ATLANTIC AND GREAT LAKES SEA DUCK MIGRATION STUDY

PROGRESS REPORT BY THE SEA DUCK JOINT VENTURE PARTNERSHIP

JUNE 2015

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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. 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 Flyway. The SDJV has made this project its highest priority in recent years and has committed substantial resources to the project since 2009.

We anticipate that more than 500 transmitters will eventually be deployed among four species: black scoter (*Melanitta americana*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*) and long-tailed duck (*Clangula hyemalis*) - all are species of high conservation concern (SDJV Management Board 2014). To date, more than 400 transmitters have been deployed throughout the Atlantic flyway and the study is generating a wealth of detailed information on migration patterns and on coastal and marine habitats used by sea ducks throughout the year (Fig. 1).

The study is 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 most effectively monitor sea ducks?

In addition to a lack of basic knowledge about sea duck biology, migration, and habitat use, another compelling reason for this study is 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 flyway 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 has partnered with SDJV to deploy transmitters in surf scoters.

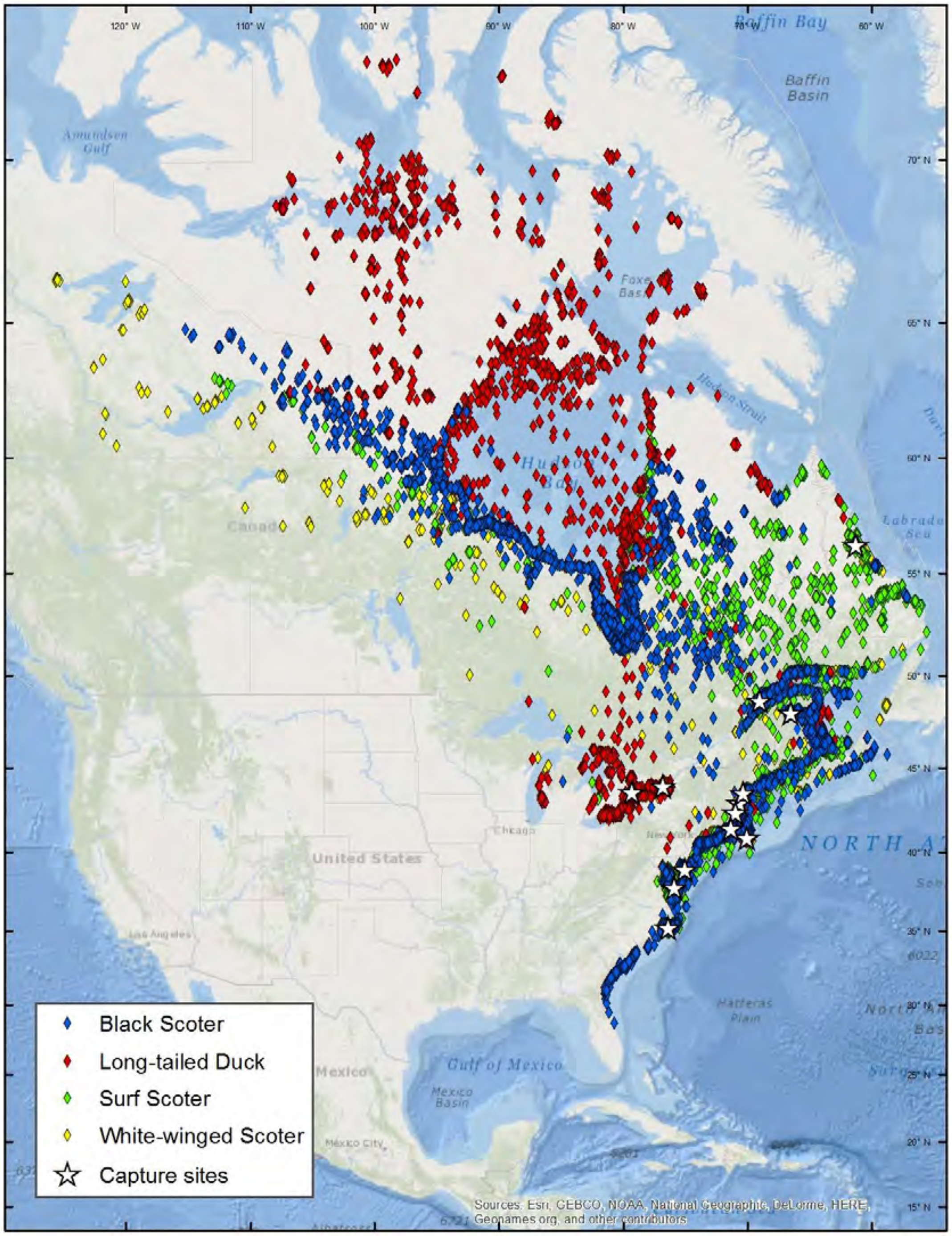


Figure 1. Geographic extent of locations determined from satellite telemetry of sea ducks marked along the Atlantic coast and Great Lakes. Points represent the best location per duty cycle. Locations are cumulative through 22 October 2014 (all birds, all species).

This progress report summarizes information gained through deployment and tracking of transmitters in Long-tailed Ducks up through 22 October 2014, 25 October 2013 for Black Scoters (when last PTT stopped transmitting), and 8 December 2014 for Surf Scoters and 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 is facilitating this study via financial support and coordination, there is a growing partnership supporting the project. Current partners include 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, 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, and Avery Outdoors. See Appendix I for a summary of partner contributions in 2010-2013. 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 are periodically reviewed by study partners and a Steering Committee currently 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 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 is 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 are striving 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 actually produce useable data over multiple life stages) are achieved for each species. By *representative* sample, we mean that each species will 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 is yielding novel discoveries that are expanding our knowledge of distribution, relative densities, migration paths, and potential structuring of populations. Now, recognizing that initial hypotheses regarding population structure may have been incorrect, partners and the Steering Committee have agreed to take an adaptive approach, whereby an effective sample size of 40 marked birds is achieved, data analyzed, and re-evaluated to determine if additional sampling may be needed to address new hypotheses (e.g., number of outcomes). The SDJV has 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.

To achieve a target sample size of 40, given an estimated 30% post-marking mortality and/or radio failure, it will be necessary to mark approximately 57 individuals per species. If transmitters fail, or birds die, at higher than expected rates, the number of deployments would be higher. Sample sizes for Great Lakes deployments would be in addition to Atlantic coast deployments (i.e., 40 additional long-tailed ducks and up to 40 additional white-winged scoters, if feasible).

Highest priority for marking is 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 will not mark additional young (hatch-year) ducks because they are unlikely to breed within one or more years and, therefore, contribute less to our understanding of population delineation, and because young birds marked in previous studies have experienced lower survival. That is not to say that migratory patterns of subadult birds is not of interest, rather, it is a matter of priorities given limited resources.

In addition to transmitter deployments supported directly by the SDJV, we have also included telemetry data from surf scoters marked as part of a U.S. Bureau of Ocean Energy Management (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 have been adult males. Likewise, the BOEM partners are reporting location data for Surf Scoters marked as part of the SDJV study.

Capture, handling, and marking

Birds have been captured using whatever technique works for that species in a particular area. This has included over-water mist nets, net-gunning from a boat, night-lighting, or drive-trapping molting birds into submerged gill nets (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 are using the following age designations: Hatch Year = less than 12 months old and bursa depth >15mm with immature plumage (e.g., light belly and notched tail feathers); Second Year = 12-24 months old and bursa depth >15mm; After Second Year = >24 months old and bursa depth <5mm 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 are surgically implanted in the abdominal cavity of each duck by a qualified veterinarian following the technique described by Korschgen et al. (1996). We are using 38-50g 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). Transmitter manufacturers were Microwave Telemetry, Inc., and Telonics, Inc. At the veterinarian's discretion, transmitters may be 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 (Fig. 2). PTTs are pressure-proofed to prevent crushing if ducks dive to great depth. Although some ducks were held more than one day in earlier projects, the current protocol is to hold radio-tagged birds in captivity for only 1-3 hours post-surgery. They are 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.

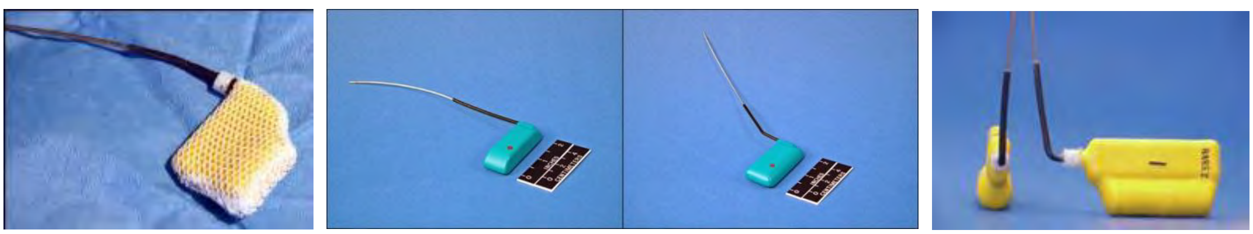


Figure 2. Implantable PTTs for use in sea ducks. Note transmitter on far left is wrapped with a mesh fabric.

