RELATIVE WATERFOWL ABUNDANCE

WITHIN NANTUCKET SOUND, MASSACHUSETTS

DURING THE 2003-2004 WINTER SEASON

Simon Perkins, Giancarlo Sadoti, Taber Allison, and 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. Systematically obtained data on the use of Nantucket Sound that would enable an accurate assessment of the risk of this wind farm to the birds utilizing Nantucket Sound have not been available until recently (Cape Wind Draft Environmental Impact Statement, 2004). Annual and seasonal surveys of avian species inhabiting the waters of Nantucket Sound are important steps necessary to evaluate possible impacts of the proposed wind farm's construction and operation on birds. This report describes the results of our first year of winter surveys of the waterfowl within Nantucket Sound; the data reported here provide an important supplement to the data presented in the recently released draft Environmental Impact Statement prepared by the Army Corps of Engineers.

If the proposed wind farm is constructed, wintering waterfowl and other birds could be directly or indirectly affected in a number of ways. Negative impacts include 1) flying birds could strike turbine blades or supporting poles and become injured or die; 2) the construction and deployment of turbines could result in a decline or a spatial displacement of the benthic and pelagic food resources of Horseshoe Shoals; 3) turbines could result in temporary or permanent displacement of the birds from their wintering habitat; and 4) an array of turbines could create a flight barrier and alter traditional flight patterns of local and migrant waterfowl. All of these potential impacts could be ecologically significant. Alternatively, construction of the wind farm may have a positive if indirect effect on these bird species. Production of energy using wind releases few if any greenhouse gases, which are assumed to be the primary driver of recent climate warming. Reduction in greenhouse gas emissions could ameliorate potential loss of nesting habitat for terns and waterfowl that utilize Nantucket Sound resulting from sea level rise or the migration northward of plant communities.

According to Christmas Bird Count data collected from various land points around Nantucket Sound, hundreds of thousands of ducks occupy the Sound for most of each winter. For example, Griscom and Snyder (1955), cited in Bellerose (1976), reported 500,000 common eiders wintering off the coast of Massachusetts. Land-based Christmas Bird Count totals from Nantucket Island have exceeded one-half million individuals for Long-tailed Duck (525,505 in 2002; http://audubon2.org/birds/cbc/hr/count_table.html). Additionally, large numbers of other sea ducks including Surf, White-winged and Black Scoters are often seen from land on Cape Cod and the Islands during winter months. The actual abundance, distribution, and movement of these species of ducks within the Sound, particularly in relation to Horseshoe Shoal, are poorly known.

We completed 13 aerial surveys and 2 boat surveys of Nantucket Sound following designated survey routes between early December 2003 and early April 2004 (Figure 1). Our specific objectives were to

1. Estimate the relative seasonal abundance and distribution of wintering waterfowl that use the Sound during the winter months and determine whether these patterns vary seasonally.

2. Estimate the heights at which duck species fly when using the Sound
3. Document behavior of ducks (e.g., traveling, feeding, resting) in and around the waters of Horseshoe Shoal

The timing of these surveys corresponded to the period in which long-term birding records indicated waterfowl occurrence within the Sound (Bird Observer Records, M. Rines, personal communication)

Study Area

Nantucket Sound is a relatively shallow water body (maximum depth less than 50 ft) that encompasses approximately 600 square miles. It is surrounded by the southern shore of Cape Cod to the north, Monomoy National Wildlife Refuge and Nantucket Island to the east and south, Tuckernuck and Muskeget Islands to the southwest, and Martha's Vineyard to the west (Figure 1). Within Nantucket Sound we focused on three areas described as alternate sites for the wind farm: 1) Horseshoe Shoal – the site preferred by the applicant, Cape Wind Inc.; 2) Tuckernuck Shoal; and 3) Monomoy-Handkerchief Shoal. The bottom substrate of the Sound is mostly sand, with a few areas, including Horseshoe Shoal, that have a higher proportion of gravel (USGS 2003). The coarser material on Horseshoe Shoal may account for the Shoal's relative geologic stability compared to the sandier areas in this region. The abundance of scoters and Common Eiders observed in the Sound indicates that mollusks such as mussels, scallops, and clams, crabs, fish and other food sources are abundant. The benthic sampling reported in the draft Environmental Impact Statement for this project (USACE, 2004) supports this view and also indicates that the benthic fauna varies seasonally and spatially.

METHODS

Waterfowl behavior, distribution, and relative abundance in the Sound and the alternate project sites were estimated from data collected on aerial surveys, and behavioral data were collected during two boat surveys on Horseshoe Shoal. The methods were similar to the protocols developed for our tern surveys during the 2003 season (e.g., Perkins, et al. 2004) with slight modifications as described below.

Aerial Surveys

Thirteen aerial surveys were conducted during the period between December 1 and April 8 along sixteen fixed, parallel transects, oriented north to south (Figure 1). The winter aerial survey grid was similar to that used during our tern surveys (Perkins, et al. 2004); however the entire grid was shifted south by about 2.2 miles, with the southern limit of the grid at 41° 20' N latitude. This shift also resulted in the elimination of the easternmost transect flown during tern surveys to avoid flying over Monomoy NWR. This slight modification in the grid location was based on the assumption that locally wintering ducks have been regularly observed in the southern portions of the Sound and the waters around Muskeget Island. The shift of our study area did not omit any of the waters on or adjacent to Horseshoe Shoal or the other project alternate sites.

Our aerial survey grid included approximately 340 mi^2, or 60% of the waters of Nantucket Sound. Individual transects were separated at 7,500 ft intervals; the total combined length of all 15 transects was 249.2 mi. The actual area of the Sound that we surveyed was 30 mi^2, or approximately five percent. This area was calculated by multiplying the transect width (600 ft) by the combined length of all transects (249.2 mi).

Aerial surveys were flown with a high-wing, twin-engine aircraft (Cessna Sky Master 337), cruising at an average altitude of 500 ft and at an average airspeed of 90 kts. This altitude allowed us to identify most birds at the sea surface and 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 ($\leq$15 kts) and on days with good atmospheric clarity (visibility >10 miles). Flights usually began mid-morning to reduced glare due to low sun angles, and the average duration of each survey was approximately 2.5 hrs.

We recorded birds observed along either side of the north-south transects out to a distance of 300 ft from each side of the plane (Figure 2). Individual birds were identified with the aid of binoculars as needed. Criteria used for the selection of transect width included:

1. Determination of the distance perpendicular to the transect centerline at which birds were detectable and identifiable with the naked eye for observers.
2. A total width narrow enough to avoid situations in which birds were too abundant and/or were spread over too wide an area to count accurately. This was especially important because sea ducks occasionally congregate in large flocks or rafts.

Each survey team was composed of a pilot, a recorder in the co-pilot seat, and two experienced observers 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. The recorder entered number of birds observed, species, behavior (sitting on the water, traveling or actively feeding), and precise geographic location into a laptop computer equipped with dLog (v.2.0, R.G. Ford Consulting, Portland, OR) that linked with the plane's onboard GPS unit. This software enabled us to automatically and accurately enter the geographical location of the plane as data were entered at the time of the sighting. Additional information recorded included starting and ending times of the survey, wind direction and velocity (kts), sea state (Beaufort scale), visibility (mi), and % cloud cover for every survey. Surveys were conducted over a wide range of tidal stages, although no attempt was made to control for this variable due to weather and time constraints. We did not attempt to estimate flight heights of waterfowl during plane surveys *unless* the birds were relatively high (300 ft or higher) such that more accurate height estimates were possible. Most flying birds observed during aerial surveys were at or near the water surface, and accurate estimation of their flight height from 500 feet was not practical.

Observers were able to identify most birds to species. Scoters were identified to the species level whenever possible, but otherwise they were recorded as "Scoter spp". Birds were recorded continuously along transects. We did not count any birds observed while we were flying the short, east-west legs between transects. Observations of marine mammals and fish

were also recorded, but the results are not reported here. These data are available from the authors upon request.

