OCS Study
MMS 2009-020

Determining Night-time Distribution of Long-tailed Ducks Using Satellite Telemetry

U.S. Department of the Interior
Minerals Management Service
Environmental Division

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COVER ART

The photograph on the cover is a female long-tailed duck with a satellite tag attached and was taken by Matthew Perry, USGS.

Project Summary

Mass Audubon staff in partnership with USGS have used satellite telemetry to gather information on nighttime roosting locations for Long-tailed Duck (LTDU) (*Clangula hyemalis*), especially with respect to Horseshoe Shoal, the proposed site of a 130-turbine wind farm. Hundreds of thousands of LTDUs overwinter in Nantucket Sound. These LTDU Nantucket display commuting behavior: each day at dawn, thousands of LTDU exit the Sound traveling to feeding sites on Nantucket Shoals, returning to the Sound at dusk. Mass Audubon and the applicant for the Cape Wind project have conducted extensive aerial surveys of Nantucket during daylight hours when the vast majority of LTDUs are absent from the Sound. Previously there was little direct information available regarding the nighttime roosting locations of LTDUs, especially in relation to Horseshoe Shoal. In particular, we needed to know whether Horseshoe Shoal is used by significant numbers of LTDUs as a nighttime roosting site or staging area as they exit or return to Nantucket Sound. If the answer to this question was yes, then the LTDUs would be potentially at risk of collision with the wind turbines when they enter, exit, or otherwise move within the project area.

Working in partnership with expert staff from the U. S. Geological Survey Patuxent Wildlife Research Center, we surgically implanted satellite transmitters into ten LTDUs and recorded locations in and around Nantucket Sound between December 12, 2007 until the instrumented ducks departed the Sound in mid-April. More than 650 satellite fixes were mapped for six of the instrumented ducks. This sample provided no direct evidence that LTDUs used Horseshoe Shoal as a nighttime roosting site. Although we were working with a small sample, sea ducks are gregarious, and telemetry with a small number of ducks often represents the behavior of the much larger group. The six surviving instrumented ducks departed Nantucket Sound in mid-April 2008, traveled via the Gaspe Peninsula, Quebec, Canada, and in Hudson Bay, and spent summer 2008 in areas north of Hudson Bay, presumably their summer breeding grounds.

Background

In late 2001, a large offshore wind farm was proposed for Horseshoe Shoal in Nantucket Sound, and comprehensive environmental review process began almost immediately. During the scoping phase of this project, Mass Audubon and others recommended that the environmental review include comprehensive surveys of avian use of Nantucket Sound. One of the focal areas was the use by winter waterfowl of Nantucket Sound and the proposed project area in order to gauge the risk of the project to this particular group of birds. Mass Audubon conducted aerial surveys of Nantucket Sound during the winter months to supplement studies conducted by the applicant (e.g., Perkins, et al. 2004).

Nantucket Sound is the winter home of 100,000’s of sea ducks, particularly Long-tailed Ducks, all three North American Scoters, and Common Eiders. Our winter aerial surveys indicated that a very large proportion of the wintering abundance of the Atlantic “stocks” of these species use Nantucket Sound as winter habitat (Sea Duck Joint Venture 2005). For Long-tailed Ducks, this wintering congregation also is thought to represent a large, but unknown, fraction of the total North American population of this species and is probably greater than 5% of the global population (del Hoyo, et al. 1992). The land-based Christmas Bird Count on Nantucket Island, coordinated nationwide by the National Audubon Society, have counted as many as ½ million individuals (525,505 in 2002 - http://audubon2.org/birds/cbc/hr/count_table.html). As the Sea Duck Monitoring Working Group noted in their recommendations for North American waterfowl, in general, nearly every sea duck is inadequately monitored, and accurate estimates of the number of sea ducks in various "stocks" or "management units" are lacking. Until recently little has been known also about annual variation in abundance and distribution of the sea ducks inhabiting Nantucket Sound during the winter.

The effect of wind turbines and wind farms on birds, particularly wind farms constructed offshore, is not well known. What little data exist suggest that location of the wind farm is a key variable. Many wind turbines appear to cause little mortality. A conspicuous exception, however, is found at the land-based wind farm at Altamont Pass in California where studies have shown substantial mortality of raptors possibly because this particular wind farm is large and occupies an area with high densities of prey species that attract the raptors to the site (e.g., Orloff and Flannery 1992; Thelander and Rugge 2000). A recent study of avian mortality at three small (<23 turbines) coastal wind farms in Belgium estimated a relatively high avian mortality per turbine (range of means = 18 – 35 birds/turbine/year) (Everaert 2003). A wind farm at Tarifa, Spain has also caused high avian mortality, particularly of raptors (Janss 2000). Other studies of offshore wind facilities in Europe that are slightly smaller than the proposed wind farm in Nantucket Sound indicate little direct mortality of sea ducks, but suggest that the turbines can cause behavioral changes such as alteration of offshore habitat use (e.g., Petersen 2005; Tulp et al. 1999); the European studies often had only one year of pre-construction survey data to compare with post-construction "response". An understanding of the shifting geographic pattern of winter habitat use of sea ducks will improve our ability to understand the ecological significance of post-construction shifts.

Based on a literature review of European wind farm studies conducted by BirdLife International (BI) (Langston and Pullan 2002), sea ducks, geese, herons, raptors, and seabirds are among the species that are potentially sensitive to wind farms from disturbance, displacement, barriers to movement, collision, and/or habitat loss or damage. BI therefore recommends that these species should be the focus of environmental assessments. The abundance of birds in Nantucket Sound indicates a need for a multi-year study to gather reliable baseline data in order to assess the impact of the construction and deployment of this wind farm on the avian species that use the Sound for winter habitat.

