---------------|------------------------------|-------------|----------|------------|----------------------------------|----------------------------------|
|                            | n<br>(all)            | n<br>(flying) | Bird flight height (in feet) |             |          |            | # in<br>rotor –<br>swept<br>zone | % in<br>rotor-<br>swept<br>zone | n<br>(all)            | n<br>(flying) | Bird flight height (in feet) |             |          |            | # in<br>rotor –<br>swept<br>zone | % in<br>rotor –<br>swept<br>zone |
|                            |                       |               | Mean                         | SD          | Min      | Max        |                                  |                                 |                       |               | Mean                         | SD          | Min      | Max        |                                  |                                  |
| Common Eider               | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 86                    | 84            | 4.1                          | 1.2         | 4        | 15         | -                                | -                                |
| Surf Scoter                | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 1                     | 1             | 4                            | -           | 4        | 4          | -                                | -                                |
| White-winged Scoter        | 36                    | 33            | 13.1                         | 7.5         | 1        | 30         | -                                | -                               | 88                    | 88            | 11.6                         | 17.2        | 4        | 80         | 3                                | 3.4                              |
| Black Scoter               | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 96                    | 96            | 47.2                         | 46.4        | 4        | 100        | 41                               | 42.7                             |
| Scoter species             | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 229                   | 218           | 7.3                          | 11.3        | 4        | 100        | 2                                | 0.9                              |
| Long-tailed Duck           | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 4                     | 4             | 4                            | 0           | 4        | 4          | -                                | -                                |
| Red-throated Loon          | 4                     | 2             | 5.5                          | 6.4         | 1        | 10         | -                                | -                               | 32                    | 28            | 20.5                         | 19.1        | 4        | 70         | 1                                | 3.1                              |
| Common Loon                | 44                    | 8             | 24.4                         | 15.7        | 10       | 60         | -                                | -                               | 65                    | 27            | 31.6                         | 30          | 4        | 100        | 5                                | 7.7                              |
| Loon species               | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 23                    | 18            | 14.7                         | 15.5        | 4        | 50         | -                                | -                                |
| Wilson's Storm-Petrel      | 20                    | 12            | 2.9                          | 1.9         | 1        | 5          | -                                | -                               | 13                    | 10            | 9.2                          | 6.1         | 3        | 15         | -                                | -                                |
| Northern Gannet            | 7                     | 4             | 16.3                         | 10.3        | 5        | 30         | -                                | -                               | 172                   | 81            | 23.7                         | 16.6        | 4        | 60         | -                                | -                                |
| Double-crested Cormorant   | 20                    | 17            | 68.9                         | 84.8        | 1        | 250        | 7                                | 35                              | 8                     | 6             | 13.5                         | 14.1        | 3        | 40         | -                                | -                                |
| Jaeger species             | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 1                     | 1             | 4                            | -           | 4        | 4          | -                                | -                                |
| Laughing Gull              | 1                     | 1             | 50                           | -           | 50       | 50         | -                                | -                               | 2                     | 2             | 10                           | 0           | 10       | 10         | -                                | -                                |
| Herring Gull               | 37                    | 31            | 50.2                         | 55.9        | 1        | 175        | 10                               | 27                              | 40                    | 32            | 24.6                         | 35.7        | 4        | 150        | 4                                | 10                               |
| Greater Black-backed Gull  | 177                   | 86            | 51.7                         | 60.9        | 1        | 250        | 26                               | 14.7                            | 260                   | 77            | 43.1                         | 65          | 4        | 500        | 19                               | 7.3                              |
| Gull species               | 10                    | 10            | 30                           | 12          | 20       | 50         | -                                | -                               | 18                    | 15            | 61.3                         | 126.8       | 4        | 500        | 2                                | 11.1                             |
| Common-Roseate Tern        | 250                   | 130           | 29.6                         | 33          | 5        | 250        | 8                                | 3.2                             | 317                   | 163           | 23.8                         | 21.8        | 4        | 100        | 9                                | 2.9                              |
| Least Tern                 | 7                     | 3             | 15                           | 0           | 15       | 15         | -                                | -                               | 3                     | 1             | 10                           | -           | 10       | 10         | -                                | -                                |
| Purple Martin              | 1                     | 1             | 10                           | -           | 10       | 10         | -                                | -                               | -                     | -             | -                            | -           | -        | -          | -                                | -                                |
| Tree Swallow               | 1                     | 1             | 50                           | -           | 50       | 50         | -                                | -                               | -                     | -             | -                            | -           | -        | -          | -                                | -                                |
| Barn Swallow               | 2                     | 2             | 10                           | 0           | 10       | 10         | -                                | -                               | -                     | -             | -                            | -           | -        | -          | -                                | -                                |
| Razorbill                  | -                     | -             | -                            | -           | -        | -          | -                                | -                               | 3                     | 3             | 14.7                         | 9.2         | 4        | 20         | -                                | -                                |
| <b>Total (all species)</b> | <b>617</b>            | <b>341</b>    | <b>35.9</b>                  | <b>47.3</b> | <b>1</b> | <b>250</b> | <b>51</b>                        | <b>8.3</b>                      | <b>1,461</b>          | <b>955</b>    | <b>21.1</b>                  | <b>35.2</b> | <b>3</b> | <b>500</b> | <b>86</b>                        | <b>5.8</b>                       |