Analysis of Aerial Survey Data

We compared relative waterfowl abundance on Nantucket Sound, Horseshoe Shoal, Tuckernuck Shoal, and Monomoy-Handkerchief Shoal (Figure 1). We estimated relative abundance as numbers of birds per mile surveyed and as the proportion of the total number of birds counted in each geographic unit. A few surveys were not completed due to bad weather or equipment malfunction. Bird distribution across the sound is probably not random, our survey grid was not laid out or sampled randomly, and we always began our surveys at the western edge of the grid. These factors inject some unknown bias into the results, especially when considering the results of incomplete surveys. Incomplete surveys were not included in the analysis of proportional waterfowl abundance.

Proportional waterfowl abundance in each site was calculated first by overlaying the boundaries of the three wind farm sites over all point data collected during surveys. Using data from the completed surveys only, the total number of birds of a given species observed within each project area was divided by the total number observed on each survey. These proportions were compared to the proportional area of each project area to determine if sea ducks were evenly distributed across the project areas and Nantucket Sound.

Relative waterfowl abundance was also calculated as number of birds-per-mile. Each transect of the survey grid was subdivided into single-mile transect segments and all bird observations were assigned to a mile segment within each transect. To answer the question of whether bird distribution varied spatially across Nantucket Sound, we calculated relative abundance of each bird species as number of birds-per-mile for the entire Sound and the three alternate project sites. We determined whether bird distribution and relative abundance varied seasonally by arbitrarily dividing the survey period into four time periods: 1) December 5, 9, 16, and 24; 2) January 22, and February 10 and 12; 3) February 17 and 24, and March 1; and 4) March 11 and 23, and April 8. Because all data were normalized by the number of times each mile segment was surveyed, we included data from incomplete surveys in this analysis.

Common Eiders were found throughout the Sound in large rafts, and we calibrated our estimates of these rafts using imaging software - Adobe Photoshop and ImageJ (v. 1.32, 2004, National Institutes of Health). In December 2003, we took photographs of seven Eider rafts and used Photoshop to represent white Common Eider drakes as dark spots on a white background. From these photographs we estimated the average number of pixels per Eider drake. Image J counted the pixels providing an independent estimate of the number of male Eiders per raft. This was then compared to our visual estimates of the picture. Additional counts by observers provided estimates of hen: drake ratios of Eiders in rafts (3 hens: 4 drakes), and we used this ratio to estimate total number of Eiders in these rafts. This procedure was not followed for every Eider raft, but used only at the beginning of our surveys. We frequently referred back to these photos of know Eider abundance to recalibrate our estimates of the size of these rafts.

Boat surveys

We conducted two boat surveys along a series of transects oriented in two parallel tracks, one mile apart (Figure 1). The location of these transects was selected to sample the waters over Horseshoe Shoal as well as the waters in the immediate vicinity of the Shoal. Surveys were conducted from a 33 ft powerboat cruising at an average speed of 17 kts. 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. The observers were positioned on each side of the boat immediately aft of the wheelhouse; bird sightings were communicated verbally to the recorder. Observers used binoculars to confirm identification to species as needed. 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. The recorder entered number of birds seen, species, behavior (sitting on the water, traveling or actively feeding) and flight altitude of birds (in feet). 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 test tower. The geographic location of all sightings was recorded in the laptop computer equipped with dLog2 (see above). Additional information recorded included start and end time, wind direction and velocity (kts), sea state (Beaufort scale), visibility (mi), % cloud cover, and water temperature (°C).

We recorded all waterfowl to the species level whenever possible. In cases where we were unable to differentiate between species when waterfowl occurred in high concentrations, we consigned these types of sightings to a more generic category, such as duck spp. or Scoter spp.

RESULTS

Aerial Surveys

Thirteen aerial surveys were initiated between December 5 and April 8 (Table 1), of which ten where completed. Surveys were conducted at one-week intervals throughout the survey period, but some surveys were postponed or cancelled due to poor weather. After January 22 and prior to February 10 we conducted no aerial surveys because the entire Sound was covered with ice. On February 10 and February 17 computer failure resulted in the loss of coverage along 36.9% and 19.3%, respectively, of the aerial survey route. On March 23, a plane instrument malfunction forced us to abort the flight after covering 38.8% of the route, and on January 22, ice covered approximately 33% of the survey route. The flights on February 10 and February 12 were flown within two days because of the loss of data on the first of these two surveys.

Relative Waterfowl Abundance

We observed 20 species of sea ducks and other waterbirds (Table 2). The most common species we observed was the Common Eider at approximately 280,000 birds counted over all surveys (all duck numbers have been rounded to the nearest one or two digits). Eider rafts

ranged from a few hundred birds to tens of thousands of birds per raft. One raft recorded on the survey had an estimated 18,000 birds. Another raft observed off the survey route contained an estimated 50,000 Eiders. Approximately 82,000 Scoter spp. (including 8,000 Surf Scoters, 600 White-winged Scoters, and 300 Black Scoters) and 33,000 Long-tailed Ducks were also observed. The highest waterfowl count was made on January 22, 2004, when a total of more than 80,000 ducks were counted. This day also represented the highest total survey count for Common Eiders (53,000) and Scoter spp. (27,000).

Relative abundance of birds ranged widely from survey to survey. When results from completed surveys were standardized by birds per survey mile, Common Eider numbers per survey ranged from 26 to 316 birds per mi per (median = 84/mi), Scoter (all species) counts ranged from three to 159 bird per mi (median = 19/mi), and the number of Long-tailed Ducks ranged from two to 32 birds per mi (median = 11/mi) (Figure 3).

Waterfowl Distribution in the Sound

Waterfowl were observed throughout the entire survey area over the survey period. Most Common Eiders were observed in dense rafts, and there were substantial areas of the Sound where no eiders were observed (36 transect miles, approximately 14% of the survey area). Scoters were more evenly distributed; with 7 transect miles (3%) containing no scoter observations. Long-tailed ducks were absent from fewer transect miles (3, or 1%) than the two other groups. Of more than 240,000 ducks observed on nine full surveys, 8.3% of Eiders, 15.8% of Scoters, and 12.1% of Long-tailed Ducks were observed on Horseshoe Shoal. This distribution changed seasonally.

Numbers of birds in individual mile segment of the survey grid ranged widely and provides another perspective on distribution of ducks in the Sound. When averaged across all surveys, Common Eider had the highest abundance in any mile segment at over 4,000 birds near Muskeget Island. Other areas with consistently high Eider numbers throughout the survey period were near Monomoy Island, Horseshoe Shoal, and the northeastern section of the Sound (Figure 4). The highest average per mile Scoter abundance was 740 and was located in the southeastern section of Horseshoe Shoal. Other areas with high Scoter numbers included adjacent areas to the east, south, and southeast of the Shoal. The highest average number of Long-tailed Ducks was 170 per mile segment; this number was observed west of Muskeget Island

A slightly greater proportion of ducks were observed over Horseshoe Shoal in December versus later in the winter season (Figure 3). During four surveys in December, 13.4% of all waterfowl counted were observed on the Shoal (an area comprising 10.9% of the survey area); among Scoters observed in December, the proportion on Horseshoe Shoal was 21.3%—almost twice the expected proportion. After January, the proportion of ducks using Horseshoe Shoal was generally less than the proportional area. On five complete surveys from February 12 to April 8 (Table 1) an average of 8.8% of all waterfowl counted were observed on Horseshoe Shoal; among Eiders and Scoters, 8.5% and 4.2%, respectively, were observed over the Shoal. Conversely, 14.5% of Long-tailed Duck observations during surveys in this period were on Horseshoe Shoal versus 3.3% on the Shoal in December. The two alternate sites, Tuckernuck Shoal and Monomoy-Handkerchief, had waterfowl abundance in proportions greater than their

area among several species and in several time periods (Table 3). Analysis of distribution in based on birds per mile yielded similar results (Figure 3).

