Atlantic and Great Lakes Sea Duck Migration Study

Final Report by the Sea Duck Joint Venture Partnership
2022

Cover photo: Rian Dickson

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Executive Summary

Understanding landscape level use and connectivity among breeding, wintering, staging, and molting areas (i.e., population delineation) is essential to understanding sea duck declines and limiting factors, and for evaluating potential impacts from development, harvest, and climate change. Prior to 2009, progress had been made in delineating populations of sea ducks in the Pacific and Arctic regions of North America, but relatively little had been done in the Atlantic and Great Lakes regions. The information gaps in eastern North America were of growing concern in the face of increasing hunting pressure and increased interest in offshore energy development. To address these important information gaps, the Sea Duck Joint Venture (SDJV) launched an ambitious, large-scale satellite telemetry study of sea ducks in the Atlantic and Mississippi Flyways. The SDJV made this project its highest priority and committed substantial resources to the project beginning in 2009.

Throughout the course of this project, more than 650 transmitters were deployed among four species: Black Scoter, Surf Scoter, White-winged Scoter, and Long-tailed Duck. Telemetry data gathered from these birds generated a wealth of detailed information on migration patterns and on coastal and marine habitats used by sea ducks throughout the year.

The study yielded results that are useful for management purposes. As a result of this extensive collaborative effort, our understanding of migration patterns and range affiliations for sea ducks in eastern North America has been greatly improved. For example, telemetry data provided a completely new view of the breeding range for Black Scoters and suggests that a large portion of the eastern population is associated with breeding areas in northern Manitoba, Nunavut, and the Northwest Territories. Similarly, telemetry data suggest that a large portion of the eastern wintering population of White-winged Scoters is associated with breeding areas in northern Quebec, northern Saskatchewan, northern Manitoba, and the Northwest Territories. Many of these areas are not surveyed by the Waterfowl Breeding Population and Habitat Survey (WBPHS), and for those that are surveyed, the timing of the survey is not adequate for late breeding sea duck species. Experimental aerial surveys were conducted in these areas based on this new information, and recommendations for improving spatial and temporal survey coverage of areas used extensively by scoters are being developed. In addition, this area was identified as an Area of Continental Significance to North American Ducks, Geese and Swans under the North American Waterfowl Management Plan (NAWMP) 2012 Revision.

This study also provided information about important sea duck wintering, staging, and molting areas. The areas identified in this study were included as key habitat sites in the Sea Duck Key Habitat Sites Atlas, a tool that can be used to prioritize areas for habitat conservation.

In addition, data from this study are being used in several environmental assessments. For example, they are being used in assessments of proposed offshore wind energy projects along the U.S. Atlantic coast, for the design of a radar migration study for a wind turbine project on the isthmus between New Brunswick and Nova Scotia, in a coastal sensitivity mapping program in South Carolina, and in a feasibility assessment for the designation of waters surrounding Torngat National Park, Labrador as an Indigenous protected area.

The study also provided notable findings on population delineation and site fidelity of sea duck species, including the confirmation of separate Atlantic and Pacific populations of Black Scoters, emerging evidence of structuring among wintering populations of Long-tailed Ducks, and relatively low fidelity of scoters to molting areas.

Capture events conducted during this study also provided biologists with an unprecedented opportunity to collect tissue samples that have been used to examine relationships among populations based on genetics and stable isotopes, screen for diseases, and determine contaminant loads. Some of these samples have already been analyzed (e.g., mercury), while other samples are being archived and will be available for future analyses. Throughout this study, capture and surgical methods were evaluated and refined, improving the likelihood of success of future telemetry projects.

Introduction

Most sea ducks breed at northern latitudes and winter in coastal, offshore, and major inland waters including the Great Lakes. Concern about apparent population declines, the impact of hunting, and a lack of understanding of what regulates sea duck populations led to the formation of the Sea Duck Joint Venture (SDJV) in 1999 under the auspices of the North American Waterfowl Management Plan. The SDJV's mission is to promote the conservation of North American sea ducks through partnerships by providing greater knowledge and understanding for effective management. Since 2001, the SDJV has helped support and coordinate research and monitoring studies to better understand this group of waterfowl.

An understanding of landscape level use and links among breeding, wintering, staging, and molting areas (i.e., population delineation) is essential to understanding sea duck declines and limiting factors, and for evaluating potential impacts from development, harvest, and climate change. Up until about 2009, much progress had been made in delineating populations of sea ducks in the Pacific and Arctic regions of North America, but relatively little had been done in the Atlantic and Great Lakes regions. The information gaps in eastern North America were of growing concern in the face of increasing hunting pressure and increased interest in offshore energy development. To address these important information gaps, the SDJV launched an ambitious, large-scale satellite telemetry study of sea ducks in the Atlantic and Mississippi Flyways. The SDJV made this project its highest priority and committed substantial resources to the project beginning in 2009.

Throughout the course of the project, more than 650 transmitters were deployed among four species: Black Scoter (*Melanitta americana*), Surf Scoter (*Melanitta perspicillata*), White-winged Scoter (*Melanitta deglandi*) and Long-tailed Duck (*Clangula hyemalis*) - all are species of high conservation concern (Sea Duck Joint Venture 2022). Telemetry data gathered from these birds generated a wealth of detailed information on migration patterns and on coastal and marine habitats used by sea ducks throughout the year (Figure 1).

The study was designed to answer several questions, such as:

1. Where do birds from a particular wintering area breed and molt?
2. Where are the most important wintering and staging areas for sea ducks?
3. How much annual variability is there in migration patterns?
4. Do sea ducks return to the same wintering, breeding, molting, and staging areas each year?
5. How should surveys be designed to monitor sea ducks most effectively?

In addition to a lack of basic knowledge about sea duck biology, migration, and habitat use, another compelling reason for this study was to help identify near-shore and offshore areas of the Atlantic coast and Great Lakes where wind power facilities and other developments would have the least impact on sea ducks. Sea ducks may use the same offshore areas where wind farms are proposed for development, prompting concerns about displacement of birds that equates to a loss of habitat, as well as collisions with structures. Many offshore wind projects have been proposed along the Atlantic coast and in the Great Lakes, and cumulative effects on sea ducks throughout the flyways need to be considered. Beginning in winter 2011-2012, the Bureau of Ocean Energy Management (BOEM) began a study to investigate this issue in the mid-Atlantic region and partnered with SDJV to deploy transmitters in surf scoters.

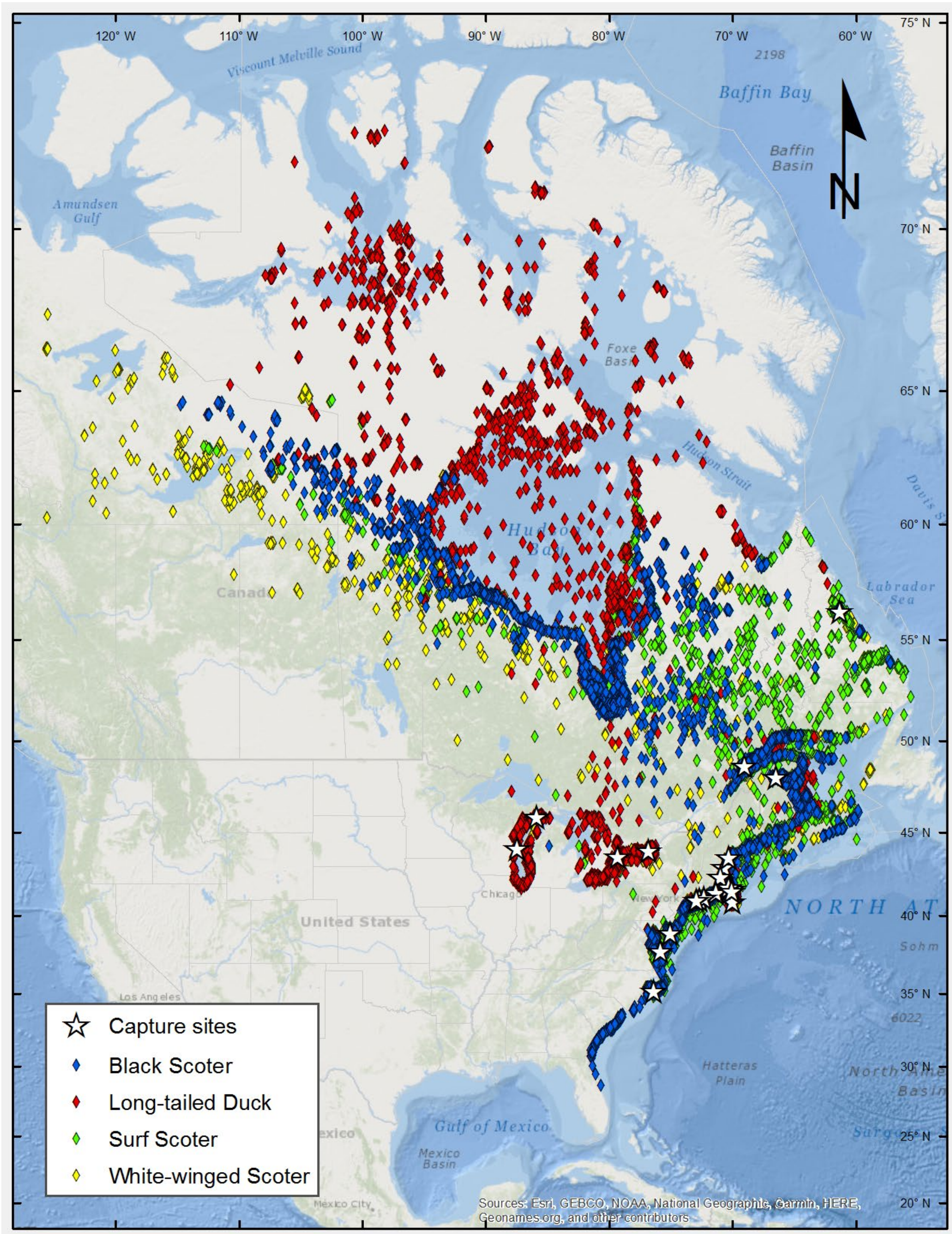

Figure 1. Geographic extent of locations determined from satellite telemetry of sea ducks marked along the Atlantic coast and within the Great Lakes. Points represent the best location per duty cycle. Locations are cumulative from October 2013 to August 2018 (all birds, all species).

This report summarizes information gained through deployment and tracking of transmitters in Long-tailed Ducks up through 19 May 2019, 25 October 2013 for Black Scoters (when last PTT stopped transmitting), 8 December 2014 for Surf Scoters, and 17 November 2018 for White-winged Scoters. This includes a few transmitters that were deployed prior to 2009. Additional information about this study can be found at http://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study/ .

Although the SDJV facilitated this study via financial support and coordination, this was a collaborative project involving many partners. Partners included the U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Department of Energy (DOE), BOEM, Massachusetts Audubon, Ducks Unlimited, Canadian Wildlife Service, Environment Canada Science and Technology Branch, Bird Studies Canada, Long Point Waterfowl, Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, Biodiversity Research Institute (BRI), University of Rhode Island, Université de Montréal, McGill University, New Brunswick Dept. of Natural Resources, Rhode Island Dept. of Environmental Management, Virginia Dept. of Game and Fish, Maryland Dept. of Natural Resources, Maine Dept. of Inland Fisheries and Wildlife, Université du Québec à Montréal, North Carolina Wildlife Resources Commission, Avery Outdoors, Southern Illinois University - Carbondale, Wisconsin Division of the Izaak Walton League of America, Delta Waterfowl, and Wisconsin Waterfowl Association. See Appendix I for a summary of partner contributions in 2010-2020. We also want to recognize the contributions of SeaTurtle.org, which is supporting a free mapping platform for data from this study.

Study results, design and deployment plans were periodically reviewed by study partners and a Steering Committee composed of the following SDJV technical team members: Shannon Badzinski (Environment Canada-CWS), Tim Bowman (USFWS), Sean Boyd (Environment Canada-S&T), Chris Dwyer (USFWS), Grant Gilchrist (Environment Canada-S&T), Scott Gilliland (Environment Canada-CWS), Christine Lepage (Environment Canada-CWS), Dan McAuley (USGS), Jay Osenkowski (Rhode Island DEM), and Emily Silverman (USFWS).

Study Objectives

1. Describe the annual migration patterns and annual variability for four species of sea ducks (Surf Scoter, Black Scoter, White-winged Scoter, Long-tailed Duck) that winter in the Atlantic flyway and Great Lakes.
2. Identify near- and offshore areas of high significance to sea ducks to better inform habitat conservation efforts.
3. Estimate rates of inter-annual site fidelity to wintering, breeding, staging, and molting areas for all four focal species in the Atlantic flyway.
4. Map local movements and estimate length-of-stay during winter, and spring and fall migration, for individual radio-marked ducks in areas proposed for placement of wind turbines along the Atlantic coast and in the Great Lakes.
5. Provide timely information to facilitate design and interpretation of monitoring surveys, particularly those currently under development. Information includes:

a. Timing of movements throughout annual cycle, especially during the survey “window” for various ongoing or proposed surveys (e.g., Atlantic Coast Winter Sea Duck Survey, scoter breeding and molting surveys, migration counts at Point Lepreau, NB and Avalon, NJ)
b. Identification of key habitat areas and length-of-stay data for sea ducks at staging, molting, and wintering areas such as Chesapeake Bay, Delaware Bay, Nantucket Sound, James Bay, St. Lawrence Estuary and Gulf, Chaleur Bay, and the Great Lakes.
c. Annual variation in use and timing of use of breeding, molting, staging, and wintering sites.
d. Determination or validation of the outer offshore survey boundary and north-south delimiters for the Atlantic Coast Winter Sea Duck Survey (Silverman et al. 2012).

The project is conducted at a flyway/population scale to enable inferences at those same scales. By planning a multi-partner large scale effort, we also realize efficiencies due to quantity discounts on transmitters, reduction in travel and logistical expenses (i.e., one big project is more efficient than several smaller projects) and capitalize on related projects currently underway that can provide staff, funding, and logistical support (e.g., BOEM and DOE offshore wind assessments).

Study Design and Methodology

The study was focused on four high priority sea duck species in the Atlantic flyway and Great Lakes: Black Scoter, Surf Scoter, White-winged Scoter, and Long-tailed Duck. We strived to capture and mark with satellite transmitters (PTTs) a representative and adequate sample to ensure that effective sample sizes (i.e., those birds/transmitters that produce useable data over multiple life stages) were achieved for each species. By *representative* sample, we anticipated that each species would be sampled throughout its wintering range (in approximate proportion to relative flyway abundance), or at “bottleneck” sites where the bulk of the Atlantic flyway population passes during spring or fall migration.

The question of “*what is an adequate sample*?” remains unresolved. We initially defined “adequate sample” to be at least 30 birds that survived post-surgery and provided information for at least one full year. A sample size of 30 is consistent with that recommended by Lindberg and Walker (2007) for satellite telemetry studies *where two possible outcomes are possible* (i.e., birds go to one of two possible areas). However, this study yielded novel discoveries that helped expand our knowledge of distribution, relative densities, migration paths, and potential structuring of populations. Ultimately, recognizing that initial hypotheses regarding population structure may have been incorrect, partners and the Steering Committee agreed to take an adaptive approach, whereby an effective sample size of 40 marked birds was achieved, data analyzed, and re-evaluated to determine if additional sampling was needed to address new hypotheses (e.g., number of outcomes). The SDJV also funded an analytical study in 2014-2015 using hypothetical and empirical data sets for sea ducks to provide additional insight in sample size requirements (Roberts et al. 2018).

To achieve a target sample size of 40, given an estimated 30% post-marking mortality and/or radio failure, it was estimated that 57 individuals per species would need to be marked. If transmitters failed, or birds died at higher-than-expected rates, the number of deployments would need to be increased.

Sample sizes for Great Lakes deployments were in addition to Atlantic coast deployments (i.e., 40 additional long-tailed ducks and up to 40 additional white-winged scoters, if feasible).

The highest priority for marking was adult females, which provide the most unambiguous data on breeding locations, and are the most important cohort for understanding population dynamics. With limited SDJV resources, we did not mark additional young (hatch-year) ducks because they are unlikely to breed within one or more years and, therefore, would contribute less to our understanding of population delineation, and because young birds marked in previous studies have experienced lower survival.

In addition to transmitter deployments supported directly by the SDJV, we have included telemetry data from surf scoters marked as part of a BOEM study to assess waterbird use of marine areas relative to offshore wind energy development along the mid-Atlantic coast. Most of the surf scoters marked as part of that study were adult males. Likewise, BOEM partners reported location data for surf scoters marked in this study.

Capture, Handling, and Marking

Birds were captured using various techniques depending on what worked for that species at a particular capture site. Capture techniques included over-water mist nets, net-gunning from a boat, night-lighting, drive-trapping molting birds into submerged gill nets, and a modified lift-net (for more information about trapping techniques, see http://seaduckjv.org/science-resources/how-we-catch-sea-ducks/).

Age was determined based on bursa depth, plumage characteristics, or both. For this study (versus for banding reports), we used the following age designations: Hatch Year = less than 12 months old and bursa depth >15 mm with immature plumage (e.g., light belly and notched tail feathers); Second Year = 12-24 months old and bursa depth >15 mm; After Second Year = >24 months old and bursa depth <5 mm or absent (Mather and Esler 1999, Peterson and Ellarson 1978, Hochbaum 1942). After Hatch Year designation was used to describe a bird that is >1 year old, but for which more definitive age determination was not possible or not attempted (i.e., the bird could be second year or older).

PTTs were surgically implanted in the abdominal cavity of each duck by a qualified veterinarian following the technique described by Korschgen et al. (1996). We used 38-50 g PTTs with a battery life of at least 750-h for large-bodied birds such as scoters, and 26-35 g PTTs with a battery life of at least 400-h for smaller-bodied birds such as Long-tailed Ducks to alleviate concerns about potential adverse physiological effects of large transmitters in small ducks (G. Olsen, USGS, personal communication). Transmitters were manufactured by Microwave Telemetry, Inc., Telonics, Inc., and GeoTrak. At the veterinarian's discretion, transmitters were wrapped in a sterile mesh that promotes additional surface area for adhesion to the body wall and provides additional anchoring points to stabilize the PTT within the bird (Figure 2). PTTs were pressure-proofed to prevent crushing if ducks dive to great depth. Although some ducks were held more than one day in earlier projects, current protocol allowed us to hold radio-tagged birds in captivity for only 1-3 hours post-surgery. They were then hydrated sub-dermally, in some cases tube-fed a formulated elemental diet (Olsen et al. 2010) and released at or near the capture site.

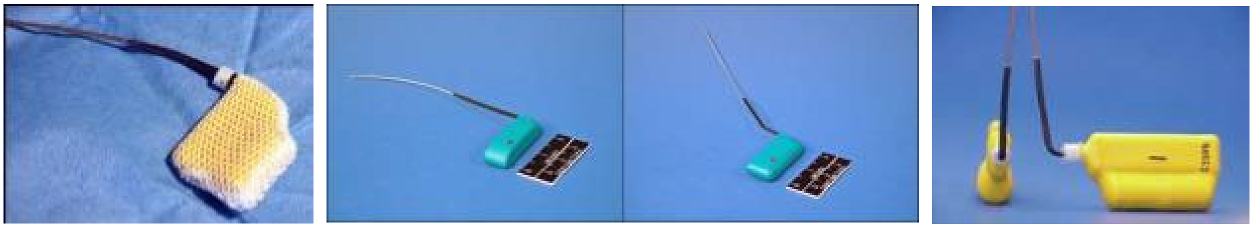

Figure 2. Implantable PTTs for use in sea ducks. Note, transmitter on the far left is wrapped in a mesh fabric.

All PTTs were programmed with duty cycles that represented a compromise between PTT longevity and frequency of location data, intended to meet multiple objectives. For example, more frequent location data would better characterize habitats used at relatively small geographic or temporal scales, whereas less frequent data but greater longevity provides better information on inter-annual site fidelity and variation in migration patterns. The duty cycle most frequently used by the SDJV is 2 hrs ON and 72 hrs OFF (i.e., one location every 3 days). This allows PTTs to last at least one year, and possibly up to three years for the larger units with more battery life. PTTs that lasted at least one, and ideally two, full annual cycles enabled an analysis of annual variation in timing of migration, habitat use, and site fidelity. The single duty cycle also enabled "trading" PTTs among project elements as necessary to capitalize on opportunities to mark additional birds. Exceptions to these duty cycles were made for partners who purchased transmitters to meet specific local objectives that required different (usually more frequent) duty cycles (e.g., daily movements during winter to evaluate potential conflicts with proposed offshore wind projects). For example, PTTs deployed in surf scoters as part of a partner study used a duty cycle designed to yield two locations per day to maximize the number of locations during the migratory and wintering periods, and a less frequent duty cycle during the rest of the year to preserve battery power.

Capture efforts also provided opportunities to collect tissue samples for analyses of genetics, stable isotopes, contaminants, and disease screening. Tissue sample collection kits and standardized operating procedures were distributed to partners prior to each capture event. Samples were sent to appropriate labs for testing or archived for future analyses.

Data Management and Mapping

Telemetry data from PTTs are available via the Argos system of satellites. Argos records data for known PTTs and stores these data for one year on its servers, but only the last ten days of data to are visible to the end-user. BRI handled Argos data management and mapping tasks for both the SDJV and BOEM studies. Nightly, BRI downloaded by telnet process the last 5 days of data using a customized program written in the Python programming language (Python 2.7, http://www.python.org/). All active programs were cycled through to download data and any active tags that transmitted during that period provided data for download and were archived for later use. BRI archived three data sets (e.g., ds, diag, and last message data) from Argos telnet servers. Argos data from this study are stored or archived at several locations including MoveBank and USGS Patuxent Wildlife Research Center. Some, but not all, of the location data was also uploaded to *widlifetracking.org*, a free service that hosts animal tracking projects and updates maps of individual birds daily with new location data (on a fairly coarse scale).

Once data were archived, they were compiled and filtered to remove redundant data and errant points using the Douglas Argos Filter (DAF, http://alaska.usgs.gov/science/biology/spatial/douglas.html). The DAF is a threshold filter that has several user-defined parameters to flag improbable locations in satellite tracking data (Douglas et al. 2012). The parameters are adjustable based on species' movement behaviors and the scale of the area under observation. With the DAF, data are retained if they pass 1) a spatial redundancy test and/or 2) a movement rate and turning angle test. Since bird data contain both short-distance, local movements, and long-distance migratory events, we employed the hybrid filter of both the distance, angle and rate (DAR), and minimum redundant distance (MRD) filters. This achieves the best of both filters and in practice has produced very clean data with few erroneous points. Using the DAF, we also chose to identify the best representative point per duty cycle for each animal to reduce redundant daily positional information. The DAF filter program is further useful as it produces the total compiled diag data including first four on-board sensors from PTTs as well as KML data that can be immediately mapped in Google Earth to look for data discrepancies and track individual movements. Sensor data (e.g., temperature, voltage) was often used to determine the final fate of birds and tags.

A database of deployment and life-history data was built for every PTT tag that was deployed or is being archived by the SDJV project (2001-2018). These data are stored in a shared Google spreadsheet that is accessible by all project PIs. The database contains as much information as possible about the PTT tags themselves as well as data about the capture and deployment history of all animals. Furthermore, to correctly map species to life-history period, we recorded the life-history period start and end dates for every animal we collected data for. This allowed us to accurately map every animal as well as provide data about durations of life-history periods. We have identified the following periods: breeding, molting, fall-staging, wintering, and spring-staging for every year that each bird was alive and transmitted locations following the life-stage criteria in Table 1. These temporal criteria varied among species due to differences in breeding chronology and overall migration patterns. Once filtered using these criteria, species experts examined individual points to eliminate erroneous locations and ensure accuracy.

We assigned final dispositions of all non-active tags and the date of disposition. Sensor data were assessed for every tag to identify confirmed mortality (by internal temperature sensor or mortality sensor) or battery/tag failure due to low voltage. We recorded the last known date alive for all birds confirmed dead during the period of tag activity. For all animals with tags that stopped transmitting for either low voltage or unknown reasons we list the day after last transmission as the last date of disposition. Tag duration dates were then calculated from the deployment start date and the final disposition date once tags were no longer active. The DAF filter works off deployment dates to correctly parse PTT data. Since PTT ID numbers can be deployed multiple times, it was necessary to re-run DAF filters once final dispositions were determined to allow the DAF filter to correctly parse the data.

BRI wrote a custom script in Python 2.7 for ArcGIS to automate map production due to the large number of species/life-period combinations that were allocated for mapping. This script used the DAF-filtered data for each species and the corresponding life-period data from the deployment database to map locations for each individual. We chose to represent only one year's worth of data per life period per animal based on the following reasons and schema. We have evidence that the movement patterns of birds may be adversely affected in the first year following capture and implantation of satellite transmitters (Lamb et al. 2020) and thus subsequent years may be more representative of the timing and movement of that animal. Therefore, we chose Year 2 data preferentially over Year 3 data and Year 1 data if only one year of data existed. Each bird then only contributed one sample to each map to ensure maps were not biased by animals with more years of data due to tag longevity or mortality. Furthermore, we included only birds that transmitted >60 days after release to reduce bias from birds that could have been negatively affected by transmitter implantation and handling. Tables 3-6 indicate the *original* sample size for each species at each deployment location and year, and the fate of those transmitters or birds (i.e., known death, unconfirmed mortality, or transmitter failure) to the extent it can be ascertained from location and PTT sensor data.