All PTTs have been programmed with duty cycles that represent 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 currently in use by the SDJV is 2 hrs ON and 72 hrs OFF (i.e., one location every 3 days). This should allow PTTs to last at least one year and possibly up to three years for the larger units with more battery life. PTTs that last at least one, and ideally two, full annual cycles will enable an analysis of annual variation in timing of migration, habitat use, and site fidelity. The single duty cycle also enables "trading" PTTs among project elements as necessary to capitalize on opportunities to mark additional birds. Exceptions to these duty cycles have been made for partners who have purchased transmitters to meet specific local objectives that require 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 the BOEM study use 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 events have also provided opportunities to collect tissue samples for analyses of genetics, stable isotopes, contaminants, and disease screening. Tissue sample collection kits and SOPs (see http://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study /) are distributed to partners prior to each capture event. Samples are 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 make available only the last ten days of data to the end-user. Biodiversity Research Institute (BRI) is currently handling Argos data management and mapping tasks for both the SDJV and BOEM studies. Nightly, BRI downloads 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 are cycled through to download data and any active tags that have transmitted during this period will provide data for download and are archived for later use. BRI archives 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 WRC. Some, but not all, of the location data have also been 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 are archived, they can be 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 have 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 DAF, we have also chosen 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) can sometimes be used to determine the final fate of birds and tags.

A database of deployment and life-history data has been built for every PTT tag that has been deployed or is being archived by the SDJV project (2001-2015). 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, in order to correctly map species to life-history period, we have recorded the life-history period start and end dates for every animal we have data for. This allows 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 the animal 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 record 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 are then calculated from the deployment start date and the final disposition date if tags are no longer active. The DAF filter works off of 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. The DAF includes data through 22 October 2014 and so final maps may include data through as late as this run date.

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 worth of data per life period per animal based on the following reasoning and scheme. We have evidence that the movement patterns of birds may be adversely affected in the first year following capture and implant of satellite tag (S. G. Gilliland, unpublished data) 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 contributes one sample to each map and so maps are 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) kernel density 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.

Kernel density maps were created for various life-history periods. Kernel density estimation involves the use of point data from telemetry to estimate relative spatial use during specified time intervals. For each location, the bird's habitat use is estimated to be greatest directly on the point, and to decrease with distance from the point (reaching zero at a bandwidth specified by the user (after Worton 1989). The density at a given location is generally calculated by adding the values of kernel surfaces for all birds at that location (for maps in this report, a "location" is a degree of latitude/longitude). We used the composite KDE method (with Gaussian kernel and Likelihood cross-validation bandwith estimator) of Loring et al. (2014) where S random points are selected for N individuals and pooled for a single composite KDE representing the utilization distribution (UD) of all animals. One difference to note however, instead of using a constant S of 40, we defined S for each life-history period by the lower quartile of the number of points for all animals represented in that life-history period (see Table 2).

Table 1. Life stage criteria used to analyze seasonal migration and distribution data for four sea duck species (black scoter: BLSC; surf scoter: SUSC; white-winged scoter: WWSC; and long-tailed duck: LTDU).

	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.

Table 2. The sample size (S) for each animal and number of animals in each KDE map by period.

Species	Period	S	N
SUSC	spring staging	6	47 (F22, M23, U2)
BLSC	molting	14	78 (F43,M 35)
	wintering	31	65 (F36, M29)
WWSC	wintering	17	36 (F15, M21)
	spring staging	7	19 (F8, M11)

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. (http://seaduckjv.org/studies/pro3/pr82.pdf)

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 involved in work at these sites: USFWS; New Brunswick Department of Natural Resources.

Results and discussion:

One hundred and eight black scoters (55 females and 53 males) have been implanted with satellite transmitters as part of this project, although not all have 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 (Table3).

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 (Fig. 3). 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 (Fig. 3). Many of the females that traveled to breeding sites in northern Quebec and Labrador (n=8) flew directly to their breeding location from the Chaleur Bay (Fig. 3). 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 (Fig. 3).

Breeding areas

The majority of 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 (Fig. 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 Bordage and Savard 1998, 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 (Fig. 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 in the 21 opportunities to switch locations, suggesting the species is highly philopatric.

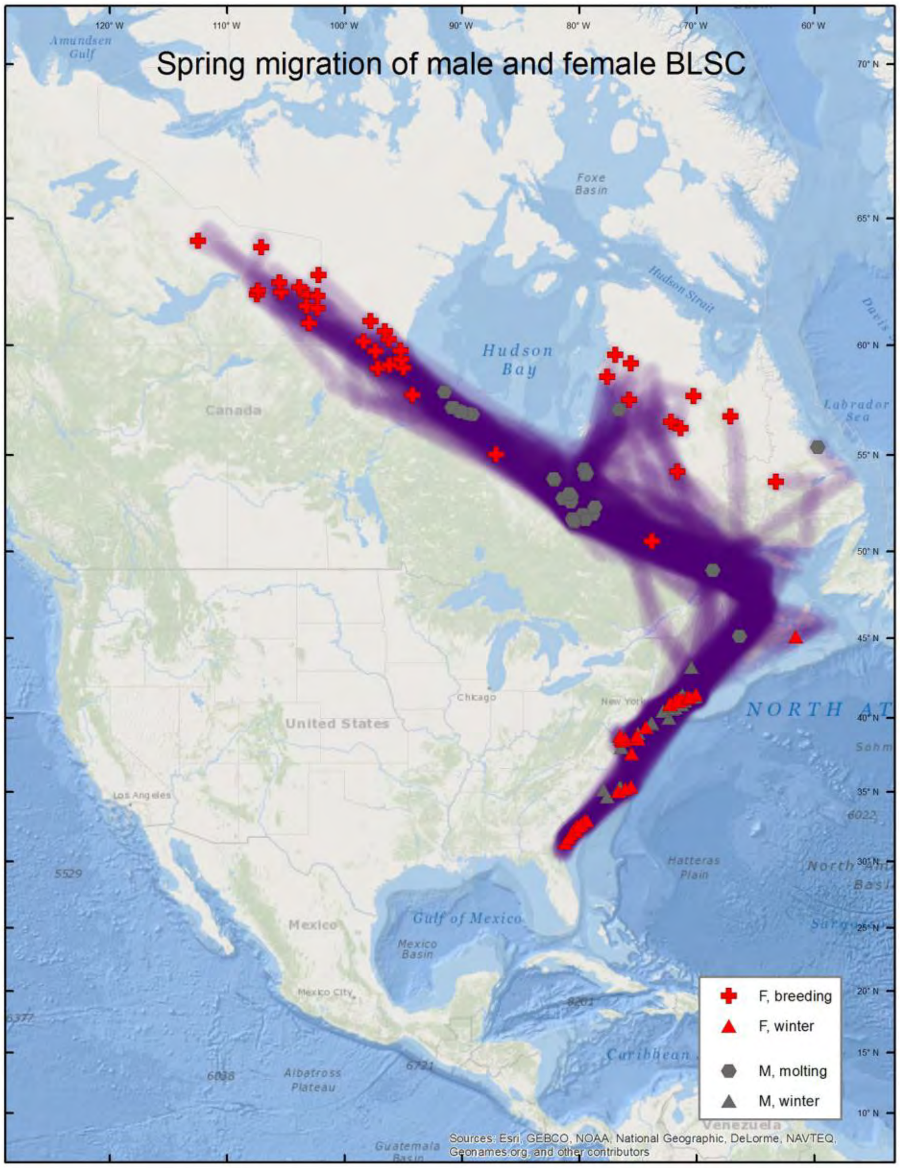


Figure 3. Spring migration of 79 adult black scoters (43 females, 36 males) from wintering areas to breeding areas (females) or molting areas (males). Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 25 October 2013, when the last transmitter stopped transmitting.

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 (Figs. 3 and 4). 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 which has encompassed locations for up to three molting seasons 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 molt site that appears 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.

Figure 4. Molting areas for 78 adult black scoters (43 females, 35 males). Numbers reflect unique animals that contributed to the map. Map includes all locations through 25 October 2013, when the last transmitter stopped transmitting.

Fall migration

Many of the males that molted on James Bay and western Hudson Bay, and most females that may have breed 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 (Fig. 5).