Eiders consistently concentrated in the southeastern section of the Sound adjacent to Muskeget Island, and near South Monomoy Island in the west-central portion of the Sound (Figure 4). High concentrations of Eiders were not observed as consistently in other areas, including Horseshoe Shoal and the northwestern portion of the Sound. Scoters exhibited higher concentrations in the northeastern quarter of the Sound (Figure 6), though various areas—generally falling within a broad diagonal band from southwest to northeast through the entire Sound—had high, somewhat inconsistent, concentrations over the entire survey period. This area included Monomoy-Handkerchief Shoal (Table 3 and Figure 3), one of the alternate sites. Long-tailed Ducks did not exhibit consistent areas of concentration over the survey period (Figure 7), although they were observed in disproportionately higher numbers on Horseshoe and Monomoy-Handkerchief Shoals.

Seasonal Abundance

Changes in seasonal abundance of ducks were assessed by arbitrarily dividing the survey counts into four periods to observe changes in abundance over time. Time periods were chosen to contain at least three surveys and span a maximum period of four weeks – these periods are not considered to be "natural" units. The average number of Common Eiders per survey increased from 50 birds per survey mile in December to 105/mi in January-early February, to 119/mi in late February-early March, to 82/mi in March-April, respectively (Figures 3 and 5). Average Scoter abundance was highest in December (42/mi), decreased in January-early February (6/mi), and rose slightly again in February-early March and March-April (18/mi and 17/mi, respectively) (Figures 3 and 6). The number of Long-tailed Ducks increased from December (8/mi), through January-early February and later February-early March (11/mi and 21/mi, respectively), then decreased in March-April (10/mi) (Figures 3 and 7).

Waterfowl Behavior

The vast majority (98.6%) of waterfowl recorded in the Sound were observed sitting and/or feeding on the water. We combined "feeding" and "sitting" ducks because 1) we could not determine whether they were diving in response to the passage of the plane or whether they were diving for food, and 2) we did not attempt to ascribe these behavioral traits to birds within large rafts because accurately recording these types of data for all individuals within such a raft would have been impossible.

Boat surveys

Two boat surveys were conducted on Horseshoe Shoal – the first on December 19, 2003 and the second on February 27, 2004. We were unable to conduct boat surveys during the month of January due to the presence of ice in the Sound. A total of 3,813 ducks were counted on these two surveys (Table 4); 2,286 (60.1%) were traveling, and 1,522 (39.9%) were sitting on the water surface. Ten other bird species were observed and these results are presented in Table 4. The altitude range of all traveling ducks (n=2,286) was between 1 and 60 feet with an average

height of 8.5 ft (SD=7.1) and a median height of = 5.0 ft. Only two birds (both Herring Gulls) were observed in the rotor swept zone between 75 and 425 feet.

During the two boat surveys, ducks were distributed throughout the entire Shoal area; concentrations of birds were in similar areas as observed on aerial surveys during the same periods (i.e., December 16 and 23, and February 24).

DISCUSSION

Common Eider, Scoter spp., and Long-tailed Ducks comprised nearly all (96.8%) of the waterfowl recorded during these surveys. To place the number of ducks observed in Nantucket Sound in context, Bellerose (1976) estimated that there are 1.5-2 million Common Eiders in North America; our highest count of 50,000 Common Eiders on one day in the Sound, therefore, represents approximately 3% of the total number of Common Eider in North America. Bellerose (1976) estimated scoter populations in North America at approximately 1.5 million and Long-tailed Duck at 3-4 million.

Published numbers of Long-tailed Ducks counted within the Sound have exceeded a half a million individuals (e.g., http://audubon2.org/birds/cbc/hr/count_table.html), but our surveys recorded relatively low numbers of this species compared to Eiders and Scoters. These results were not unexpected given the apparent diurnal foraging patterns of Long-tailed Ducks. The majority of wintering Long-tailed Ducks observed in Nantucket Sound likely spend at least a portion of each night roosting within the Sound; in the morning it is suspected that Long-tailed Ducks departed to feeding areas south and southeast of Nantucket via the west end of the island and, therefore, outside our survey area.

Determining the locations of the night-time roost sites of Long-tailed Ducks within the Sound will require detailed surveys at dusk and dawn, when the birds have been observed gathering in the Sound to roost, or preparing to exit the Sound for the day. Details regarding the nighttime use of Nantucket Sound by Long-tailed Ducks are important in the context of the project proposal, and we plan to pursue relevant studies this coming winter.

The relative abundance of Common Eider, Scoters, and Long-tailed Ducks changed during the course of the survey season, but changes in their distribution throughout the study period were less pronounced. This was especially true of Common Eider. While Eiders were distributed widely within the study area, the largest concentrations were found most consistently in only two areas - the vicinity of Muskeget Island and southwest of S. Monomoy Island, Chatham. Waterfowl studies in Denmark (Guillemette, et al. 1999) have demonstrated a direct correlation between the abundances of sea ducks such as Common Eider and the abundance and availability of their food supplies. Between-year fluctuations in local sea duck numbers were also directly related to food (Guillemette, et al. 1999).

The surface of the Sound froze almost completely from Nantucket Island to Cape Cod during the week following the January 22 survey. According to the meteorological records for Boston, January 2004 was the coldest since 1880. The highest single-day Eider and Scoter totals were recorded on January 22. We speculate that birds displaced by the ice already formed in

areas surrounding the Sound (e.g., Buzzards Bay, the waters around Martha's Vineyard, the Elizabeth Islands) may have contributed to the high concentrations observed.

The presence of ice likely influenced the distribution and relative abundance of waterfowl in the Sound during the study period. Prior to January 22 when ice was first observed on the Sound, Scoters comprised a large percentage of the total recorded waterfowl (41%). After the Sound froze over, Scoters were not as abundant in Nantucket Sound, and therefore may have been permanently relocated to ice-free areas after initial displacement. . Anecdotal data from local bird records (Bird Observer, M. Rines, personal communication) suggest that Scoters may have moved to ice-free waters just to the west of the Sound around Martha's Vineyard. After the break-up of sea ice, Scoter numbers were not as high as the pre-ice period. It will be important to examine seasonal variation in the absence of sea ice in the following two years of this study, if freezing does not occur.

During the two boat surveys, estimating relative abundance of waterfowl was not possible. This was mainly because of the high numbers of waterfowl that flushed in response to the survey boat and other vessels. Often, the birds flushed when our vessel was one mile away or more. As the birds flushed, they scattered in all directions, making it impossible to avoid recounting birds. Additionally, we were unable to control for other boats in the area of Horseshoe Shoal prior to or during our surveys. We were able to estimate flight heights of flushed birds and none them were flying within the rotor swept zone from 75 feet to 425 feet. Although these data may not reflect the ducks usual flight behavior, they are indicative of how the birds might respond to the presence of vessels in the area. If the wind farm is constructed, the number of maintenance boat trips is expected to be substantial (ACOE, 2004).

The results from our initial survey indicate that Horseshoe Shoal is an important location for wintering sea ducks. Roughly one-third of all waterfowl recorded in December were observed within the region of Horseshoe Shoal, an area comprising approximately 11% of Nantucket Sound. Scoters were particularly abundant on the Shoal at this time. This disproportionately high numbers of Scoters on Horseshoe Shoal suggests that the Shoal area provided significant foraging habitat and stable and persistent patterns of prey availability during the study period.

We propose to continue our surveys for at least two additional years. In particular, we hope to determine the extent to which the distribution of ducks shifts within the Sound, presumably in response to shifts in food availability. During the scoping phase of the environmental review of the Cape Wind project, Mass Audubon and the U.S. Fish and Wildlife Service strongly recommended that three years of avian surveys was the minimum period necessary to begin to understand the short-term dynamics of avian use of Nantucket Sound and Horseshoe Shoal.