We produced two basic map types: 1) movement maps showing mean location points for each animal per period (i.e., breeding, molt, and winter) connected by migratory path lines and 2) dynamic Brownian-bridge movement maps that show broad-scale utilization distribution for all animals. Movement maps were created to show male movements from *winter to molting*, which included spring migration and movements during the breeding and post-breeding periods, and *molting to winter*, which included fall migration. Female movement maps consisted of *winter to breeding,* which included spring migration, and *breeding to winter,* which included post-breeding movements, molt, and fall migration. Period locational means for winter, breeding, and molting locations were used for these maps, calculated from all best location per duty cycle available for those periods. Movement lines were created from all intermediate points between “book-end” periods such as winter and breeding and show the linkage between these periods. The broad, diffuse lines were created as a stacked series of semi-transparent lines to create the spray-paint effect as shown. This method allows multiple tracks from individuals to stack up and get darker where tracks overlay, drawing the viewer’s attention away from any one track to focus on major migratory pathways instead. Note that lines are straight-line paths between points and do not necessarily reflect the true path of the animal. The broadness of the lines and stacked transparency was intended to illustrate generalized paths.

Dynamic Brownian-bridge movement maps were created for various life-history periods. Utilization distributions (UDs) were determined for each species by calculating individual level dynamic Brownian-bridge movement model (dBBMM) surfaces (Kranstauber et al. 2012) using package Move for R (Kranstauber and Smolla 2016). Separate dBBMM surfaces were calculated for each of two winters with at least five days of data and combined into a weighted mean surface for each animal (as a percentage of the total number of days represented in the surface) with a minimum 30 total combined days of data. This method of combining multiple seasons was used for the migration periods as well, but with relaxed requirements for days of data, requiring only five days per year and seven total days per period since migration duration often occurred over a much shorter time period. Utilization contour levels of 50%, 75%, and 95% were calculated for the mean UD surface. The final UD was cropped to the 95% contour for mapping and further analyses (Spiegel et al. 2017).

Table 1. Life stage criteria used to analyze seasonal migration and distribution data for four sea duck species (BLSC = Black Scoter; SUSC = Surf Scoter; WWSC = White-winged Scoter; LTDU = Long-tailed Duck).

	BLSC	SUSC	WWSC	LTDU Atlantic	LTDU Great Lakes
Breeding	• Stay for >= 14 days • Arrive between May and June • Depart between July and August	• Stay for >= 14 days • Arrive between late May and June • Depart between July and August	• Stay for >= 14 days • Arrive between May and June • Depart between July and August	• Stay for >= 14 days • Arrive between late May and June • Depart between July and August	• Stay for >= 14 days • Arrive between June and July • Depart between July and August
Molting	• Stay for >= 21 days • Arrive between July and September • Depart between August and October	• Stay for >= 21 days • Arrive between July and September • Depart between August and October	• Stay for >= 21 days • Arrive between July and September • Depart between August and October	• Stay for >= 21 days • Arrive between July and September • Depart between August and October	• Stay for >= 21 days • Arrive between July and September • Depart between August and October
Wintering	• Month of fix is January or February • Month of fix is November, December, March or April AND distance between consecutive movements are <=50km.	• Arrive between October and November • Depart late March early April	• Month of fix is January or February • Month of fix is November, December, March or April AND distance between consecutive movements are <=50km.	• Arrive between October and November • Depart late March early April	• Arrive between October and November • Month of fix is November to late April or May AND distance between consecutive movements are <=50km.
Staging	**Not identified**	Along migration bird stays in same location for >= 15 days.	Along migration bird stays in same location for >= 10 days.	Along migration bird stays in same location for >= 15 days.	Along migration bird stays in same location for >= 7 days.

Species Summaries

Black Scoters

Capture Sites: Chaleur Bay, New Brunswick/Quebec, Canada, and coastal Rhode Island

Chaleur Bay, a coastal area on the border of New Brunswick and Quebec, is the major spring stop-over site for migrating Black Scoters in eastern North America. It is thought that most of the eastern North American population of Black Scoters stages here for 2-3 weeks before continuing their northward migration to the breeding grounds. Black Scoters were captured with the use of floating mist nets in 2009 and 2010, although several were captured by night-lighting in earlier years (2001-05). Transmitters deployed in 2009 were programmed with a duty-cycle of 6 h on and 72 h off while transmitters deployed in 2010 were programmed with a duty-cycle of 2 h on and 72 h off.

In addition to the main objectives of the study (i.e., population delineation and habitat use), we also sought to identify molting areas for male Black Scoters and quantify molting site fidelity to help evaluate a monitoring survey of molting scoters in James and Hudson Bays.

Lead Investigators: **Chaleur Bay, New Brunswick/Quebec**: Scott Gilliland, Keith McAloney, Jean-Pierre Savard (Environment Canada) and Matthew C. Perry (USGS Patuxent Wildlife Research Center); **Rhode Island**: Scott McWilliams (University of Rhode Island), Jay Osenkowski (Rhode Island Department of Environmental Management).

Other Partners: USFWS; New Brunswick Department of Natural Resources.

Results and Discussion:

One hundred and eight Black Scoters (55 females and 53 males) were implanted with satellite transmitters as part of this project, although not all provided useful information due to transmitter failure and/or bird mortality (Table 3). Survival of adult radio-tagged Black Scoters was relatively high, with nearly 90% of the bird/radios surviving the first 60 days after release. Ninety-five percent of the 2009 tagged birds that survived the initial release period remained active for the 1.2-year potential life expectancy of the radios. Radio failure or bird mortality rates were higher for the tagged birds released in 2010 with about 85% radios remaining active to 1.2 years. The duty-cycle used in 2010 resulted in average longevity of 2.2 years with 7 birds transmitting for more than 3 years (max=3.5 years). In contrast, survival of PTTs or birds tagged during winter 2010 (mostly hatch-year birds) was low with 33% failing in the first 45 days and only three tags lasting longer than 1.2 years. Notably, nine of eleven hatch-year birds died within 60 days of marking (Table 3).

Spring Migration

Spring migration generally followed a coastal route along the eastern seaboard of the USA and Canada to the spring staging area in Chaleur Bay between New Brunswick and Quebec (Figure 3, Figure 4). After departing Chaleur Bay, a small proportion of the birds spent a few days in the St. Lawrence Estuary and Gulf before flying overland over southern Quebec towards their breeding areas. Most females moved to James Bay where they staged for 1-2 weeks before continuing to their inland breeding locations in northern Quebec, northern Ontario, northern Manitoba, the Northwest Territories (NWT), and Nunavut (NU). Two females that staged along the central part of the Quebec North Shore of the Gulf moved directly to breeding areas in central Labrador and eastern Quebec. Many of the females that traveled to breeding sites in northern Quebec and Labrador (n=8) flew directly to their breeding location from Chaleur Bay. Most males, and some females, did not go to breeding sites and flew directly to their molting location in James Bay using a similar overland migration across southern Quebec.

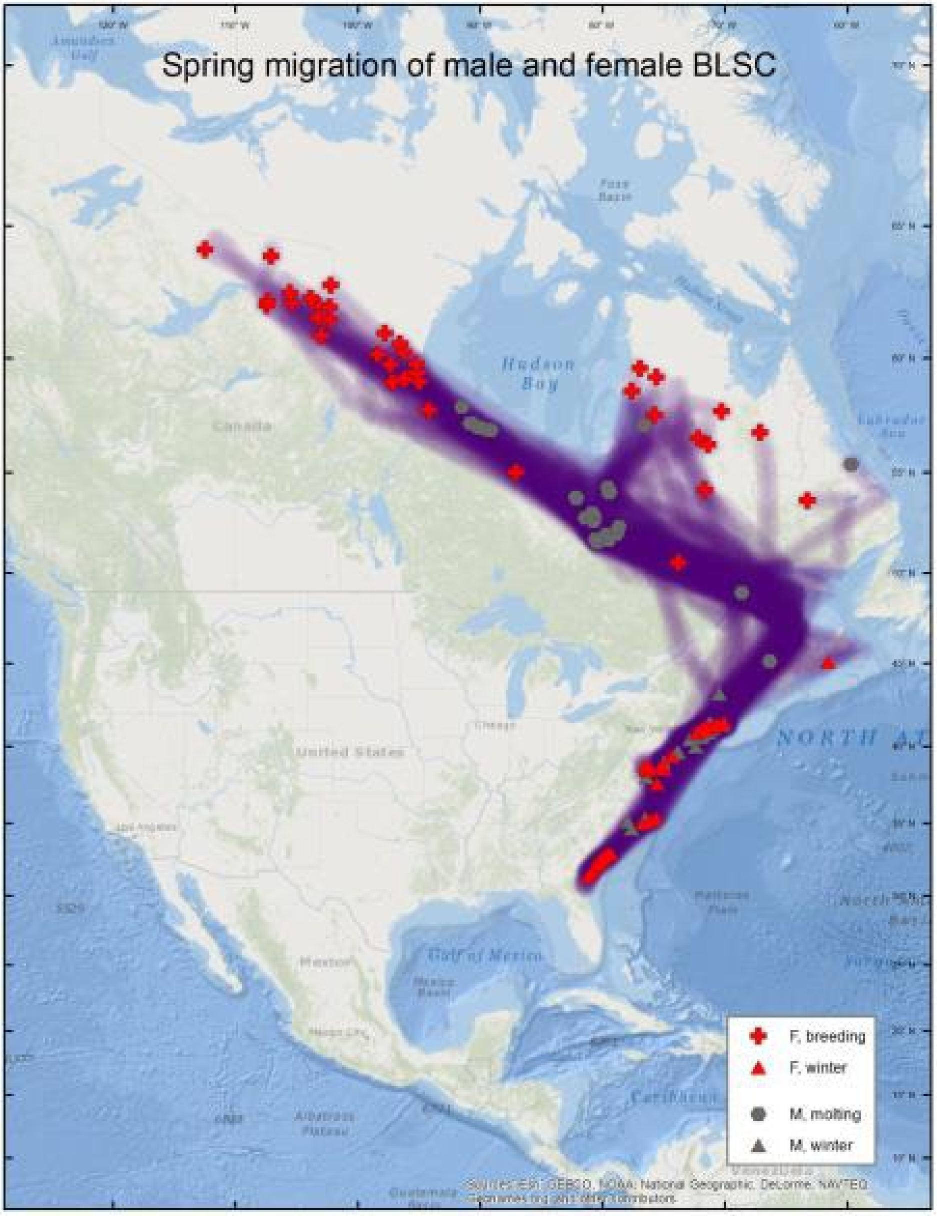

Figure 3. Spring migration of 79 adult Black Scoters (43 females, 36 males) from wintering areas to breeding areas (females) or molting areas (males). Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 25 October 2013.

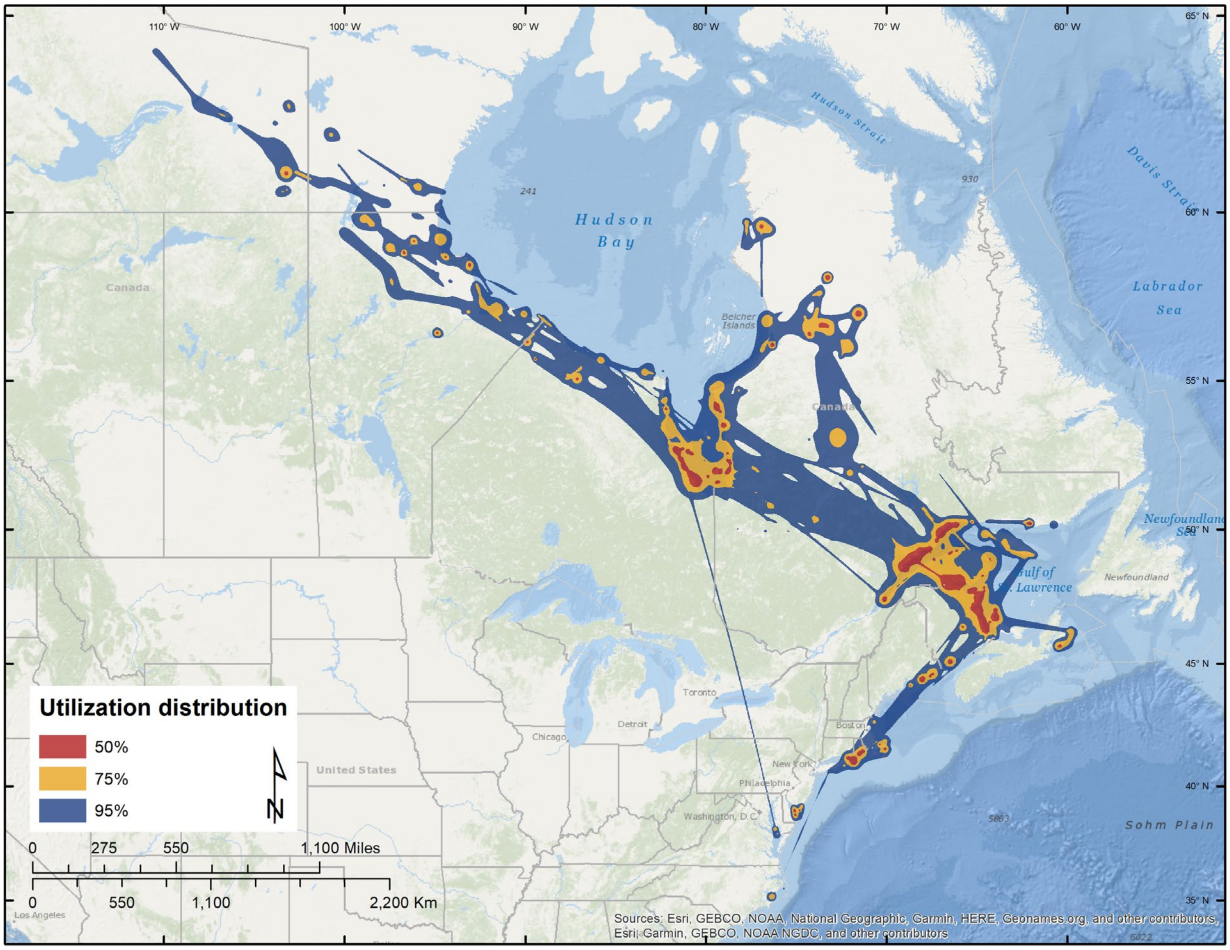

Figure 4. Dynamic Brownian-bridge movement models of spring migration and staging areas for 76 adult Black Scoters.

Breeding Areas

Most females (~70%) migrated to breeding sites that encompassed an area along the southern edge of the Taiga from the Hudson Bay coast of Manitoba west-northwest almost to Great Slave Lake (Figure 3). This was surprising as the birds were located well outside the previously documented breeding areas in western Labrador and central Quebec, and the Hudson Bay Lowlands in Ontario (see Anderson et al. 2020, Brook et al. 2012). The breeding range appears to be divided into two major regions: one covering the Hudson Bay Lowlands through part of northern Manitoba and eastern NWT, and the second covering north-central Quebec and Labrador (Figure 3).

The 2 h on 72 h off duty-cycle used for tags in 2010 allowed us to track birds for up to 3.5 years including locations for up to four breeding seasons providing useful information on breeding site fidelity. Twelve females used the same breeding site for 2 consecutive seasons, 2 females for 3 consecutive seasons and 1 female for 4 consecutive seasons (average distance between breeding sites was 3.25 km, SD=2.47); one female moved its breeding site 63 km between years. Only one female may have moved its breeding site between years, suggesting the species is highly philopatric.

Molting Areas

There are two primary molting areas for males – one centered on Western Hudson Bay and one in James Bay, with individual males molting at three other sites: north shore of the St. Lawrence Estuary, Chaleur Bay, and coastal Labrador. The 2 h on 72 h off duty-cycle used for tags in 2010 allowed us to track birds for up to 3.5 years, encompassing locations for up to three molting seasons, and providing useful information on molting site fidelity.

Several male black scoters exhibited high fidelity to molting areas among years. For example, six of the 15 tagged males that provided molting locations for three consecutive years used the same molting area, whereas seven switched areas on at least one occasion. Several birds shifted molting areas among years, particularly between molting areas in James Bay and Western Hudson Bay, and a relatively weak association between the Eastern and Western James Bay molting areas. There were also direct linkages between the molting area in the St. Lawrence Estuary and the Western Hudson Bay and Eastern James Bay molting areas. The only molting site that appeared to be isolated was Labrador; however, tagged birds that used this site only provided data for one year and the sample size may not be adequate to detect transitions from this site.

Fall Migration

Many of the males that molted on James Bay and western Hudson Bay, and most females that may have bred or molted in central Quebec or central Canada, staged on James Bay during the fall. When departing the James Bay staging area, most birds took a more westerly route on their southward migration in the fall than they did during spring, with evidence that some birds flew directly overland at night (based on telemetry locations over land at night) from James Bay to the New England coast (Figure 5, Figure 6).

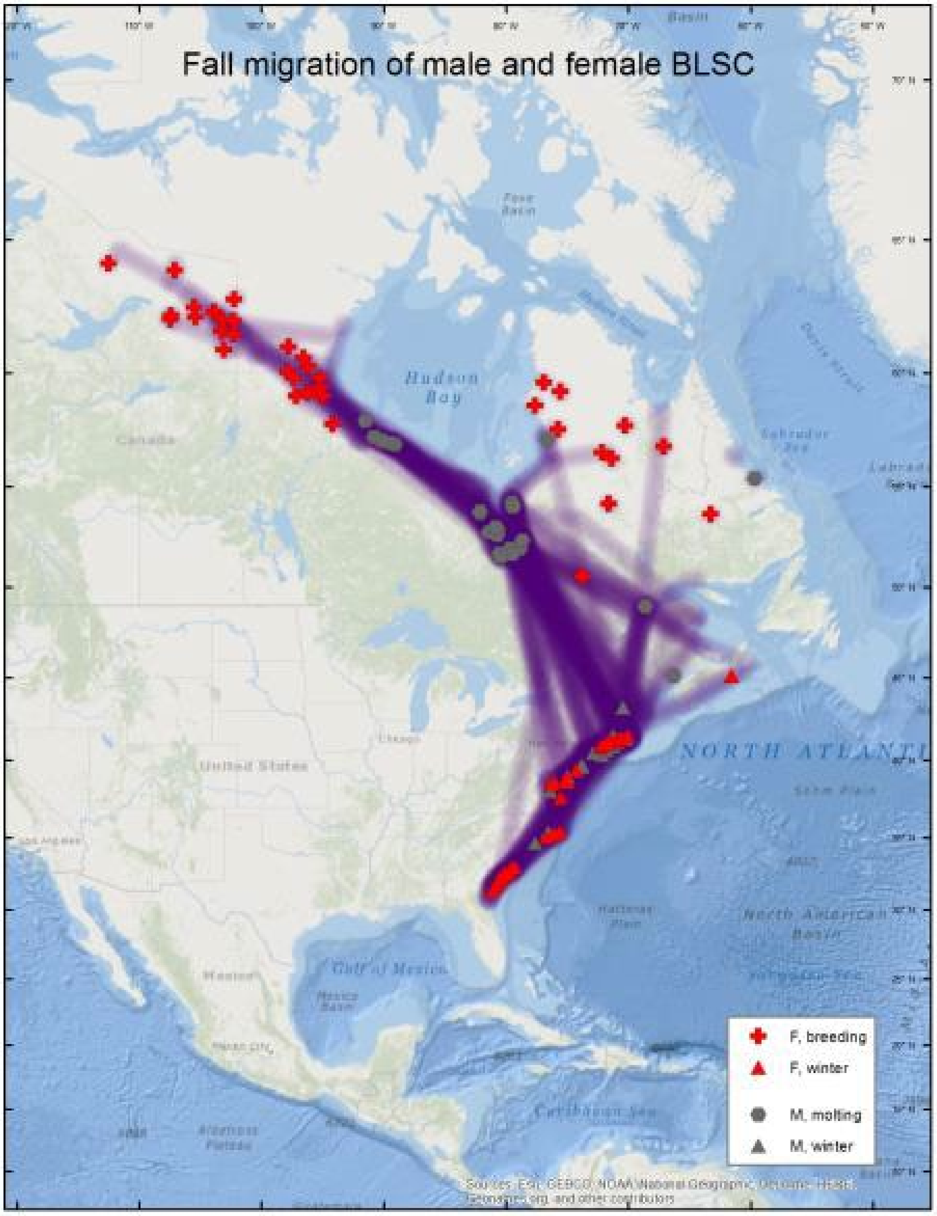

Figure 5. Fall migration of 78 adult Black Scoters (43 females, 35 males) from breeding/molting areas to wintering areas. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 25 October 2013.

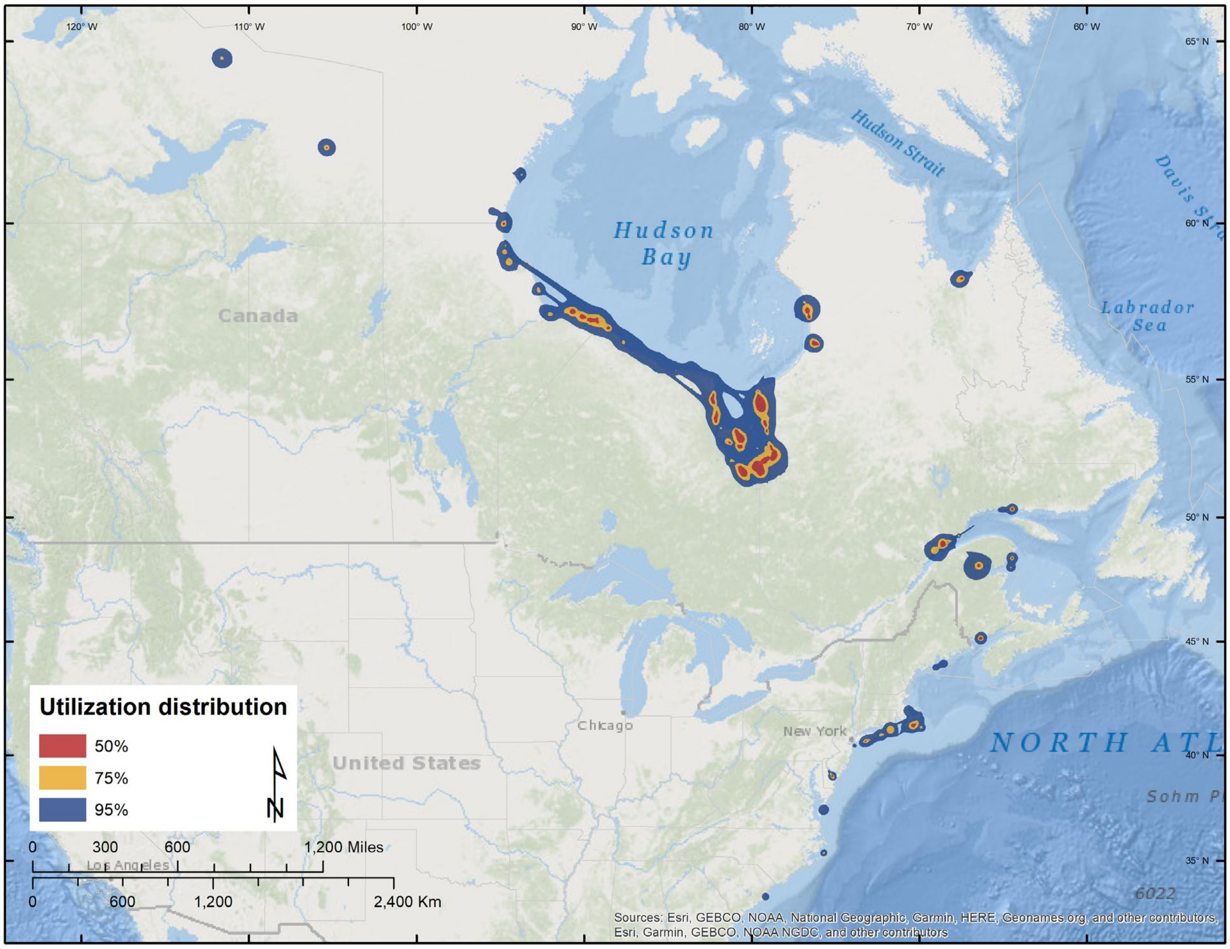

Figure 6. Dynamic Brownian-bridge movement models of fall migration and staging areas for 80 adult Black Scoters.

Wintering Areas

Most birds staged for a few weeks at various locations along the Atlantic coast of the USA before arriving at their wintering areas, mostly between Massachusetts and northern Florida (Figure 7). Significant movement of birds occurred during winter both within and among years.