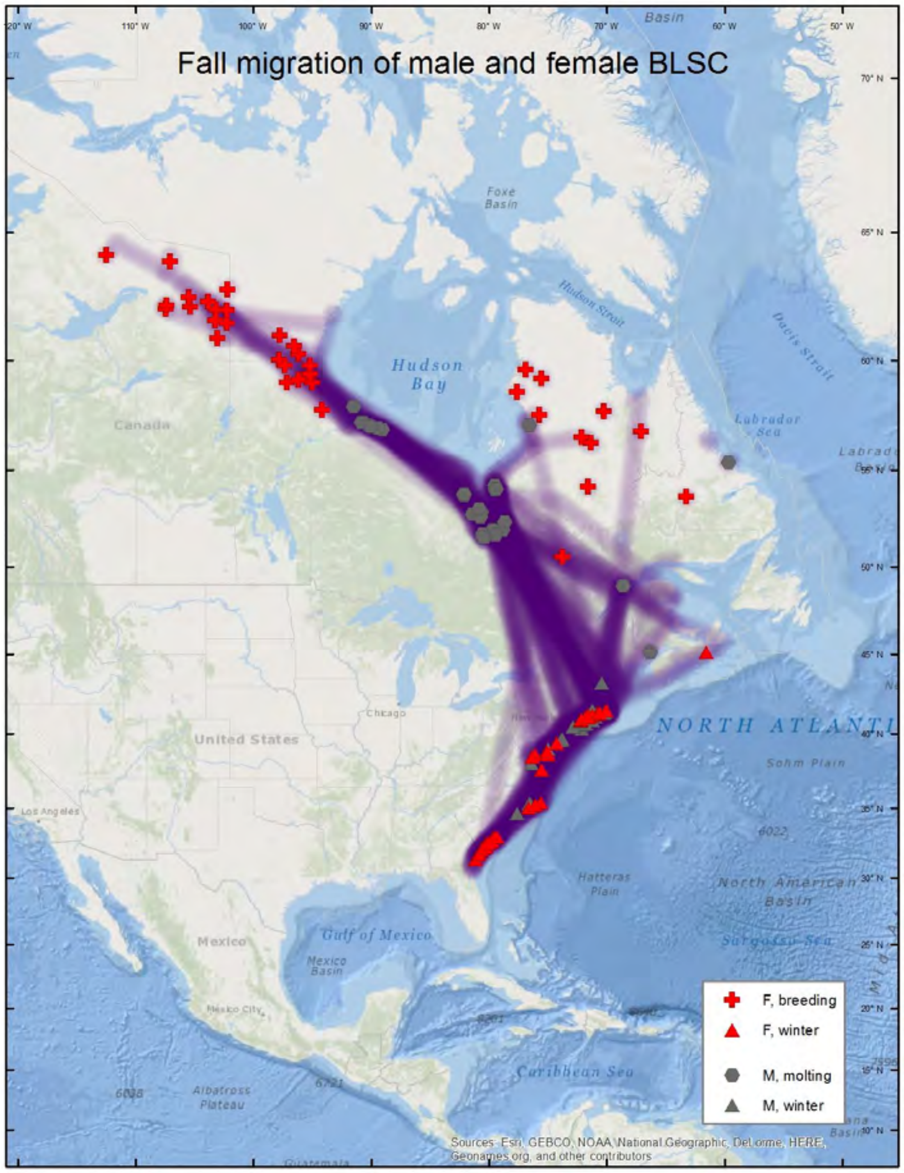


Figure 5. Fall migration of 78 adult black scoters (43 females, 35 males) from breeding/molting areas to wintering areas. Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 25 October 2013, when the last transmitter stopped transmitting.

Wintering areas

The majority of birds staged for a few weeks at various locations along the eastern coast of the USA before arriving at their wintering areas, mostly between Massachusetts and northern Florida (Figs. 5 and 6). A detailed analysis of the wintering data has yet to be completed, however preliminary results suggest that there is significant movement of birds during winter both within and among years.

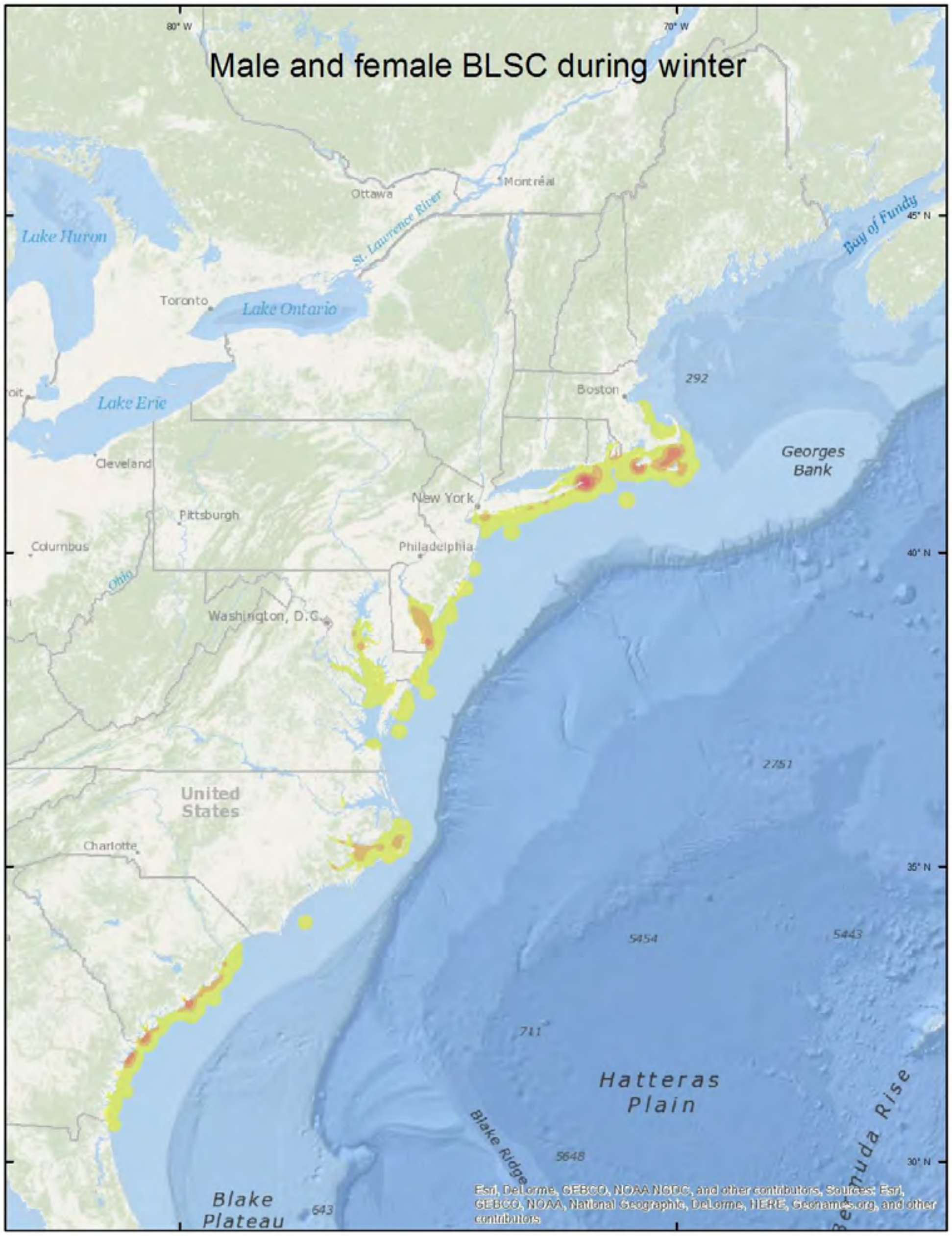


Figure 6. Kernel density polygons illustrating wintering areas for 65 black scoters (36 females, 29 males) marked during spring migration from Chaleur Bay, New Brunswick/Quebec. Numbers reflect unique animals that contributed to the map. Polygons are based on the best location per duty cycle for all individuals. Map includes all locations through 25 October 2013, when the last transmitter stopped transmitting.

Other important observations

The telemetry data show 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 as long as 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, the Chaleur Bay on the New Brunswick – Quebec border, and the St. Lawrence Estuary.

Implications for management and conservation:

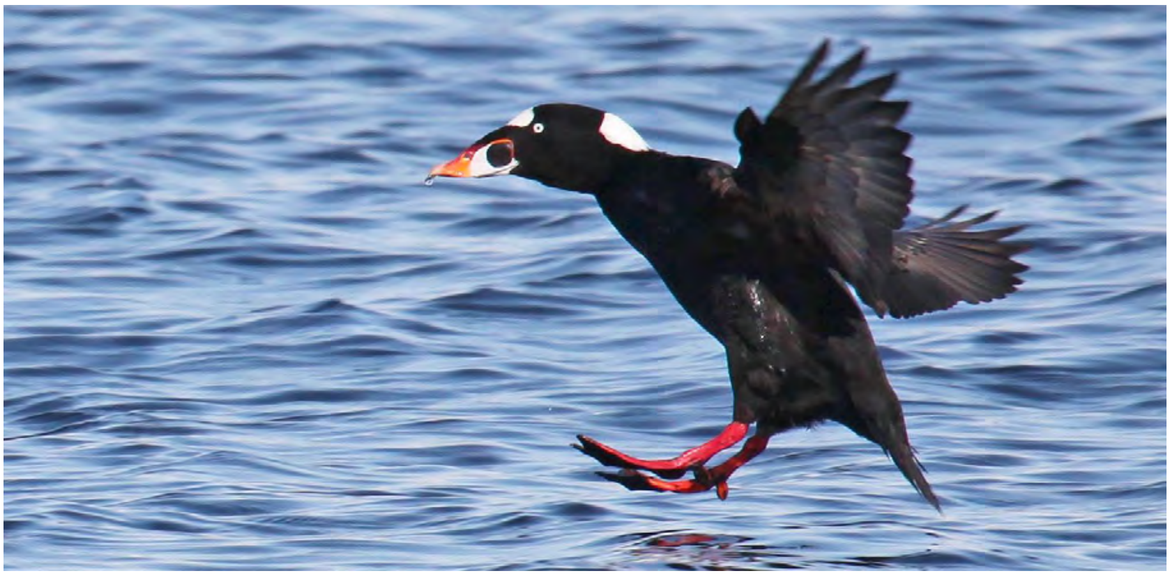
1. Telemetry data have provided a completely new view of the breeding range for the species, and suggest that a large portion of the eastern population is associated with breeding areas in northern Manitoba, Nunavut and the Northwest Territories. As a result of this study, this area has been identified as an Area of Continental Significance to North American Ducks, Geese and Swans under 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), but an exploratory fixed-wing survey of the area was conducted during summer 2014 and will be repeated in 2015 to determine the extent of the breeding area and relative breeding densities of 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 so far 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. We also are gathering information on the fall and spring distribution of scoters and the time spent at staging areas. Again, this will help interpret and plan surveys during these periods, as well as assess important habitats for the species, which may eventually lead to habitat protection.
5. Data from the study are being used in several environmental assessments. For example, they are being used in an assessment of a large offshore wind project in Rhode Island, 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.
6. 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.

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 are below the desired target and we may need to mark additional birds 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.
3. A reconnaissance aerial survey of breeding areas in northern Manitoba, Nunavut and the Northwest Territories in 2014 revealed relatively high densities of black scoters in this area, and demonstrated that a breeding survey may be a practical alternative for monitoring Atlantic black scoters, providing

that scoters can be reliably separated to species. Expanded and/or more intensive surveys would help reveal the geographic boundaries and relative densities of black scoter breeding in eastern Northern America. Methods need to be developed to determine the accuracy of species identification and help inform development of a breeding survey.