ACKNOWLEDGMENTS

We thank the Island Foundation and Foundation M for providing financial support for the surveys described in this report. We are grateful to Glenn Ford for having the foresight to develop the mapping software. We thank the following for their assistance as either recorders

and/or observers during surveys: Ellen Jedrey, Peter Flood, Nat Donkin, Liz Brousseau, and Denny Chow. Carolyn Mostello, Dr. Jeremy Hatch, Dr. Ian Nisbet, and Mark Koneff provided valuable consultation and advice. Ellen Jedrey provided helpful comments in preparation of this report. We are very grateful to Ambroult Aviation and pilots John Ambroult and Jack O'Brian for skillfully and safely flying the planes, and to Len Greiner of Cape Cod Sportsman, Inc. for the boat charter services.

LITERATURE CITED

Bellrose, F.C., ed. 1980. Ducks, geese, and swans of North America. 3rd ed. Stackpole Books, Harrisburg, PA.

Brown, P.W., and L.H. Fredrickson. 1997. White-winged Scoter (*Melanitta fusca*). *In* The Birds of North America, No. 274 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Everaert, J. 2003. Wind Turbines and birds in Flanders: Preliminary study results and recommendations. Natuur.Oriolus 69(4): 145-155.

Goudie, R.I., G.J. Robsertson, and A. Reed. 2000. Common Eider (*Somateria mollissima*). *In* The Birds of North America, No. 546 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Guillemette, J., K. Larsen, and I. Clausager. 1999. Assessing the impact of the Tuno Knob wind park on sea ducks; the influences of food resources. NERI Tech. Report No. 263. Denmark

Perkins, S., T. Allison, A. Jones, and G. Sadoti. 2004. A survey of tern activity within Nantucket Sound, Massachusetts, during the 2003 breeding season. Final Report to the Massachusetts Technology Collaborative. Massachusetts Audubon Society, Lincoln, MA. 18 pp.

USACE (Army Corps of Engineers). 2004. Draft Environmental Impact Statement, Cape Wind Project. USACE-NAE-2004-338-1.

U.S. Geological Survey. 2003. Surficial Sediment Data from the Gulf of Maine, Georges Bank, and Vicinity: A GIS Compilation. Open-File Report 03-001. URL: http://pubs.usgs.gov/of/2003/of03-001/htmldocs/data.htm.

Table 1. Dates of 13 aerial surveys on Nantucket Sound, winter 2003-2004.

Survey Date	Comments
12/5/2003	100% complete, though data missing for several species.
12/9/2003	100% complete.
12/16/2003	100% complete.
12/23/2003	100% complete.
1/22/2004	100% complete. 32% of sound covered by ice, generally in the northern part of study area (42% of Horseshoe Shoal, 32% of non-Horseshoe Shoal).
2/10/2004	63% complete. Missing 6.5 transects (10 - 15) in eastern part of study area. Missing 0% of Horseshoe Shoal, 46% of non-Horseshoe Shoal.
2/12/2004	100% complete.
2/17/2004	81% complete. Missing 3 transects (2 - 4) in western part of study area. Missing 68% of Horseshoe Shoal, 10% of non-Horseshoe Shoal.
2/24/2004	100% complete.
3/1/2004	100% complete.
3/10/2004	100% complete.
3/23/2004	33% complete. Missing 9 transects (7 - 15) in eastern two-thirds of study area. Missing: 17% of Horseshoe Shoal, 72% of non-Horseshoe Shoal.
4/8/2004	100% complete.

Table 2: Total bird numbers observed on aerial surveys of Nantucket Sound, winter 2003-2004. Numbers are typically rounded to the two left-most digits.

Species	Total Number
Brant	7
Common Eider	280,000
Surf scoter	7,500
White-winged scoter	600
Black scoter	270*
Scoter (undifferentiated)	83,000
Long-tailed Duck	32,000*
Red-breasted Merganser	55
Duck (undifferentiated)	18
Common Loon	160
Red-throated Loon	154*
Loon (undifferentiated)	3,400
Red-necked Grebe	1
Horned Grebe	1
Grebe (undifferentiated)	4
Northern Gannet	630
Double-crested Cormorant	1
Great Cormorant	3*
Cormorant (undifferentiated)	3
Shorebird (undifferentiated)	3
Bonaparte's Gull	33
Herring Gull	630
Great Black-backed Gull	170
Black-legged Kittiwake	560*
Gull (undifferentiated)	2,240
Razorbill	2,580
Alcid (undifferentiated)	4
Unidentified bird	1,020

* = Numbers include estimated numbers not recorded on December 5, 2003 due to computer errors. An estimated 40 Red-throated Loons, 2 Great Cormorants, 100 Black scoters, 1,000 Long-tailed ducks, and 15 Black-legged Kittiwakes are included.

Table 3. Relative waterfowl abundance observed in three alternative Cape Wind project sites and the remaining non-project area on nine aerial surveys of Nantucket Sound from December 5, 2003 to April 8, 2004. Survey periods include the following survey dates: 1) 12/5, 12/9, 12/16, and 12/23; 2) 2/12; 3) 2/24 and 3/1; 4) 3/11 and 4/8. Data from incomplete surveys is not included. Long-tailed Duck averages do not include data from December 5, when computer errors prevented recording this species. Species-area-period combinations with proportional abundances greater than the proportional area are shown in bold.

			Proposed Cape Wind project areas		
		Non-shoals (183.1 miles)	Horseshoe Shoal (28.7 miles)	Monomoy-Handkerchief Shoal (15.7 miles)	Tuckernuck Shoal (23.5 miles)
Species	Survey Period	Proportional area			
		72.1%	10.9%	6.9%	10.9%
Common Eider	1	90.3%	7.8%	0.7%	1.3%
	2	98.6%	1.3%	0.1%	0.1%
	3	93.5%	4.9%	0.3%	1.3%
	4	85.1%	**13.8%**	0.9%	0.2%
	All	90.3%	8.3%	0.6%	0.8%
Long-tailed Duck	1	91.5%	3.2%	2.1%	3.2%
	2	62.1%	**16.1%**	**14.0%**	7.8%
	3	62.2%	**12.4%**	**18.6%**	6.8%
	4	62.3%	**19.3%**	**11.5%**	6.9%
	All	68.4%	**12.1%**	**13.3%**	6.1%
Scoter species	1	46.8%	**21.3%**	**17.1%**	**14.9%**
	2	79.5%	3.7%	3.8%	**12.9%**
	3	75.9%	3.5%	9.1%	11.5%
	4	75.5%	5.1%	**9.3%**	10.1%
	All	56.3%	**15.8%**	**14.3%**	**13.7%**
Total	1	71.4%	**13.4%**	**7.9%**	7.3%
	2	92.0%	3.3%	2.1%	2.6%
	3	85.3%	6.2%	4.9%	3.6%
	4	82.3%	**13.1%**	2.7%	1.9%
	All	79.9%	10.5%	5.2%	4.4%

Table 4. Total bird numbers observed on two boat surveys of Horseshoe Shoal. Survey dates were December 19, 2003 and February 27, 2004.

Species	Total Number
Common Eider	794
Surf scoter	11
White-winged scoter	728
Black scoter	87
Scoter (undifferentiated)	924
Long-tailed Duck	1,209
Red-breasted Merganser	1
Duck (undifferentiated)	59
Loon (undifferentiated)	2
Horned Grebe	1
Northern Gannet	1
Bonaparte's Gull	5
Herring Gull	26
Great Black-backed Gull	6
Black-legged Kittiwake	6
Gull (undifferentiated)	9
Razorbill	19
Dovekie	1

Figure 1. Nantucket Sound study area and surrounding features. Project area polygons based on information from Cape Wind Associates.