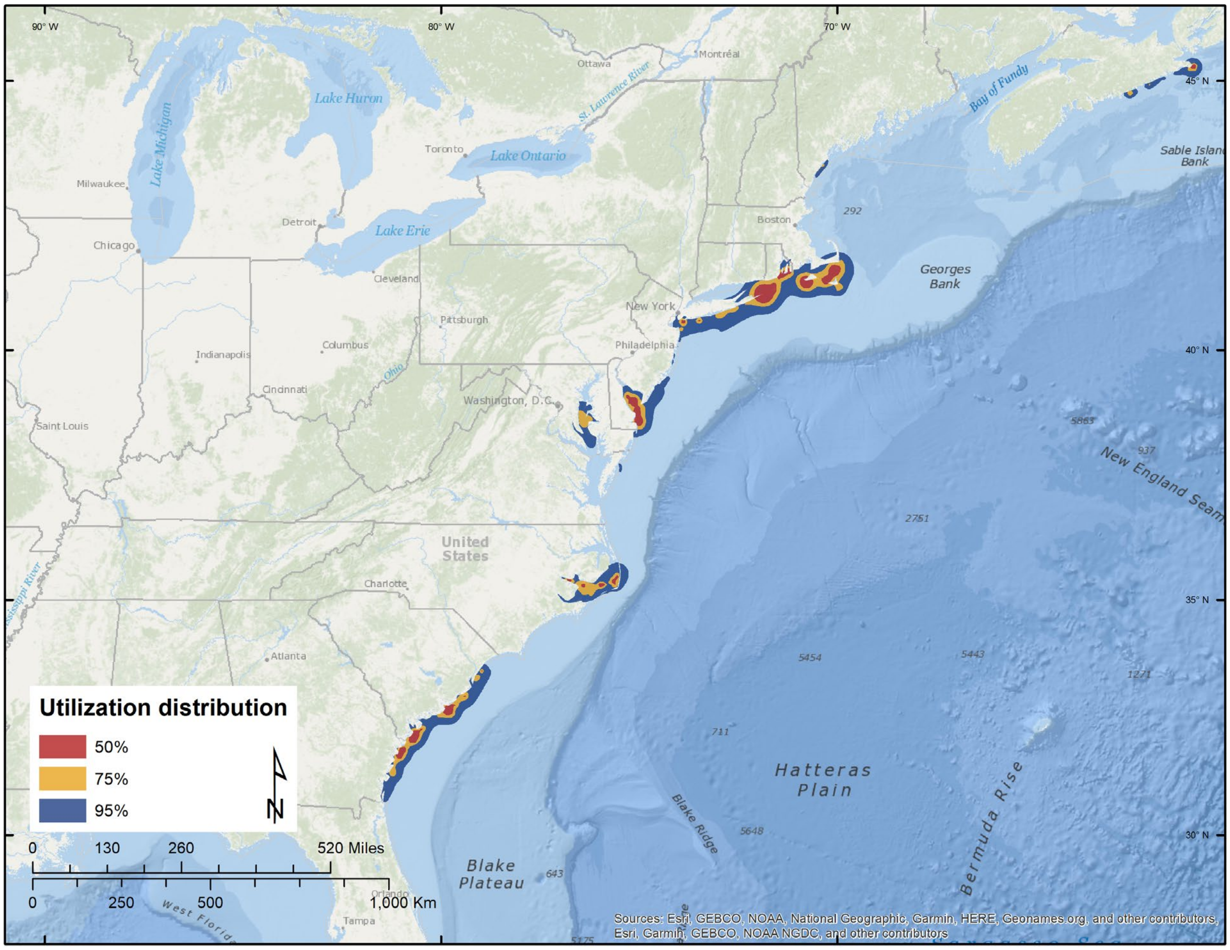

Figure 7. Dynamic Brownian-bridge movement models of wintering areas for 61 adult Black Scoters.

Other Observations

Telemetry data showed that James Bay and southwestern Hudson Bay are occupied for a large portion of the annual cycle by Black Scoters. The first birds arrive in James Bay in May and the last birds leave in late November, which suggests that birds use this area if it is ice-free. These areas may be very important for nutrient acquisition for breeding, molting, and rebuilding energy reserves after breeding. This marine area would be a good candidate for habitat protection.

Particularly important areas during fall and spring migration along the Atlantic coast include the area around Cape Cod and Nantucket Shoals, Chaleur Bay on the New Brunswick – Quebec border, and the St. Lawrence Estuary.

Implications for Management and Conservation:

1. Telemetry data have provided a completely new view of the breeding range for the species and suggest that a large portion of the eastern population is associated with breeding areas in northern Manitoba, Nunavut, and the Northwest Territories. As a result of this study, this area has been identified as an Area of Continental Significance to North American Ducks, Geese and Swans under

the North American Waterfowl Management Plan (NAWMP) 2012 Revision. This area has not been covered by traditional waterfowl breeding surveys (see Brook et al. 2012 for survey data for Hudson Bay lowlands). Experimental sea duck surveys of these areas were conducted from 2014-2019 to develop recommendations on how to integrate this new information into current waterfowl survey programs and improve monitoring of scoters and other sea ducks.

2. Molting sites for males have been delineated in western Hudson Bay, James Bay, the St. Lawrence Estuary and Labrador; there is some interchange among these sites between years for some individuals.
3. Data collected provide more insight into the origin and composition of molting flocks. It confirms the idea that unpaired males do not go to the breeding areas but fly directly to their molting area. This has important implications for the interpretation of survey data.
4. Data from this study are being used in several environmental assessments. For example, they are being used in multiple assessments of proposed offshore wind energy projects along the U.S. Atlantic coast, for the design of a radar migration study for a wind turbine project on the isthmus between New Brunswick and Nova Scotia, and in a coastal sensitivity mapping program in South Carolina.
5. The telemetry data have been used for the design and interpretation of the James Bay molt survey and the Atlantic Coast Winter Sea Duck survey (https://seaduckjv.org/pdf/studies/pr109.pdf).

Recommendations for Future Work on Black Scoters:

1. Capture techniques (mostly mist-netting on staging areas) were efficient and do not need to be modified. However, the effective sample sizes were below the desired target, and additional birds may need to be tagged to increase confidence in results.
2. Data on Black Scoters show that the surgery associated with transmitter implantation affected the timing of migration and movements of implanted birds in the year they undergo surgery (i.e., migration was delayed by 1-2 weeks). Censoring data from the first year may help overcome bias associated with marker effects in future studies (Lamb et al. 2020).
3. A reconnaissance aerial survey of breeding areas in northern Manitoba, Nunavut, and the Northwest Territories revealed relatively high densities of Black Scoters and demonstrated that a breeding survey may be a practical alternative for monitoring Atlantic black scoters, provided that scoters can be reliably identified to species. On-going analyses to identify optimal survey timing, assess species identification, estimate detection from different survey platforms, and develop habitat selection models should be completed to inform the development of a breeding survey (Reed et al. 2020).

Surf Scoters

Capture Sites: Chesapeake Bay, MD/VA; Nain, Labrador; Pamlico Sound, NC; Narragansett Bay, RI; St. Lawrence Estuary, Quebec

The initial deployment plan for Surf Scoters was to concentrate captures on wintering areas along the mid-Atlantic coast, particularly along the Maryland, Delaware, and Virginia coasts, and in Chesapeake and Delaware Bays. The deployment schedule required that tags be distributed along the Atlantic coast relative to the abundance of Surf Scoters as measured by the Atlantic Coast Winter Sea Duck Survey (Silverman et al. 2012). Capture of adult females in several wintering areas proved difficult and most Surf Scoters captured in the initial effort were adult males from Chesapeake Bay from a previous study in 2001-05, and this study in 2011-12.

In winter 2012, we re-examined deployment alternatives for marking a sample of adult female Surf Scoters that would be representative of the Atlantic flyway population. Surveys of the spring and fall staging areas around the St. Lawrence Estuary and Gulf of St. Lawrence identified major staging sites in spring and fall (Falardeau and Savard 2003; Rail and Savard 2003; F. Bolduc, CWS-QC, unpubl. data). Examination of all satellite telemetry data collected up to 2012 showed two major spring migration routes: one that followed the Atlantic coast with staging along the east coast of New Brunswick and St. Lawrence Estuary and north shore of the Gulf, and a secondary route that crossed inland from Chesapeake Bay to the Great Lakes. However, data for the fall migration suggested that most birds used a route that passed through the St. Lawrence Estuary and Gulf with a large proportion of tagged birds using a known staging area near Forestville, Québec. In fall 2012, we initiated a pilot program to determine if adult females could be captured at this site. We also conducted an aerial survey of the Québec portion of the Gulf of St. Lawrence to determine if there were other major staging sites. In fall 2012, 26 tags were deployed on adult females at Forestville. The aerial survey did not identify other significant staging sites. In 2013, we deployed an additional 53 tags at the Forestville site. We also expanded coverage of the aerial survey to include possible staging sites along the Gulf coasts of

Newfoundland, Nova Scotia, New Brunswick, and the Madeleine Islands in Québec, and no significant staging sites were identified (F. Bolduc, CWS-QC, pers. comm.).

Capture techniques included floating mist nets (St. Lawrence Estuary), net gunning, and night-lighting (Atlantic U.S. coast). Several transmitters were deployed on male Surf Scoters during molt in Labrador in 2006 for a different but complementary study; these data are included in these analyses.

Lead Investigators: **Québec and Labrador**: Scott Gilliland and Christine Lepage (Environment Canada, Canadian Wildlife Service), and Lucas Savoy (BRI); **Atlantic Coast US:** Alicia M. Berlin, Ronald E. Therrien, and Matthew C. Perry (USGS Patuxent Wildlife Research Center), Doug Howell (North Carolina Department of Wildlife Management), Scott McWilliams (University Rhode Island), Jay Osenkowski (Rhode Island Department of Environmental Management), Lucas Savoy (BRI).

Other Partners: Maryland Department of Natural Resources, Virginia Department of Game and Fish, USFWS, Ducks Unlimited, North Carolina Department of Wildlife Management, BOEM, DOE, University of Quebec at Montreal, Environment Canada Science and Technology Branch, McGill University, University of Montreal.

Results and Discussion:

A total of 202 adult Surf Scoters (89 males, 113 females) were radio-tagged, with 101 marked on wintering areas, 15 tagged on a molting area near Nain, Labrador, 80 tagged during fall near Forestville, Québec, and 6 tagged at Chaleur Bay, New Brunswick/Quebec (Table 4). Overall, we have observed a 39% loss rate (this includes known death, known transmitter failure, and undetermined loss) for Surf Scoters (Table 4), reducing the number of individuals used in analyses. The radio tags used in 2012 were heavier than expected (49-53 g), and there was evidence of a higher rate-of-loss using the large radios in Surf Scoters (Table 4). Due to concerns that the larger 48-51 g transmitters were too large and/or heavy for Surf Scoters, especially females, we switched to a smaller 33-35 g model for 2013. There was no indication that the smaller transmitter improved survival of marked birds. Additional deployments of the larger units were done during winter 2014 under the BOEM element of the study.

We also evaluated the effectiveness of the anesthetic midazolam in reducing stress and early mortalities of Surf Scoters in the Forestville component of the program. In conjunction with the anesthetic study, we implemented new handling procedures for the capture and veterinarian crews to control for effects of handling on stress. Females were aged and adults were treated 5-10 minutes after capture. Twenty-nine females were treated with midazolam and 28 females with a saline solution. The average handling time between capture and release was of 5.5 h (range: 3.1 – 8.8 h). The midazolam treatment appeared to increase the postsurgical survival of female Surf Scoters; the presumed mortality at 30 days for the midazolam group (23%) was lower than for the saline group (61%; Le Net et al. 2019).

Spring Migration

Spring migration for Surf Scoters generally follows a coastal route along the eastern seaboard of the USA and Canada with key stopover and staging areas at Nantucket Shoals, along the Northumberland Strait of New Brunswick and Nova Scotia, Chaleur Bay between New Brunswick and Québec, and along the St. Lawrence Estuary and north shore of the Gulf of St. Lawrence (Figure 8, Figure 9). One notable exception was a male that migrated from the Chesapeake Bay overland through the Great Lakes (in two consecutive years). This male continued transmitting through another spring migration but took the Atlantic coast route to the breeding area in central Quebec. After departing spring staging areas, 77% of females moved to their inland breeding locations in the boreal forest zone of Quebec and Labrador (Figure 9), while the rest flew overland over southern Québec towards their breeding areas along the northern edge of the boreal forest west of Hudson Bay.

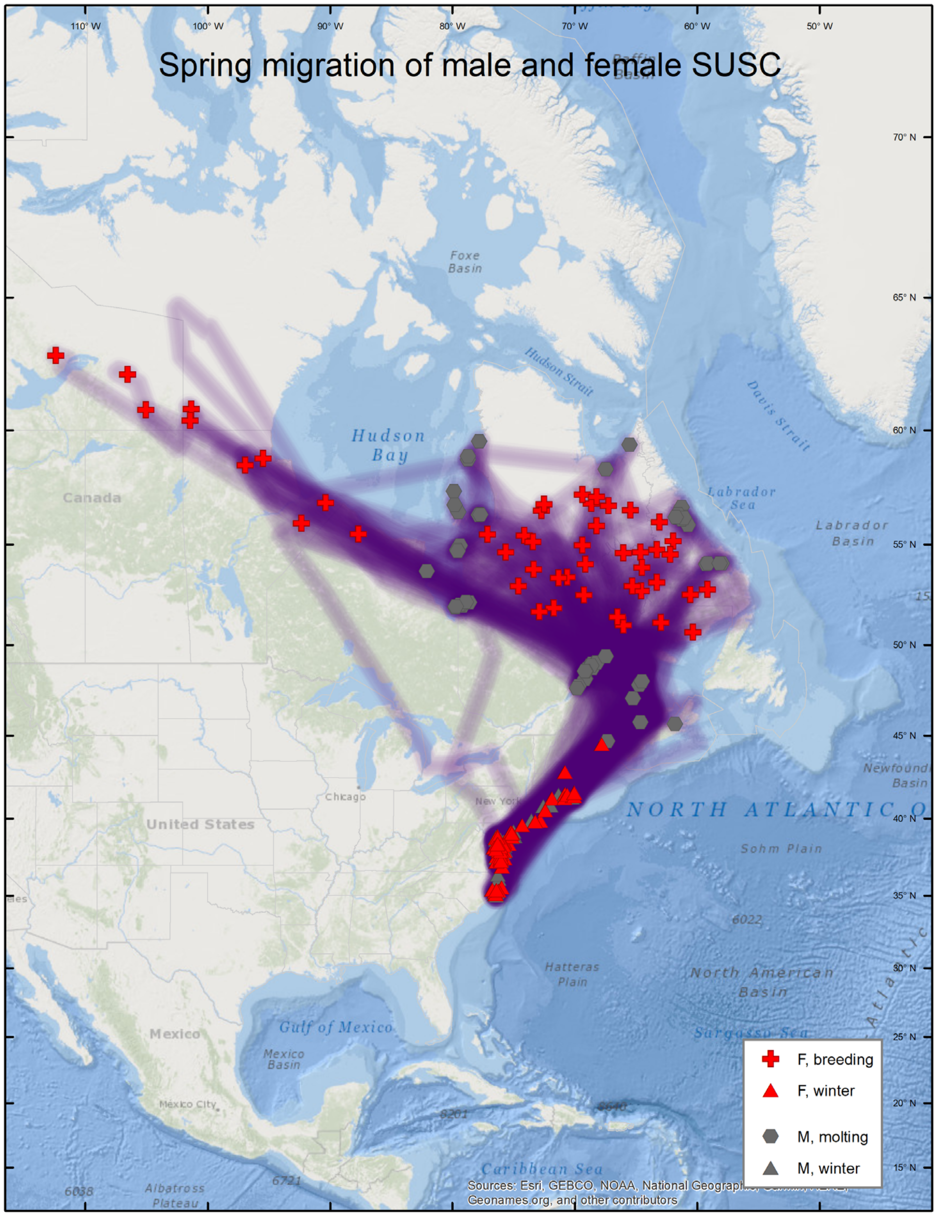

Figure 8. Spring migration routes for 114 adult Surf Scoters (62 females, 52 males) from wintering areas to breeding areas (females) or molting areas (males). Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 9 November 2015.

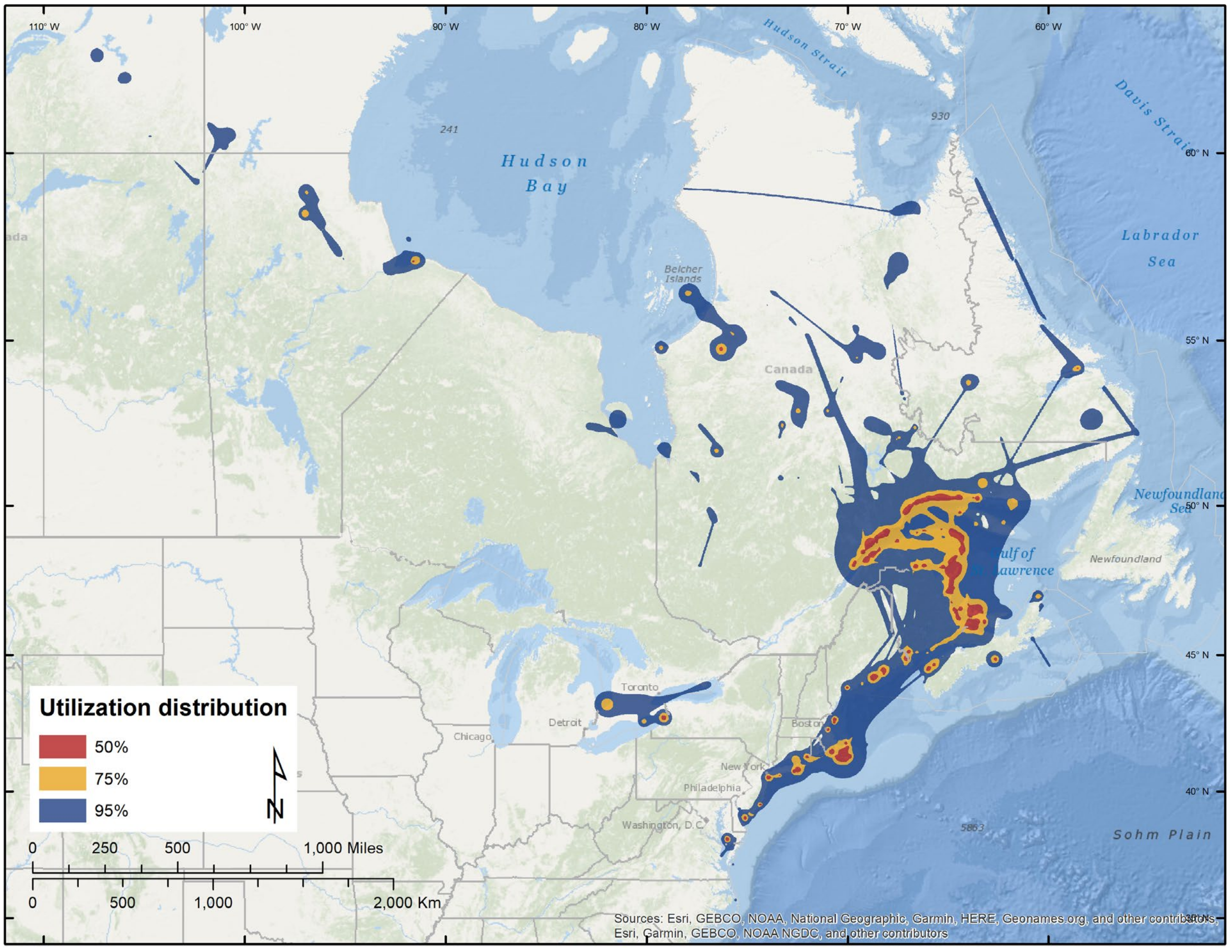

Figure 9. Dynamic Brownian-bridge movement models of spring migration and staging areas for 87 adult Surf Scoters.

Breeding Areas

Our sample of marked adult female surf scoters indicated that apparent breeding occurs in the northern portion of the boreal forest (taiga) in Québec and Labrador, and from the Hudson Bay coast of Ontario west-northwest to the Great Slave Lake in NWT (Figure 9) along a line just to the south of the breeding area identified for Black Scoters. Surveys completed in eastern Canada confirmed that Surf Scoters are breeding near small, forested lakes in the northern boreal forest (Canadian Wildlife Service Waterfowl Committee 2013), but other known breeding areas (e.g., Hudson Bay lowlands in Ontario, Brook et al. 2012) were not detected due to the small sample of marked birds and low breeding density in these areas. Two females provided breeding locations for two years; both exhibited strong site fidelity to their breeding areas with an average of only 0.5 km between breeding sites.

Molting Areas

Molting sites were identified for 33 adult male Surf Scoters (excludes any males tagged during molt) (Figure 11). Molting sites used by male Surf Scoters were much more widely dispersed than for Black Scoters; the three principal molting areas were the east coast of Hudson Bay-James Bay (including the Belcher Islands), the St. Lawrence Estuary, and coastal Labrador; two secondary areas were Ungava Bay and a southern area encompassing Chaleur Bay, New Brunswick, the Northumberland Strait coast of New Brunswick and Nova Scotia, and the Bay of Fundy. The 10 males that provided data for two years exhibited significant variation (3.3 – 1367.8 km) in their molting locations between years.

Of the 25 females caught during fall in the St. Lawrence Estuary in 2012 and 2013 and transmitted more than one year, almost 90% returned to the Estuary to molt and stage during the following fall. One other female molted in eastern James Bay and the other in the Backway, Labrador; these were previously known molt sites for males.

Fall Migration

During fall, Surf Scoters departed breeding and/or molting areas and funneled through the St. Lawrence Estuary with a large proportion of birds stopping over on the Nantucket Shoals area before migrating south to wintering areas (Figure 10, Figure 11). Key fall staging areas included the St. Lawrence Estuary, Northumberland Strait coast of New Brunswick and Nova Scotia, and Nantucket Shoals. One male that migrated northbound through the Great Lakes in spring (Figure 9) and molted in James Bay was tracked for two fall migrations and used the Atlantic coastal route to return to the wintering area during both years.

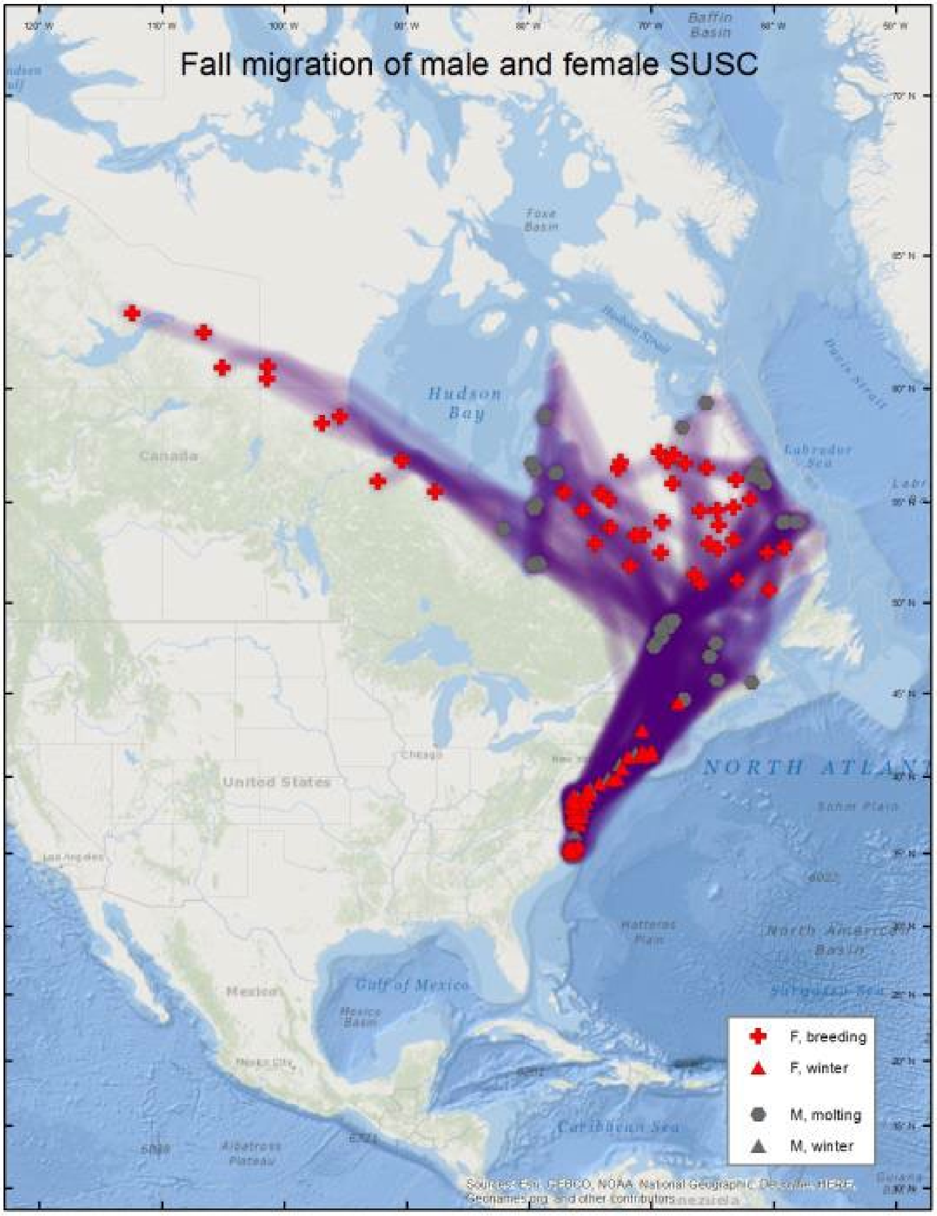

Figure 10. Fall migration routes for 114 adult Surf Scoters (62 females, 52 males) from breeding/molting areas to wintering areas. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 8 December 2014.