A principal goal of our avian monitoring has been to obtain a reliable baseline estimate of the relative abundance of wintering sea ducks that will, in future surveys, allow us to detect and interpret changes in bird abundance and distribution in Nantucket Sound. These baseline data will enable us to detect whether the numbers of wintering sea ducks change in response to the construction of the wind farm, or whether the ducks experience habitat loss or displacement – hypothesized impacts of wind farms as discussed by the BI report cited previously. These data also will provide valuable information toward the conservation and management of the Nantucket Sound waters that may provide critical habitat to feeding and roosting seabirds and waterfowl. Industrial and urban development on the Cape and the Islands may result in the degradation of habitat quality in wintering areas, but the effects of this habitat degradation on sea duck populations are also unknown. Development pressures on these wintering areas will continue to increase. Therefore, reliable estimates of variation in annual abundance and distribution of sea ducks on their winter range are needed to assess the impacts of existing and proposed development on these species (e.g., NAWMP, 1998). These data most likely could be utilized to inform natural resource policy and management decisions.

Statement of the Problem

Between 2003 and 2006, Mass Audubon staff conducted regular daytime aerial surveys of winter sea duck populations in Nantucket Sound (see for example, Perkins, et al. 2004). From these surveys we developed accurate estimates of relative abundance and distribution of winter waterfowl in Nantucket Sound and Horseshoe Shoal, the proposed project area. Combined with data collected by the applicant, Cape Wind, a reasonably comprehensive picture of winter bird life in Nantucket Sound during daytime hours had been obtained.

One significant gap was the distribution and abundance of LTDU. LTDUs reportedly number in the 100,000's in Nantucket Sound during the months of November through March. Each day at dawn, these ducks exit the Sound traveling to feeding sites, returning to the Sound at dusk. The extensive aerial surveys of Nantucket Sound had been conducted by Mass Audubon and the applicant during daylight hours when LTDUs are largely absent from the Sound. We had, therefore, no information on the nighttime roosting locations of this species. If significant numbers of LTDU roosted on Horseshoe Shoal at night, then the species may be at risk of collision with the wind turbines when they enter, exit, or otherwise move within the project area.

Working in partnership with expert staff from the U. S. Geological Survey Patuxent Wildlife Research Center, we surgically implanted satellite transmitters into LTDUs and record locations in and around Nantucket Sound. The extended battery life enabled us to track the ducks to their summer breeding range and to a possible return to Nantucket Sound the following winter. The results from the work would provide a solid baseline for future telemetry.

Methods

Our telemetry methods required several steps: 1) capture of LTDUs, 2) surgical implantation of transmitters, 3) tracking of ducks, 4) mapping of locations of ducks.

Our first efforts included the use of radio transmitters and a tracking plane or boat for the close-range (2-5 miles) detection of a radio signal emitted at a unique frequency by each of the implanted transmitters. During the winter 2006-2007 field season we implanted radio transmitters into six ducks, but our night-time tracking attempts were repeatedly thwarted by inclement weather. We therefore switched to the use of satellite transmitters in winter 2007-2008 to eliminate the logistical challenges and safety issues associated with plane and boat tracking over water in winter at night. The results of the satellite telemetry work are reported here.

1) CAPTURE OF WATERFOWL

During late winter of 2006, we attempted to capture LTDUs using several capture methods including those described in detail at http://www.pwrc.usgs.gov/resshow/perry/scoters/CaptureTechniques.htm. These included attempts to outrun the ducks with a high speed (50 mph) boat and shooting a net over them from a "net gun". This technique was unsuccessful because the ducks were much faster than the boat. We also attempted to capture the ducks by deploying floating mist nets and an array of decoys to attract the birds to the nets. This failed because the local currents were too strong to secure the net pole anchors. Finally, we achieved success with the night-lighting method. Ducks were located from a boat with the use of powerful spotlights as the birds rested on the water at night. When a bright spotlight was trained on ducks in darkness, they became somewhat disoriented, making them easier to approach. Under these conditions, they were captured from the bow of the boat with large, long-handled hoop nets. The capture team consisted of at least one capture person, one assistant, and one boat driver.

2) TRANSMITTER IMPLANTATION

Once the ducks were captured, they were transported to a local veterinary clinic (MSPCA Animal Care and Adoption Center, 21 Crooked Lane, Nantucket, MA), where Dr. Glenn Olsen, USFWS veterinarian, performed surgical implantation of a transmitter in each of the ducks. Implantation (vs. an external harness) was necessary to prevent abnormal behavior that has been observed with other diving ducks rigged with external loop harnesses (see Perry et al. 2004 for more information on sea duck radio telemetry). Following the surgery, the ducks were kept for observation for at least one day, and then released during morning hours in roughly the same areas in which they were captured.

3) TRACKING/LOCATING

Satellite tracking of instrumented ducks was performed by Argos, Inc (http://www.argos-system.org/). The number of data points (geographic fixes for each duck) was limited by the 400-hour "life" of each battery within each of the transmitters. Within that limitation, all the transmitters were programmed to perform identical "duty cycles" to maximize the number of data points collected during a 12-month period. The periodicity of the duty cycles was programmed to be different within two discrete tracking seasons: winter (December 1 – April 15) and migration/breeding (April 15 – November 15).

During the winter tracking season each transmitter was programmed with a 52-hour duty cycle – 4 hours on and 48 hours off- for a total of 253 battery hours. This program provided us with approximately 61 fixes per duck during the winter season. These fixes indicated whether we had instrumented ducks that conducted the daily commute and where their nighttime locations were within Nantucket Sound.

During the spring migration, summer breeding, and fall migration seasons, each transmitter was programmed for one 4-hour duty cycle every 5 days, for a total of 120 battery hours. These fixes would indicate where each bird spent the summer, and, assuming they survived migration and the breeding season, whether these ducks returned to Nantucket Sound the following winter.