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 the majority of 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) and net gun 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 the analyses.

Lead investigators: **Québec and Labrador**: Scott Gilliland and Christine Lepage (Environment Canada, Canadian Wildlife Service), and Lucas Savoy (Biodiversity Research Institute); **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 (Biodiversity Research Institute).

Other Partners involved in work at these sites: Maryland Department of Natural Resources, Virginia Department of Game and Fish, USFWS, Ducks Unlimited, North Carolina Department of Wildlife Management, Bureau of Ocean Energy Management, U.S. Department of Energy, 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) have been 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.

In 2013, we also initiated an evaluation of 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). Preliminary analyses indicate there is a positive effect of the midazolam treatment; 75% of the midazolam treated birds survived to 30 days, whereas only 35% of the saline treated birds survived to 30 days.

Spring migration

Spring migration for surf scoters generally follows a coastal route up the eastern seaboard of the USA and Canada with key stopover and staging areas at Nantucket Shoals, along the Northumberland Strait shore 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 (Figs. 7 and 8). 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 (Fig. 7), while the rest flew overland over southern Québec towards their breeding areas along the northern edge of the boreal forest west of Hudson Bay.

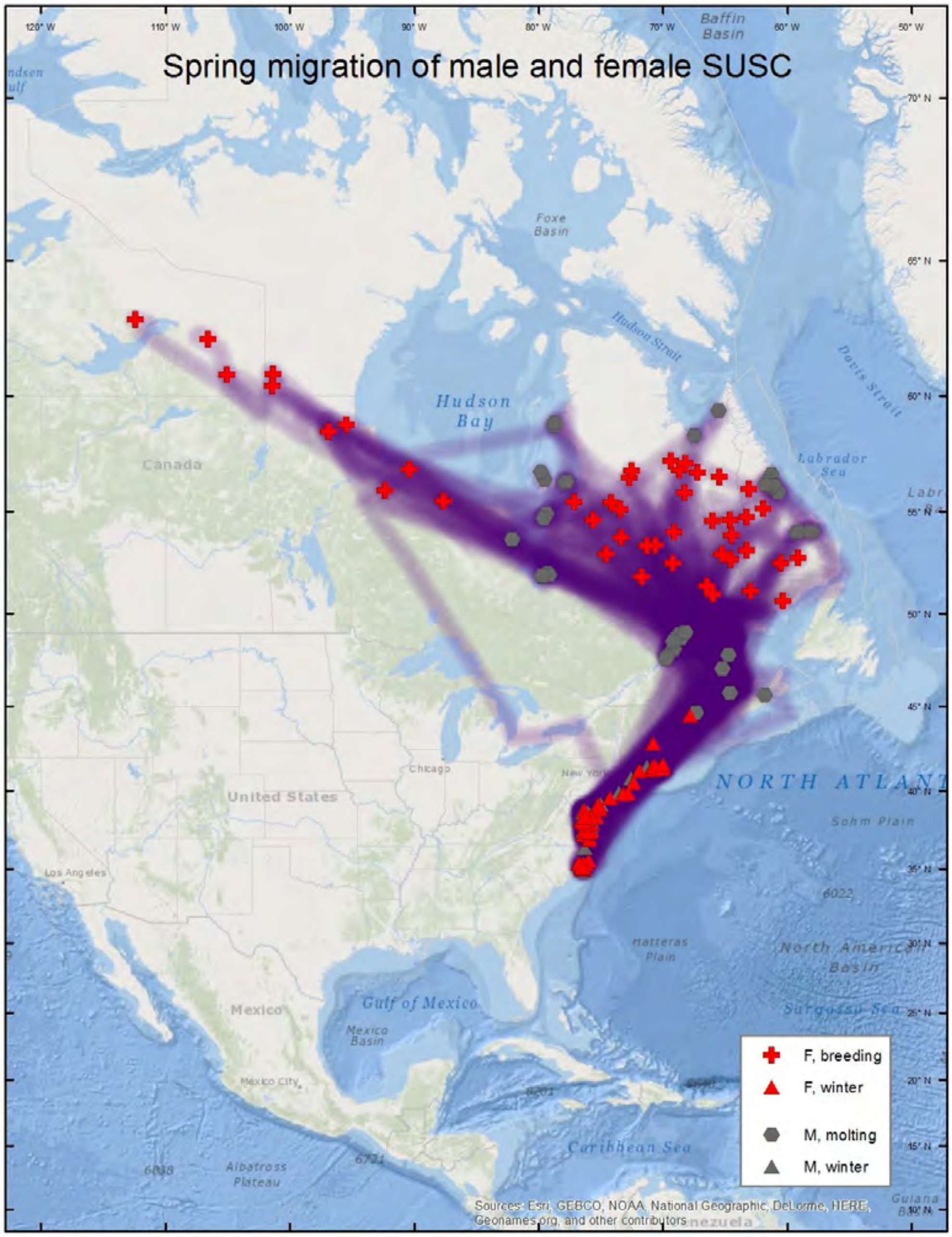


Figure 7. Spring migration routes for 114 adult surf scoters (62 females, 52 males) from wintering areas to breeding areas (females) or molting areas (males). Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 8 December 2014.

Figure 8. Kernel density estimate of spring staging areas for 47 surf scoters (22 females, 23 males, 2 unknown sex) marked during winter along the Atlantic coast or during fall staging in the St. Lawrence Estuary, Quebec. Numbers reflect unique animals that contributed to the map. Map includes staging location data through 8 December 2014.

Breeding areas

Our sample of marked adult female surf scoters indicated that surf scoters apparently breed 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 (Fig. 7) along a line just to the south of the breeding area identified for black scoters (Figs. 1, 3 and 17). Surveys completed in eastern Canada confirmed that surf scoters are breeding on 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

Molt locations were identified for 33 adult male surf scoters (excludes any males tagged during molt) (Figs. 7 and 9). 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 on molt location in 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 which transmitted more than one year, almost 90% returned to the Estuary to molt and stage during 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 further south to wintering areas (Fig. 9). 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 (see Fig. 7) and molted in James Bay was tracked for two fall migrations and used the Atlantic coastal route to return to the wintering area in both years (Fig. 9).

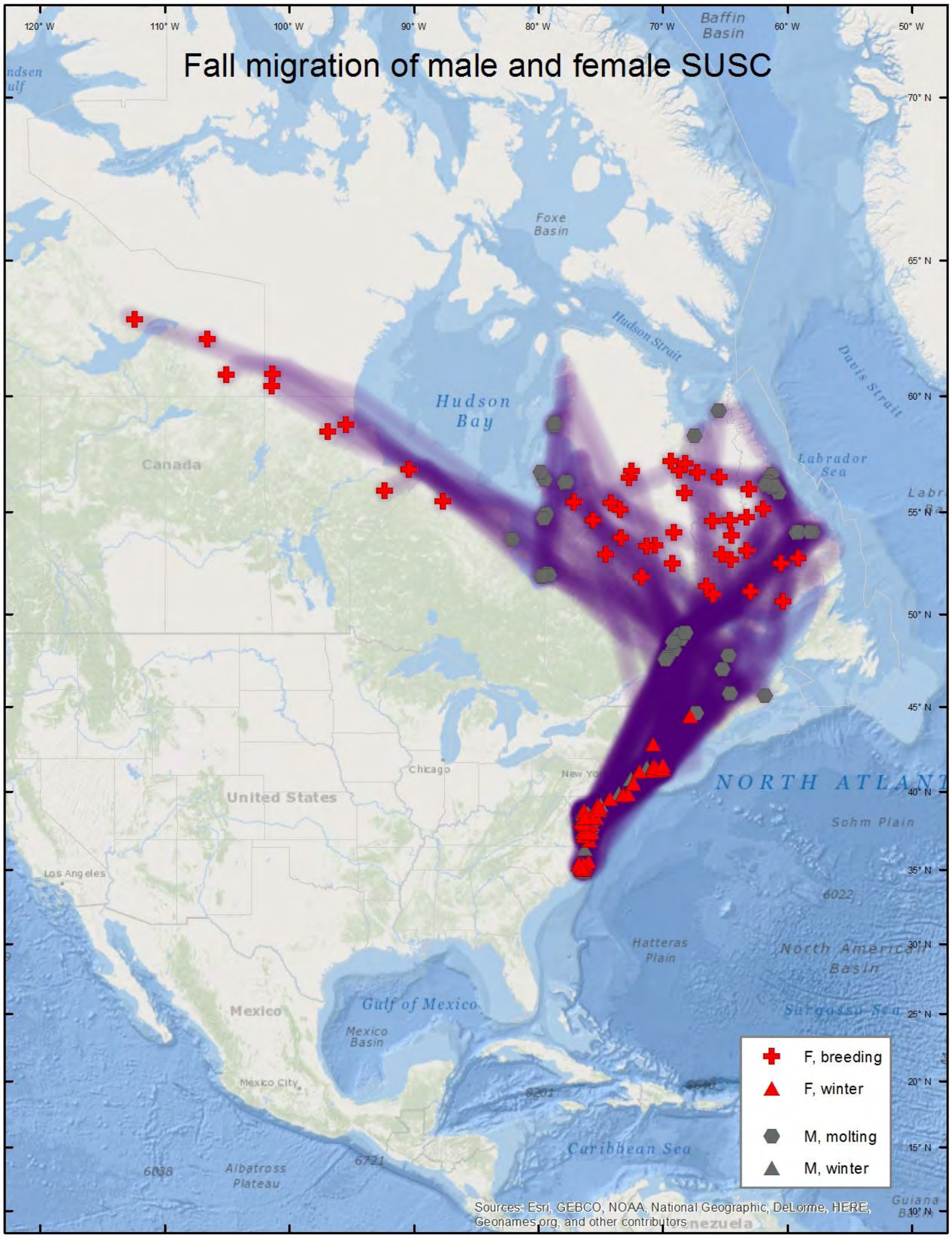


Figure 9. Fall migration routes for 114 adult surf scoters (62 females, 52 males) from breeding/molting areas to wintering areas. Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 8 December 2014.