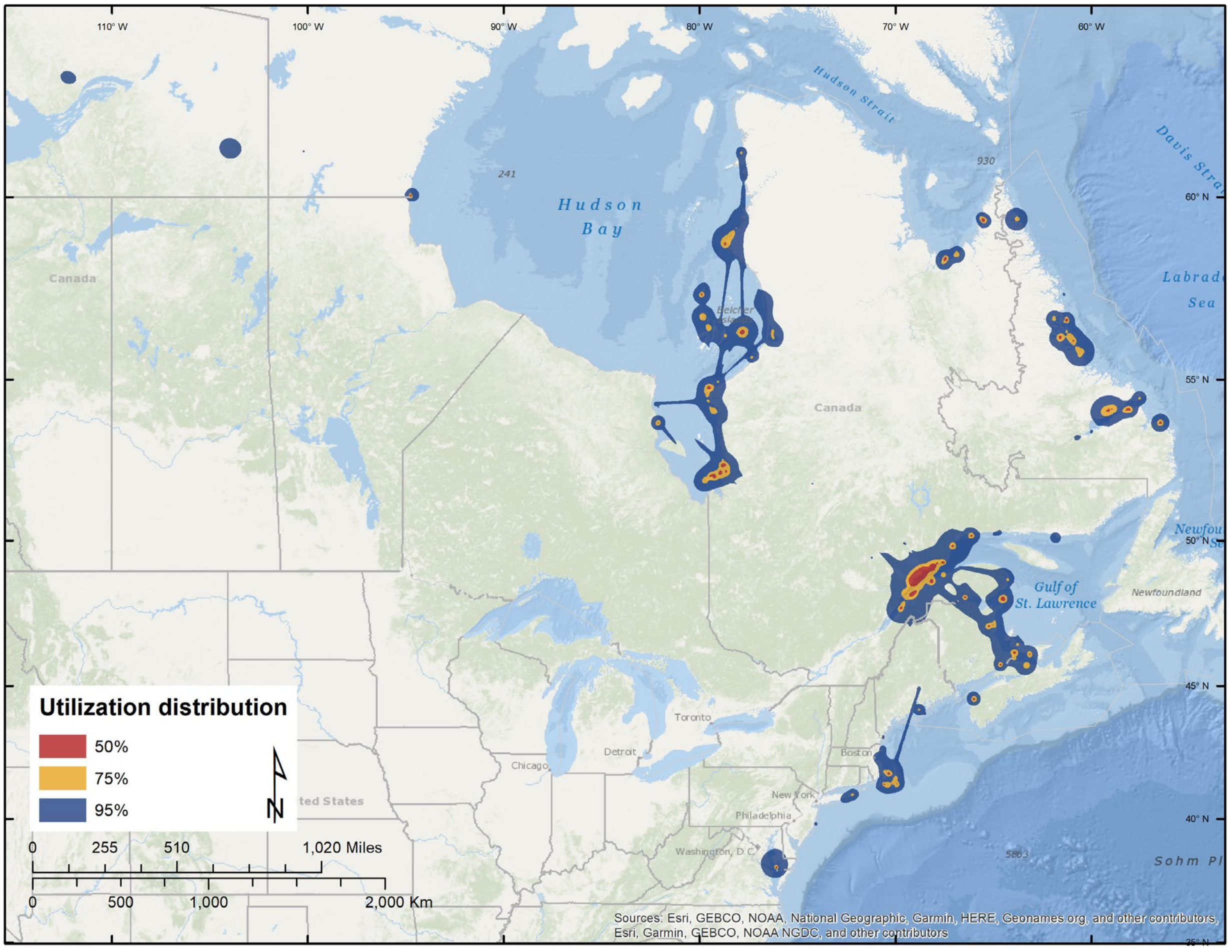

Figure 11. Dynamic Brownian-bridge movement models of fall migration and staging areas for 83 adult Surf Scoters.

Wintering Areas

On average, both sexes of Surf Scoters exhibited strong site fidelity to wintering grounds (mean 84 km difference between years). Because winter distribution is influenced by capture location, we developed two maps: one with winter-marked birds excluded (i.e., only Surf Scoters marked during fall in Quebec, 2012 and 2013), and one with locations of Surf Scoters marked during winter (Figure 13). The former provides a more representative sample of winter distribution from Maine south to North Carolina.

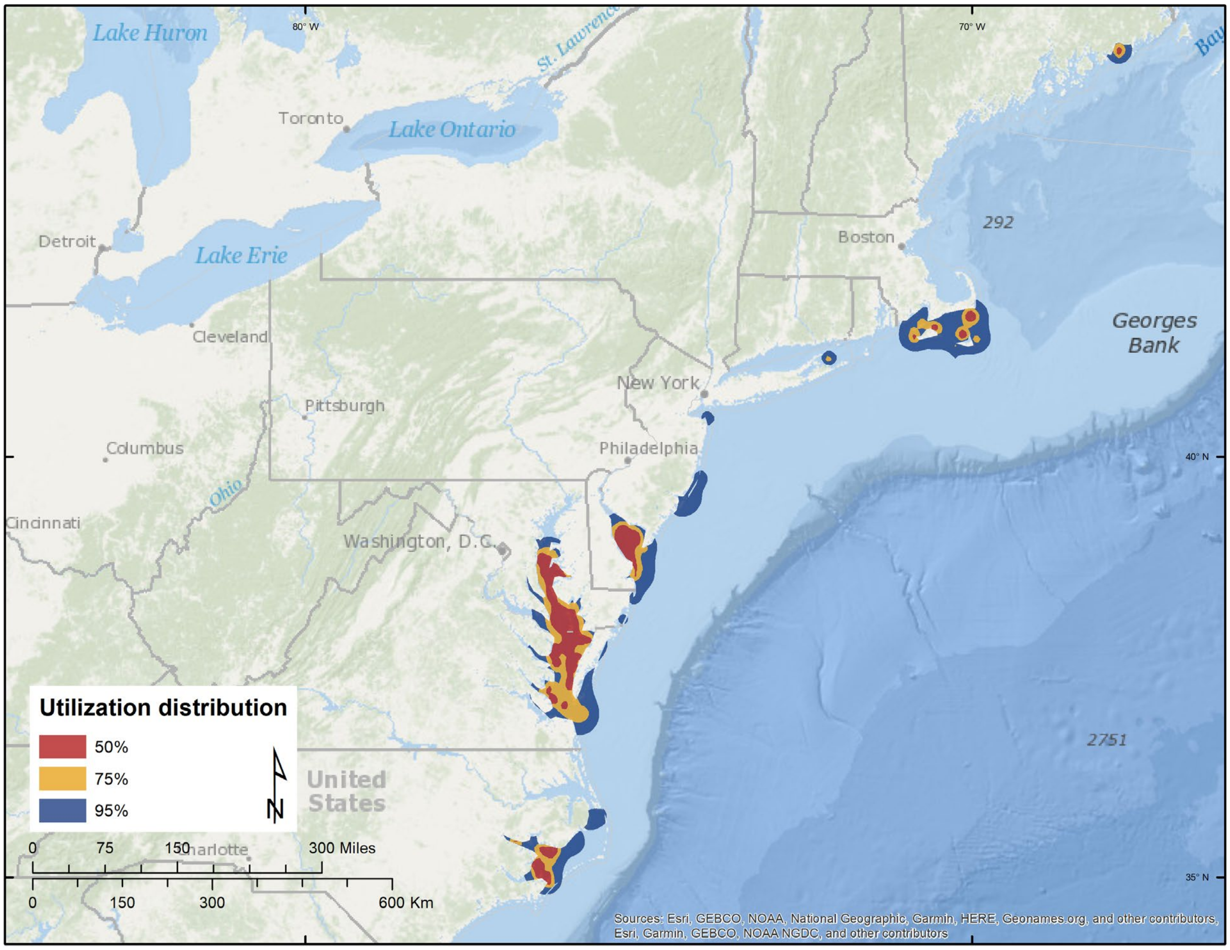

Figure 12. Dynamic Brownian-bridge movement models of wintering areas for 78 adult Surf Scoters.

An Assessment of the Forestville, Quebec Capture Site

The St. Lawrence Estuary and Gulf region is a major fall staging site for Surf Scoters and appears to be used by a large proportion of the eastern population of Surf Scoters. The Forestville, Quebec capture site was chosen as an alternative to winter capture sites because of the efficiency of catching large numbers of birds there. One concern with this approach was that some segments of the eastern population might be missed if they used an alternate fall migration route.

In 2012, we examined the 28 fall migratory tracks for all Surf Scoter tagged at capture sites other than Forestville. Twenty-one of the 28 tracks included stopovers on the St. Lawrence Estuary and eastern part of the Gulf, while another five birds passed directly over this area. Two of the tracks from the birds tagged on the molt site in Labrador used a route that passed to the east of the Forestville capture site through the Strait of Belle Isle and over the Madeleine Islands stopping over at the Northumberland Strait in the border region between New Brunswick and Nova Scotia. As described above, one of the males tagged in the winter on the Chesapeake used a spring migration route that crossed inland from

Chesapeake Bay to the Great Lakes and we suspected that some birds might use a similar route during fall, however, this bird migrated through Forestville during the subsequent fall migration.

The winter distribution of Surf Scoters marked at the Forestville site (Figure 13) is similar to the winter distribution of all other tagged birds suggesting that the sample of birds using the Forestville stop-over is likely representative of the wintering distribution of the Atlantic population of Surf Scoters. The distribution of the Forestville scoters is also roughly proportional to the relative abundance of Surf Scoters estimated through aerial surveys (Silverman et al. 2012), although we are cautious about direct comparisons with the survey data because of potential survey biases. Nevertheless, on a regional scale, relative densities of telemetry locations were roughly comparable to relative densities from the aerial survey data.

We also compared the distribution of Surf Scoter harvest in eastern North America with locations of the Forestville birds during the hunting season. Surf Scoter harvest was measured as the average harvest over the period 1998-2011, and the relative harvest by each jurisdiction was calculated as the percentage of the total harvest in eastern North America. Winter locations of birds marked in Forestville corresponded well to the distribution of harvest in the eastern United States. However, there were some minor discrepancies: 1) in eastern Canada, harvest data suggested that Newfoundland and Nova Scotia accounted for 3% and 6% of the eastern North American harvest of Surf Scoters, respectively; however, none of the females tagged in Forestville have used these sites in the fall. About 0.01% of the harvest occurred in Michigan while the remainder of the jurisdictions surrounding the Great Lakes took less than 0.01% of the harvest, indicating that some Surf Scoters used the Great Lakes region during fall.

Overall, the winter locations of females tagged in Forestville appear to be relatively representative of the winter distribution of Surf Scoters along the east coast of the United States. However, harvest data, and the migration patterns from the small sample of males tagged in Labrador suggest marking birds at Forestville may miss a small segment of the population (possibly adult males migrating from molting areas) that take a more easterly migration route in fall that follows the west coast of Newfoundland over the eastern Gulf and Nova Scotia. Similarly, harvest data show a weak signal that the Great Lakes region is used during the fall by Surf Scoters. Because none of the Surf Scoters tagged to date have used this region in the fall, we are not able to determine whether a small segment of the population uses an overland migration from the Great Lakes to the southern part of their wintering range.

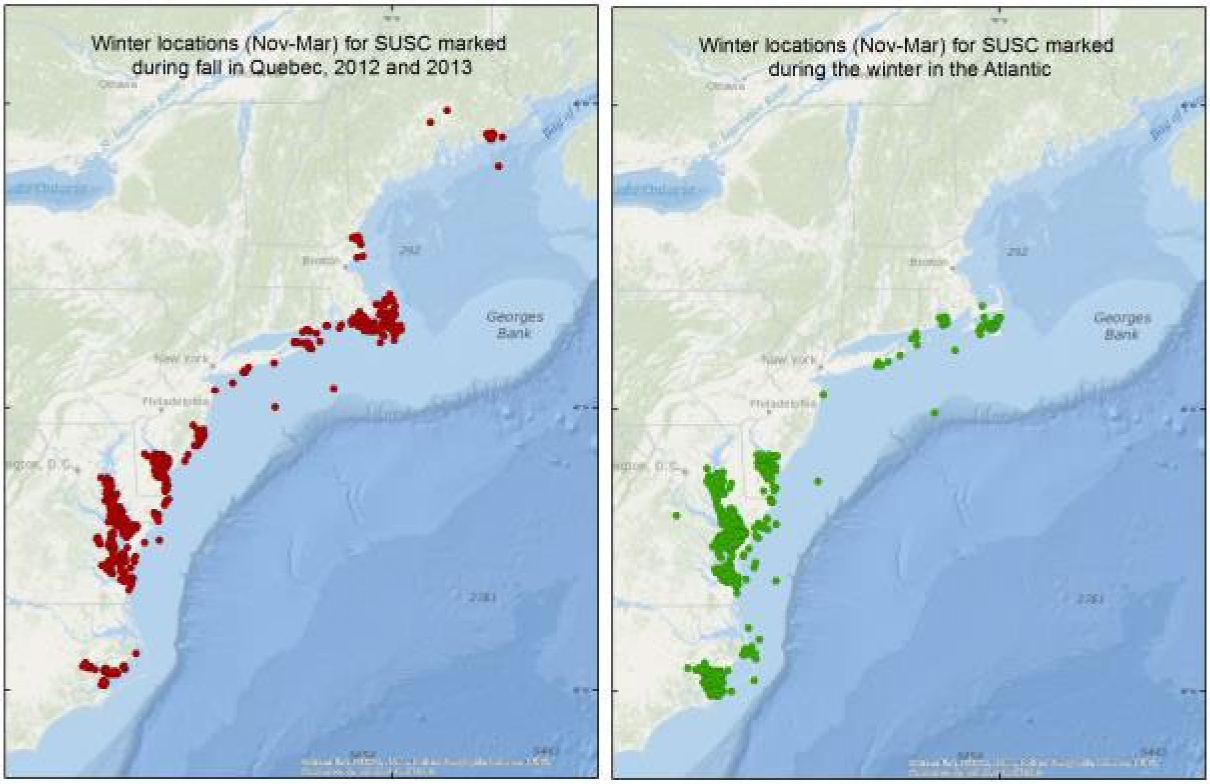

Figure 13. Location of wintering areas for 47 Surf Scoters (all adult females) marked during fall staging on the St. Lawrence Estuary, QC (left) and 48 Surf Scoters marked on Atlantic coastal wintering areas (right). Symbols reflect unique animal locations that contributed to the map. Map includes all locations through 8 December 2014.

Other Observations

1. Scoters appear to exhibit strong site fidelity to wintering and staging areas, but more data are needed to better quantify the degree of fidelity to molt and breeding areas.
2. Timing of migration appears to vary little among years.

Implications for Management and Conservation:

1. These data are being used by USFWS and BOEM to create a “risk” map of sea duck distributions to better inform the siting of offshore wind power projects along the Atlantic coast (Figure 27).
2. Northumberland Strait and St. Lawrence Estuary appear to be key bottleneck areas for Surf Scoters during spring and fall migration, and both warrant habitat conservation efforts.
3. The timing and use of key stopover areas could be linked to management of aquaculture farms in those areas.
4. Large-scale oyster restoration projects in high use areas of the Chesapeake Bay could provide more food resources to support higher concentrations of scoters during winter.

Recommendations for Future Work on Surf Scoters:

1. Further evaluate potential effects of transmitter size on post-release mortality, especially in females.
2. Test alternative transmitter technologies relative to survival of marked birds, data quality, and transmitter reliability and longevity.

3. The geographic distributions of breeding Surf and Black Scoters in eastern north America overlap throughout most of their range, with a large portion of the Surf Scoters breeding in northern Quebec and Labrador, and a large portion of Black Scoters breeding in the NWT and NU. Although the breeding range of the Black Scoter generally lies north of the surf's breeding range, it is possible that these two populations can be surveyed at the same time, provided a reliable method for speciation is used.

White-winged Scoters

Capture Sites: Forestville, St. Lawrence River Estuary, Quebec, Canada; Merrimack River, Salisbury (MA); Revere Beach, Revere (MA); Cape Cod Bay (MA); Saco Bay, Scarborough (ME); Newport (RI); Long Island Sound (NY); and Lake Ontario, Ontario, Canada.

Although the sampling design for this study called for marking a representative sample of each target species throughout their range, initial attempts to capture White-winged Scoters on wintering areas were difficult due to low numbers and densities of accessible birds, restricted winter distribution, and poor knowledge of local distribution during winter. The 2010 and 2012 capture efforts in the St. Lawrence Estuary were part of a separate but complementary Canadian Wildlife Service (CWS) study, and results are included here to provide additional information about their distribution, although it is recognized that any inference may apply only to the population of White-winged Scoters that molt in this area. Forestville, Quebec is a known molting area for thousands of Surf and White-winged Scoters; it is also used by 10,000-40,000 scoters (all 3 species) each spring and fall for staging. Successful winter captures were conducted in the fall and winter of 2015-2016 in Cape Cod Bay (MA), where a large percentage of the Atlantic population is estimated to winter, as well as additional molting captures in the St. Lawrence Estuary. Full annual cycle movements and migratory connectivity for these birds are summarized in greater detail in Lamb et al. (2019), Meattey et al. (2019), Lamb et al. (2020), and Lepage et al. (2020).

Lead Investigators: **Quebec:** Christine Lepage, Jean-Pierre L. Savard, and Scott Gilliland (Environment Canada); **New England and mid-Atlantic coast**: Lucas Savoy (BRI), Scott McWilliams (University Rhode Island), Dustin Meattey (BRI), and Jay Osenkowski (Rhode Island Department of Environmental Management); **Great Lakes**: Shannon Badzinski (Environment Canada, Canadian Wildlife Service, Ontario region), Phil Wilson (University of Western Ontario / Long Point Waterfowl).

Other Partners: **Quebec:** Université du Québec à Montréal, Université de Montréal; USFWS; **New England and mid-Atlantic coast**: Maine Department of Inland Fisheries and Wildlife; USGS Patuxent Wildlife Research Center, Dr. Malcolm McAdie, Dr. Darryl Heard, and Dr. Scott Larsen (Denver Zoo).

Results and Discussion:

Between 2009 and 2016, 103 White-winged Scoters were tagged in eastern North America (70 females, 33 males). Forty-one were tagged at wintering areas or spring migration stopovers along the Atlantic coast and on Lake Ontario, and 62 were tagged at molting locations in the St. Lawrence Estuary (Table 5).

Molting White-winged Scoters were caught in the St. Lawrence Estuary (Forestville, QC) by driving birds into a submerged gill net and were implanted with transmitters in 2010 (n=19), 2012 (n=17), and 2016 (n=26). Wintering White-winged Scoters were mist-netted and implanted with transmitters along the Atlantic Coast in Maine, Massachusetts, New York, and Rhode Island between 2010 and 2016 (n=37); on Lake Ontario, two adult females were captured by mist-netting and marked in March 2013 at Hamilton Harbor, Ontario (Table 5). Finally, during spring staging at Chaleur Bay, New Brunswick/Quebec, two males were tagged and implanted in 2009 (Table 5). Survival of White-winged Scoters (>60 days) is estimated to be approximately 81%; 10 of 70 marked females and 10 of 33 marked males were lost (i.e., PTT failure) or died within the 60-day period following implantation (Table 5).

Spring Migration

During spring migration, White-winged Scoters that wintered along the Atlantic coast followed three distinct paths: a) a direct overland path to staging areas in the St. Lawrence Estuary and Gulf, James Bay, or northern breeding areas; b) a coastal route north along the Atlantic U.S. and Canada seaboard with key stopover locations including Northumberland Strait, Chaleur Bay, and the St. Lawrence Estuary and Gulf; and c) an overland path through the Great Lakes (Figure 14, Figure 15).

Three adult female White-winged Scoters were marked in March 2014 at different sites in Long Island Sound, NY. All three migrated to potential breeding areas (2 NWT, 1 Saskatchewan), but took different routes to their respective breeding sites, mostly following the paths described above. One female used the Atlantic coastal migration route, departing from Long Island Sound and passing through Prince Edward Island, the Gulf of St. Lawrence, through northern Manitoba, and finally to its breeding site in northern Saskatchewan. The second female left Long Island Sound, and then over a nine-day period appeared to move overland from Nantucket to northern Manitoba, arriving at its breeding site in NWT. Lastly, a third female moved overland from Long Island through the Great Lakes, staging at Lake Erie for 25+ days, before passing through southwestern Ontario and northern Saskatchewan, arriving at a potential breeding site in NWT.

Scoters from all capture locations in 2015 and 2016 generally initiated spring migration by either heading northeast along the Canadian Maritime coast (i.e., Nova Scotia and New Brunswick) or northwest overland. Within the group that undertook the northwest overland route, three distinct spring migration routes to suspected breeding areas were identified including an overland route stopping over at James Bay, a direct overland route from the wintering areas to inland breeding locations, and an overland route stopping over in the Great Lakes. Those that migrated along the coastal route through the Canadian Maritime provinces crossed over the St. Lawrence River Estuary before continuing to eventual breeding areas (Figure 14). Two scoters were recorded using different migration routes between years. Both birds migrated from southern New England using the overland route through James Bay during their first spring migration; one switched to the coastal route through the St.

Lawrence River Estuary during its second year and the other took a direct inland route apparently bypassing James Bay during the second year. However, this bird had a large gap in transmissions (~3 weeks) between its last location in the wintering area and its first inland location, so a stopover in James Bay could have occurred without being detected.

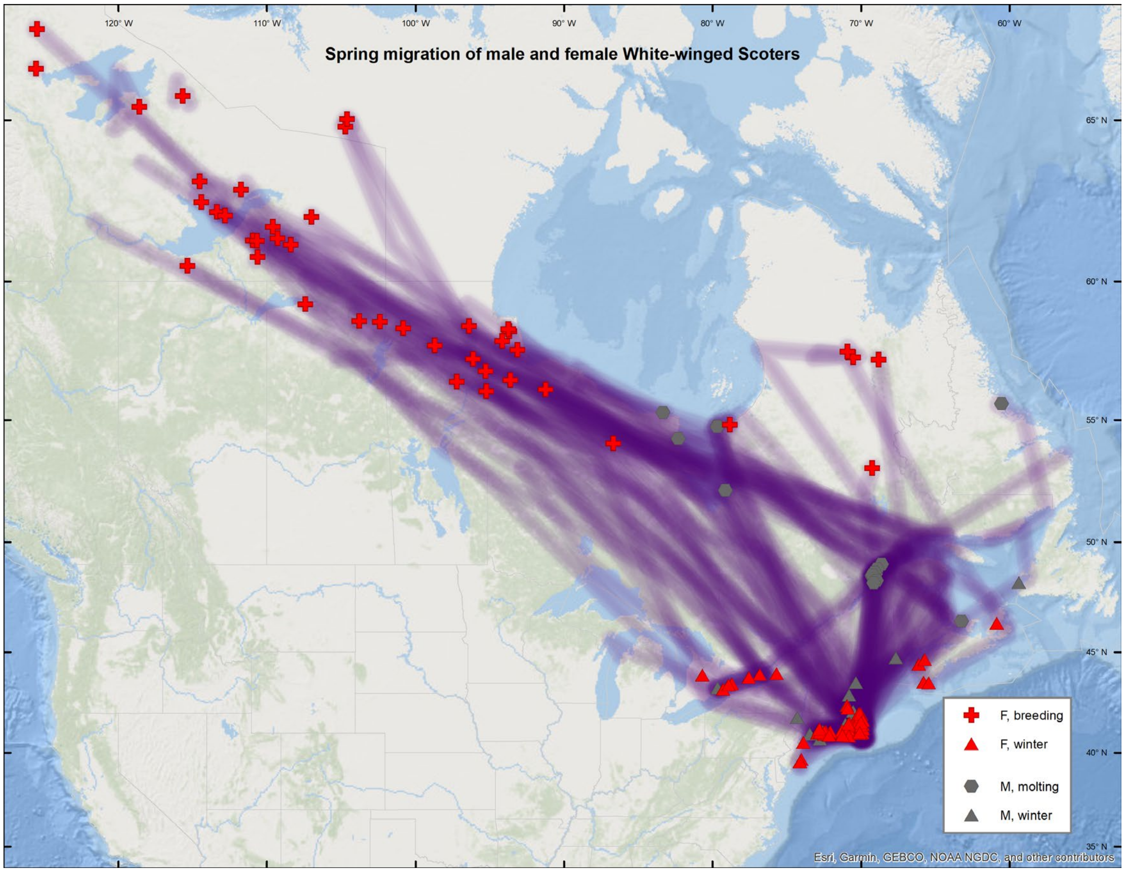

Figure 14. Spring migration routes for 83 adult White-winged Scoters (60 females, 23 males). Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through June 2018.