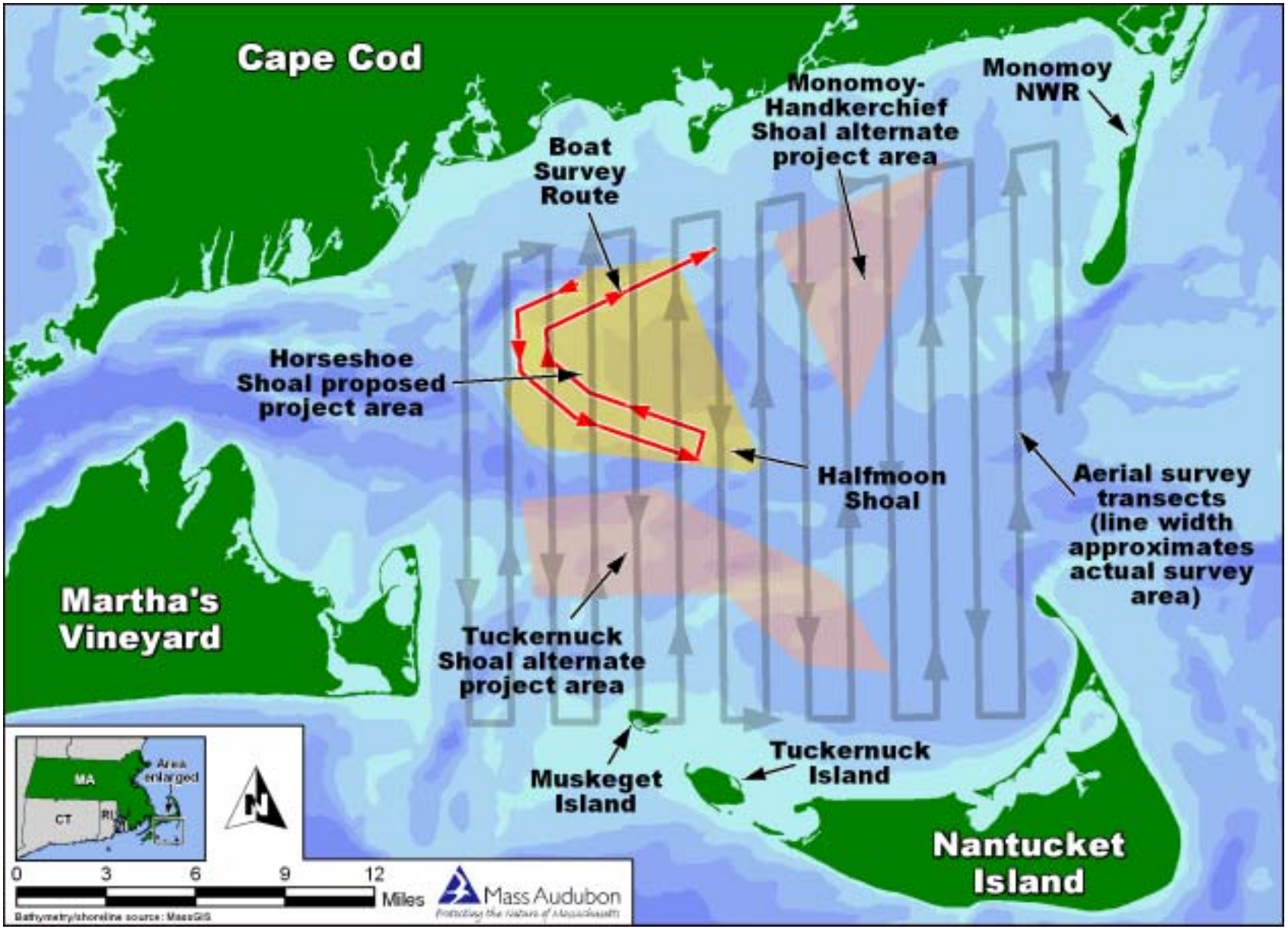


Figure 2. Diagram illustrating observation angles and distances of aerial surveys of Nantucket Sound.

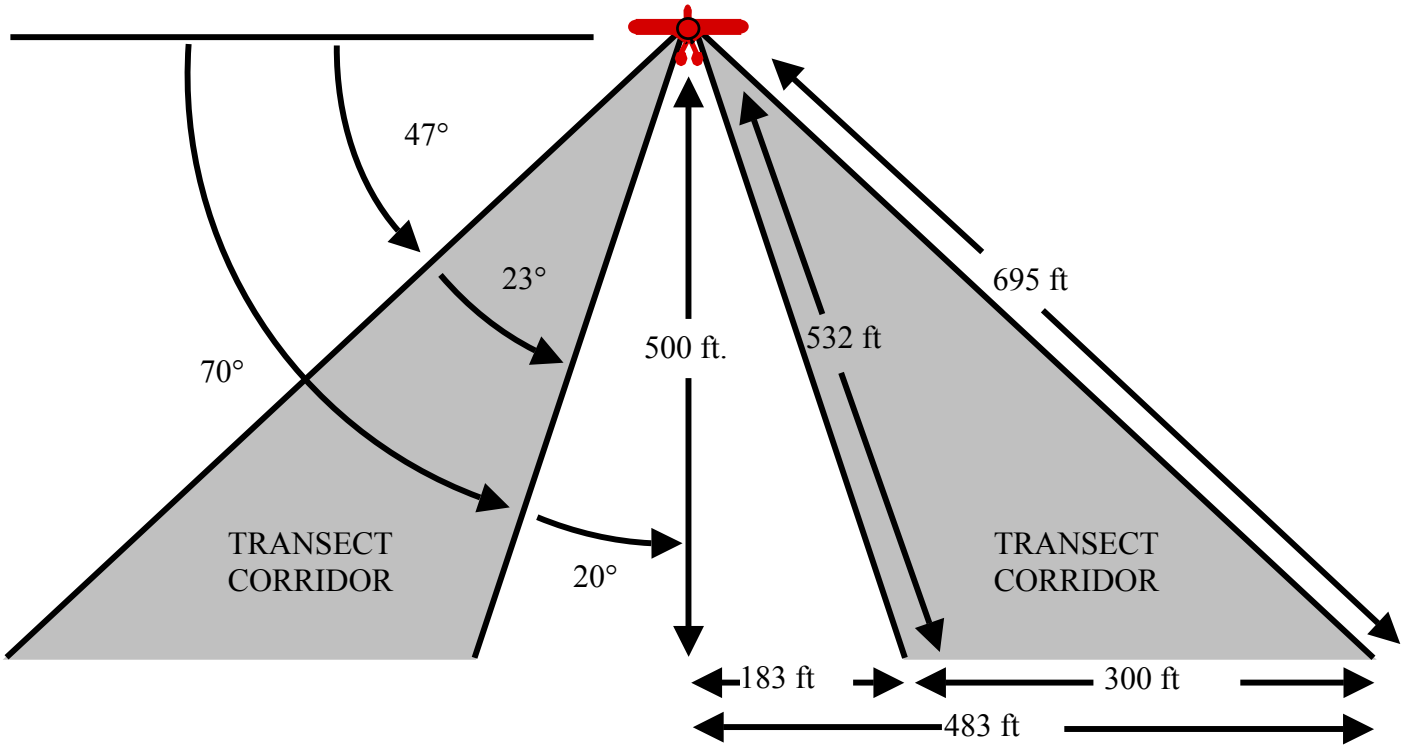


Figure 3. Numbers of Common Eiders, scoters (all species), Long-tailed Ducks, and waterfowl (all species combined) per mile, winter 2003-2004. Values are calculated from total birds observed in each area (Non-shoals, Horseshoe Shoal, Monomoy-Handkerchief Shoal, and Tuckernuck Shoal) divided by miles surveyed within each area. Incomplete surveys occurred on January 22, February 10 and 17, and March 23. Long-tailed Duck abundances do not include data from December 5, when computer errors prevented recording this species. Data from March 23 is missing for Monomoy-Handkerchief shoal due to an incomplete survey.