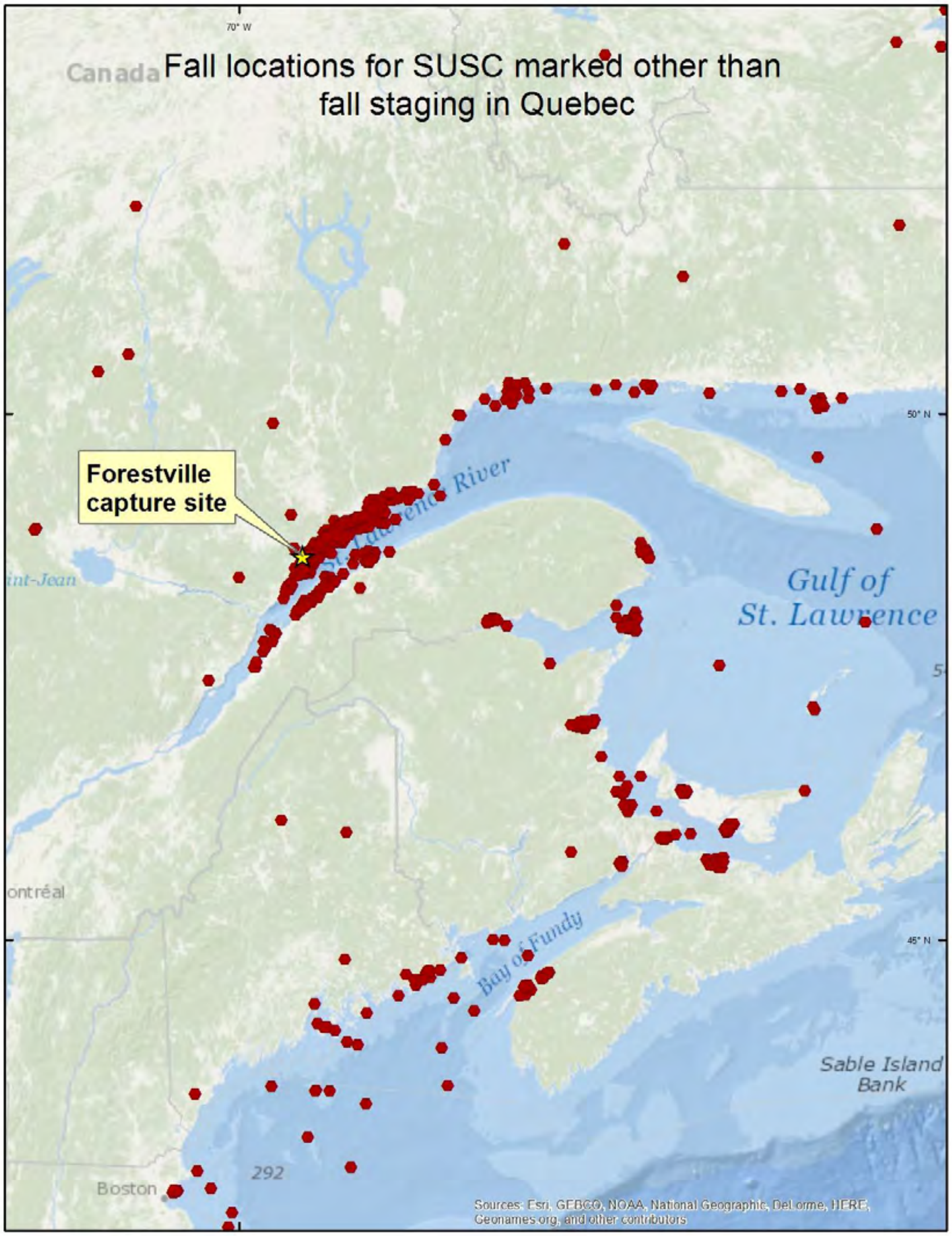


Figure 10. Fall staging locations for 60 adult surf scoters (14 females, 46 males) that were marked at wintering areas along the Atlantic coast (n = 53) or at molting areas in Labrador (n = 7). Numbers reflect unique animals that contributed to the map. Map includes all locations through 8 December 2014.

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 excluded winter-marked birds and displayed winter distribution for the surf scoters marked during fall in Quebec, 2012 and 2013, and for surf scoters marked during winter (Fig. 11). The former provides a more representative sample of winter distribution from Maine south to North Carolina.

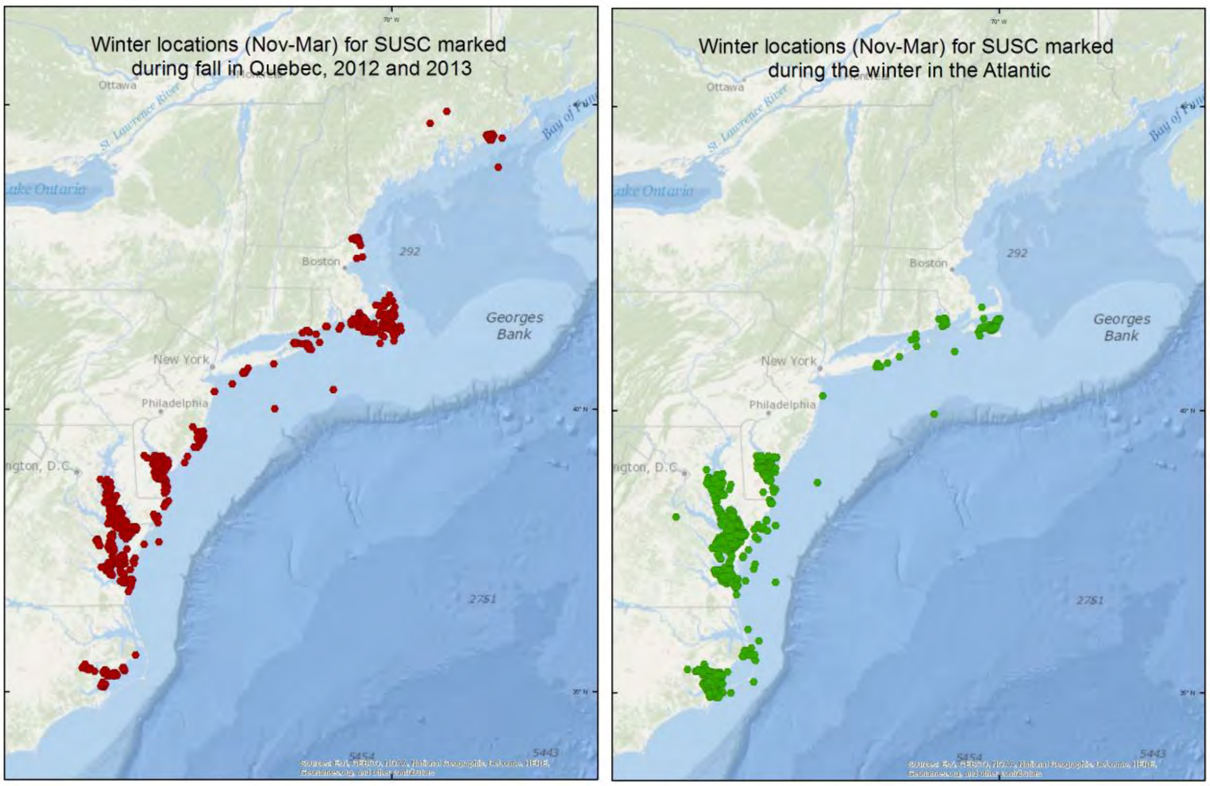


Figure 11. Location of wintering areas for 47 surf scoters (all adult females) marked during fall staging on the St. Lawrence Estuary, Quebec, 2012 and 2013 (left) and 48 surf scoters marked on Atlantic coastal wintering areas (right). Numbers reflect unique animals that contributed to the map. Map includes all locations through 8 December 2014.

An assessment of how representative the Forestville, Quebec sample is of the eastern population

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 site was chosen as an alternative to winter sites as a capture and marking location 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 site thought the Strait of Belle Isle and down over the Madeleine Islands stopping over on 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 (Fig. 11), is similar to the winter distribution of all other tagged birds (Figs. 9 and 11) 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 relatively crude regional scale, relative densities of telemetry locations were roughly comparable to relative densities from the 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 suggest that Newfoundland and Nova Scotia account for 3% and 6% of the eastern North American harvest of surf scoters, 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 the fall.

Overall, the winter locations of females tagged in Forestville appear to be representative of the winter distribution of surf scoters along the east coast of the United States. However, harvest data, and the migration pattern of 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.

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 (Fig. 12).
2. Northumberland Strait and St. Lawrence Estuary both appear to be key bottleneck areas for surf scoters during spring and fall migration, and 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.