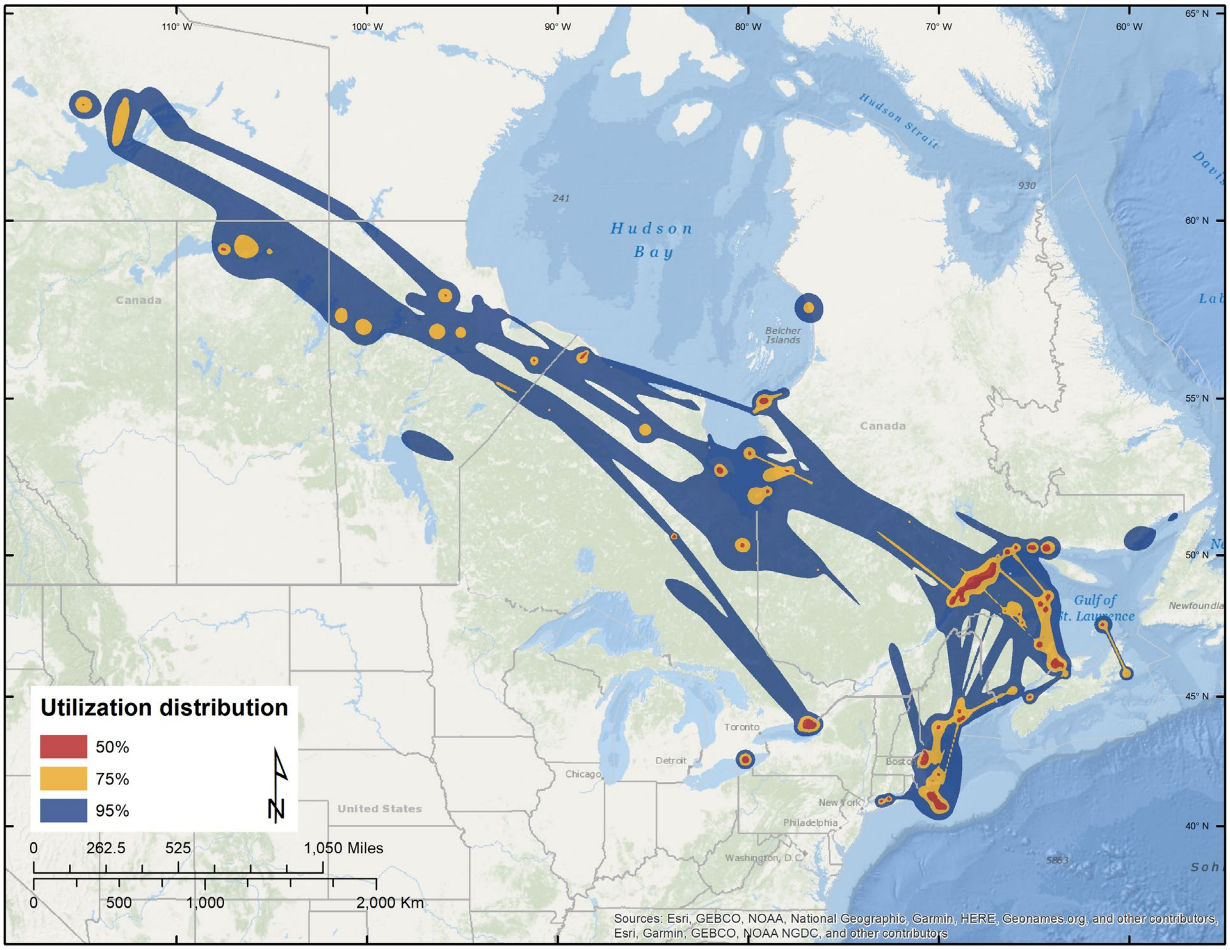

Figure 15. Dynamic Brownian-bridge movement models of spring migration and staging areas for 45 adult White-winged Scoters.

Breeding Areas

A total of 56 (20 males, 36 females) of the 83 (67%) marked White-winged Scoters provided location data during at least one full breeding period, and 43 (52%; 7 males, 36 females) traveled to potential breeding locations. Most White-winged Scoters arrived on their potential breeding areas between late May and early June (29 May-12 June) but one female arrived on her breeding area in northern Manitoba on 25 June. Many of the apparently non-breeding or sub-adult scoters traveled directly to suspected molting and staging areas in the St. Lawrence Estuary, James Bay, and mid-coast Maine, where they remained until fall.

Potential breeding sites for all White-winged Scoters were in the Northwest Territories (Great Bear Lake and Great Slave Lake), Nunavut, northern Saskatchewan and Manitoba, northwestern Ontario (location provided by a male), and Northern Quebec (inland northeast of James Bay and south of Ungava Bay) (Figure 14). These locations formed a line parallel and just to the south of the breeding area identified for Black Scoter and Surf Scoter. For birds with data from more than one breeding season and did not travel to a breeding location during their first breeding season, seven (3 males, 4 females) provided potential breeding locations in the second breeding season, and one (male) in its third breeding season. Ten individuals (3 males, 7 females) provided potential breeding locations for two consecutive breeding seasons.

The females that provided breeding locations for two breeding seasons used the same breeding site, while the three males for which we have multiple breeding seasons changed breeding locations among years, which likely resulted from pairing with a different female. Distances between breeding locations for males ranged from 501– 1,812 km.

Molting Areas

Molting areas of birds tagged in 2015 and 2016 appeared to be directly related to breeding status. Most birds that migrated to suspected breeding areas, and transmitted long enough to record subsequent molting areas, spent the molt period in James Bay. Other birds appeared to molt in Nunavut along the western shore of Hudson Bay, along the southwest shore of Hudson Bay, near the Belcher Islands in southeastern Hudson Bay, and in the St. Lawrence River Estuary. One bird that apparently nested near Great Slave Lake, NWT appeared to migrate only 50 km west to molt on a small inland pond. Non-breeding females primarily molted in the St. Lawrence River Estuary, apart from two birds that molted in James Bay and mid-coast Maine, respectively. Two breeding females transmitted long enough to document consecutive molting sites, and both returned to the same location within James Bay in both years.

Nineteen White-winged Scoters captured in Quebec provided location data for at least one molting period. Important molting areas included southern Hudson Bay (including the Belcher Islands), James Bay, St. Lawrence Estuary, and Prince Edward Island (Figure 17). A few individuals also molted in the Northwest Territories, Saskatchewan, and Manitoba within the breeding range of other marked birds. One male molted on the Labrador coast.

Molting locations between years were highly variable among individual White-winged Scoters. Eight individuals (6 males, 2 females) provided molting locations for three consecutive years. Only three (2 males, 1 female) of these birds selected the same location during all three years. Four individuals (all males) provided four years of molt locations: all molted in at least one different molting location among years and one molted in a different location each year (St. Lawrence Estuary in 2010, Labrador coast in 2011, interior Manitoba in 2012, and Belcher Islands in 2013).

Birds that did not go to breeding areas (likely unpaired adult males and subadults) and staged and molted in the St. Lawrence Estuary, stayed as long as five months in the area (from early June to late October) until they began migrating to wintering areas. Non-breeding birds returned to their previous molting location in 12 out of 15 occasions. Interestingly, a female initially captured molting at Forestville in 2010 did not breed in 2011 and molted at Forestville; in 2012, she moved to a breeding site near Great Slave Lake NWT before returning to molt at Forestville. She resided in the molting area between 9 July and 15 September in 2011, and between 3 September and 22 October in 2012.

Fall Migration

During fall, White-winged Scoters departed molting locations and either flew across land directly to their Great Lakes and Atlantic wintering areas, or congregated on staging locations (i.e., James Bay, St. Lawrence Estuary, Prince Edward Island; Figure 17).

Fall migration routes follow three particular patterns (Figure 17): 1) presumably direct overland flights over interior New York and New England to the Atlantic coast; 2) a coastal route from the St. Lawrence Estuary to the Canadian Maritimes, and south along the U.S. Atlantic coast; and 3) from molting and staging locations to the Great Lakes. In 2015 and 2016, most birds (n=12) that molted in James Bay undertook a direct overland flight to southern New England, except one individual that flew along a coastal route through the St. Lawrence River Estuary and Canadian Maritimes. Birds that molted in the St. Lawrence River Estuary (n=13) either took a direct overland route to southern New England, a coastal route to Nova Scotia, or an overland route to Lake Ontario.

For birds captured in 2015 and 2016 in Cape Cod Bay and the St. Lawrence Estuary for which a full fall migration was documented (n=28), total migration duration was 6 ± 3 (2 – 79) days. Most scoters migrated directly to their wintering areas without using stopover locations.

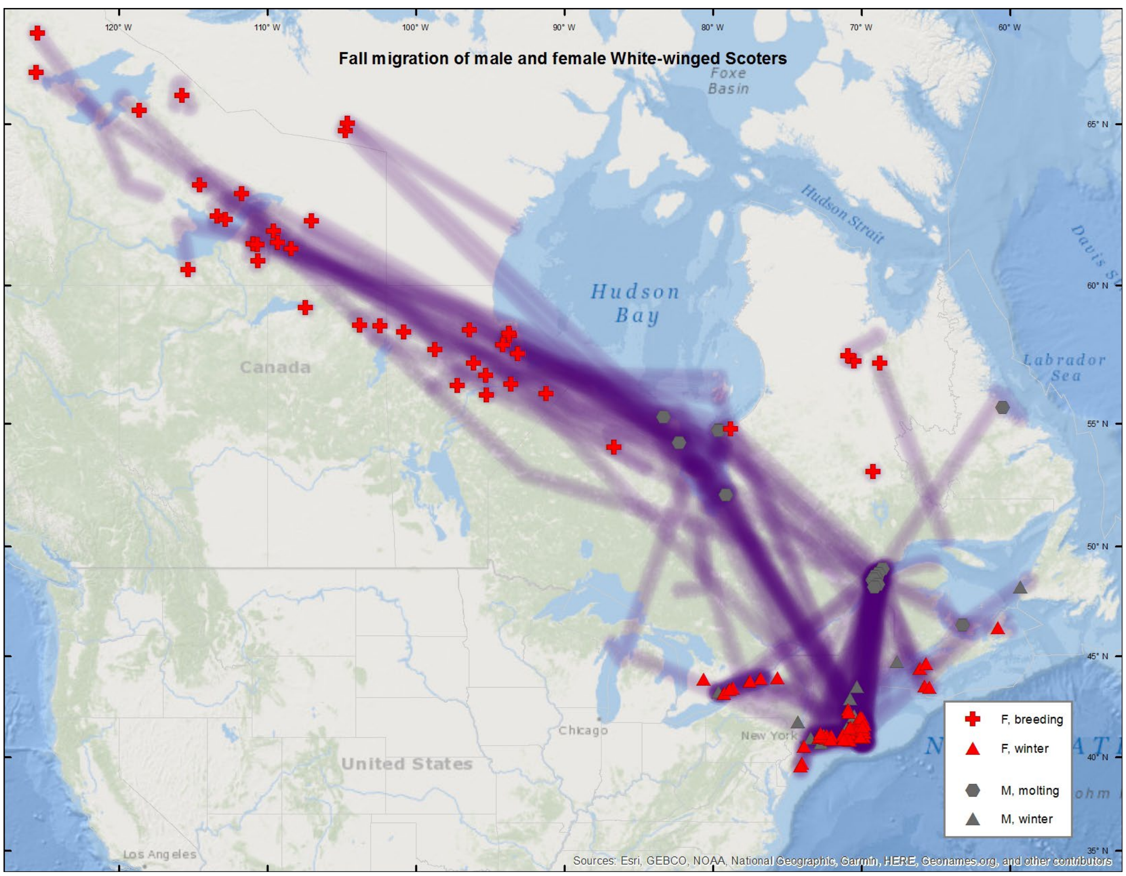

Figure 16. Fall migration routes for 83 White-winged Scoters (60 females, 23 males) from breeding/molting areas to wintering areas. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through June 2018.

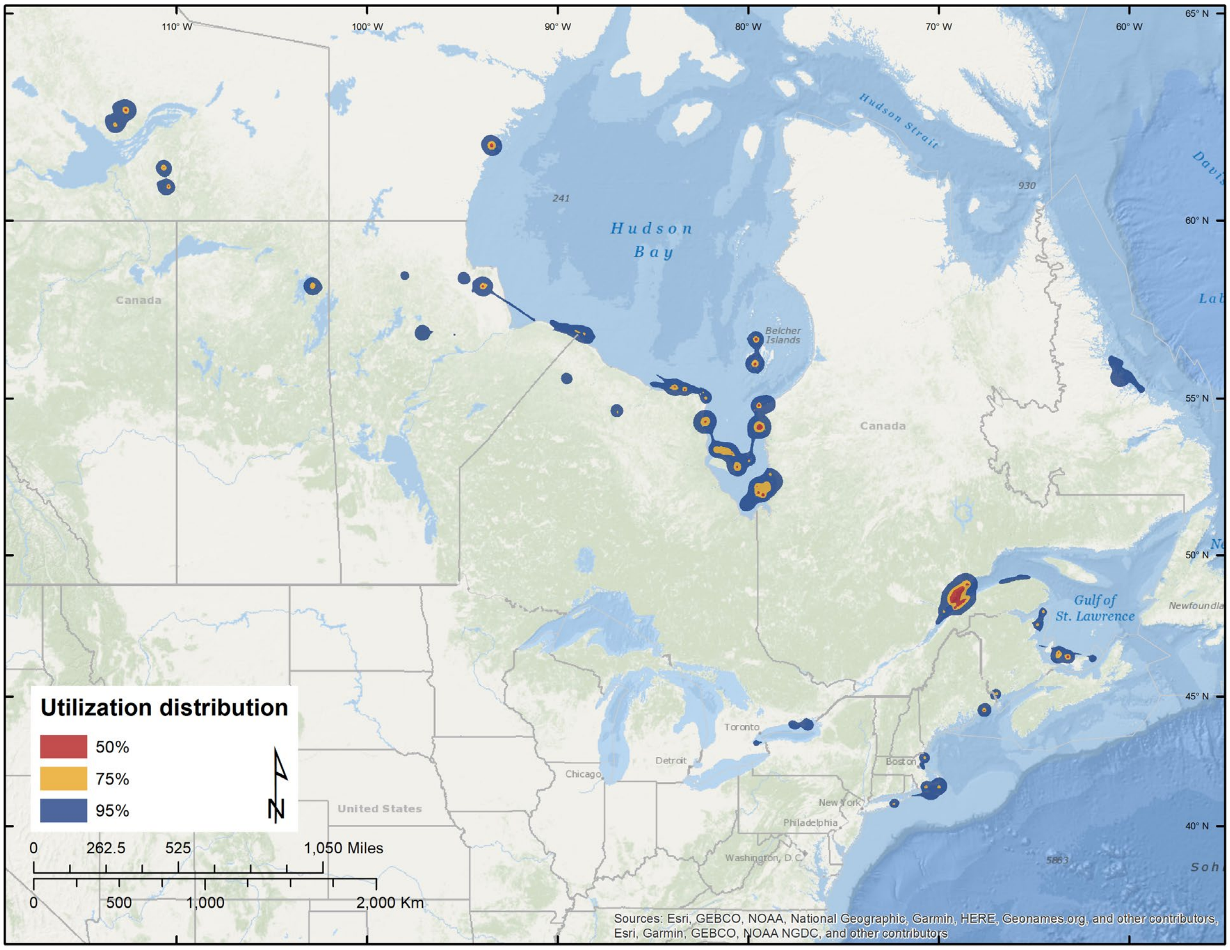

Figure 17. Dynamic Brownian-bridge movement models of fall migration and staging areas for 62 adult White-winged Scoters.

Wintering Areas

White-winged Scoters generally reached their wintering areas from mid-October through November. Birds spent 3-6 months on wintering sites, mostly from early November to late March. One adult male even spent seven months in the Nantucket area, from Oct 10 to May 17, 2011.

A total of 66 marked White-winged Scoters (18 males, 48 females) provided locations through at least one complete wintering season. Wintering areas used by marked scoters included Newfoundland (St. George's Bay near Stephenville), Nova Scotia (St. Marys Bay, Lyons Ledges and Cape Breton), Maine, Massachusetts (Boston, Cape Cod, Martha's Vineyard, and Nantucket), Rhode Island (Narragansett Bay), New York (Long Island), Lake Michigan, and Lake Ontario (Figure 15). Most White-winged Scoters wintered between Massachusetts and Long Island, New York. All female scoters captured near Cape Cod or Long Island in 2015 and 2016 generally remained in southern New England throughout the winter, except one bird that migrated west to Lake Ontario approximately three weeks after deployment. In contrast, birds captured during the molting period in the St. Lawrence River Estuary wintered throughout a broader geographic range. Fifteen of 24 (62%) scoters captured in Quebec that survived through fall migration wintered throughout southern New England to south of Long Island, NY, with one bird later relocating to Lake Ontario for the remainder of the winter. Three scoters wintered along the coast of Nova Scotia, four individuals spent most of the winter on Lake Ontario, and one wintered along the mid-coast of Maine. Mean total length of stay in the wintering areas was 189 ± 6 (110-225) days.

A few birds changed locations during winter; for example, three White-winged Scoters started wintering near Nantucket Island (November to January) then moved to Long Island (Feb to mid-March) before returning to Nantucket later in the spring (mid-March to mid-May). One female moved 250 km from Newburyport, MA (December and January) to Belfast, ME (February to mid-April). One male moved from Long Island Sound to Lake Ontario (517 km) during the wintering period in two consecutive years. During the winter of 2010-2011, this bird arrived in Massachusetts on 30 October and almost immediately flew to Lake Ontario, being located there on 3 November. It remained on Lake Ontario until 5 January and returned to the Long Island Sound area on 8 January. This bird then flew back to Lake Ontario in the spring, arriving on 16 April. The following winter, this bird again arrived in Massachusetts (31 October) and then flew to Lake Ontario, arriving 3 November. The bird remained on Lake Ontario for two weeks, and then flew to the Long Island Sound area, where it remained for the winter. This bird also wintered in Long Island Sound during its third winter.

Of the birds that did not winter along the New England coast, one male overwintered on Lake Ontario (moving from the northeast side to the southwest side of the lake during winter), one male spent two consecutive winters in the St. George's Bay near Stephenville, on the west coast of Newfoundland, and three females wintered in Nova Scotia (two at the southern end and one by Cape Breton; Figure 18).

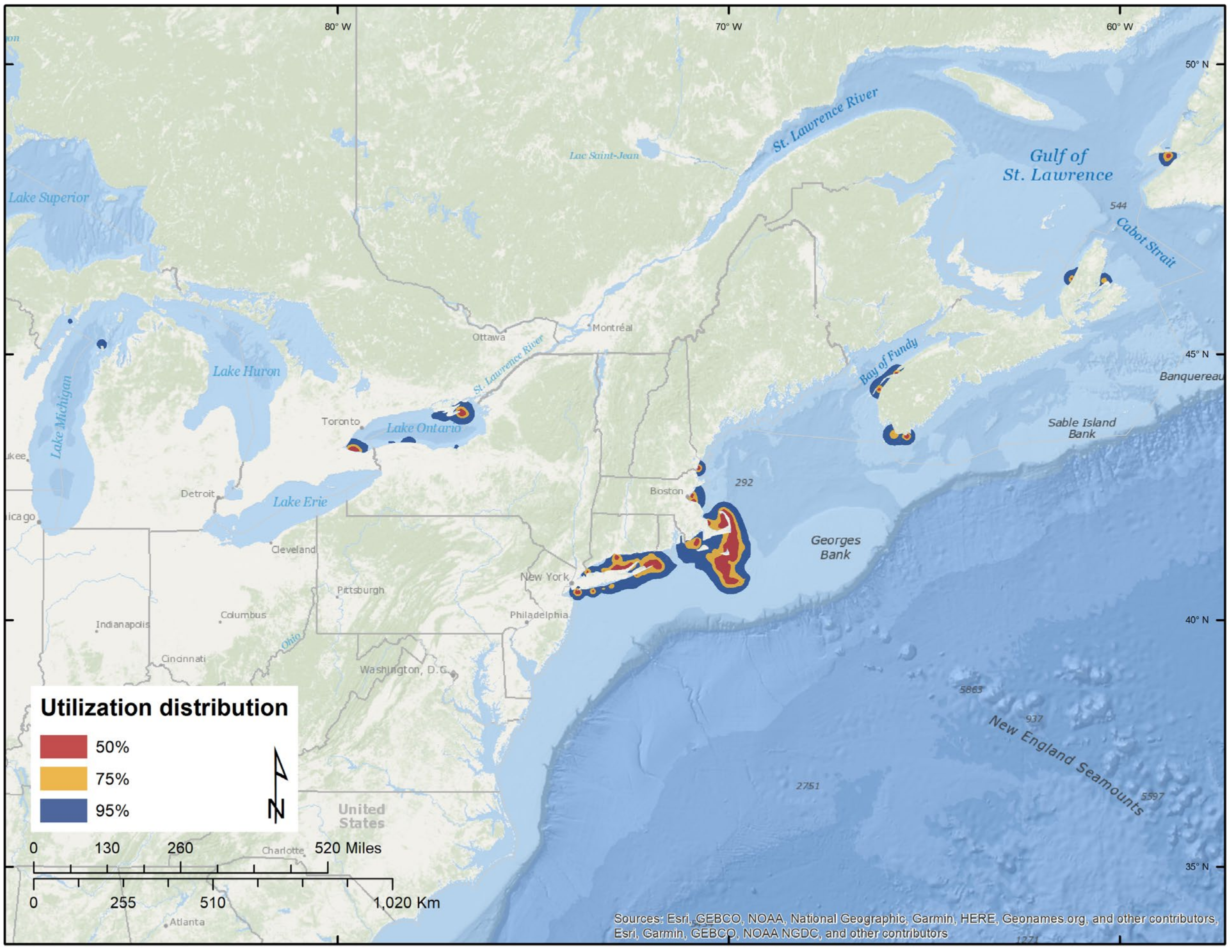

Figure 18. Dynamic Brownian-bridge movement models of wintering areas for 66 adult White-winged Scoters.

Most White-winged Scoters tagged in 2010 and 2012 exhibited high site fidelity to wintering areas. For the 18 birds for which we have either two or three full wintering seasons, twelve (67%) showed strong wintering site fidelity (< 50 km). Three birds switched between the Nantucket area and the Long Island area (198 km) between winters. Eleven of the 18 scoters provided location data for three complete winters. All but four scoters occupied the same wintering locations for three consecutive winters. Two females wintered in Long Island Sound during winters 1 and 2, and in the Nantucket area in the third winter (198 km). A male wintered in the Boston area during winter 1, and then switched to the Nantucket area for the two next winters (150 km). A female caught in early December in Massachusetts in 2010 spent the two following winters (2011-12 and 2012-13) in Nova Scotia.

Six females tagged in Cape Cod Bay in 2015 continued to provide data into the following winter. Females that returned exhibited a relatively high degree of site fidelity to the broad wintering area, but varying levels of fidelity to individual home ranges from the previous year. More than half the birds tagged in southern New England occupied two or more disjoint core-use home range areas throughout a single winter. Several of these individuals occupied core-use areas in both Cape Cod and Long Island within a single winter, with up to 404 km between key areas. The mean distance between first- and second-year core-use areas across individuals was 106 ± 15 km, with a maximum distance of 188 km.

Other Observations

Sixty percent of inferences about White-winged Scoters presented here come from birds captured at the St. Lawrence Estuary molting site and may not be representative of the Eastern population as a whole. The mean abundance index for White-winged Scoters from the Atlantic Coast Wintering Sea Duck Survey from 2009-2011 was 58,595 birds (SE = 11,069; Silverman et al. 2012). At least 10,000 White-winged Scoters are reported to overwinter on the Lower Great Lakes (Petrie et al. 2006; L. Savoy, personal communication). An estimated 5,000 White-winged Scoters used the molt sites at Forestville (Lepage and Savard 2013). Hence, this site may represent approximately 15% of after-hatch-year males that winter in the eastern USA and Great Lakes. We do not expect there to be strong segregation at molt sites for sea ducks, but instead, a mixture of birds from different breeding and wintering areas. In addition, an unexpected finding from this study was that all three species of scoters showed relatively high levels of inter-annual movements among molting areas. Hence, it is reasonable to expect that the results from the St. Lawrence Estuary molt-marked birds may provide a reasonable representation of the distribution and patterns of movement for male white-winged scoters from the eastern North American range.

Implications for Management and Conservation:

1. Telemetry data suggest that a large portion of the eastern wintering population of White-winged Scoters is associated with breeding areas in northern Quebec, northern Saskatchewan, northern Manitoba, and the Northwest Territories. Many of these areas are not surveyed by the Waterfowl Breeding Population and Habitat Survey, and for those that are surveyed, the timing of the survey is not adequate for late breeding sea duck species. We encourage on-going development of experimental breeding scoter surveys of the area as a potential means for providing a population index.
2. Data suggest that birds molting at a given molting location originate from several wintering and breeding populations and have different migration patterns.
3. White-winged Scoters exhibit strong site fidelity to wintering and staging areas, although fidelity to molting areas seems variable.
4. We gathered important data on the location and the time spent at each different period (e.g., spring migration, staging areas, molting, wintering). This information will help to:
    a. Interpret and plan surveys during these periods (e.g., survey of wintering sea ducks along the Atlantic coast); and,
    b. Assess the importance of each site and provide justification for protective measures if warranted, particularly considering that some individuals (unpaired males, unsuccessful breeding females, and likely subadults) spend from 4 to 6 months at their molting and fall staging areas (e.g., St. Lawrence Estuary), and that most birds spend from 4 to up to 7 months on wintering locations (e.g., Boston area, Cape Cod—Nantucket Island—Martha's Vineyard area, Long Island area and Lake Ontario).