Transmitters also provide information on the accuracy of the satellite fix and the internal body temperature of the instrumented duck. The recording of body temperature provides useful information on the physiological status of the duck, especially if the duck is still living. If the internal body temperature of the duck indicates that the duck has died, the satellite transmitter automatically begins transmitting, and the "radio-track" mode begins operating potentially enabling us to relocate the animal. We have successfully used this feature to relocate five transmitters.

There are six codes denoting the accuracy of the location determined by the satellite transmissions, i.e., the true location was within an estimated distance of the reported location (in latitude and longitude). We plotted only those locations that had an accuracy code specifying the precision of the location estimate, generally within 350-1,000m.

4) LOCATION MAPPING

Geographical and diagnostic data (e.g., internal body temperature) were downloaded weekly from the Argos web site. Mass Audubon staff plotted the geographical coordinates of each duck using ArcGIS software to create distribution maps of the birds on a regular basis.

Results and Discussion

Sixteen ducks were captured, and we instrumented ten healthy (determined by weight), breeding-age LTDUs (identifiable in the hand by several characteristics) in order to maximize our chances of tracking birds to their true breeding grounds. Two ducks died within a few days of release, possibly related to predation by gulls[1]. Two other ducks died during the winter season, perhaps the result of natural attrition; locations for these latter two ducks are included in this report.

As presented here, the analysis of our data collected to date is relatively straightforward. More sophisticated statistical analysis using SAS-based mapping software will be conducted in the following field season after additional ducks have been instrumented (see below).

More than 650 satellite fixes were mapped for all instrumented ducks including those that died before the end of the winter; each duck contributed a minimum of 40 locations (Figure 1). As we described previously, we excluded satellite fixes when the location error was not definable or greater than 1000 meters. Our limited sample provides no direct evidence that day-time commuting LTDUs used Horseshoe Shoal as a nighttime roosting site, and answering this question was a primary driver of this project. Although we were working with a small sample, sea ducks are gregarious, and telemetry with a small number of ducks often represents the behavior of the much larger group.

[1] We have subsequently learned that LTDU are very susceptible to predation by gulls on release. LTDU do not preen well, and they have to "pull-up" on land to avoid wetting. While on land they are extremely susceptible to attack by the abundant gulls on Nantucket Island. We modified our release procedure and this reduce predation losses to nought.

We were not continuously tracking locations of individual ducks; it is possible, therefore, that instrumented ducks could have roosted on the Shoal during periods when the transmitters were turned off (not transmitting). As our aerial surveys indicated (Perkins, et al. 2004) habitat use by sea ducks varied annually, and it is reasonable to assume that LTDU nighttime habitat use also shifts from year to year, i.e., patterns observed this winter may not be repeated in subsequent winters. Additional tracking of instrumented ducks in the next field season would further test the hypothesis that LTDUs do not use Horseshoe Shoal as a primary nighttime roosting site.

Maps for individual ducks are presented in Figures 2 through 7. Two ducks were located within one to two miles of Horseshoe Shoal (Figures 2 and 4), but that distance is well within the margin of error of the mapped locations.

Despite the limited sample size the data do provide definitive answers to several questions about LTDU habitat use. These conclusions are presented briefly below:

1. Not all LTDUs commute on a regular basis. Ducks will commute on some days and not others. Some ducks rarely if ever made the commute (Figures 4 and 5), and in some cases remained concentrated in a small area around Tuckernuck and Muskeget Islands for most of the winter (Figures 2 and 5).
2. It is hypothesized that LTDUs commute to Nantucket Shoals to feed during the day and return to the safety of Nantucket Sound at night, but it appears that LTDUs will spend the night on Nantucket Shoals. Almost all of our instrumented ducks demonstrated this behavior multiple times during the winter.
3. LTDUs use a wide area of southern and eastern Nantucket Sound. Individual ducks may have a "preference" for certain regions, but collectively the ducks appear to use the entire range of waters within 10-15 miles of Nantucket Island.
4. The location data provide no evidence of major nighttime concentrations of ducks. As described in "3)" above, ducks are dispersed over 100's of square miles of Nantucket Sound.
5. Ducks do not return necessarily to the same locations on a regular basis. Individual ducks may vary their daytime and nighttime locations – tendencies toward certain large areas in the waters around Nantucket are visible, but the area used by individual ducks is substantial.

The six surviving instrumented ducks departed Nantucket Sound in mid-April 2008, traveled via the Gaspe Peninsula, Quebec, Canada, and Hudson Bay, and spent summer 2008 in areas north of Hudson Bay, presumably their summer breeding grounds (Figure 8). Two ducks (#35 and #37) returned to Nantucket Sound in the fall of 2008, and LTDU #37 continues to transmit every 4 days. The fate of the other four ducks is unknown, and they either perished on their breeding grounds or the batteries on the transmitters died.

Our success this past winter has encouraged us to tag additional ducks next winter season (2008-2009) in order to increase our sample size and to test the generality of the tentative conclusions listed above. We will also conduct DNA analysis of instrumented ducks to determine the origin of wintering populations of LTDUs and to determine whether LTDU breeding populations can be delineated to specific geographic areas. The results will allow us to understand whether a proposed wind farm, or other factors (such as development on the Cape and Islands) affecting the LTDU habitat, could be of concern to the breeding populations that winter in the Sound.

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Figure Legends

Figure 1: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of all instrumented Long-tailed Ducks as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). Some instrumented ducks died or stopped transmitting before April 2008, but their locations are included. Surviving ducks had departed Nantucket Sound by mid-April. The potential error in "true" location of each of the 654 points is a maximum of 1000 m. Map was created on May 19, 2008.