Table 4. All bird species and numbers observed during 2003 and 2004 breeding period boat surveys on Horseshoe Shoals, Nantucket Sound.

| <b>Species</b>            | <b>2003</b> | <b>2004</b>  | <b>Grand Total</b> |
|---------------------------|-------------|--------------|--------------------|
| Common Eider              | 0           | 86           | <b>86</b>          |
| Surf Scoter               | 0           | 1            | <b>1</b>           |
| White-winged Scoter       | 35          | 88           | <b>123</b>         |
| Black Scoter              | 0           | 96           | <b>96</b>          |
| Scoter species            | 0           | 229          | <b>229</b>         |
| Long-tailed Duck          | 0           | 4            | <b>4</b>           |
| Loon species              | 48          | 120          | <b>168</b>         |
| Wilson's Storm-Petrel     | 20          | 13           | <b>33</b>          |
| Northern Gannet           | 7           | 172          | <b>179</b>         |
| Double-crested Cormorant  | 20          | 8            | <b>28</b>          |
| Jaeger species            | 0           | 1            | <b>1</b>           |
| Laughing Gull             | 1           | 2            | <b>3</b>           |
| Herring Gull              | 37          | 40           | <b>77</b>          |
| Greater Black-backed Gull | 177         | 260          | <b>437</b>         |
| Gull species              | 10          | 18           | <b>28</b>          |
| Common/Roseate Tern       | 250         | 317          | <b>567</b>         |
| Least Tern                | 7           | 3            | <b>10</b>          |
| Razorbill                 | 0           | 3            | <b>3</b>           |
| Purple Martin             | 1           | 0            | <b>1</b>           |
| Tree Swallow              | 1           | 0            | <b>1</b>           |
| Barn Swallow              | 2           | 0            | <b>2</b>           |
| <b>Grand Total</b>        | <b>616</b>  | <b>1,461</b> | <b>2,077</b>       |

Table 5. Terns observed during the 2003 and 2004 breeding period aerial surveys of Nantucket Sound, Massachusetts. Birds in the Common/Roseate Tern spp. column are undifferentiated. One flight, May 20, 2004 was not completed due to deteriorating weather conditions.

**2003**

| <b>Date</b>   | <b>Common Tern</b> | <b>Roseate Tern</b> | <b>Common/<br/>Roseate<br/>Tern spp.</b> | <b>Grand Total</b> |
|---------------|--------------------|---------------------|--|--------------------|
| 3-Jun-03      | 186                | 0                   | 95                                       | <b>281</b>         |
| 14-Jul-03     | 275                | 9                   | 85                                       | <b>369</b>         |
| 30-Jul-03     | 10                 | 0                   | 19                                       | <b>29</b>          |
| <b>Totals</b> | <b>471</b>         | <b>9</b>            | <b>199</b>                               | <b>679</b>         |