Recommendations for Future Work on White-winged Scoters:

1. Explore emerging tracking technologies (e.g., GSM-GPS with accelerometry) to continue fine-scale habitat use assessments and time-energy budgets to determine pre- and post-construction impacts of offshore wind energy development.

Long-tailed Ducks

Capture Sites: Lake Ontario, ON; Cape Cod and Nantucket, MA; Chesapeake Bay, MD & VA; Lake Michigan, MI & WI

According to sea duck survey data reported by Silverman et al. 2012, the Cape Cod/Nantucket and Chesapeake Bay areas are the most important wintering areas for Long-tailed Ducks along the Atlantic Coast, therefore, these areas were chosen as capture areas. Long-tailed Ducks also overwinter on the Great Lakes, primarily on Lake Ontario, where numbers of have increased in recent years (Petrie and Schummer 2002), and Lake Michigan, where there has been a sizeable wintering population since the 1950's (Peterson and Ellarson 1977). Long-tailed Ducks were marked with satellite transmitters at all locations as part of an effort to mark a geographically representative sample of birds wintering in eastern North America; however, Lake Michigan was not added until a later date and had a reduced sample size.

Long-tailed Ducks were captured at Lake Ontario during winters 2010-2011, 2011-2012, and 2012-2013 using overwater mist-nets and a modified lift-net technique (Ware et al. 2013). Capture and marking was a collaborative effort coordinated by the CWS – Ontario, Long Point Waterfowl, and the University of Western Ontario. Part of this effort was focused on an M.Sc. project (Phil Wilson) aimed at describing habitat selection of Long-tailed Ducks overwintering on Lake Ontario, how habitat selection may be influenced by certain environmental factors, and how habitat use patterns relate to proposed offshore wind turbine development.

Long-tailed Ducks were captured by night-lighting at Nantucket, MA in 2007-09, Cape Cod, MA in 2010, and Chesapeake Bay, MD/VA in 2010-12.

Long-tailed Ducks were captured on Lake Michigan as part of a feasibility study in spring 2015 and followed by capture work and radio-marking during winters 2015-2016, 2016-2017, and 2017-2018. Capture and marking were a collaborative effort coordinated by the U.S. Geological Survey Upper Midwest Environmental Sciences Center and was associated with an M.Sc. project by Luke Fara (Fara 2018). Both over-water mist netting and night-lighting capture techniques were used and successful, but night-lighting was far more effective in the deep-water environments that Long-tailed Ducks used on Lake Michigan.

Lead Investigators: **U.S. Atlantic coast**: Alicia Berlin, Ronald Therrien, and Matthew Perry (USGS Patuxent Wildlife Research Center); **Lake Ontario**: Shannon Badzinski (CWS Ontario), Scott Petrie (Long Point Waterfowl), and Phil Wilson (University of Western Ontario); **Lake Michigan**: Luke Fara (Southern Illinois University - Carbondale and USGS Upper Midwest Environmental Sciences Center) and Kevin Kenow (USGS Upper Midwest Environmental Sciences Center).

Other Partners: **U.S. Atlantic coast:** Maryland Department of Natural Resources, Virginia Department of Game and Fish, USFWS, Ducks Unlimited, Massachusetts Audubon Society. **Lake Ontario**: Toronto Zoo, USGS Patuxent Wildlife Research Center, USFWS, Natural Sciences and Engineering Research Council of Canada, Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, Wildlife Habitat Canada, TD Friends of the Environment Foundation, Ducks Unlimited Inc. **Lake Michigan**: Avian Specialty Veterinary Services, Wisconsin Department of Natural Resources, Michigan Department of Natural Resources, Southern Illinois University Cooperative Wildlife Research Laboratory and Zoology Department, U.S. Fish and Wildlife Service Migratory Birds, Wisconsin Division of the Izaak Walton League of America, Delta Waterfowl, Wisconsin Waterfowl Association, and numerous volunteers.

Results and Discussion: Mortality of Long-tailed Ducks post-release has been moderate to high at all sites, thereby reducing overall effective sample size. About 45% of birds either died or stopped transmitting data within the first 60 days after implantation and release (Table 6, Figure 19).

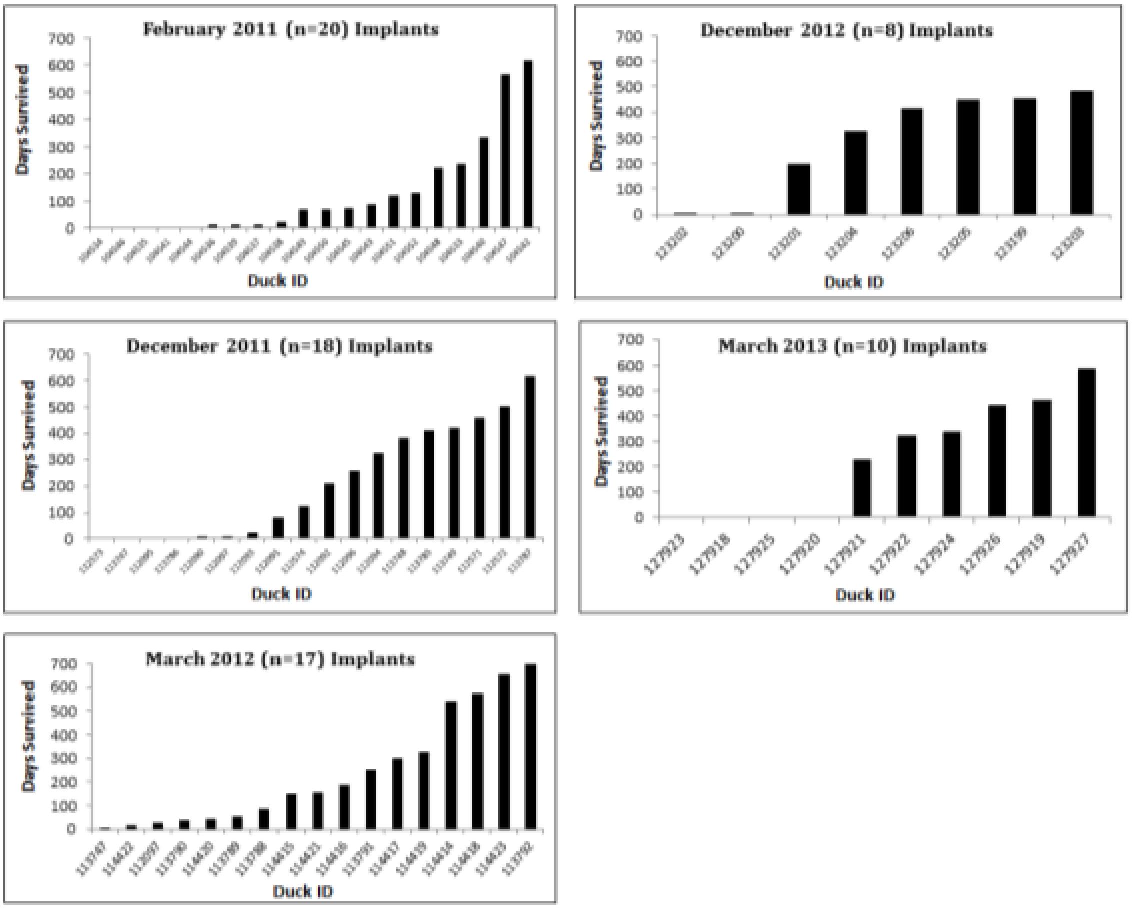

Figure 19. Number of days that Long-tailed Ducks captured at Lake Ontario survived/transmitted data after being implanted with satellite transmitters.

Currently it is not clear why Long-tailed Duck post-release survival is low, but it may be related to a combination of factors including predation by gulls or other aerial predators soon after release, weather- or temperature-related stresses, loss of waterproofing and subsequent hypothermia due to handling stress, diminished body condition during late winter, behavioral effects on diving/feeding activity or other size/weight-related issues related to the transmitters, and hunting. At Lake Ontario, three Long-tailed Ducks (1 female, 2 males) were harvested in December 2011 within two weeks following post-surgery release. Two of these (1 female, 1 male) were shot on different dates while flying in a flock of conspecifics. Another male was harvested after flying solo into a flock of hunting decoys. During winter 2012-2013, a male was harvested on the U.S. side of the Niagara River after having not transmitted in 279 days. Similarly, two female Long-tailed Ducks were harvested during winter 2013-2014 (one by a hunter in Trenton, Ontario and the second hunter from northern Alabama) that had gone offline prematurely and not transmitted data for 305 and 261 days, respectively. Both hunters reported that implanted transmitters in harvested Long-tailed Ducks appeared to be exiting out of the back. It is possible that ducks are going offline because transmitters are being ejected through the dorsal region where the trocar punch was created to allow passage for the antenna. This has been documented in other waterfowl species (Mulcahy et al. 1999 and Perry et al. 2008).

The following results are based on two assumptions: 1) that the ducks are not impacted by the transmitters and 2) that despite a small sample size the information provided on their migratory pathways are representative of the population. These results show that ducks exhibited similar pathways each year, suggesting that any transmitter/surgery effects may be minimal once birds have survived the immediate post-surgical period.

Spring Migration

Most Long-tailed Ducks tracked from Cape Cod/Nantucket area departed in early to mid-April (3-12 April) and passed through the Northumberland Strait and either stopped over in the St. Lawrence Estuary or Chaleur Bay before departing to breeding/molting areas (Figure 20, Figure 21, Figure 22). One female stayed in the Gulf of Maine before migrating to its breeding site. All males and females, with three exceptions, migrated across Quebec to the Hudson Bay area, and onto the breeding/molting grounds. The remaining three birds traveled directly north to the breeding/molting areas in northern Quebec. Minor stops of only a few hours were made at various sites as they passed overland across Quebec. With one exception, tagged ducks that were released in Chesapeake Bay departed the area from early to mid-April and migrated to Lake Erie where they stopped before moving on to suspected breeding/molting areas. One of the females used an alternate route; it staged just outside Pittsfield, New York and then moved to Lake Erie before traveling north to its potential breeding site.

Median departure dates for Long-tailed Ducks from Lake Ontario were relatively similar among the 3 years of study (Table 2) and tended to occur in late April and late May. During spring 2013 the average distance traveled was 5,410 km over 36 days with daily distances averaging 130 km/day (maximum = 1,429 km). Spring staging areas (Figure 17) below the 50˚ parallel were at the mouth of the St. Clair River, Point Clark, North Point Shore, Lake Huron; Lake Simcoe; and Manitoulin Island, Georgian Bay. North of the 50˚ parallel, spring staging areas were in the vicinity of Akimiski Island, the Belcher Islands, Cape Henrietta Maria; Nunalla and Cape Churchill, Manitoba; Arviat, Tavani, Whale Cove, and Chesterfield Inlet, Nunavut.

Table 2. Spring departure dates (median, earliest, latest) by Long-tailed Ducks wintering at Lake Ontario and breeding/molting location arrival dates (median, earliest, latest); 2011 (n=7; 1 female, 6 males); 2012 (n=19; 17 females, 2 males); 2013 (n=12; 11 females, 1 male).

	Departure			Arrival		
Year	**Median**	**Earliest**	**Latest**	**Median**	**Earliest**	**Latest**
2011	15 May	16 April	1 June	22 June	4 June	15 July
2012	18 May	16 April	24 May	18 June	1 June	24 July
2013	19 May	9 April	5 June	16 June	11 June	30 June

Figure 20. Spring staging areas used by adult Long-tailed Ducks (n = 29 females, 8 males) marked at Lake Ontario.

On Lake Michigan, eight Long-tailed Ducks provided some information on spring migration routes. Two of those birds had intermittent and/or poor locations during spring migration, but all birds appeared to depart Lake Michigan or Green Bay in May. Most Long-tailed Ducks departed in mid-May with departure occurring between 11-21 May for five of eight tagged birds. One Long-tailed Duck departed between 1-10 May and two others had poor transmissions making departure difficult to assess. Lake Michigan Long-tailed Ducks generally traveled north from Lake Michigan or Green Bay using James Bay and Hudson Bay as short migratory stopover sites. One bird used Lake Superior for a short time, and another made many stops through Nunavut, Canada and one short visit to the Northwest Territories. Only one Long-tailed Duck, a male, staged for great than seven days, using an area just south of Coats Island in Hudson Bay for most of that time.

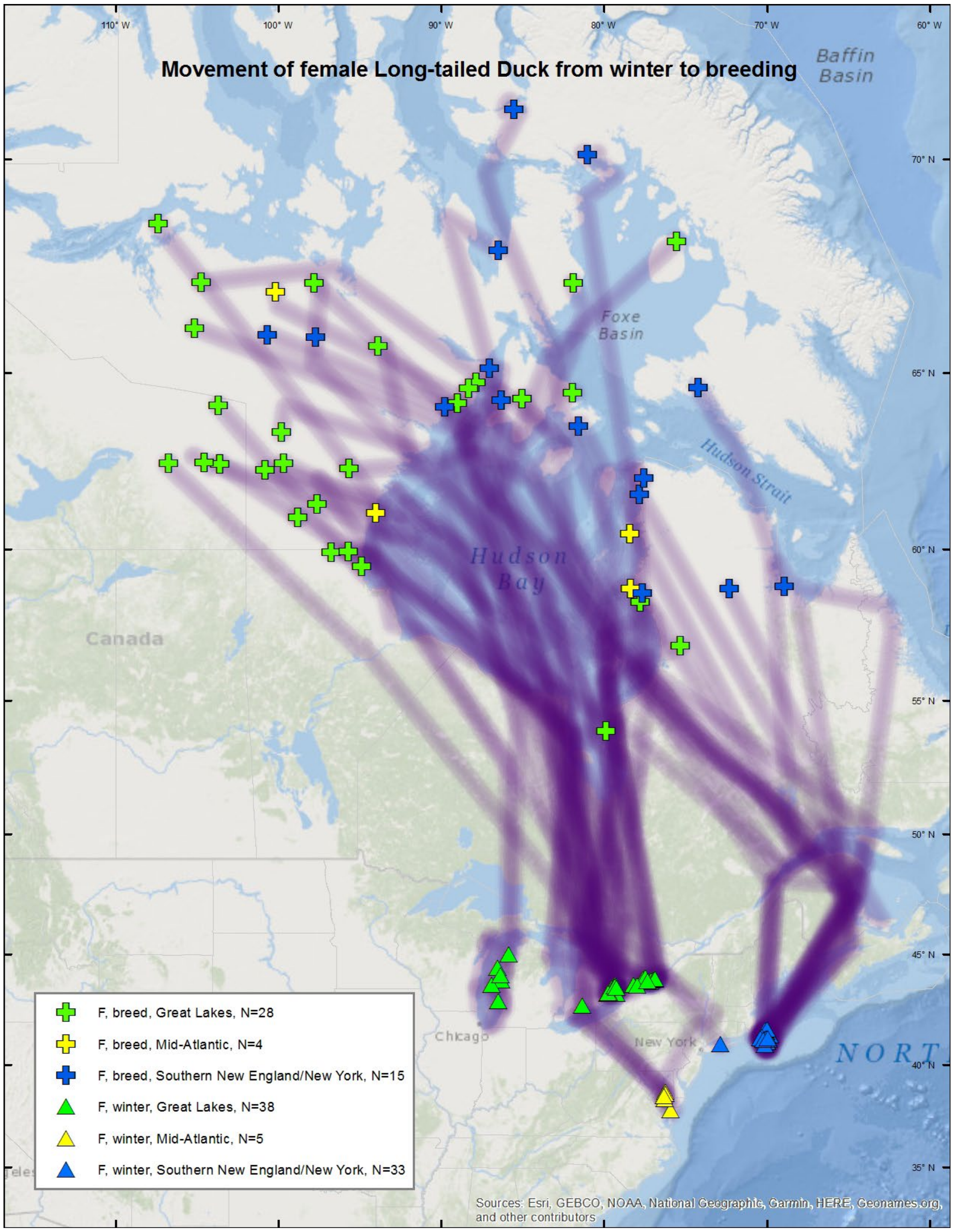

Figure 21. Spring migration routes for adult female Long-tailed Ducks marked during winter along the Atlantic coast and Great Lakes. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 22 August 2018.

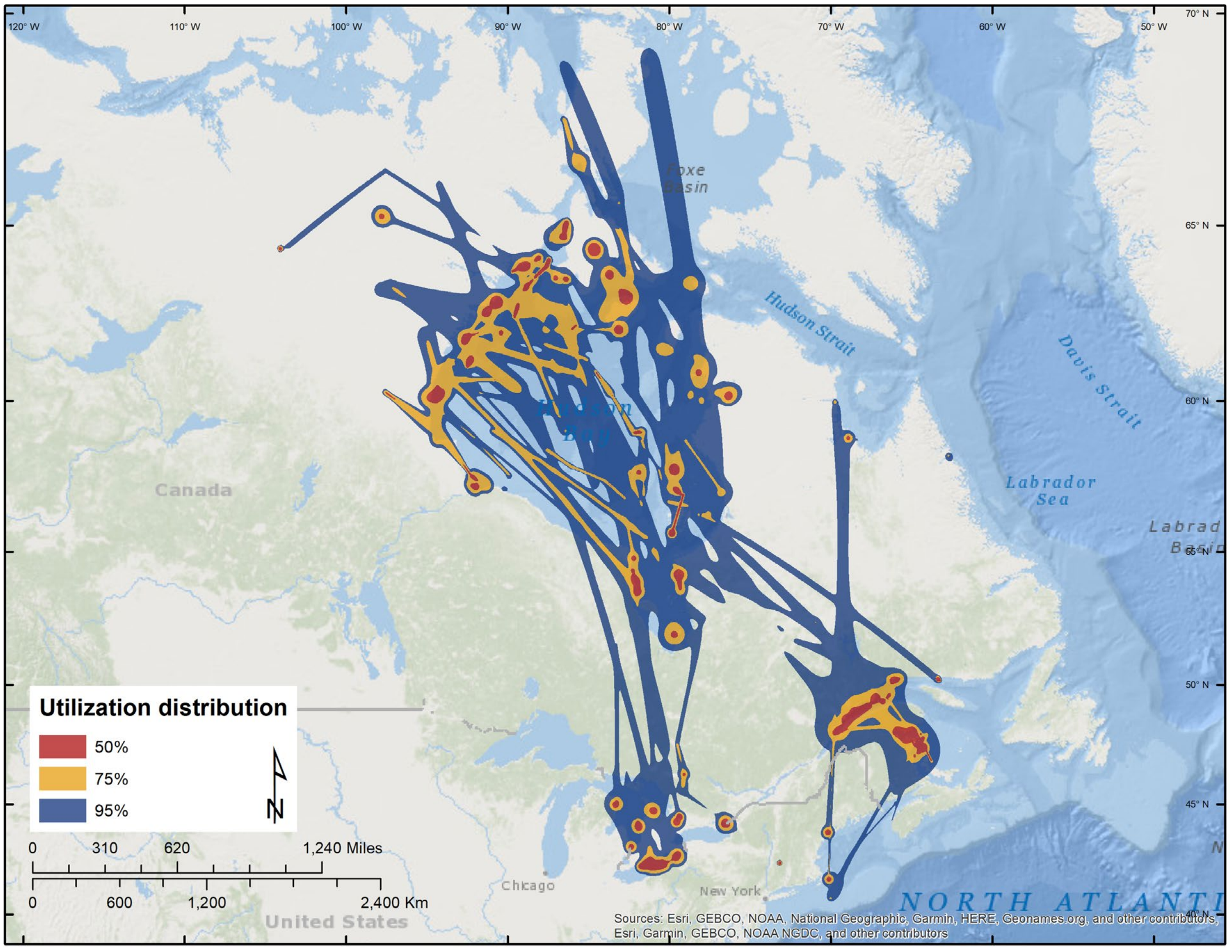

Figure 22. Dynamic Brownian-bridge movement models of spring migration and staging areas for 60 adult Long-tailed Ducks.

Breeding Areas

We tracked 42 females to potential breeding sites. The pattern of settlement suggests that the western boundary of the breeding range of eastern Long-tailed Ducks occurs around Bathurst Inlet, NU, with breeding sites spread across tundra regions of northeastern Manitoba, Nunavut, and northern Quebec (Figure 18). Satellite locations and digital land cover mapping suggests that breeding female Long-tailed Ducks select wet sedge meadows, hummock and tussock graminoid tundra, low shrub tundra and shrub thickets surrounded by a mosaic of exposed peatlands and wetlands.

Probable breeding locations for female Long-tailed Ducks marked on Lake Ontario were widely scattered throughout Manitoba, Nunavut, eastern Northwest Territories, and the Ungava Peninsula in Quebec. It is not clear whether there is segregation among Long-tailed Ducks that were marked during winter along the Atlantic coast or on the Great Lakes once they settled at northern breeding areas. There may be a tendency for Long-tailed Ducks that winter on, or migrate during spring through, the Great Lakes to breed a bit further west than Long-tailed Ducks marked along more northerly wintering areas of the Atlantic coast (Figure 22). However, sample sizes are small and additional marking would provide additional insight.

Two female Long-tailed Ducks from Lake Michigan provided information on potential breeding areas. One female appeared to breed ~60 km south southwest of Karrak Lake, Nunavut, Canada, while the other used an area ~175 km north northwest of Baker Lake, Nunavut, Canada. This pattern is similar to those shown by other radiomarked long-tailed ducks from Lake Ontario and the Atlantic Coast. Breeding site fidelity was not assessed, as no transmitters lasted longer than one year.

Molting Areas

Long-tailed Ducks appear to exhibit site fidelity to molting areas, although the sample size of birds tracked for more than one year is small (n = 5). Satellite telemetry data suggest there may be an important molting area for male Long-tailed Ducks in the vicinity of the Adelaide Peninsula and King William Island in Nunavut (Figure 19). Fewer numbers of males were presumed to have molted at other locales including Prince of Wales Island - Nunavut, northwestern and southwestern Baffin Island Foxe Basin near north end of Southampton Island, and the Puvirnituq region in Quebec. There seems to be no apparent difference in pattern of use of molting areas between birds marked at Lake Ontario, Lake Michigan, or the Atlantic coast.

Three males from Lake Michigan provided information on potential molting areas. One male used an area ~110 km northeast of Karrak Lake, Nunavut, Canada; one used an area ~50 km west of the mouth of the Back River, Nunavut, Canada; while the last one used an area ~100 km southwest of Arviat, Nunavut, Canada but was very mobile after being in this location during June. Molting site fidelity was not assessed, as no transmitters lasted longer than one year.

Fall Migration

Departure of Long-tailed Ducks from breeding and/or molting areas occurred in September and October when many birds moved to Hudson Bay, particularly the vicinity of the Belcher Islands (Figure 23, Figure 24, Figure 25), where they staged from 10 days to 2 months before continuing their migration. Long-tailed Ducks showed high site fidelity to their wintering areas with birds returning to the wintering areas where they were initially marked. For example, birds marked in Lake Ontario returned to winter there and those marked at Chesapeake Bay returned to Chesapeake Bay. Most of the Cape Cod/Nantucket ducks flew directly back to the wintering area from the Belcher Islands, arriving in November. One exception was a female that migrated from the Belcher Islands to Lake Ontario and then returned to Cape Cod/Nantucket wintering area. A few ducks stopped over in the St. Lawrence Estuary before returning to the Nantucket area. All Lake Ontario-marked Long-tailed Ducks returned to winter at Lake Ontario, but one male did move to Short Beach Island east of Brooklyn, NY. This male stayed for 64 days (10 Jan – 14 Mar) before departing and returning to Lake Ontario to complete wintering prior to spring migration.