Figure 2: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #33 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 3: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #35 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 4: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #36 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 5: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #37 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 6: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #38 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 7: Daytime (red dot) and nighttime (black dot) locations between December 12, 2007 and mid-April 2008 of Long-tailed Ducks #41 as interpreted from satellite fixes with respect to Horseshoe Shoal (red outline). The potential error in "true" location of each of the points is a maximum of 1000 m. "N" equals the number of mapped points. Map was created on May 19, 2008.

Figure 1

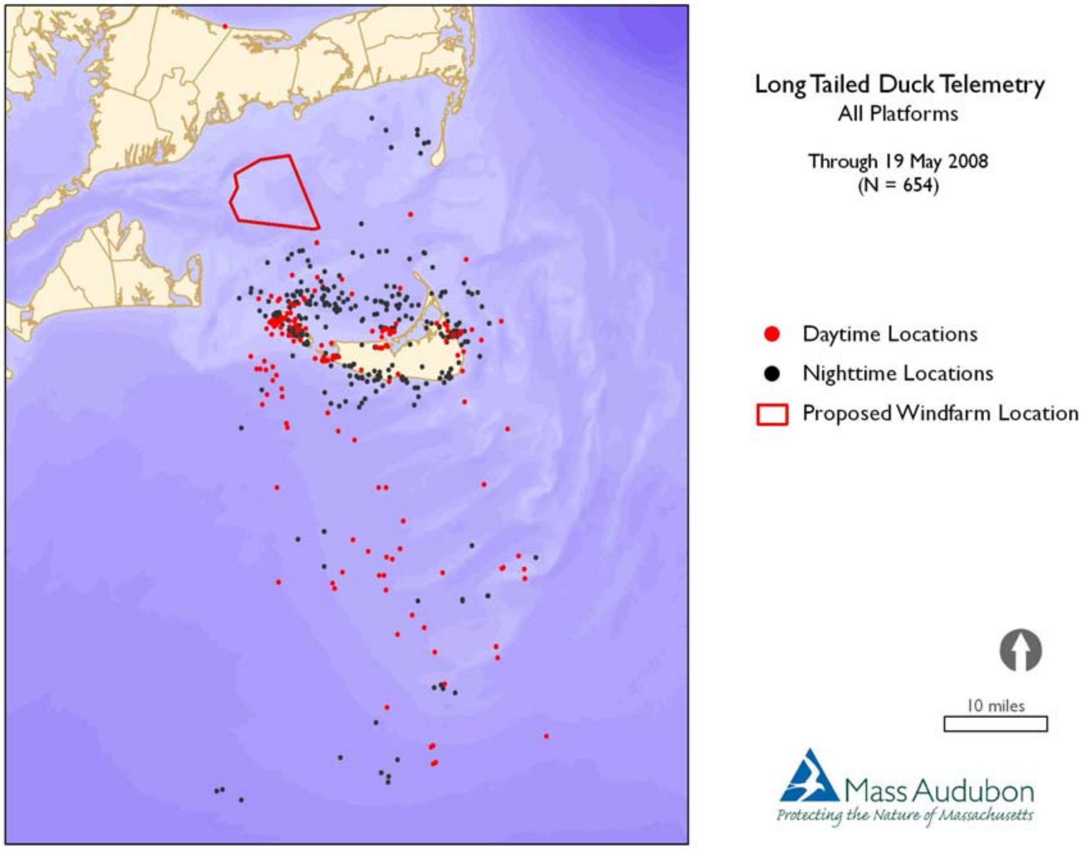

Long Tailed Duck Telemetry
All Platforms
Through 19 May 2008
(N = 654)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 2