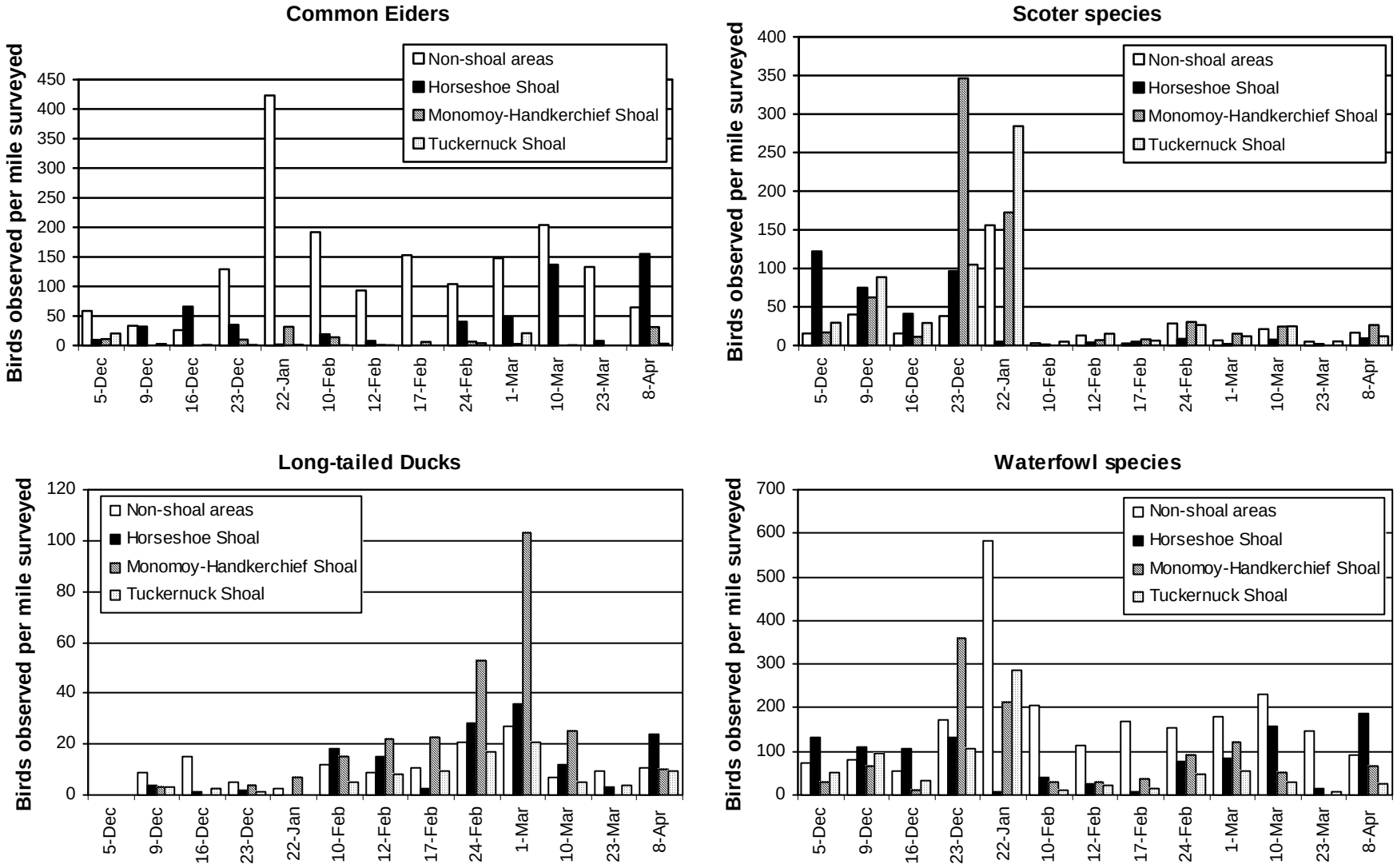


Figure 4. Distribution and abundance of approximately 280,000 Common Eiders, 91,000 scoters (all species), 32,000 Long-tailed ducks, and all waterfowl species combined (401,000) recorded on 13 aerial surveys, December 2003 - April 2004. An estimated 100 Black scoters and 1,000 Long-tailed ducks (observed on December 5, 2003) are not included. Bird per survey-mile values have been adjusted accordingly.

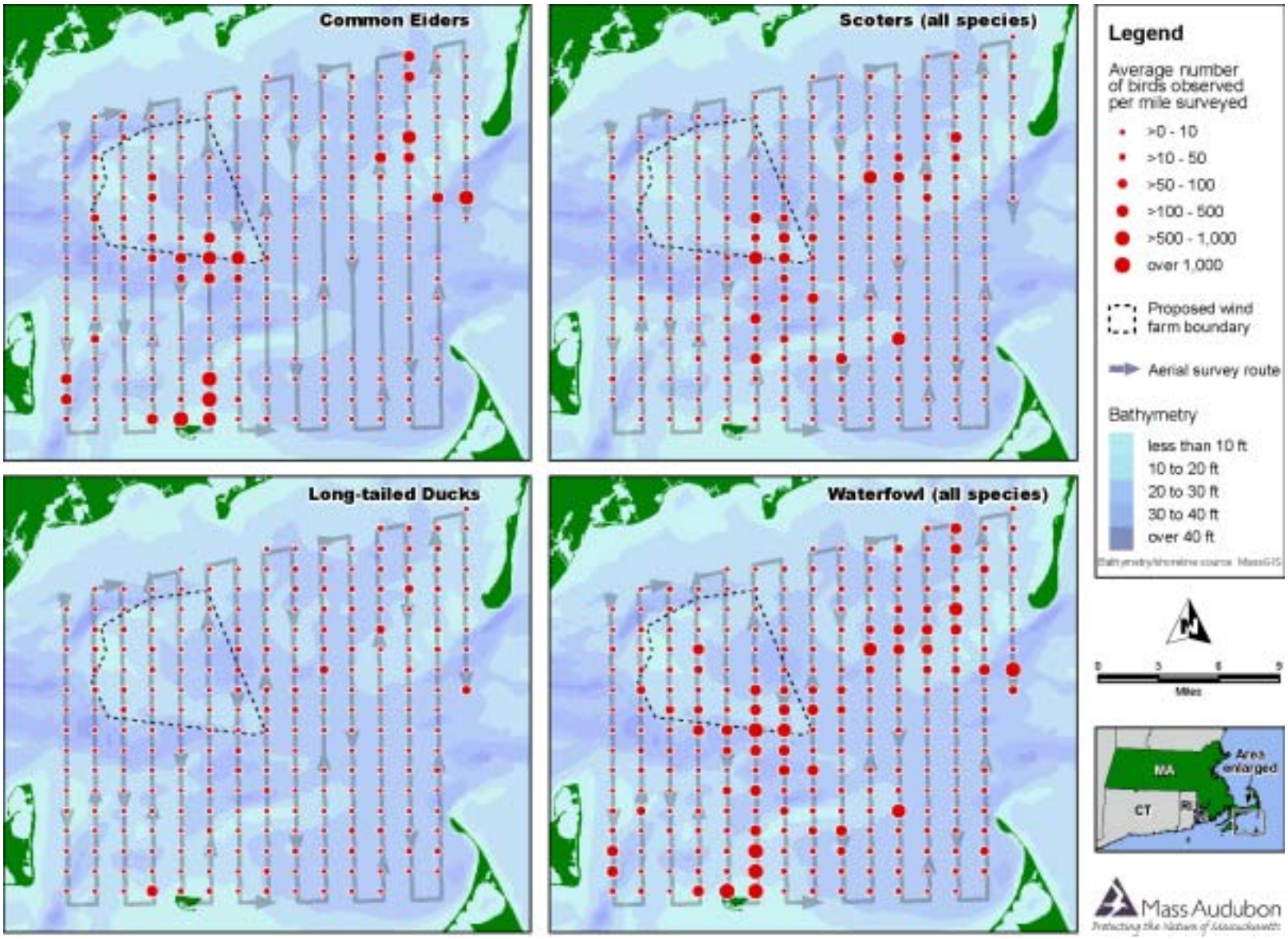


Figure 5. Distribution and abundance of approximately 280,000 Common Eiders recorded on 13 aerial surveys between December 2003 - April 2004 broken into four periods. Abundance calculated as average number of birds per mile.