**2004**

| <b>Date</b>   | <b>Common Tern</b> | <b>Roseate Tern</b> | <b>Common/<br/>Roseate<br/>Tern spp.</b> | <b>Grand Total</b> |
|---------------|--------------------|---------------------|--|--------------------|
| 20-May-04     | 0                  | 0                   | 97                                       | <b>97</b>          |
| 30-Jun-04     | 0                  | 0                   | 488                                      | <b>488</b>         |
| 7-Jul-04      | 1                  | 0                   | 55                                       | <b>56</b>          |
| <b>Totals</b> | <b>1</b>           | <b>0</b>            | <b>640</b>                               | <b>641</b>         |

Table 6. Bird species and numbers observed during 2003 and 2004 breeding period aerial surveys over Nantucket Sound (6 flights total: June 3, July 14, and July 30, 2003; and May 20, June 3, and July 7, 2004). One flight, May 20, 2004 was not completed due to deteriorating weather conditions.

| <b>Species</b>            | <b>2003</b>  | <b>2004</b>  | <b>Grand Total</b> |
|---------------------------|--------------|--------------|--------------------|
| Common Eider              | 0            | 1            | <b>1</b>           |
| Scoter species            | 0            | 2            | <b>2</b>           |
| Loon species              | 32           | 30           | <b>62</b>          |
| Wilson's Storm-Petrel     | 1            | 9            | <b>10</b>          |
| Northern Gannet           | 1            | 28           | <b>29</b>          |
| Double-crested Cormorant  | 258          | 7            | <b>265</b>         |
| Jaeger species            | 0            | 2            | <b>2</b>           |
| Laughing Gull             | 16           | 0            | <b>16</b>          |
| Bonaparte's Gull          | 0            | 15           | <b>15</b>          |
| Herring Gull              | 84           | 57           | <b>141</b>         |
| Greater Black-backed Gull | 209          | 374          | <b>583</b>         |
| Gull species              | 56           | 180          | <b>236</b>         |
| Common/Roseate Tern       | 679          | 641          | <b>1,320</b>       |
| Least Tern                | 2            | 1            | <b>3</b>           |
| <b>Grand Total</b>        | <b>1,338</b> | <b>1,347</b> | <b>2,685</b>       |

Table 7. Proportional abundance of terns observed on aerial breeding period surveys in alternative project areas of Nantucket Sound, Massachusetts, 2003-2004. Length in miles for each alternative project area and the remaining non-project area is indicated and was calculated in terms of overlap with the transect grid used for surveys. Results are presented for two survey areas: 1) survey transects adjacent to the South Monomoy Island tern breeding colony excluded and 2) adjacent transects included. Project areas with proportional tern abundance greater than the proportional area are shown in bold. Total numbers of birds observed in each survey area and in each year are noted below each proportion value. Incomplete surveys were excluded from analysis.

A. Transects 14-16 excluded:

|                            | <b>Alternative project areas</b>                 |   |                                       | <b>Non-project areas<br/>(153.2 mi)</b> |
|----------------------------|--|---|---------------------------------------|---|
|                            | <b>Horseshoe Shoal<br/>(28.7 mi)</b>             | <b>Monomoy-Handkerchief Shoal<br/>(15.7 mi)</b> | <b>Tuckernuck Shoal<br/>(23.5 mi)</b> |   |
|                            | <b>Proportion of survey miles in study area</b>  |   |                                       |   |
|                            | 12.2%  | 7.3%  | 11.3%                                 | 68.7%                                   |
| <b>Year (# of surveys)</b> | <b>Proportion of terns observed (# of terns)</b> |   |                                       |   |
| 2003 (n = 3)               | 11.2%<br>(n = 10)                                | 0.0%<br>(n = 0)                                 | <b>18.0%</b><br>(n = 16)              | 70.8%<br>(n = 63)                       |
| 2004 (n = 2)               | 0.0%<br>(n = 0)                                  | 8.7%<br>(n = 4)                                 | 0.0%<br>(n = 0)                       | 91.3%<br>(n = 42)                       |