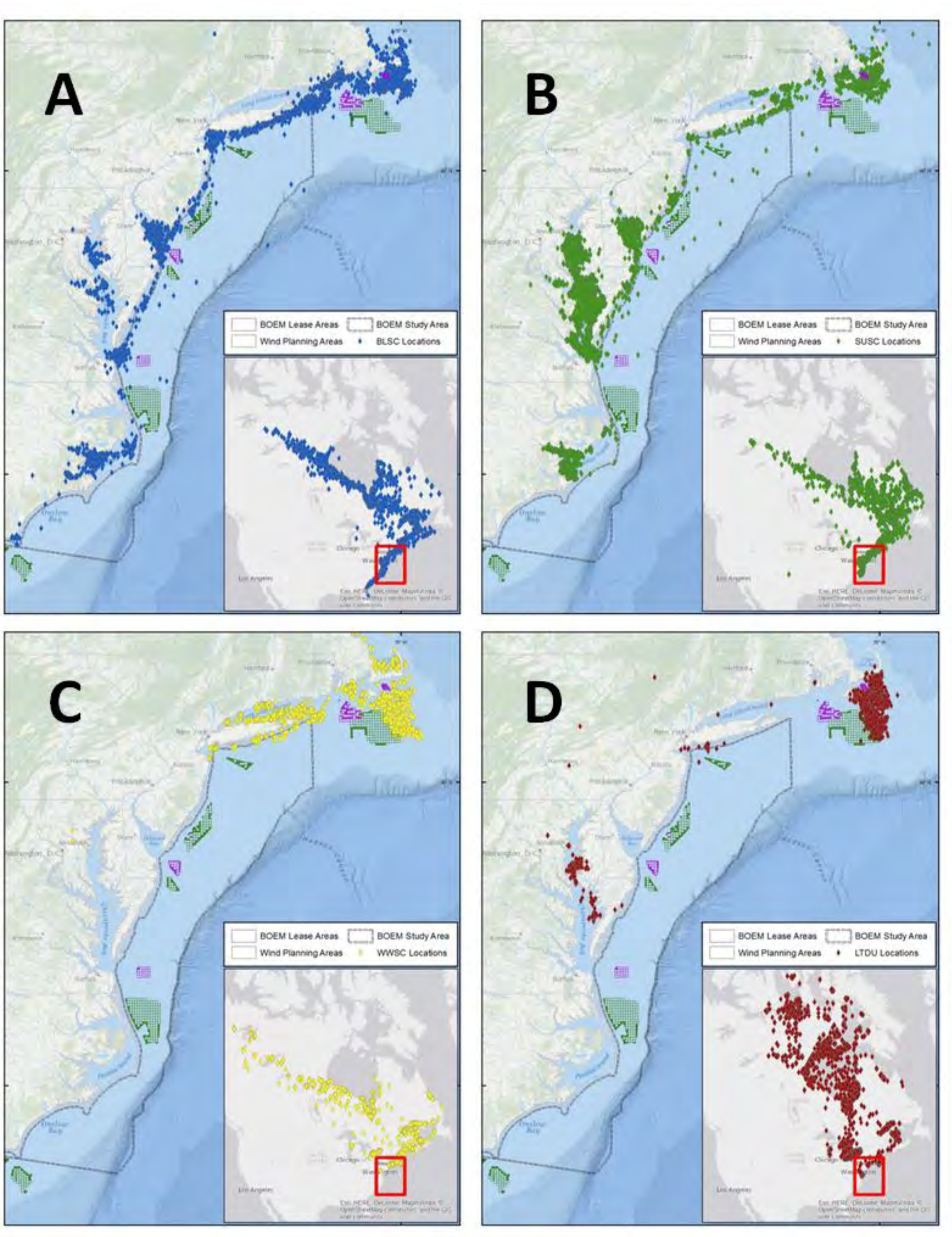


Figure 12. Best quality locations per duty cycle for (A) Black Scoter, (B) Surf Scoter, (C) White-winged Scoter, and (D) Long-tailed Duck during winter and migration through the proposed mid-Atlantic wind energy lease areas. Disclaimer: Caution should be used in identifying patterns or drawing conclusions from maps. More formal data interpretation regarding bird use relative to WEAs will be conducted for the Bureau of Ocean Energy Management and peer reviewed manuscripts.

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 ranges, 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), Saco Bay, Scarborough (ME), Newport (RI), Long Island Sound (NY), and Lake Ontario, Ontario, Canada.

Although the sampling design for this study calls for marking a representative sample of each target species throughout their range, initial attempts to capture white-winged scoters on wintering areas have been difficult due to low numbers and densities of accessible birds, restricted winter distribution, and poor knowledge of local distribution during winter. The capture effort in the St. Lawrence Estuary was part of a separate but complementary CWS study, but results are included here to provide additional information about their distribution, although it was recognized that any inference may apply only to the population of white-winged scoters that molt in this area. Although we are still exploring ways to capture and mark white-winged scoters on wintering areas, one alternative may be to mark on known molting areas. 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.

Lead investigators: **Quebec:** Christine Lepage, Jean-Pierre L. Savard, and Scott Gilliland (Environment Canada); **New England and mid-Atlantic coast**: Lucas Savoy (Biodiversity Research Institute), Scott McWilliams (University Rhode Island) 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 involved in work at these sites: **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 2014, 51 white-winged scoters were tagged in eastern North America. Fifteen were tagged at wintering areas or spring migration stopovers along the Atlantic coast and in Lake Ontario and 36 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) and 2012 (n=17). 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 2014 (n=11; 3 hatch year, 6 adult females, 2 adult males); on Lake Ontario, two adult females were captured by mist-netting and marked in March 2013 at Hamilton Harbour, Ontario (Table 5). Finally, during spring staging at Chaleur Bay, New Brunswick/Quebec, two males were tagged and instrumented in 2009 (Table 5). Survival of white-winged scoters (>60 days) is estimated to be approximately 75%; 3 of 18 marked females and 10 of 33 marked males died or were lost (i.e., PTT failure) within the 60-day period following implantation (Table 5).

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) (Fig. 13).

Fall migration routes follow three particular patterns (Fig. 13): 1) presumably direct flights overland 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. coast; and 3) from molting and staging locations to the Great Lakes.

Wintering areas

White-winged scoters generally reach 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 32 marked white-winged scoters (23 males, 9 females) provided locations through at least one complete wintering season. Wintering areas selected by the marked scoters included Newfoundland (St. George's Bay near Stephenville), Nova Scotia (St. Marys Bay and Lyons Ledges), Maine, Massachusetts (Boston, Cape Cod, Martha's Vineyard, and Nantucket), Rhode Island (Narragansett Bay), New York (Long Island), Lake Michigan, and Lake Ontario (Fig. 14). The majority (75%) of white-winged scoters wintered between Massachusetts and Long Island, New York. Of those birds, three males wintered in the Boston area; ten (8 males, 2 females) in the Cape Cod—Nantucket Island—Martha's Vineyard area; and eleven (6 males, 5 females) in the Long Island area; some birds utilized both the Nantucket and Long Island areas. Two adult males arrived in the Cape Cod area in late October, staying briefly (<3 days) and then flew to Lake Ontario where they wintered.

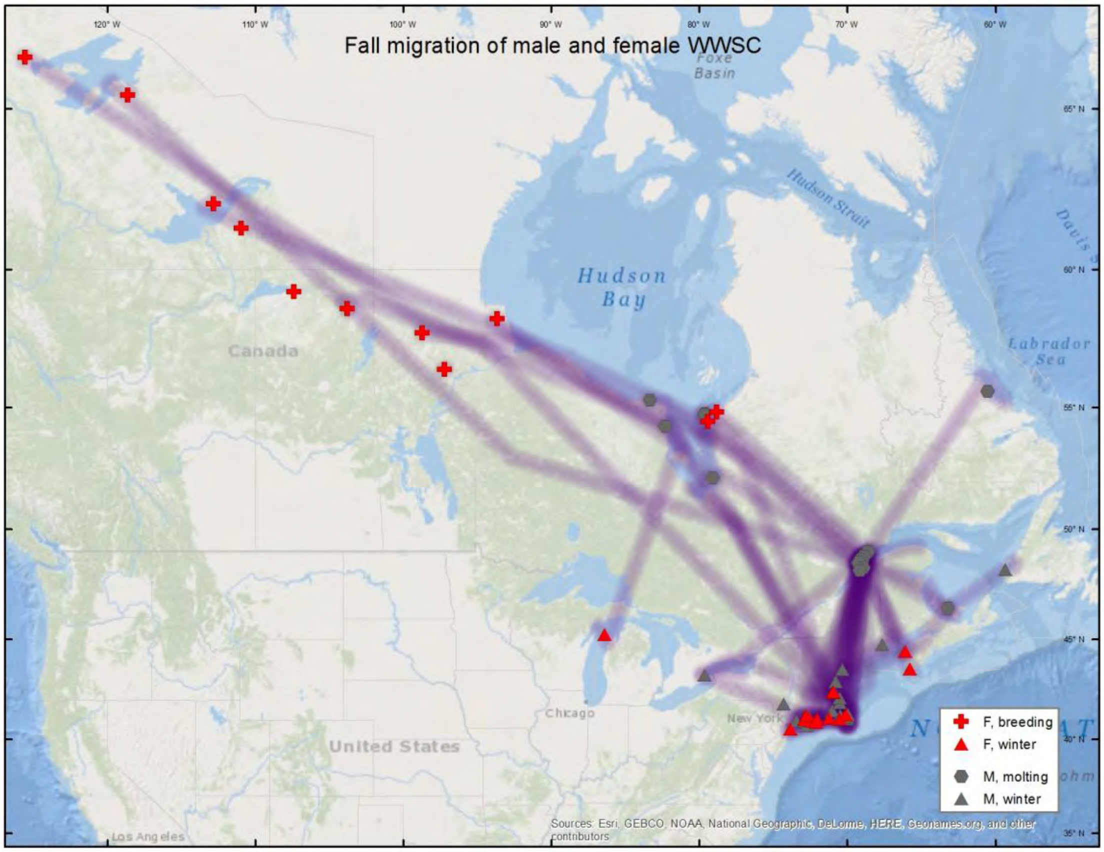


Figure 13. Fall migration routes for 38 white-winged scoters (15 females, 23 males) from breeding/molting areas to wintering areas. Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 8 December 2014.