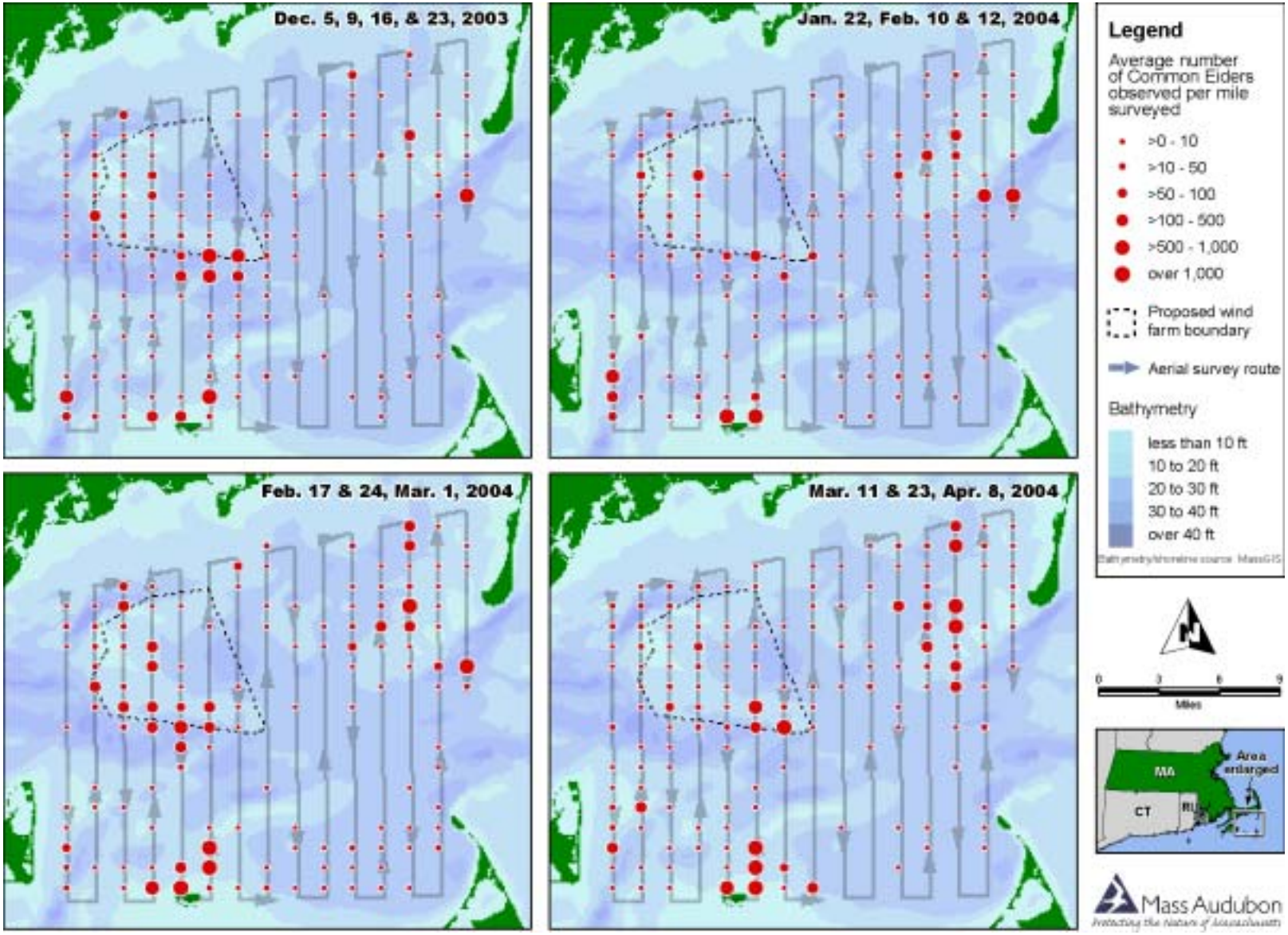


Figure 6. Distribution and abundance of approximately 91,000 scoters (all species) recorded on 13 aerial surveys between December 2003 - April 2004 broken into four periods. Abundance calculated as average number of birds per mile. An additional estimated 100 Black scoters (observed on December 5, 2003) are not included.