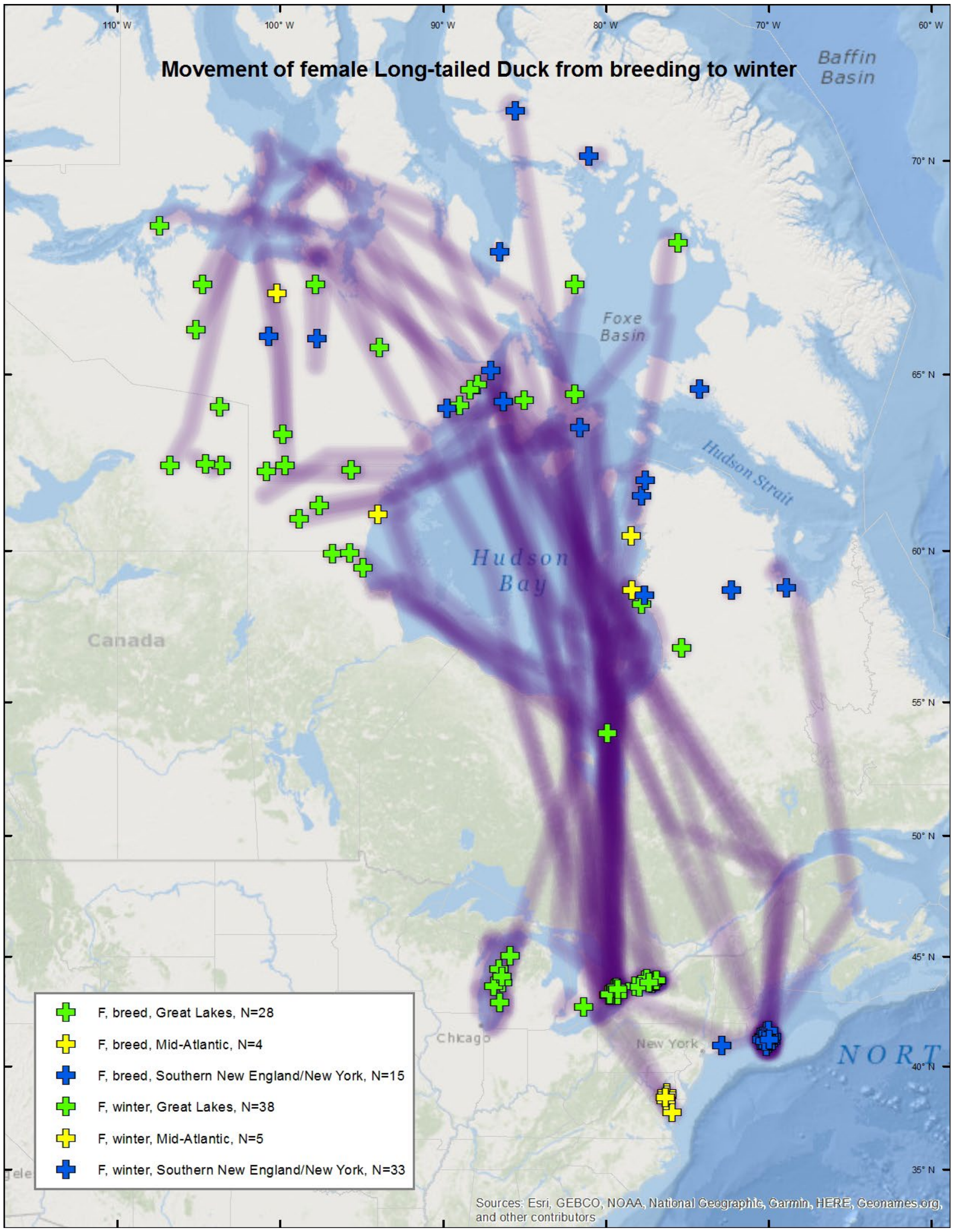

Figure 23. Fall migration routes for female Long-tailed Ducks marked during winter along the Atlantic coast and Great Lakes. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 22 August 2018.

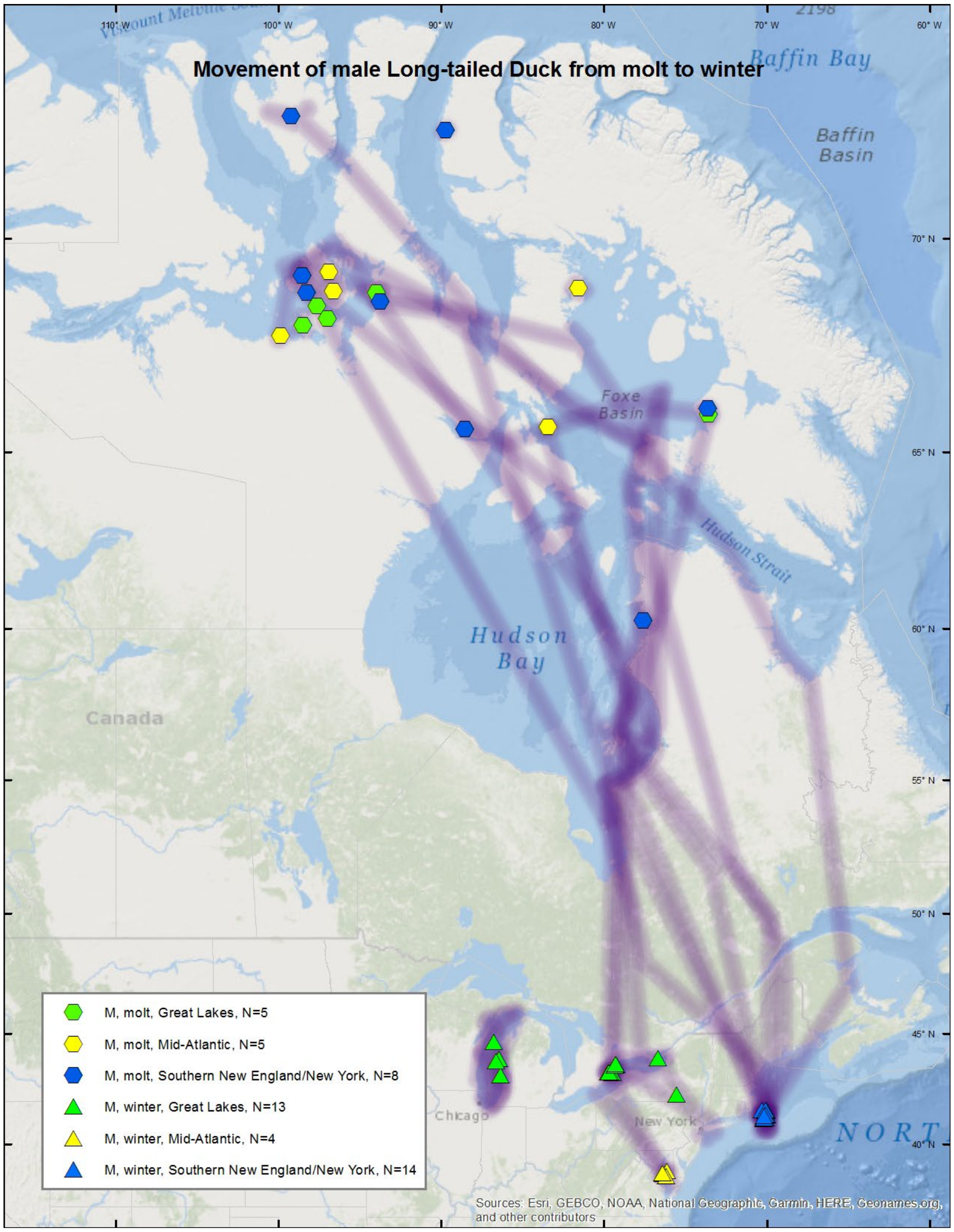

Figure 24. Fall migration routes for adult male Long-tailed Ducks marked during winter along the Atlantic coast and Great Lakes. Symbols reflect unique animal locations that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 22 August 2018.

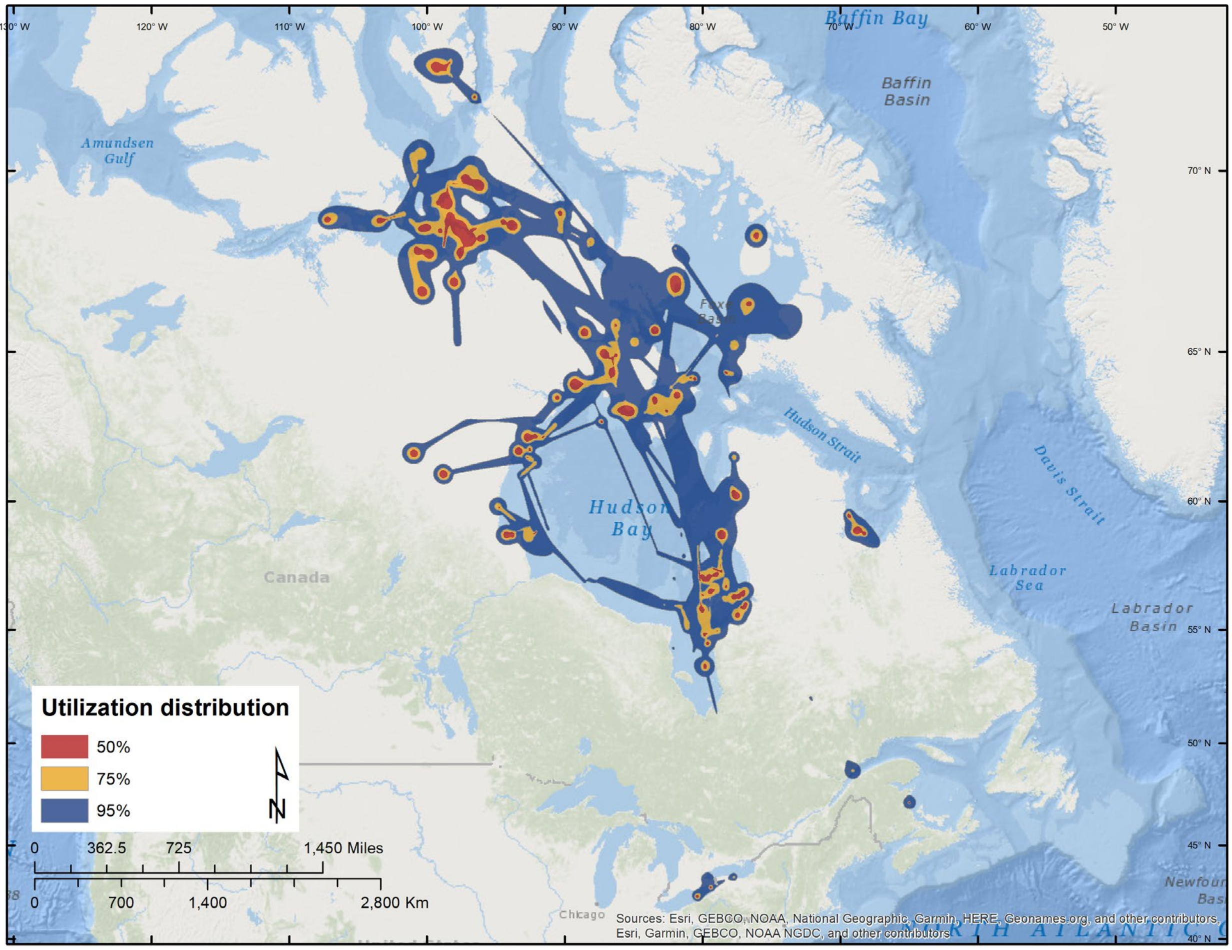

Figure 25. Dynamic Brownian-bridge movement models of fall migration and staging areas for 37 adult Long-tailed Ducks.

Three Long-tailed Ducks from Lake Michigan (one female and two males) provided fall migration information. All three birds moved frequently during fall migration. The following staging sites were identified by location data from these three individuals: James Ross Strait; East of Collinson Peninsula; Wager Bay; Schwatka and La Trobe Bay of King William Island; Pelley Bay, Nunavut; and James Bay near North Twin Island, Nunavut.

Wintering Areas

Both male and female Long-tailed Ducks exhibited site fidelity to wintering areas (Figure 26). One bird initially marked in Lake Ontario migrated to New York in the fall where it stayed for two months before returning to its wintering site on Lake Ontario. Three Long-tailed Ducks from Lake Michigan provided data for a second wintering period and all three returned to Lake Michigan, showing high site fidelity to wintering areas.

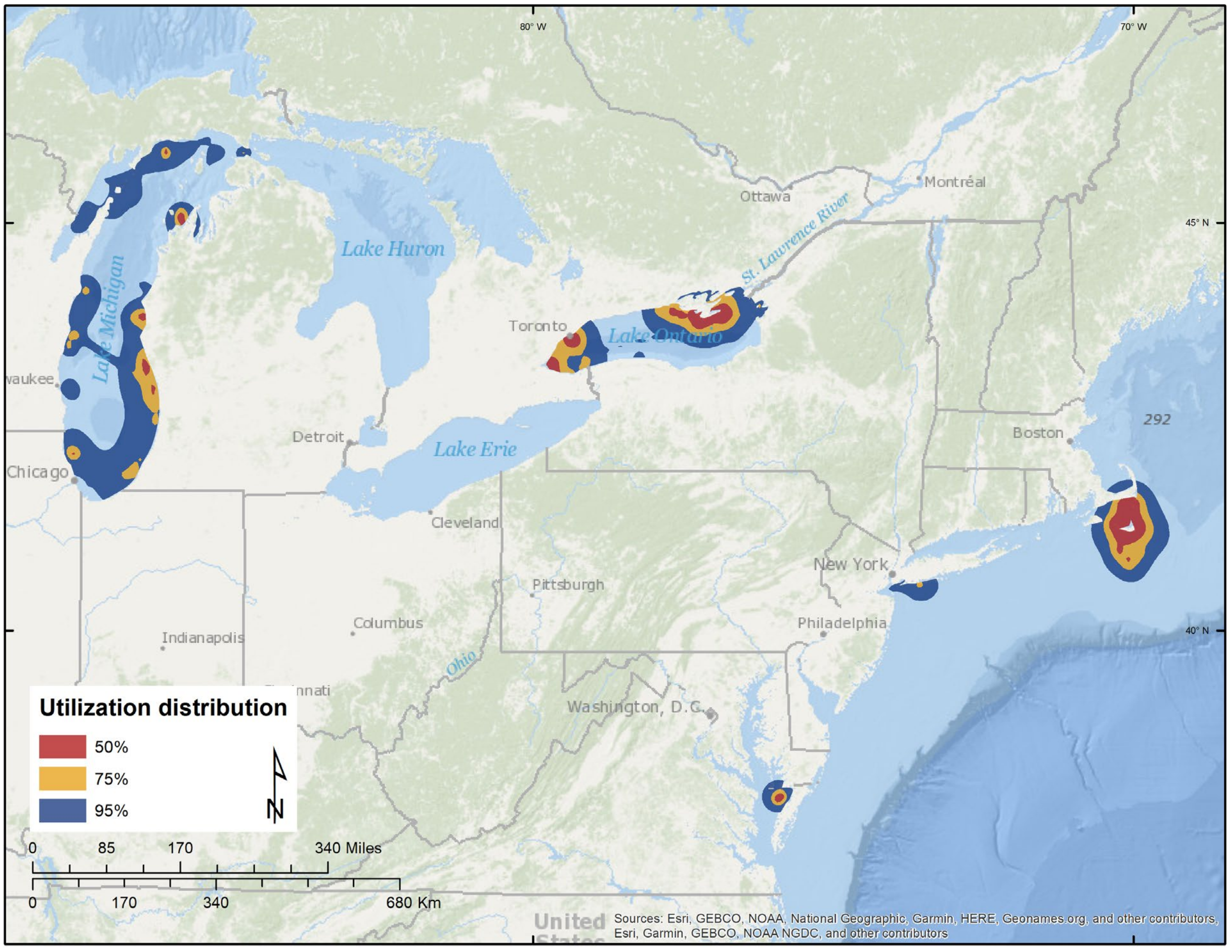

Figure 26. Dynamic Brownian-bridge movement models of wintering areas for 49 adult Long-tailed Ducks.

Implications for Management and Conservation*:*

1. Potential for offshore wind power development in the Great Lakes could impact distribution of Long-tailed Ducks at critical stopover areas and major wintering areas.
2. Changes in salinity gradients in marine areas near the Belcher Islands (related to hydro power development in Quebec) may influence benthic communities and could impact habitat quality and use by Long-tailed Ducks (and other sea ducks) that molt there (Heath et al. 2011).
3. As with other species, key staging areas including Northumberland Strait, Chaleur Bay, Belcher Islands, and St. Lawrence Estuary may warrant special management or protection.
4. Emerging evidence of structuring among wintering populations of Long-tailed Ducks, one wintering primarily off the coast of Nantucket, MA, another wintering in Chesapeake Bay, MD, another wintering on Lake Michigan, and the most recent wintering at Lake Ontario.
5. While the overall strategy for delineating Long-tailed Duck populations in eastern North America was based on capturing and marking birds throughout wintering areas, we were limited to capture sites in Ontario, Lake Michigan, and sites in the Atlantic US. However, a small proportion of the overall Atlantic wintering population winters in northeastern Canada (e.g., Hudson Bay, Hudson

Strait, Frobisher Bay), southeastern Canada (e.g., Gulf of St. Lawrence in Quebec, coastal Newfoundland, and Maritime Provinces) and possibly in Greenland, Iceland, and the British Isles, that originate from breeding areas in Canada. Therefore, we acknowledge that 1) the data collected in this study does not reveal breeding areas for these birds, and 2) that our depictions of wintering areas in eastern North America are biased by the sampling strategy and do not portray birds that winter in areas outside our sampling area (e.g., eastern Canada or Greenland).

Recommendations for Future Work on Long-tailed Ducks*:*

1. Focus deployment in under-sampled areas (Lake Erie, ON; Delaware Bay; New Jersey Coastline; Maine; Lake Huron; and increased sampling on Lake Michigan). Some of these areas may be migratory staging areas (e.g., Lake Huron and Lake Erie) that may shed more light on both wintering and breeding areas.
2. Focus efforts on determining how to increase survivorship for birds implanted with transmitters. Increasing sample size across all the study areas and evaluating timing of capture, age, weight, physiological blood parameters, surgeon, surgical methods, and capture area may provide insight into how to increase survivorship.

Outreach Efforts and Presentations

A project web page has been created on the SDJV website, http://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study/. The web page includes some general outreach products such as photos, descriptions of how sea ducks are captured, and maps.

Oral presentations related to this study, presented at the 4th International Sea Duck Conference in Seward, Alaska (abstracts available at http://seaduckjv.org/pdf/sea_duck_conference_2011_abstracts_web.pdf):

Bowman, Timothy D., Scott G. Gilliland, Matthew C. Perry, Jean-Pierre Savard, Alicia M. Wells-Berlin, Christine Lepage, Taber D. Allison, and Keith McAloney. 2011. Atlantic and Great Lakes Sea Duck Migration Study.

Ford, Scott L., Glenn H. Olsen, and Matthew Perry. 2011. Comparison of trends in physiological parameters of long-tailed ducks undergoing intracoelomic satellite transmitter implantation and two different post-operative care protocols.

Paton, Peter W. C., Kristopher Winiarski, Carol L. Trocki, Pamela H. Loring, Jason E. Osenkowski, and Scott R. McWilliams. Using density surface models to assess the spatial distribution and abundance of sea ducks using Rhode Island’s offshore waters.

Silverman, Emily D., Walt Rhodes, and Scott G. Gilliland. 2011. Distribution, abundance, and movements of black scoters wintering along the southern Atlantic coast of the U.S.: habitat associations and lessons for monitoring.

Silverman, Emily D., J. B. Leirness, D. Saafeld, M. Koneff, and K.D. Richkus. 2012. Atlantic Coast Wintering Sea Duck Survey, 2008-2011 Summary Report October 2012 (draft). USFWS Laurel, MD.

Wells-Berlin, Alicia, Taber D. Allison, Matthew C. Perry, Glenn H. Olsen, and Simon Perkins. 2011. Spatial ecology of long-tailed ducks wintering in Nantucket Sound: pre-construction analysis of Cape Wind offshore wind project.

Wilson, Philip, L., Scott A. Petrie, Shawn Meyer, Shannon Badzinski, Ted Barney, and Michael Schummer. 2011. Sea ducks of the lower Great lakes: current state of knowledge, research needs, and threats.

Posters related to this study, presented at the 4th International Sea Duck Conference in Seward, Alaska (abstracts available at http://seaduckjv.org/pdf/sea_duck_conference_2011_abstracts_web.pdf):

Gilliland, Scott G., and Sean Boyd. Tradeoffs in duty cycles for satellite tracking programs for sea ducks.

Perry, Matthew C., Glenn H. Olsen, Alicia M. Wells-Berlin, Scott G. Gilliland, Keith McAloney, Jean-Pierre Savard, Pamela Loring, and Taber D. Allison. 2011. Survival of Atlantic coast sea ducks within 2 weeks and 2 months of instrumentation with implantable satellite transmitters.

Savoy, Lucas J., Timothy D. Bowman, Dustin Meattey, Oksana Lane, Jason E. Osenkowski, Scott G. Gilliland, Glenn H. Olsen, Nancy Pau, Kate O'Brien, Alicia M. Wells-Berlin, Phillip Wilson, Shannon Badzinski, and Shawn Meyer. 2011. Mercury concentrations in blood of migratory and wintering sea ducks from the Atlantic and Great Lakes regions

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Oral presentations related to this study, presented at the 5th International Sea Duck Conference in Reykjavik, Iceland (abstracts available at http://seaduckjv.org/pdf/ISDC-Iceland-2014-Program-Abstracts.pdf):

Lepage, Christine, Jean-Pierre L. Savard, and Scott G. Gilliland. 2014. Annual fidelity to molting, staging and wintering areas by White-winged scoters in eastern North America.

Posters related to this study, presented at the 5th International Sea Duck Conference in Reykjavik, Iceland (abstracts available at http://seaduckjv.org/pdf/ISDC-Iceland-2014-Program-Abstracts.pdf):

Savard, Jean-Pierre L., Scott G. Gilliland, Christine Lepage, Matthew C. Perry. 2014. Spring and fall migration of Scoters in eastern North America: routes, timing and duration.

Savoy, Lucas J., Timothy D. Bowman, Dustin Meattey, Kevin Reagan, Jason E. Osenkowski, Josh Beuth, Scott G. Gilliland, Glenn H. Olsen, Nancy Pau, Kate O'Brien, Alicia M. Wells-Berlin, Phillip Wilson, Shannon Badzinski, Shawn Meyer, and Christine Lepage. 2014. A comparison of mercury concentration in blood tissue of sea ducks from the Atlantic and Great Lakes regions.

Oral presentations related to this study, presented at the 6th International Sea Duck Conference in San Francisco, California (abstracts available at https://seaduckjv.org/wp-content/uploads/2014/11/6th-Intl-Sea-Duck-Conference-ABSTRACTS-reduced.pdf):

Meattey, Dustin, Scott R. McWilliams, Peter W.C. Paton, Jason Osenkowski, Christine Lepage, Scott G. Gilliland, and Glenn H. Olsen. 2017. Annual cycle movements and winter habitat use of White-winged Scoters in southern New England.

Posters related to this study, presented at the 6th International Sea Duck Conference in San Francisco, California (abstracts available at https://seaduckjv.org/wp-content/uploads/2014/11/6th-Intl-Sea-Duck-Conference-ABSTRACTS-reduced.pdf):

Fara, Luke J., Kevin P. Kenow, Michael W. Eichholz, and Steven C. Houdek. 2017. Migration patterns, habitat use, food habits, and harvest characteristics of long-tailed ducks wintering on Lake Michigan.

Fara, Luke J., Kevin P. Kenow, Michael W. Eichholz, Brian R. Lubinski, Larry R. Robinson, and Steven C. Houdek. 2017. Using thermal imagery and "Judas" birds to increase capture of long-tailed ducks on Lake Michigan.