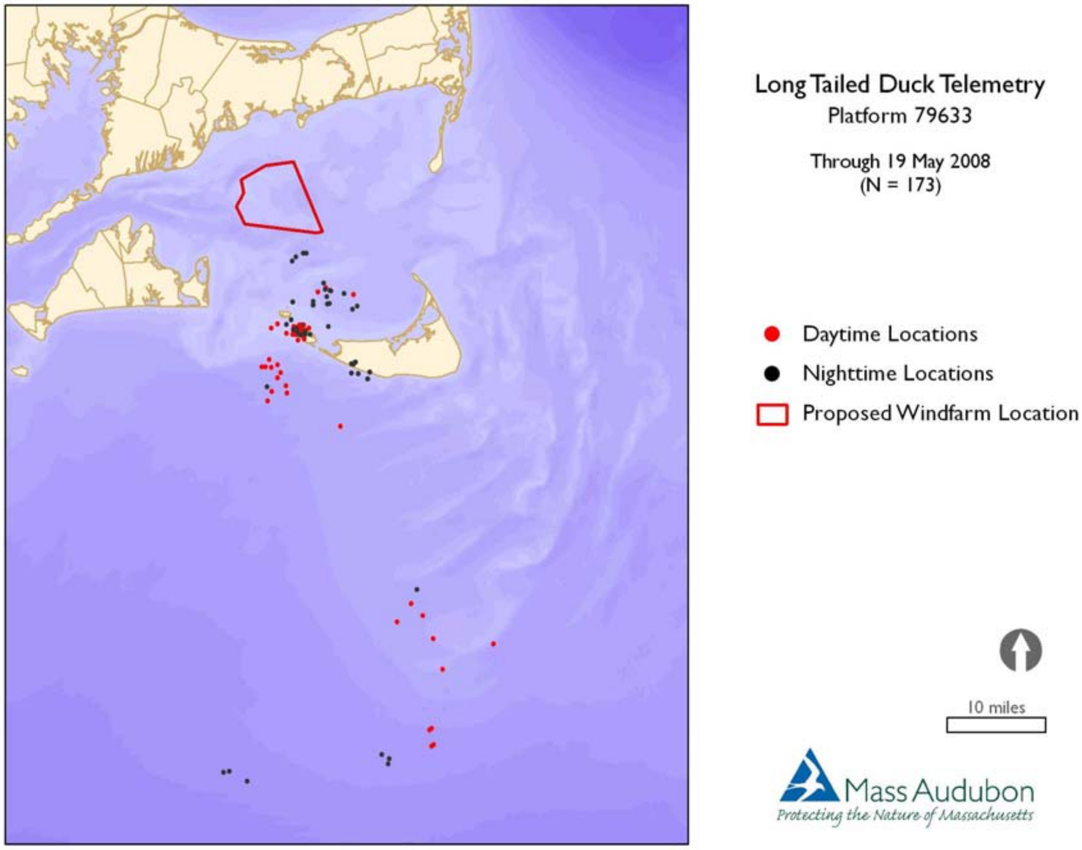

Long Tailed Duck Telemetry
Platform 79633
Through 19 May 2008
(N = 173)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 3

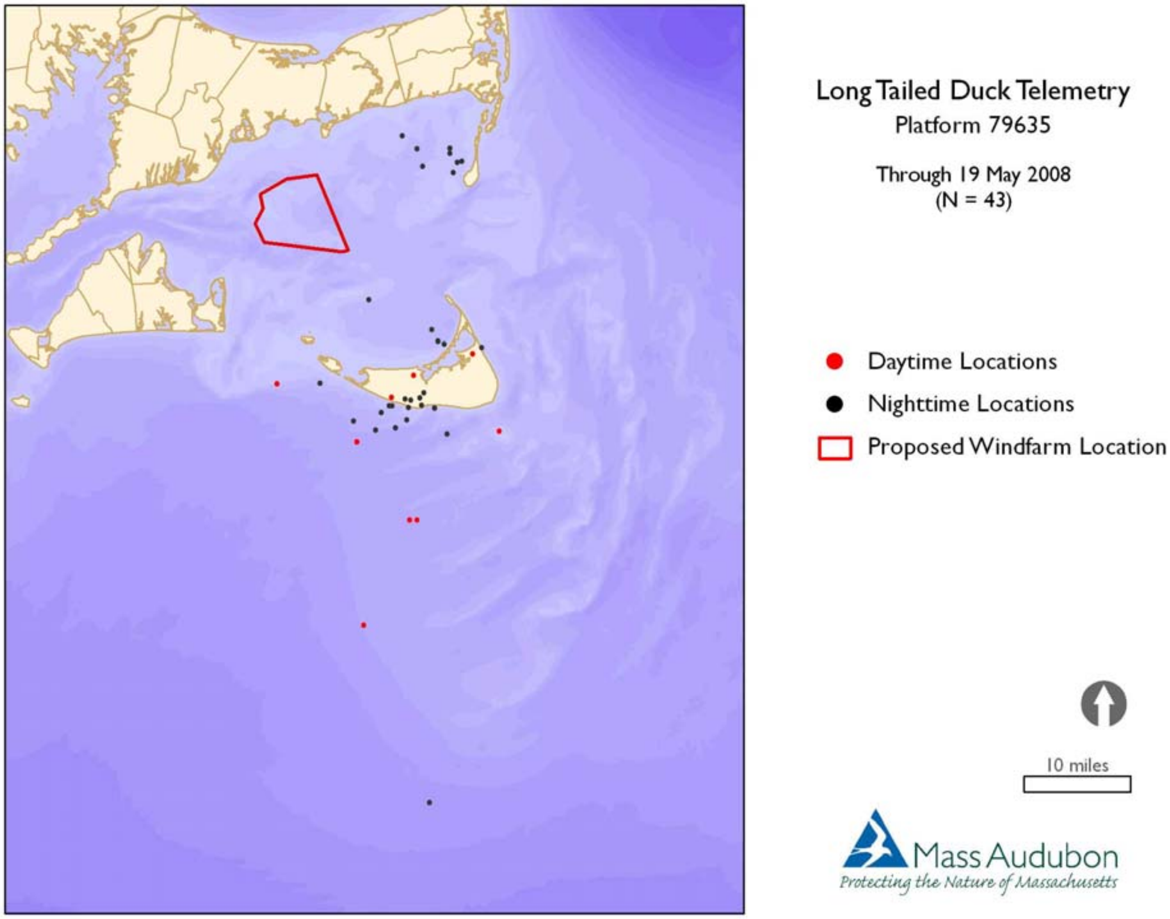

Long Tailed Duck Telemetry
Platform 79635
Through 19 May 2008
(N = 43)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 4