B. Transects 14-16 included:

|                            | <b>Alternative project areas</b>                 |   |                                       | <b>Non-project areas<br/>(179.5 mi)</b> |
|----------------------------|--|---|---------------------------------------|---|
|                            | <b>Horseshoe Shoal<br/>(28.7 mi)</b>             | <b>Monomoy-Handkerchief Shoal<br/>(15.7 mi)</b> | <b>Tuckernuck Shoal<br/>(23.5 mi)</b> |   |
|                            | <b>Proportion of survey miles in study area</b>  |   |                                       |   |
|                            | 10.9%  | 6.9%  | 10.9%                                 | 72.1%                                   |
| <b>Year (# of surveys)</b> | <b>Proportion of terns observed (# of terns)</b> |   |                                       |   |
| 2003 (n = 3)               | 1.5%<br>(n = 10)                                 | 5.3%<br>(n = 36)                                | 2.5%<br>(n = 17)                      | 90.7%<br>(n = 616)                      |
| 2004 (n = 2)               | 0.0%<br>(n = 0)                                  | 0.7%<br>(n = 4)                                 | 0.0%<br>(n = 0)                       | 99.3%<br>(n = 540)                      |

Figure 1. Nantucket Sound study area and associated features, including aerial and boat transect routes, proposed wind power project areas, and major tern colonies.