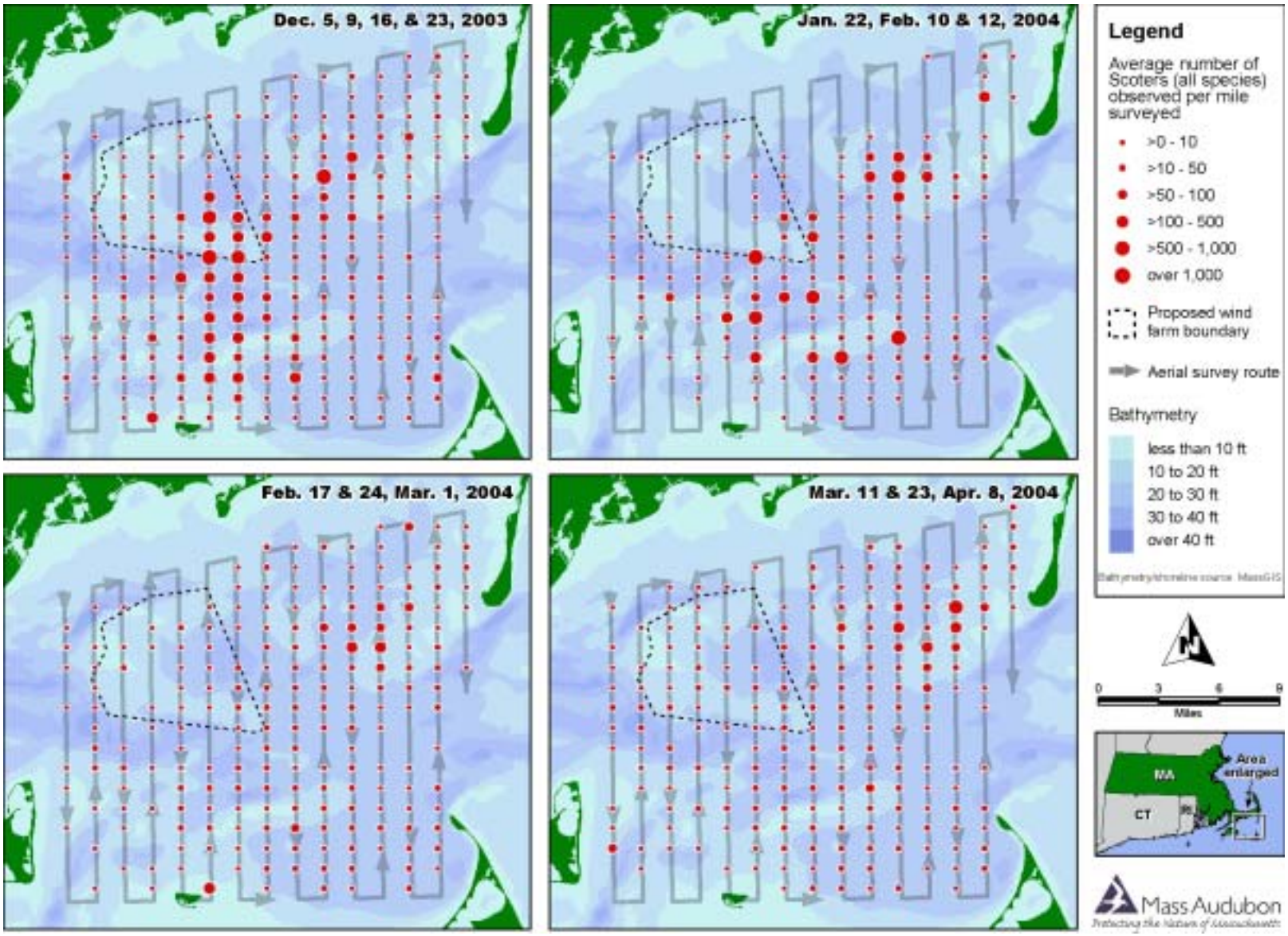
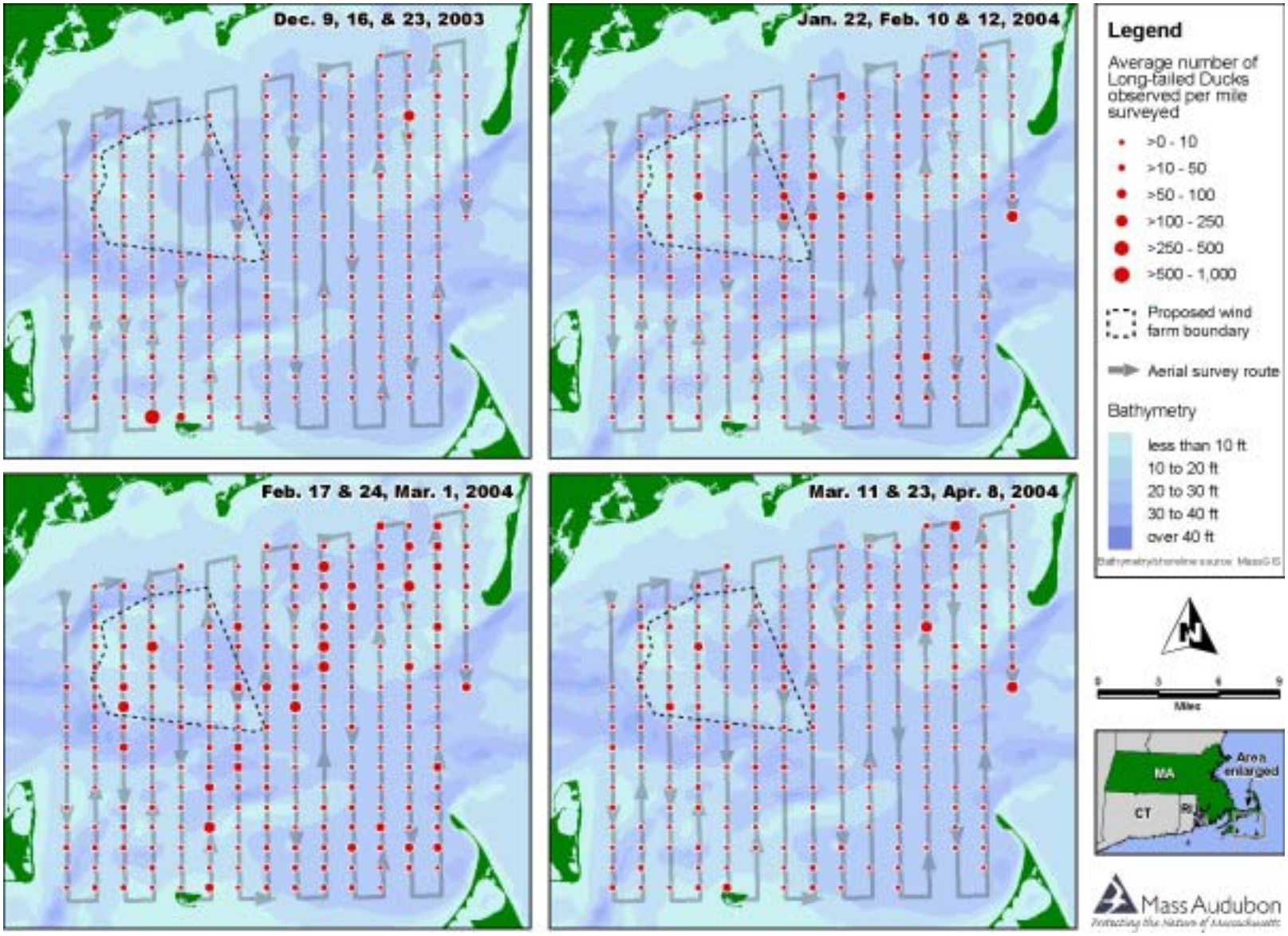


Figure 7. Distribution and abundance of approximately 32,000 Long-tailed Ducks recorded on 12 aerial surveys between December 2003 - April 2004 broken into four periods. Abundance calculated as average number of birds per mile. An additional estimated 1,000 birds (observed on December 5, 2003) are not included and this day was not included in calculations of abundance.



Appendix A. Total counts of birds observed during aerial surveys of Nantucket Sound, Massachusetts, Fall 2003 – Spring 2004.

Species/Taxa	12/5/03*	12/9/03	12/16/03	12/23/03	1/22/04	2/10/04	2/12/04	2/17/04	2/24/04	3/1/04	3/10/04	3/23/04	4/8/04	**Grand Total**
Brant	0	0	0	0	0	7	0	0	0	0	0	0	0	**7**
Common Eider	11,541	6,933	6,488	24,432	53,278	20,196	17,079	23,610	20,080	28,511	40,551	8,085	16,393	**277,177**
Surf Scoter	919	658	1,148	2,359	1,046	168	549	219	102	414	69	38	47	**7,736**
White-winged Scoter	73	68	75	71	48	6	47	14	126	42	6	11	17	**604**
Black Scoter	100	9	3	4	3	0	141	1	0	10	0	0	0	**271**
Scoter species	6,150	11,813	3,637	15,398	25,727	294	2,199	507	6,300	1,346	5,005	363	3,894	**82,633**
Long-tailed Duck	1,000	1,782	2,820	1,111	349	1,903	2,566	2,244	5,770	8,087	2,049	685	3,013	**33,379**
Red-breasted Merganser	32	7	9	1	0	0	1	1	0	2	0	0	2	**55**
Red-throated Loon	40	12	2	17	4	2	7	4	1	55	0	10	0	**154**
Common Loon	25	76	0	13	4	6	10	4	0	20	2	0	0	**160**
Loon species	49	168	21	35	28	88	77	86	214	372	118	67	2,119	**3,442**
Horned Grebe	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Red-necked Grebe	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Grebe species	0	1	0	0	0	0	0	0	0	2	1	0	0	**4**
Northern Gannet	22	13	39	6	1	1	0	0	0	0	1	5	541	**629**
Cormorant species	2	0	0	0	0	1	0	0	0	0	1	0	1	**5**
Shorebird species	0	3	0	0	0	0	0	0	0	0	0	0	0	**3**
Bonaparte's Gull	15	3	0	4	11	0	0	0	0	0	0	0	0	**33**
Herring Gull	17	177	78	91	23	19	58	30	38	35	33	4	25	**628**
Greater Black-backed Gull	12	41	30	27	9	9	1	8	2	9	2	0	18	**168**
Black-legged Kittiwake	15	245	77	184	8	5	27	2	7	0	7	0	0	**577**
Gull species	271	572	735	411	4	35	16	2	76	5	54	0	45	**2,226**
Razorbill	0	173	13	488	3	100	128	64	366	757	117	14	353	**2,576**
Alcid species	0	0	1	2	0	0	1	0	0	0	0	0	0	**4**
Grand Total	**20,283**	**22,754**	**15,176**	**44,654**	**80,546**	**22,841**	**22,907**	**26,796**	**33,082**	**39,668**	**48,016**	**9,282**	**26,468**	**412,473**

* = Totals include estimated numbers not recorded on December 5, 2003 due to computer errors. An estimated 40 Red-throated Loons, 2 Great Cormorants, 100 Black scoters, 1,000 Long-tailed ducks, and 15 Black-legged Kittiwakes are included.