A few birds changed locations during winter: for example, three white-winged scoters started wintering near Nantucket Island (Nov to Jan) then moved to Long Island (Feb to mid-March), returning again to Nantucket (mid-March to mid-May). One female moved 250 km from Newburyport, MA (Dec and Jan) to Belfast, ME (Feb to mid-Apr). 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 two females wintered at the southern end of Nova Scotia.

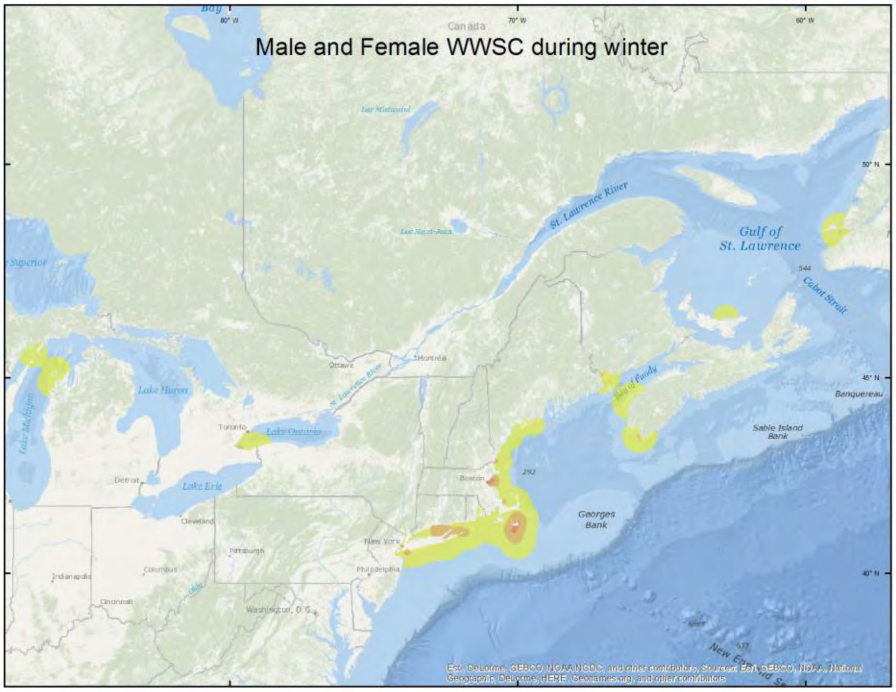


Figure 14. Kernel density estimate of wintering areas for 36 white-winged scoters 21 males, 15 females marked on wintering or molting areas in St. Lawrence estuary (n = 27), along the Atlantic coast (n =8), or on Lake Ontario (n=1). Numbers reflect unique animals that contributed to the map. Map includes wintering location data through 8 December 2014.

The majority of tagged white-winged scoters exhibited high 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.

Spring migration

During spring migration, white-winged scoters that wintered along the Atlantic coast (Fig. 14) 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 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.

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 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 breeding site in NWT.

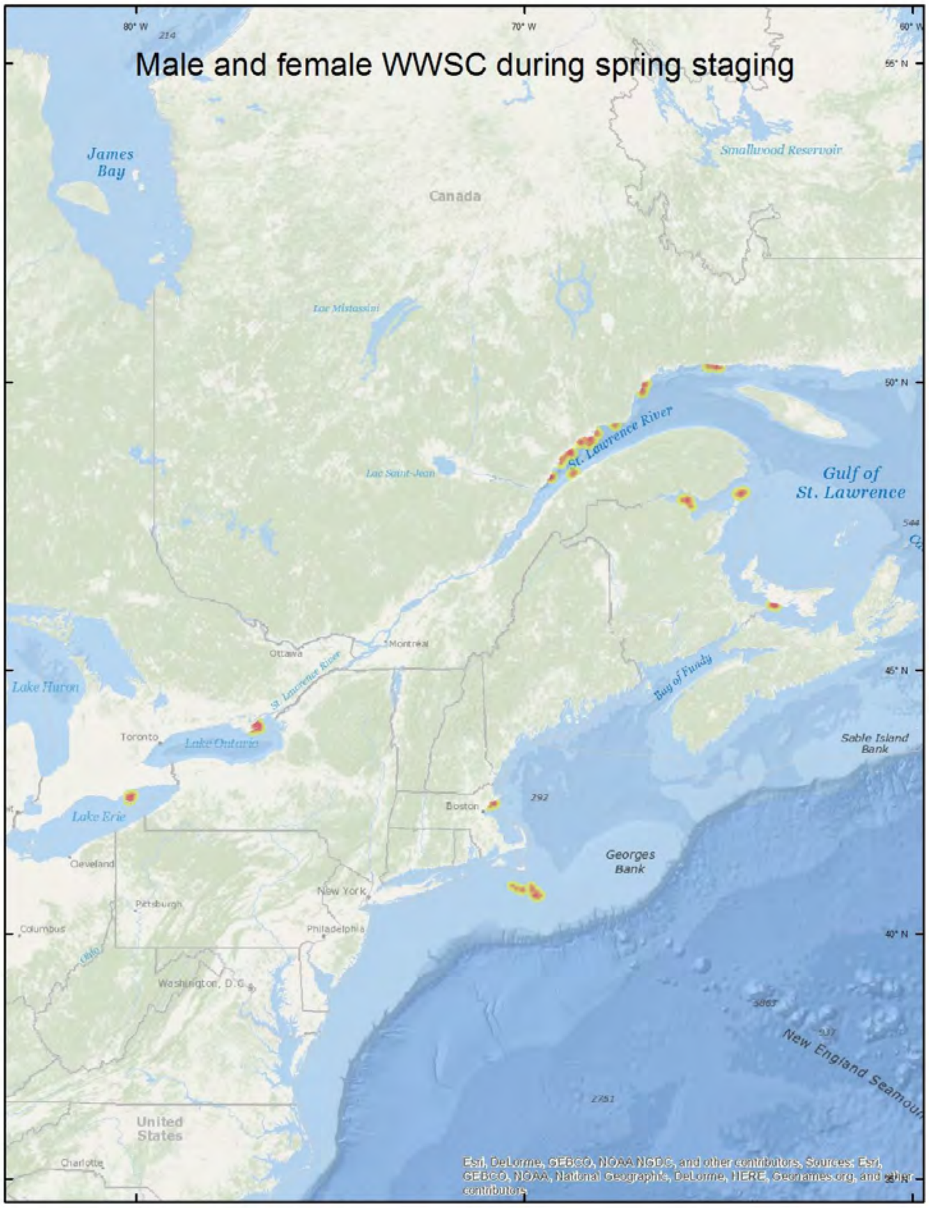


Figure 15. Kernel density estimate of spring staging areas for 19 White-winged Scoters (8 females, 11 males) marked during winter along the Atlantic coast or during molt in the St. Lawrence Estuary, Quebec. Numbers reflect unique animals that contributed to the map. Map includes staging location data through 8 December 2014.

Breeding areas

A total of 32 (20 males, 12 females) of the 51 (63%) marked white-winged scoters provided location data during at least one full breeding period, and 19 (37%; 7 males, 12 females) traveled to potential breeding locations. Most white-winged scoters arrived on their 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 to the St. Lawrence Estuary in spring, where they remained until fall.