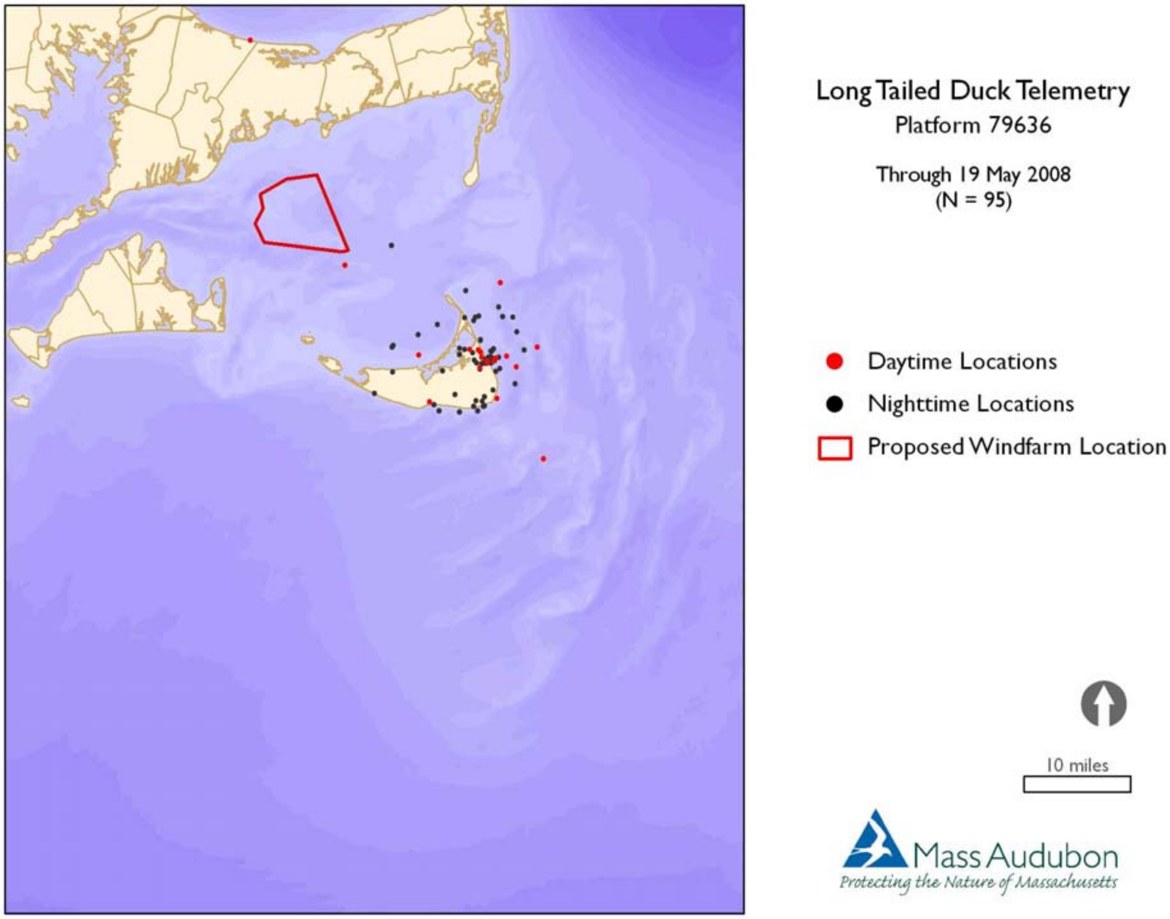
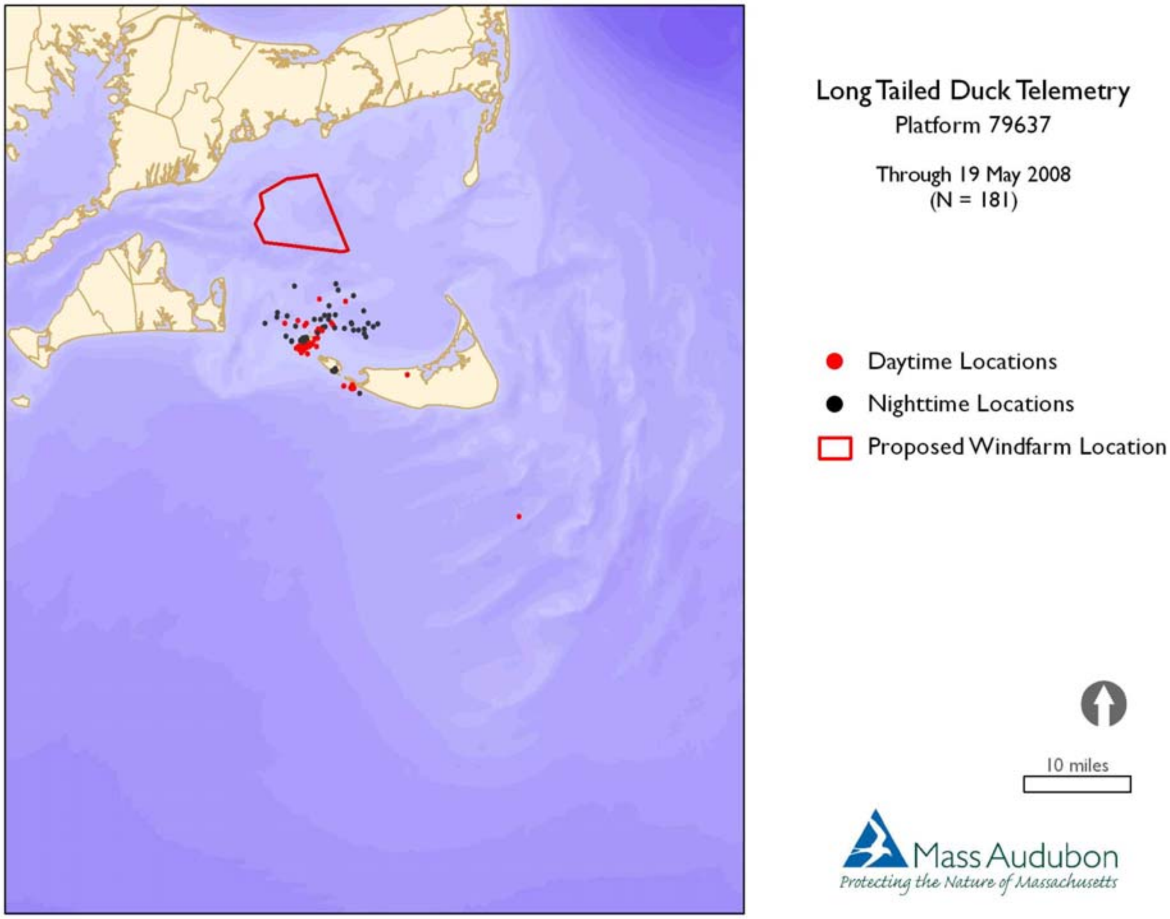

Long Tailed Duck Telemetry
Platform 79636
Through 19 May 2008
(N = 95)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 5