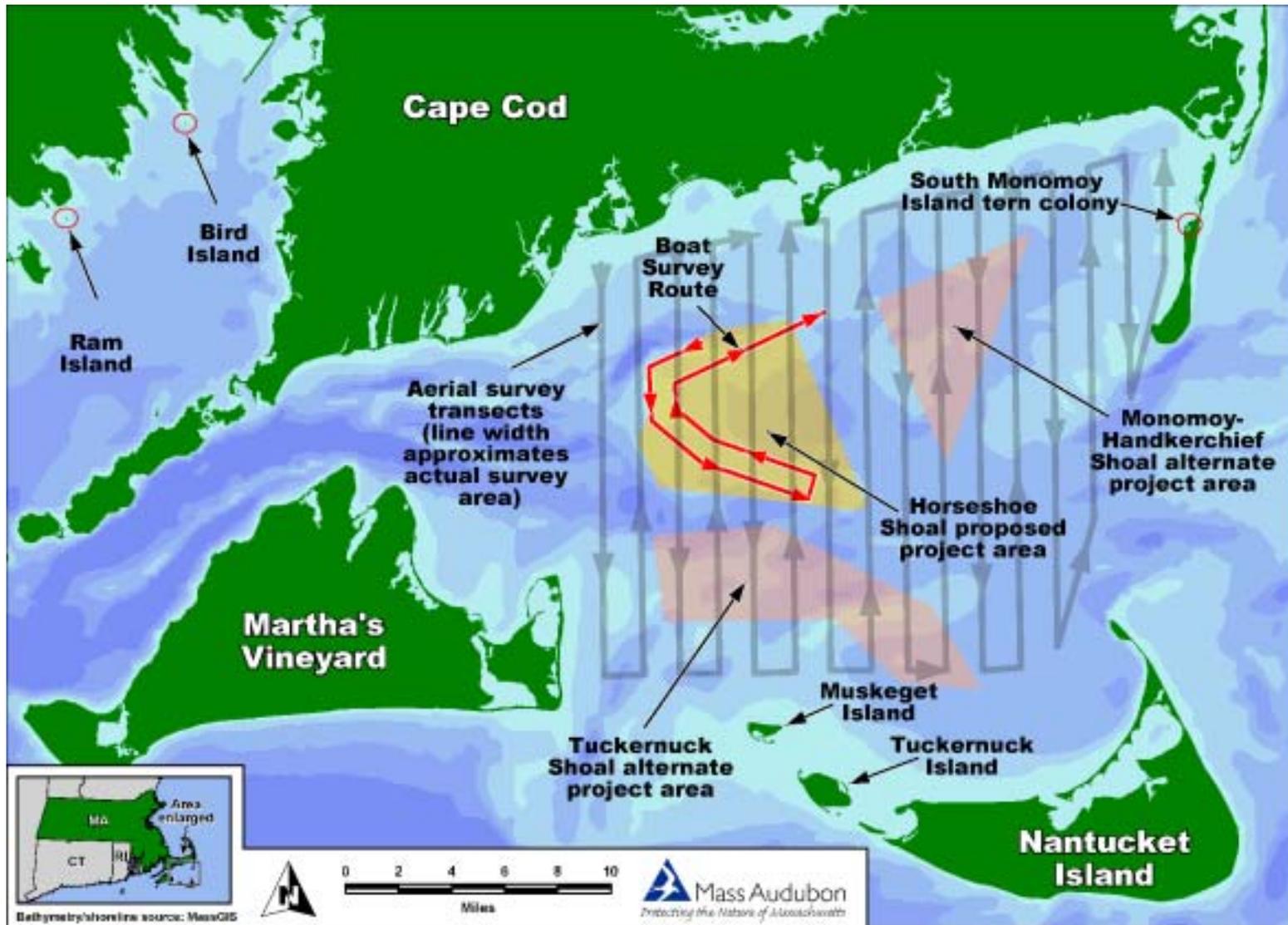


Figure 2. Viewing angles and distances used in aerial surveys (derived from figure drawn