Other presentations or products related to this study:

Title or Topic of Product	Lead author(s) or Presenter	Co-authors	Venue	Date
Importance of the lower Great Lakes to Waterfowl and the Potential Impact of Wind Turbine Development.	Scott Petrie		State of the Science Workshop on the Ecological Effects of Wind Turbine Development	Mar 2011
Spatial and temporal distribution, abundance, and flight ecology of birds in inshore and offshore waters of RI	Kris Winiarki	C. Trocki, P. Paton, S. McWilliams	Marine Bird Cooperative Meeting	Feb 2011
Wintering ecology of sea ducks in southern New England in relation to potential offshore wind facilities	Kris Winiarski,	C. Trocki, P. Paton, J. Osenkowski, S. McWilliams, P. Loring	5th North American Ornithological Conference	Aug 2012
Developing a framework to monitor sea ducks for offshore wind developments	Scott McWilliams	P. Paton	5th North American Ornithological Conference	Aug 2012
Atlantic and Great Lakes Sea Duck Migration Study	Alicia Berlin	R. Therrien, M. Perry, T. Bowman, S. Gilliland, J-P.L. Savard, C. Lepage, Allison, McAloney, McBride, Vormwald, Osenton	Microwave Telemetry Avian and Marine Tracking Conference	Mar 2012
Research on Wintering Waterfowl on Chesapeake Bay: What we have learned and where we are headed	Alicia Berlin	R. Therrien, Olsen, Osenton, S. Therrien, and McBride	Virginia Ducks Unlimited Convention	Feb 2012
Phenology and habitat use of scoters along the southern New England Continental Shelf	Pamela Loring		MS Thesis, University of Rhode Island	2012

Title or Topic of Product	Lead author(s) or Presenter	Co-authors	Venue	Date
Habitat selection by long-tailed ducks overwintering at Lake Ontario	Philip Wilson	Petrie, Schummer, Bowman, Badzinski	6th North American Duck Symposium Ontario Bird Bander's Association AGM	Jan 2013 Feb 2013
Satellite tracking of Atlantic Black Scoters: what we have learned in just a few short years	S. Gilliland	W.S. Boyd, J-P.L. Savard, E. Reed, D. Saalfeld and M. Perry	6th North American Duck Symposium	Jan 2013
Wintering and migratory use of the Great Lakes by multiple sea duck species tagged in the Atlantic Flyway	Dustin Meattey	C. Lepage, S. Gilliland, A. Berlin, M. Perry, L. Savoy, S. McWilliams, P. Paton, P. Loring, J. Osenkowski, T. Bowman	Great Lakes Sea Duck Symposium	Jul 2017
Annual cycle phenology and winter habitat use of White-winged Scoters in eastern North America	Dustin Meattey		MS Thesis, University of Rhode Island	2018
Pilot study: Migration patterns, habitat use, food habits, and harvest characteristics of long-tailed ducks wintering on Lake Michigan	Luke Fara	K. Kenow, S.Houdek	The Wildlife Society Joint Minnesota/Wisconsin Meeting	2015
Pilot study: Migration patterns, habitat use, food habits, and harvest characteristics of long-tailed ducks wintering on Lake Michigan	Luke Fara	K. Kenow, S. Houdek	Wisconsin Waterfowl Hunters Conference	2015
Migration patterns, habitat use, food habits, and harvest of long-tailed ducks wintering on Lake Michigan	Luke Fara	K. Kenow, M. Eichholz, S. Houdek	7th North American Duck Symposium	2016
Migration patterns, habitat use, food habits, and harvest of long-tailed ducks wintering on Lake Michigan	Luke Fara	K. Kenow, M. Eichholz, S. Houdek	Wisconsin Waterfowl Hunters Conference	2016
Migration patterns, habitat use and harvest of long-tailed ducks wintering on Lake Michigan	Luke Fara	K. Kenow, M. Eichholz, S. Houdek	Great Lakes Sea Duck Symposium	2017
Migration patterns, habitat use, prey items, and hunter harvest of long-tailed ducks (*Clangula hyemalis*) that overwinter on Lake Michigan	Luke Fara		MS Thesis, Southern Illinois University – Carbondale	2018
Long-tailed duck harvest characteristics from Two Rivers, Wisconsin: Lake Michigan	Luke Fara	B. Gray, K. Kenow, M. Eichholz	8th North American Duck Symposium	2019
Lake Michigan long-tailed ducks: Migration patterns and habitat use	Luke Fara	K. Kenow, S. Houdek, M. Eichholz	8th North American Duck Symposium	2019
Increasing capture efficiency of long-tailed ducks on Lake Michigan	Luke Fara	B. Lubinski, L. Robinson, K. Kenow, S. Houdek, M. Eichholz	8th North American Duck Symposium	2019

Title or Topic of Product	Lead author(s) or Presenter	Co-authors	Venue	Date
Seasonal habitat partitioning by sympatric sea ducks in eastern North America	Juliet Lamb	P. Paton, J. Osenkowski, S. McWilliams	8th North American Duck Symposium	2019
Network analysis reveals multi-species annual-cycle movement patterns of sea ducks	Juliet Lamb	P. Paton, J. Osenkowski, S. McWilliams	8th North American Duck Symposium	2019
Migration patterns and habitat use of long-tailed ducks that overwinter on Lake Michigan	Luke Fara	K. Kenow, S. Houdek, M. Eichholz	Wisconsin Ducks Unlimited State Convention	2020

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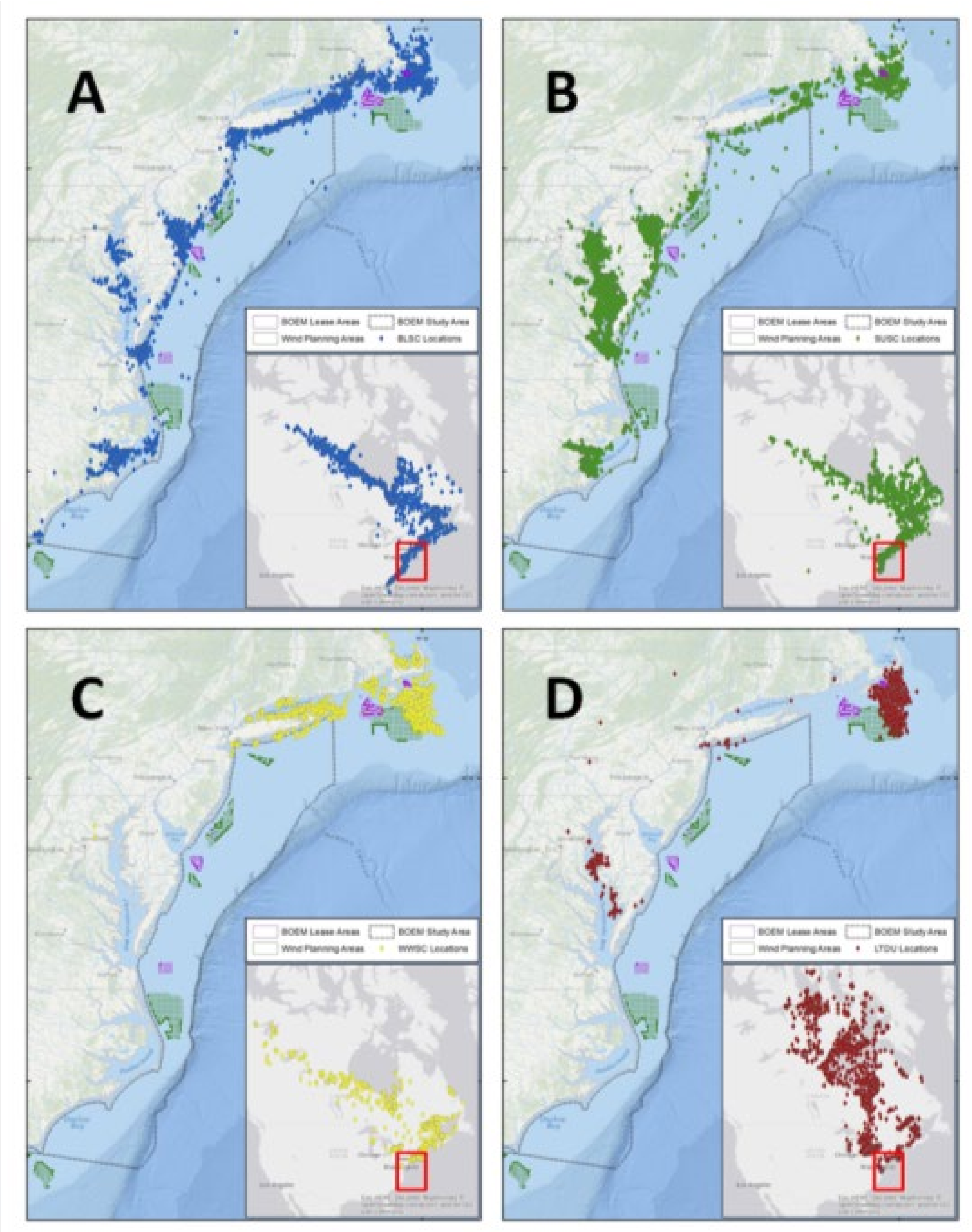

Figure 27. Best quality locations per duty cycle for (A) Black Scoter, (B) Surf Scoter, (C) White-winged Scoter, and (D) Long-tailed Duck during winter and migration through the proposed mid-Atlantic wind energy lease areas. Disclaimer: Caution should be used in identifying patterns or drawing conclusions from maps. More formal data interpretation regarding bird use relative to Wind Energy Areas (WEAs) has been presented in BOEM reports and peer-reviewed manuscripts.

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Appendix I

Table 3. Numbers of Black Scoter marked by site, year, age, sex, and fate.

	Chaleur Bay, NB/QC (April-May)				Chesapeake Bay (April)	Rhode Island (Dec)	
ADULT BIRDS (>1 YR OLD)	**2002**	**2004**	**2009**	**2010**	**2003**	**2010**	**TOTAL**
Male deployed	11	4	0	28	0	11	54
Female deployed	2	6	20	19	2	7	56
Total deployed	**13**	**10**	**20**	**47**	**2**	**18**	**110**
Male lost or died >60d	11	3	0	26	0	2	42
Female lost or died >60d	2	4	16	18	2	4	46
Total lost or died >60d	**13**	**7**	**16**	**44**	**2**	**6**	**88**
Male died <=60d[1]	0	1	0	2	0	9	12
Female died <=60d[1]	0	1	4	1	0	3	9
Male lost <=60d[2]	0	0	0	0	0	0	0
Female lost <=60d[2]	0	1	0	0	0	0	1
Male lost or died <=60d	0	1	0	2	0	9	12
Female lost or died <=60d	0	2	4	1	0	3	10
Total lost or died <=60d	**0**	**3**	**4**	**3**	**0**	**12**	**22**
Male missing data	2	0	0	1	0	0	3
Female missing data	0	0	1	0	0	0	1
Total missing data	**2**	**0**	**1**	**1**	**0**	**0**	**4**
% M lost or died <=60d	0	25	0	7	0	82	22
% F lost or died <=60d	0	33	20	5	0	43	18
% Total lost or died <=60d	**0**	**30**	**20**	**6**	**0**	**67**	**20**

HATCH-YEAR BIRDS (<1 YR OLD)	**Chaleur Bay, NB/QC Apr-May 2010**	**Rhode Island Dec 2010**	**TOTAL**
Male deployed	1	8	9
Female deployed	0	3	3
Total deployed	**1**	**11**	**12**
Male lost or died >60d[1,2]	1	1	2
Female lost or died >60d[1,2]	0	1	1
Total lost or died >60d	**1**	**2**	**3**
Male died <=60d	0	7	7
Female died <=60d	0	2	2
Male lost or died <=60d	0	7	7
Female lost or died <=60d	0	2	2
Total lost or died <=60d	**0**	**9**	**9**
% M lost or died <=60d	0	88	78
% F lost or died <=60d	0	67	67
% Total lost or died <=60d	**0**	**82**	**75**

[1] Mortality indicated by transmitter temperature falling below normal body temperature during initial 60 days or mortality flag indicated.

[2] Lost = transmitter battery voltage drops to low level or malfunctions.

Table 4. Numbers of adult Surf Scoter marked by site, year, sex, and fate.

	Chaleur Bay NB/QC			Chesapeake Bay, MD/VA						Delaware			Labrador	Pamlico Sound, NC					Rhode Island	St. Lawrence River, QC			
ADULTS (>1 YR OLD)	**Apr-May 2004**	**Apr-May 2005**	**Apr-May 2010**	**winter 2001**	**winter 2002**	**winter 2004**	**winter 2011**	**winter 2012**	**winter 2013**	**winter 2013**	**winter 2014**	**winter 2015**	**summer 2006**	**winter 2011**	**winter 2012**	**winter 2013**	**winter 2014**	**winter 2015**	**winter 2010**	**summer 2010**	**fall 2012**	**fall 2013**	**TOTAL**
Male deployed	0	0	1	5	7	0	16	12	12	4	6	4	15	2	0	7	8	5	1	1	0	0	105
Female deployed	1	4	0	0	0	4	4	11	4	0	3	1	0	2	1	4	4	1	0	0	26	53	121
Total deployed	**1**	**4**	**1**	**5**	**7**	**4**	**20**	**23**	**16**	**4**	**9**	**5**	**15**	**4**	**1**	**11**	**12**	**6**	**1**	**1**	**26**	**53**	**226**
Male lost or died >60d	0	0	1	3	5	0	10	8	9	3	3	4	7	1	0	2	6	4	1	0	0	0	71
Female lost or died >60d	1	3	0	0	0	4	2	4	3	0	0	0	0	1	1	0	3	0	0	0	13	31	68
Total lost or died >60d	**1**	**3**	**1**	**3**	**5**	**4**	**12**	**12**	**12**	**3**	**3**	**4**	**7**	**2**	**1**	**2**	**9**	**4**	**1**	**0**	**13**	**31**	**139**
Male died <=60d[1]	0	0	0	1	2	0	5	4	3	1	2	0	7	1	0	1	1	1	0	1	0	0	29
Female died <=60d[1]	0	1	0	0	0	0	1	5	1	0	3	1	0	1	0	1	1	1	0	0	4	16	35
Male lost <=60d[2]	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	5
Female lost <=60d[2]	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	9	6	18
Male lost or died <=60d	0	0	0	2	2	0	6	4	3	1	3	0	8	1	0	1	2	1	0	1	0	0	34
Female lost or died <=60d	0	1	0	0	0	0	2	7	1	0	3	1	0	1	0	1	1	1	0	0	13	22	53
Total lost or died <=60d	**0**	**1**	**0**	**2**	**2**	**0**	**8**	**11**	**4**	**1**	**6**	**1**	**8**	**2**	**0**	**2**	**3**	**2**	**0**	**1**	**13**	**22**	**87**
% M lost or died <=60d	0	0	0	40	29	0	38	33	25	25	50	0	53	50	0	14	25	20	0	100	0	0	32
% F lost or died <=60d	0	25	0	0	0	0	50	64	25	0	100	100	0	50	0	25	25	100	0	0	50	42	44
% Total lost or died <=60d	**0**	**25**	**0**	**40**	**29**	**0**	**40**	**48**	**25**	**25**	**67**	**20**	**53**	**50**	**0**	**18**	**25**	**33**	**0**	**100**	**50**	**42**	**38**

[1] Mortality indicated by transmitter temperature falling below normal body temperature during initial 60 days or mortality flag indicated.

[2] Lost = transmitter battery voltage drops to low level or malfunctions.

Table 5. Numbers of White-winged Scoter marked by site, year, age, sex, and fate.

	Boston Harbor	Cape Cod Bay	Chaleur Bay	Lake Ontario	Long Island Sound		Maine		Rhode Island	St. Lawrence River			
ADULT BIRDS (>1 YR OLD)	**winter 2013**	**2015**	**Apr/May 2009**	**winter 2013**	**winter 2014**	**winter 2016**	**winter 2011**	**winter 2016**	**winter 2010**	**summer 2010**	**summer 2012**	**spring 2016**	**TOTAL**
Male deployed	0	0	2	0	0	0	1	0	1	16	12	0	32
Female deployed	3	23	0	2	3	4	0	1	0	3	5	26	70
Total deployed	**3**	**23**	**2**	**2**	**3**	**4**	**1**	**1**	**1**	**19**	**17**	**26**	**102**
Male lost or died >60d	0	0	0	0	0	0	1	0	1	11	10	0	23
Female lost or died >60d	2	20	0	1	3	4	0	0	0	3	5	22	60
Total lost or died >60d	**2**	**20**	**0**	**1**	**3**	**4**	**1**	**0**	**1**	**14**	**15**	**22**	**83**
Male died <=60d	0	0	0	0	0	0	0	0	0	4	2	0	6
Female died <=60d	1	3	0	0	0	0	0	1	0	0	0	3	8
Male lost <=60d	0	0	0	0	0	0	0	0	0	1	0	0	1
Female lost <=60d	0	0	0	1	0	0	0	0	0	0	0	1	2
Male lost or died <=60d	0	0	0	0	0	0	0	0	0	5	2	0	7
Female lost or died <=60d	1	3	0	1	0	0	0	1	0	0	0	4	10
Total lost or died <=60d	**1**	**3**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**5**	**2**	**4**	**17**
% M lost or died <=60d	0	0	0	0	0	0	0	0	0	31	17	0	22
% F lost or died <=60d	33	13	0	50	0	0	0	100	0	0	0	15	14
% Total lost or died <=60d	**33**	**13**	**0**	**50**	**0**	**0**	**0**	**100**	**0**	**26**	**12**	**15**	**17**

	Merrimack River, MA
HATCH-YEAR BIRDS (<1 YR OLD)	**winter 2010**
Male deployed	1
Female deployed	2
Total deployed	**3**
Female lost or died >60d	1
Total lost or died >60d	**1**
Male died <=60d	1
Female died <=60d	1
Male lost or died <=60d	1
Female lost or died <=60d	1
Total lost or died <=60d	**2**
% M lost or died <=60d	100
% F lost or died <=60d	50
% Total lost or died <=60d	67

[1] Mortality indicated by transmitter temperature falling below normal body temperature during initial 60 days or mortality flag indicated.

[2] Lost = transmitter battery voltage drops to low level or malfunctions.

Table 6. Numbers of Long-tailed Duck marked by site, year, age, sex, and fate.

	Casco Bay,ME	Chesapeake Bay		Chincoteague Bay	Lake Ontario			Nantucket Sound				Lake Michigan			
ADULT BIRDS (>1 YR OLD)	**winter 2012**	**winter 2011**	**winter 2012**	**winter 2010**	**winter 2011**	**winter 2012**	**winter 2013**	**winter 2007**	**winter 2008**	**winter 2009**	**winter 2010**	**winter 2016**	**winter 2017**	**winter 2018**	**TOTAL**
Unk deployed	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Male deployed	0	6	0	0	20	3	0	7	11	4	10	0	5	6	72
Female deployed	1	4	10	1	19	22	10	3	3	6	9	2	2	9	101
Total deployed	**1**	**10**	**10**	**1**	**39**	**25**	**10**	**11**	**14**	**10**	**19**	**2**	**7**	**15**	**174**
Male lost or died >60d	0	4	0	0	11	1	0	4	4	1	6	0	3	4	38
Female lost or died >60d	0	0	6	0	9	16	6	2	1	5	4	1	2	3	55
Total lost or died >60d	**0**	**4**	**6**	**0**	**20**	**17**	**6**	**6**	**5**	**6**	**10**	**1**	**5**	**7**	**93**
Unk died <=60d	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Male died <=60d	0	2	0	0	7	1	0	3	6	2	4	0	0	2	27
Female died <=60d	1	3	3	1	7	6	0	1	2	1	4	1	0	6	36
Male lost <=60d	0	0	0	0	2	1	0	0	1	1	0	0	2	0	7
Female lost <=60d	0	1	1	0	3	0	4	0	0	0	1	0	0	0	10
Unk lost or died <=60d	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Male lost or died <=60d	0	2	0	0	9	2	0	3	7	3	4	0	2	2	34
Female lost or died <=60d	1	4	4	1	10	6	4	1	2	1	5	1	0	6	46
Total lost or died <=60d	**1**	**6**	**4**	**1**	**19**	**8**	**4**	**5**	**9**	**4**	**9**	**1**	**2**	**8**	**81**
% U lost or died <=60d	0	0	0	0	0	0	0	100	0	0	0	0	0	0	100
% M lost or died <=60d	0	33	0	0	45	67	0	43	64	75	40	0	40	33	47
% F lost or died <=60d	100	100	40	100	53	27	40	33	67	17	56	50	0	67	46
% Total lost or died <=60d	**100**	**60**	**40**	**100**	**49**	**32**	**40**	**45**	**64**	**40**	**47**	**50**	**29**	**53**	**47**

	Lake Ontario	Lake Michigan
HATCH-YEAR BIRDS (<1 YR OLD)	**winter 2011**	**winter 2017**
Male deployed	0	1
Female deployed	1	0
Total deployed	**1**	**1**
Male died <=60d	0	1
Female died <=60d	1	0
Male lost or died <=60d	0	1
Female lost or died <=60d	1	0
Total lost or died <=60d	**1**	**1**
% F lost or died <=60d	100	100
% Total lost or died <=60d	**100**	**100**

[1]Mortality indicated by transmitter temperature falling below normal body temperature during initial 60 days or mortality flag indicated or individual killed by hunter.

[2] Lost = transmitter battery voltage drops to low level or malfunctions.

Appendix II

Table 7. Summary of SDJV and partner contributions ($1000s) to the Atlantic and Great Lakes Sea Duck Migration Study, 2010-2018.

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2010	185.5									
2010		50								USFWS Region 5
2010		48.6								MMS/BOEM
2010					8.6					Mass Audubon
2010					42					USGS - Patuxent
2010				50						Waterfowl Research Fund via Ducks Unlimited
2010						28	64			Canadian Wildlife Service - Atlantic Region
2010						22.3	24.4			Canadian Wildlife Service - Quebec Region
2010							7.3			Env Canada - Science and Technology
2010									5	Univ Quebec and Montreal
2010									12.7	NB Dept Nat Resources
2010					6.1					Avian Specialty of Alaska
2010				3.8						RI Dept Environmental Mgt
2010				2.8						University of Rhode Island
Totals	**185.5**	**98.6**	**0.0**	**56.6**	**56.7**	**50.3**	**95.7**	**0.0**	**17.7**	
		98.6		**113.3**		**146**		**17.7**		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2011	203									
2011		5								USFWS Maine Coastal Programs
2011					8.5					BioDiversity Research Institute
2011			2.7							USFWS - Parker River NWR
2011					4.5					University of Florida
2011					3					VA Dept Game and Inland Fisheries
2011		3.5	18.1							USGS - Patuxent
2011				0.5	3					MD Dept Natural Resources
2011		0.5	6.35							USFWS - Chesapeake Bay field office
2011				0.2	1.75					Ducks Unlimited - Delaware
2011						23.985	22.5			Canadian Wildlife Service - Ontario
2011								6.5	18.5	Long Point Waterfowl
2011				4	6.3					RI Dept Environmental Mgt
2011				80	3.3					University of Rhode Island
2011							3			Canadian Wildlife Service - Atlantic Region
2011						8				Canadian Wildlife Service - Quebec Region
Totals	**203.0**	**9.0**	**27.2**	**84.7**	**30.4**	**32.0**	**25.5**	**6.5**	**18.5**	
		36.2		**115.1**		**57.5**		**25.0**		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2012	191.77									note: included in SDJV total for 2012 are some Argos costs for future years
2012										BOEM (Bureau of Ocean Energy Management)
2012					2.64					BioDiversity Research Institute
2012		30.13								U.S. Department of Energy
2012					4.20					VA Dept Game and Inland Fisheries
2012			39.31							USGS - Patuxent
2012			5.00							USFWS - Chesapeake Bay field office
2012						59.10	24.35			Canadian Wildlife Service - Ontario
2012						8.00	8.50			Canadian Wildlife Service - Atlantic Region
2012						3.30	10.60			Canadian Wildlife Service - Quebec Region
2012								56.42	13.00	Long Point Waterfowl
2012					4.80					RI Dept Environmental Mgt
2012				15.33	7.20					NC Wildlife Resources Commission
Totals	191.77	30.13	44.31	15.33	18.84	70.40	43.45	56.42	13.00	
		74.4		34.2		113.9		69.4		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2013	194.24									
2013						12.00	20.85			EC - Canadian Wildlife Service - Quebec region
2013						22.00	12.85			EC - Canadian Wildlfe Service -Atlantic region
2013				3.54	8.18					BioDiversity Research Institute
2013							2.15			Environment Canada S&T
2013									6.40	Univ of Montreal
2013		8.70								U.S. Dept of Energy
2013					1.50					All Creatures Vet Hospital
2013		25.78								BOEM (Bureau of Ocean Energy Management)
Totals	194.24	34.48	0.00	3.54	9.68	34.00	35.85	0.00	6.40	
		34.5		13.2		69.9		6.4		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2014	45.21									Sea Duck Joint Venture (USFWS)
2014					20.90					BioDiversity Research Institute
Totals	45.21	0.00	0.00	0.00	20.90	0.00	0.00	0.00	0.00	
		0.00		20.90		0.00		0.00		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other U.S. federal contributions		U.S. non-federal contributions		Canadian federal contributions		Canadian non-federal contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2015	142.90									Sea Duck Joint Venture (USFWS)
2015					16.69					BioDiversity Research Institute
2015					127.06					RI DEM
2015					41.47					Univ Rhode Island
2015		15.55								USGS Midwest region
2015					3.00					Wisconsin Waterfowl Association
Totals	142.90	0.00	0.00	0.00	188.22	0.00	0.00	0.00	0.00	
		0.00		188.22		0.00		0.00		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other US Federal Contributions		US Non-Federal Contributions		Canadian Federal Contributions		Canadian Non-Federal Contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2016	188.0									
2016		69.4								USGS - Midwest
2016				15.0						Southern Illinois University
2016				1.5						Wisconsin Waterfowl Hunters' Conference
2016				1.0						Bill Cook Chapter of the Izaak Walton League of America (IWLA)
2016				1.0						Wisconsin Division of the IWLA
2016				1.0						Delta Waterfowl Association
2016					2.7					Volunteer Hours
2016						29.6				Canadian Wildlife Service
2016				190.7						Rhode Island Department of Environmental Management
2016				10.2						Biodiversity Research Institute
2016				71.1						University of Rhode Island
Totals	**188.0**	**69.4**	**0.0**	**291.5**	**2.7**	**29.6**	**0.0**	**0.0**	**0.0**	
		69.4		**294.2**		**29.6**		**0**		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other US Federal Contributions		US Non-Federal Contributions		Canadian Federal Contributions		Canadian Non-Federal Contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2017	108.1									
2017		69.4								USGS - Midwest
2017				15.0						Southern Illinois University
2017				1.0						Wisconsin Waterfowl Hunters' Conference
2017				1.0						Illinois Federation for Outdoor Resources
2017				3.0						Wisconsin Division of the IWLA
2017				0.2						Lakeshore Chapter of Wisconsin Waterfowl Association
2017					2.7					Volunteer Hours
2017				93.2						Rhode Island Department of Environmental Management
2017				8.5						Biodiversity Research Institute
2017				55.6						University of Rhode Island
Totals	**108.1**	**69.4**	**0.0**	**177.5**	**2.7**	**0.0**	**0.0**	**0.0**	**0.0**	
		69.4		**180.2**		**0**		**0**		

SDJV Fiscal Year	SDJV (USFWS) Contribution	Other US Federal Contributions		US Non-Federal Contributions		Canadian Federal Contributions		Canadian Non-Federal Contributions		Source of Contribution (name of agency or organization)
		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2018	8.4									
2018		2.4								USGS - Midwest
2018				1.9						Biodiversity Research Institute
2018				15.0						Southern Illinois University
2018					1.8					Volunteer Hours
Totals	**8.4**	**2.4**	**0.0**	**16.9**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	
		2.4		**18.7**		**0**		**0**		