Long Tailed Duck Telemetry
Platform 79637
Through 19 May 2008
(N = 181)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 6

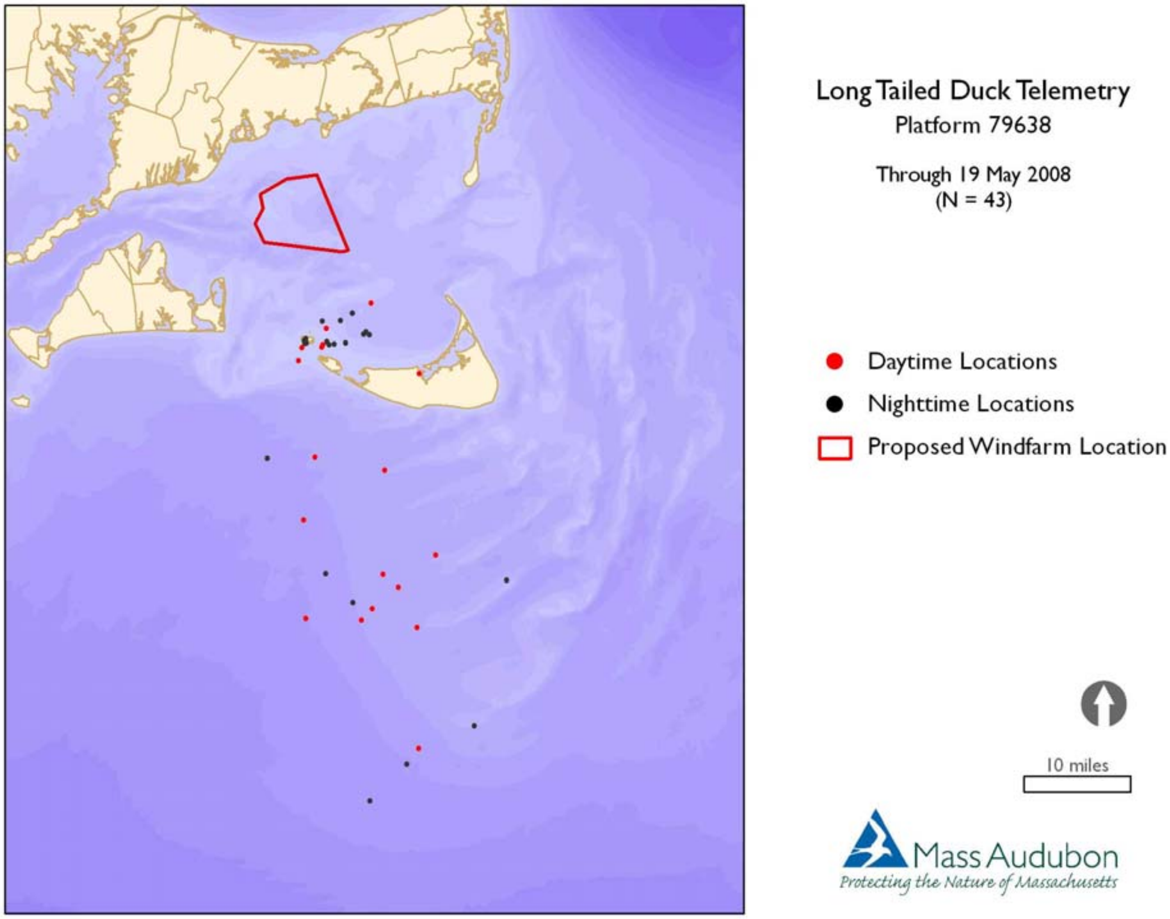

Long Tailed Duck Telemetry
Platform 79638
Through 19 May 2008
(N = 43)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 7