by Doug Forsell, U. S. Fish and Wildlife Service)

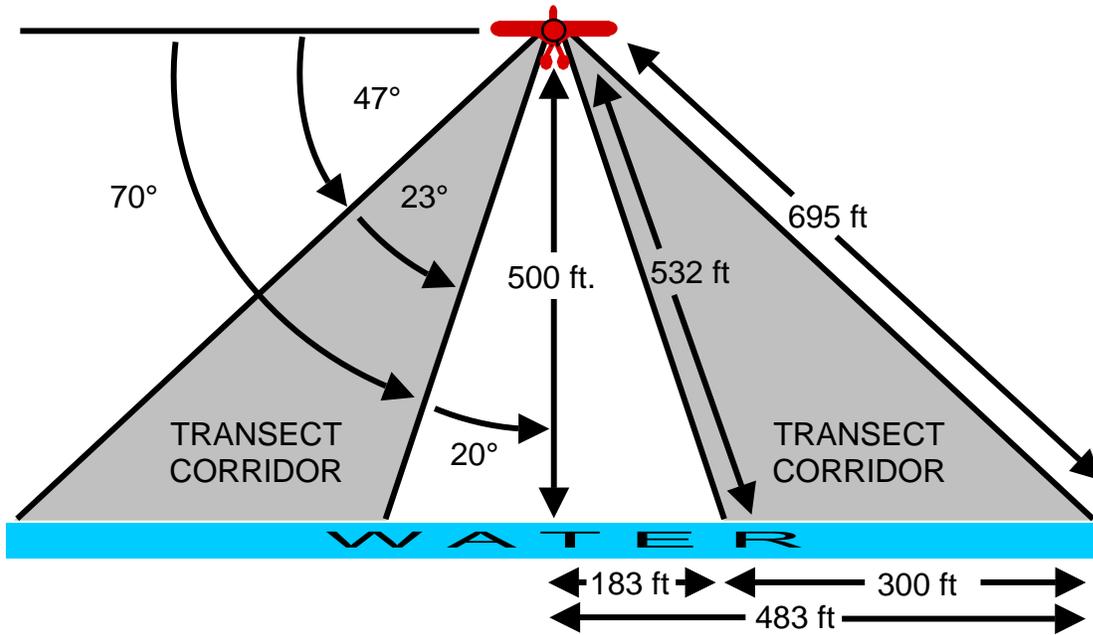
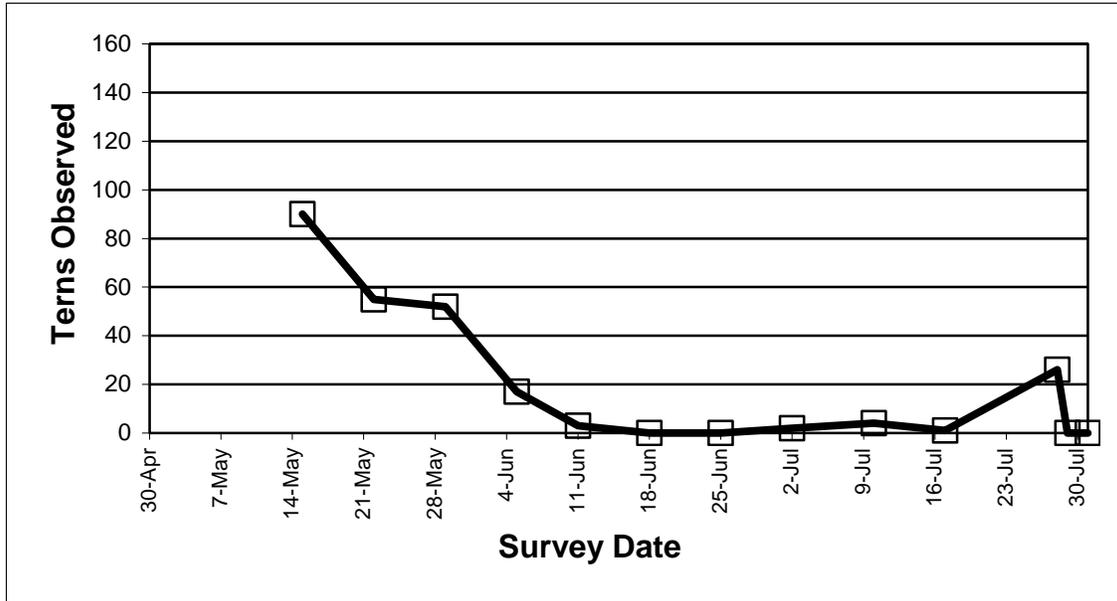