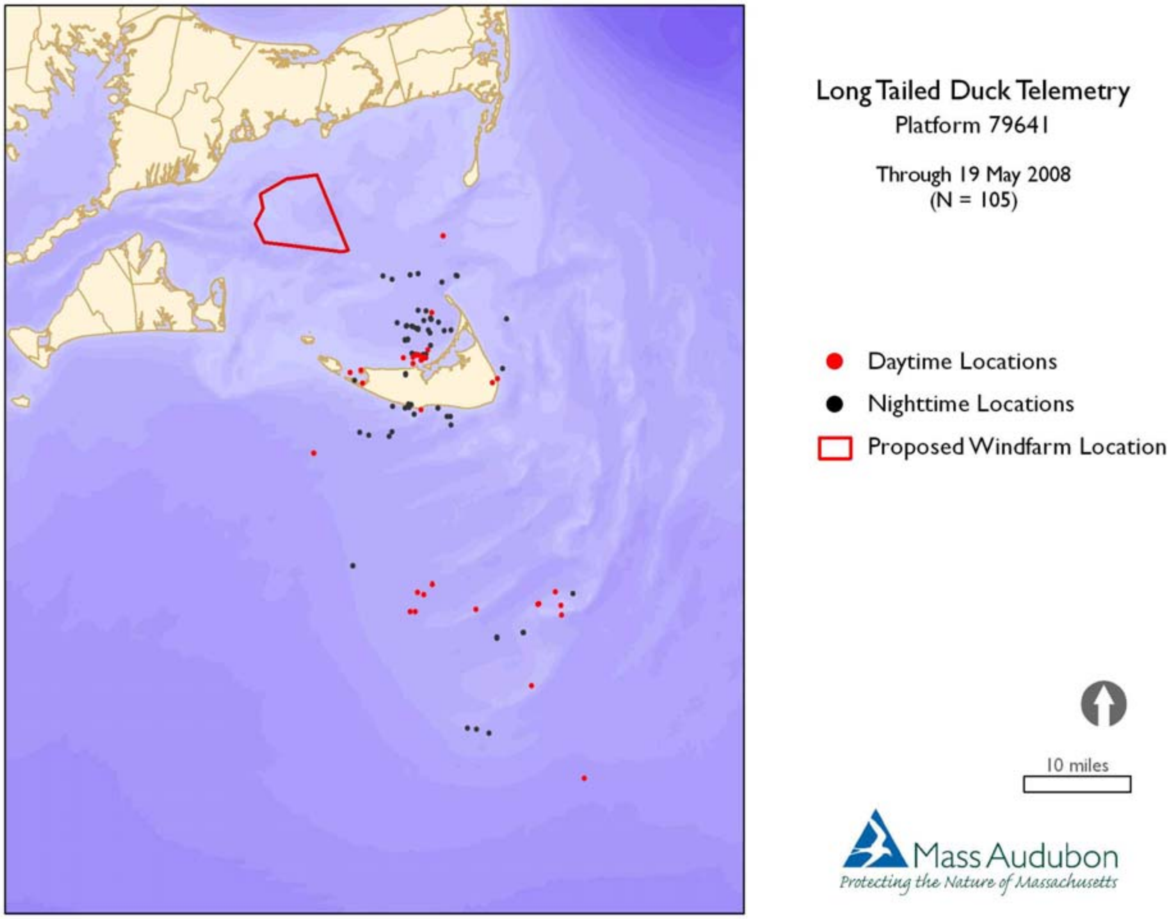
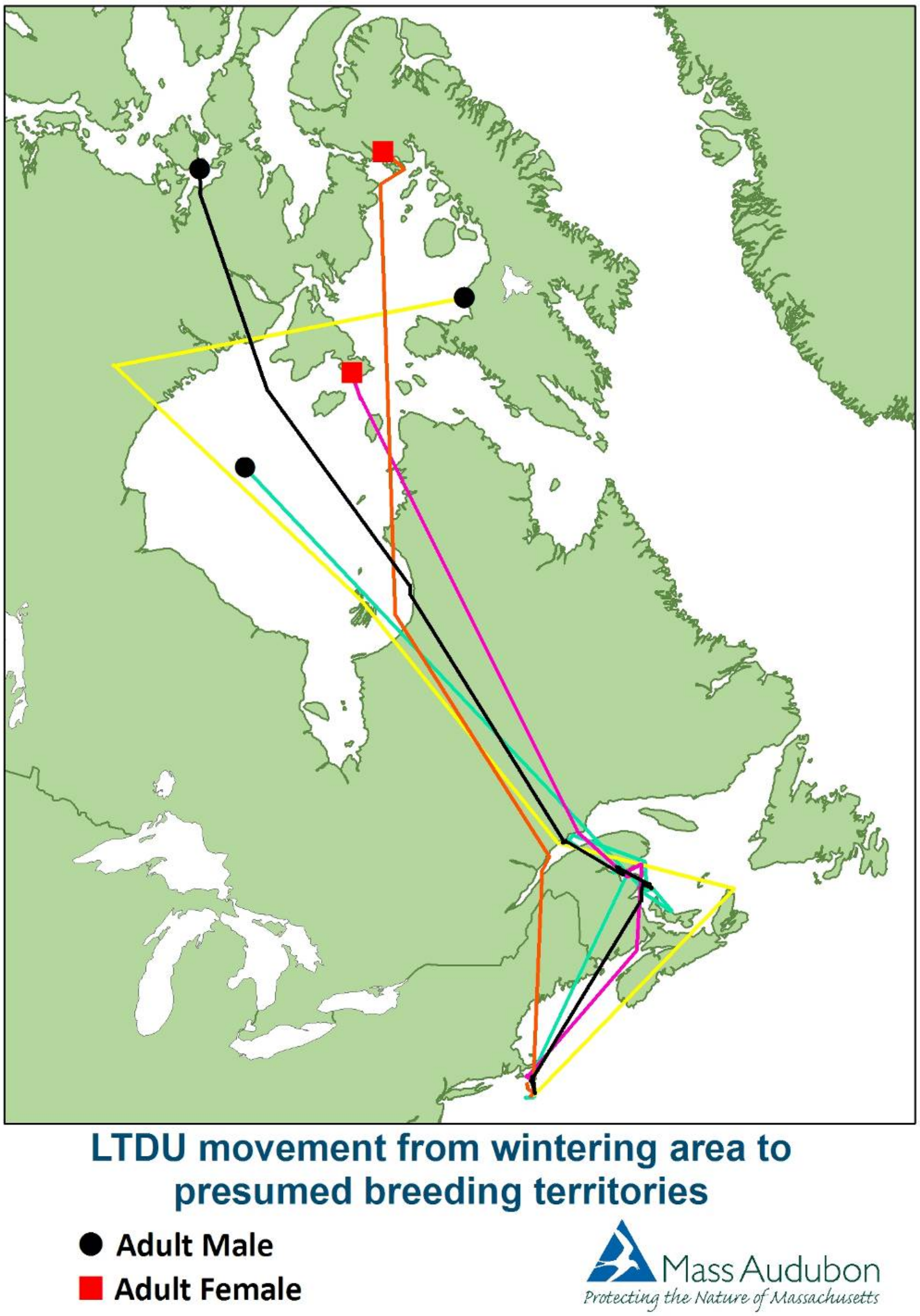

Long Tailed Duck Telemetry
Platform 79641
Through 19 May 2008
(N = 105)
Daytime Locations
Nighttime Locations
Proposed Windfarm Location
10 miles
Mass Audubon
Protecting the Nature of Massachusetts

Figure 8: Locations of surviving LTDUs as of September 15, 2008. The lines connect locations recorded at different times during migration and end points in northern Canada suggesting possible breeding locations of the ducks.



The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Energy and Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.