Figure 3. Total numbers of terns observed during breeding period boat surveys in 2003 (n=13 surveys) and 2004 (n=12 surveys) of Horseshoe Shoal, Nantucket Sound by date. Horizontal and vertical scale is the same for both charts.

**2003**



**2004**

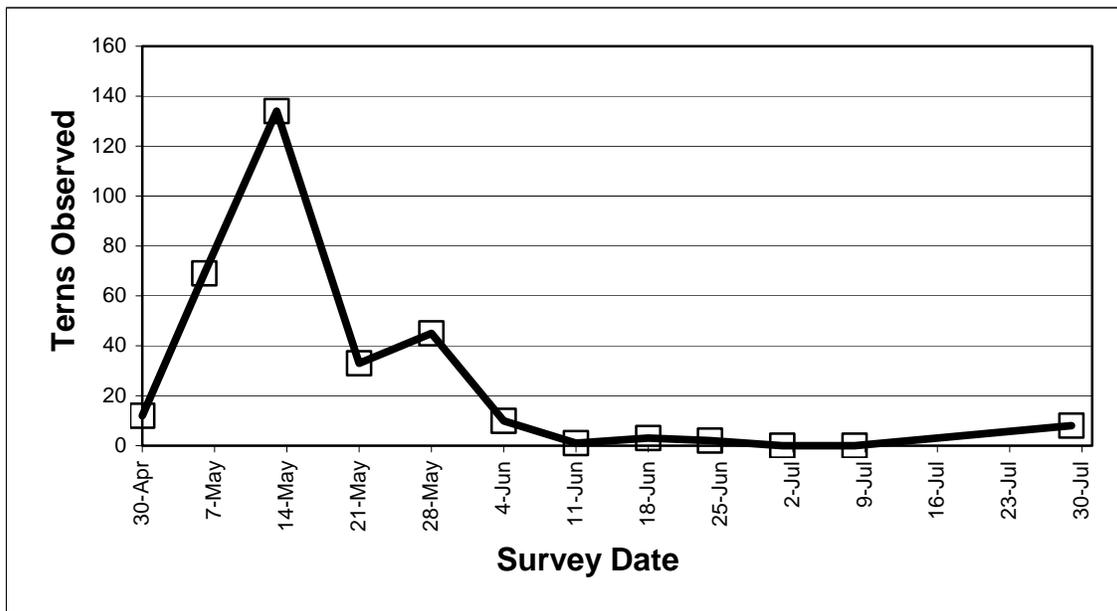
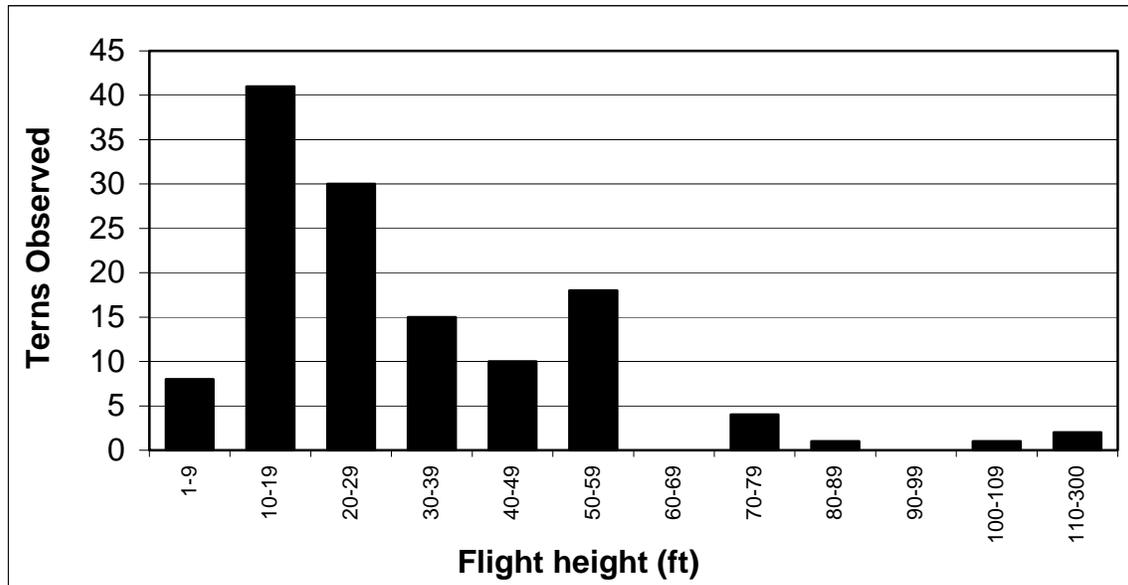


Figure 4. Frequency distribution of flight heights of traveling terns (in feet) observed during 2003 (n=13 surveys) and 2004 (n=12 surveys) breeding period boat surveys on Horseshoe Shoal, Nantucket Sound. Numbers are based on all boat surveys combined. Total number of traveling terns observed in 2003 and 2004 with recorded flight heights were 130 and 163, respectively. Of the 40 terns observed traveling below ten feet in 2004, 29 were observed during April 30 – May 13. No surveys were conducted during this period in 2003.

2003



2004

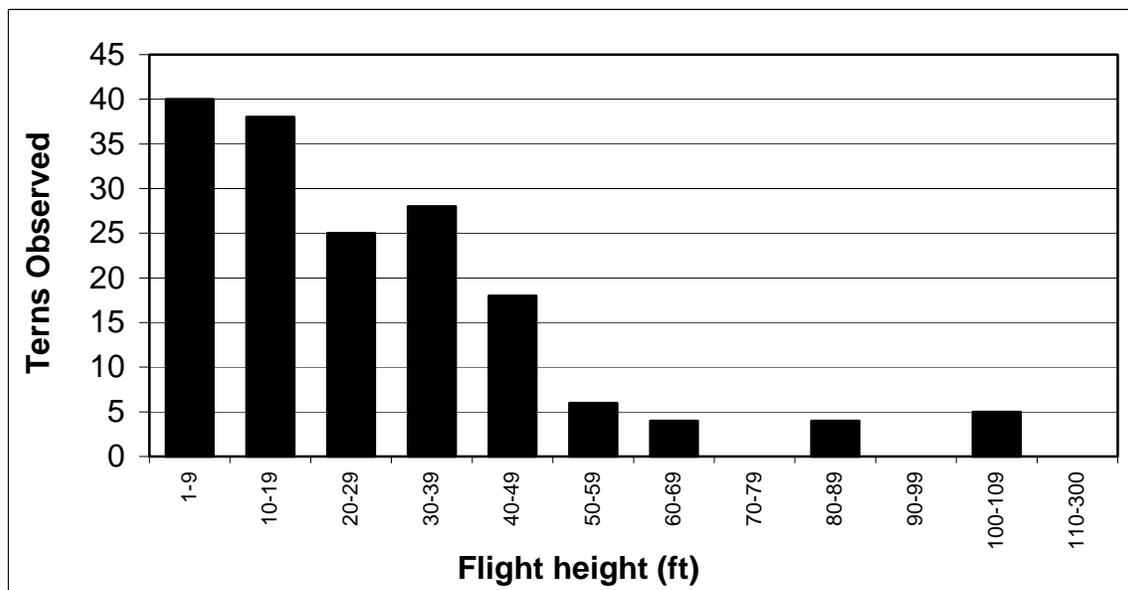


Figure 5. Distribution of tern sightings by species observed during 2004 boat surveys of Horseshoe Shoal, Nantucket Sound. Numbers of terns seen is indicated by the circle diameter and are based on all surveys combined.

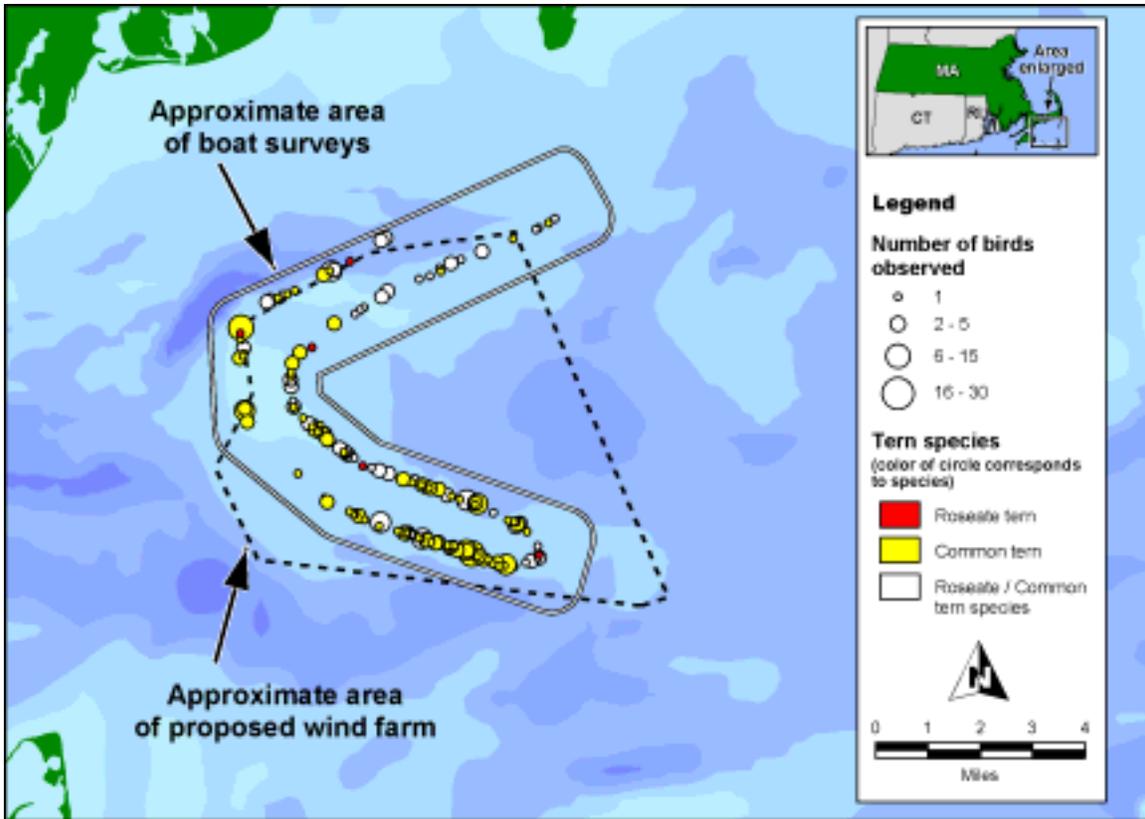


Figure 6. Summary distribution map of terns by species observed during 2004 breeding period aerial surveys (n=3) of Nantucket Sound. Number of terns seen at any one location represents the combined total of three aerial surveys and the magnitude indicated by the diameter of the circle.