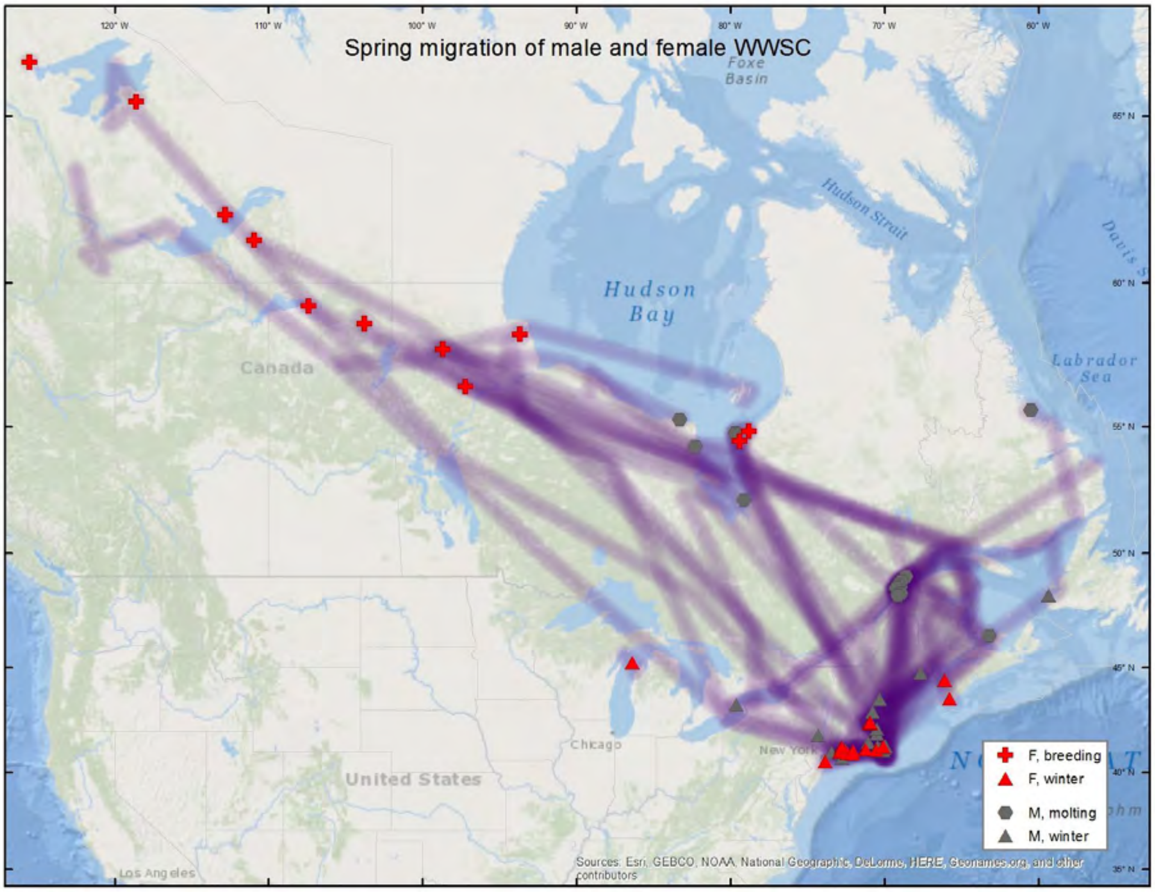


Figure 16. Spring migration pattern for 38 adult white-winged scoters (15 females, 23 males), most of which (n=31) were marked when molting at Forestville, Quebec in 2011-2013. Numbers reflect unique animals that contributed to the map. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all relevant locations through 8 December 2014.

Twelve white-winged scoters (9 females, 3 males) provided locations of potential breeding sites during their first potential breeding season following implantation of the transmitters. Potential breeding sites for all white-winged scoters were located in the Northwest Territories (Great Bear Lake and Great Slave Lake), northern Saskatchewan and Manitoba, northwestern Ontario (location provided by a male), and Northern Quebec (inland northeast James Bay) (Figs. 16 and 17), along a line parallel and just to the south of the breeding area identified for black scoter (Fig. 3). For birds with more than one breeding season data, and which did not travel to a breeding location during their first breeding season, six (3 males, 3 females) provided potential breeding locations in the second breeding season, and one (male) in its third breeding season. Five individuals (3 males, 2 females) provided potential breeding locations for two consecutive breeding seasons.

The two females that provided breeding locations for two breeding seasons used the same breeding site (one near Great Bear Lake, and the other near the Great Slave Lake, NWT), 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.

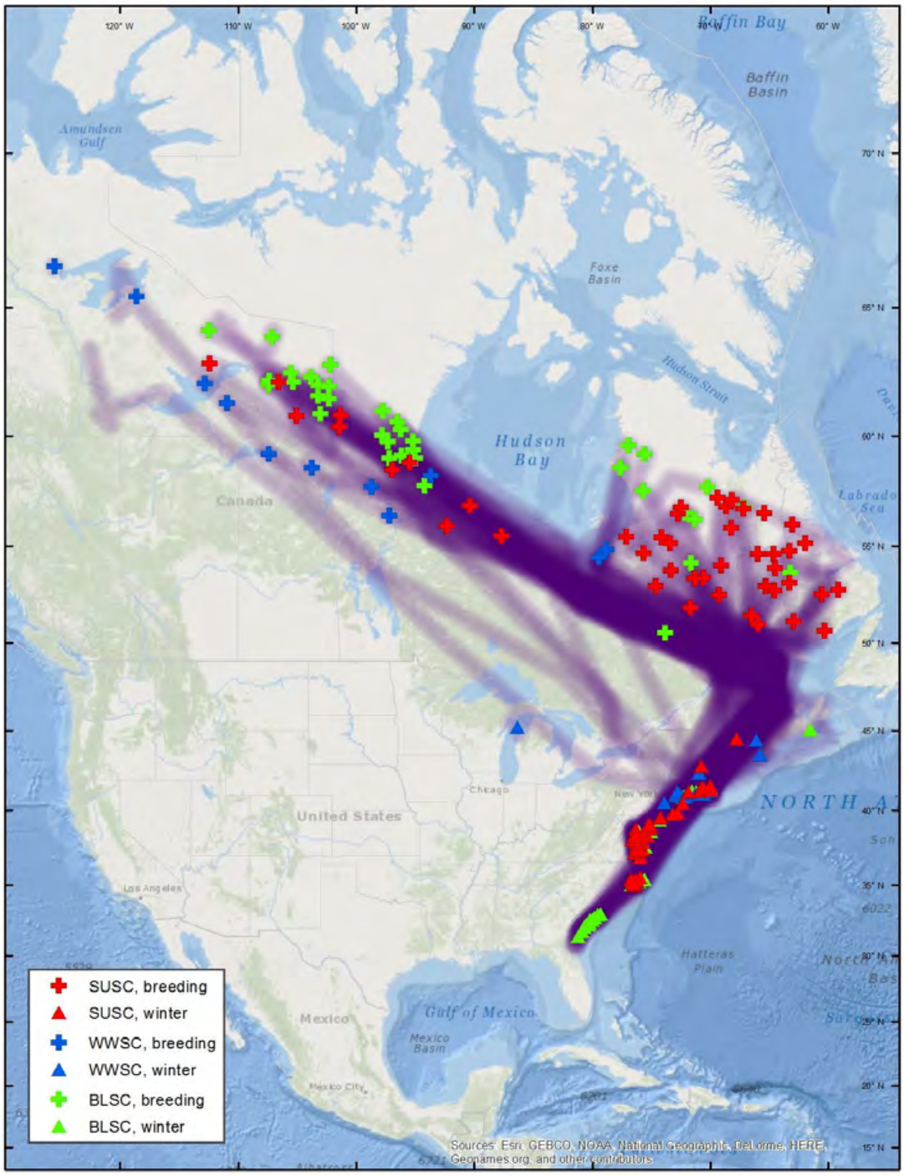


Figure 17. Spring migration routes from breeding areas (females) to wintering areas for black scoter, surf scoter, and white-winged scoter. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 8 December 2014.

Molting areas

Nineteen marked white-winged scoters 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 (Figs. 13 and 16). A few individuals also molted within the breeding range of marked birds, consisting of the Northwest Territories, Saskatchewan, and Manitoba. One male molted on the Labrador coast during only one molting season.

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 for all three years. Four individuals (all males) provided four years of molt locations: all molted at 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 that staged and molted in the St. Lawrence Estuary, stayed as long as five months in the area (from early June to late Oct), until they began migrating to wintering areas. Non-breeding birds returned to their previous molting location (12/15 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.

Other observations

Most 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 form 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 5000 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 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 the Atlantic and Great Lakes Sea Duck Migration Study was that all three species of scoters showed relatively high levels if 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 is associated with breeding areas in northwest 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 ducks species. We encourage exploratory surveys of the area to determine extent of breeding and relative breeding densities for white-winged scoters.
2. Data suggest that birds molting at a given molting location originate from several wintering and breeding populations and have different migration patterns.

3. We are gathering 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).
    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).
4. White-winged scoters exhibit strong site fidelity to wintering and staging areas, although fidelity to molting areas seems quite variable.

Recommendations for future work on white-winged scoters:

1. Increase effective sample size of PTTs for both females and males. If possible, capture and implant white-winged scoters with satellite transmitters at the most important wintering locations to better ensure a representative sample of the Eastern population (according to the Atlantic coast wintering sea duck survey, 94% of individuals are present in the Cape Cod-Long Island Sound stratum; Silverman et al. 2012).
2. Determine relative densities of birds at the identified breeding, molting and wintering locations.
3. If capture on wintering areas is not possible, and capture at molting sites is the only option, then capture of birds at different molting sites may prove adequate because:
    a. Logistically, capture is easier at molting sites than at wintering areas, and it would be possible to implant large number of birds.
    b. Implanting adult females at molting sites may be a good strategy as it would provide good data the following spring in terms of migration timing. Data also indicate that molting sites include birds from several wintering areas.
    c. Differences in the proportion of females captured each year during molt indicate that the number of molting females captured could be increased by capturing birds later in August or early September.
    d. Birds implanted during molt are more likely to exhibit "normal" spring migration timing chronology than birds implanted in winter, just prior to spring migration.
    e. To ensure the marked sample is representative of the Eastern population, it would be important to locate and mark birds at additional molting sites throughout the range.

Long-tailed Ducks

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

According to the sea duck surveys 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 in Lake Ontario, where numbers of wintering long-tailed ducks have increased there in recent years (Petrie and Schummer 2002). Long-tailed ducks were marked with satellite transmitters at all three areas as part of an effort to mark a geographically representative sample of birds wintering in eastern North America.

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 Canadian Wildlife Service – 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 at 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.

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).

Other partners involved in work at these sites: **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.

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 approximately the first 60 days after implantation and release (Table 6).

Currently it is not clear why long-tailed duck post-release survival is low, but 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 2 weeks following post-surgery release. Two adult long-tailed ducks (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 species of sea ducks (e.g., harlequin ducks [Mulcahy et al. 1999] and scaup [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 migrational pathways are representative of the population. These results show that ducks exhibited similar pathways each year; therefore, we feel that any transmitter/surgery effects may be minimal once birds have survived the immediate post-surgical period.

Spring migration

The majority of the 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 (Figs. 18 and 19). 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 breeding site.

Median departure dates for long-tailed ducks from Lake Ontario were relatively similar among the 3 years of study (Table 2), although departures 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 (Fig. 19) 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.

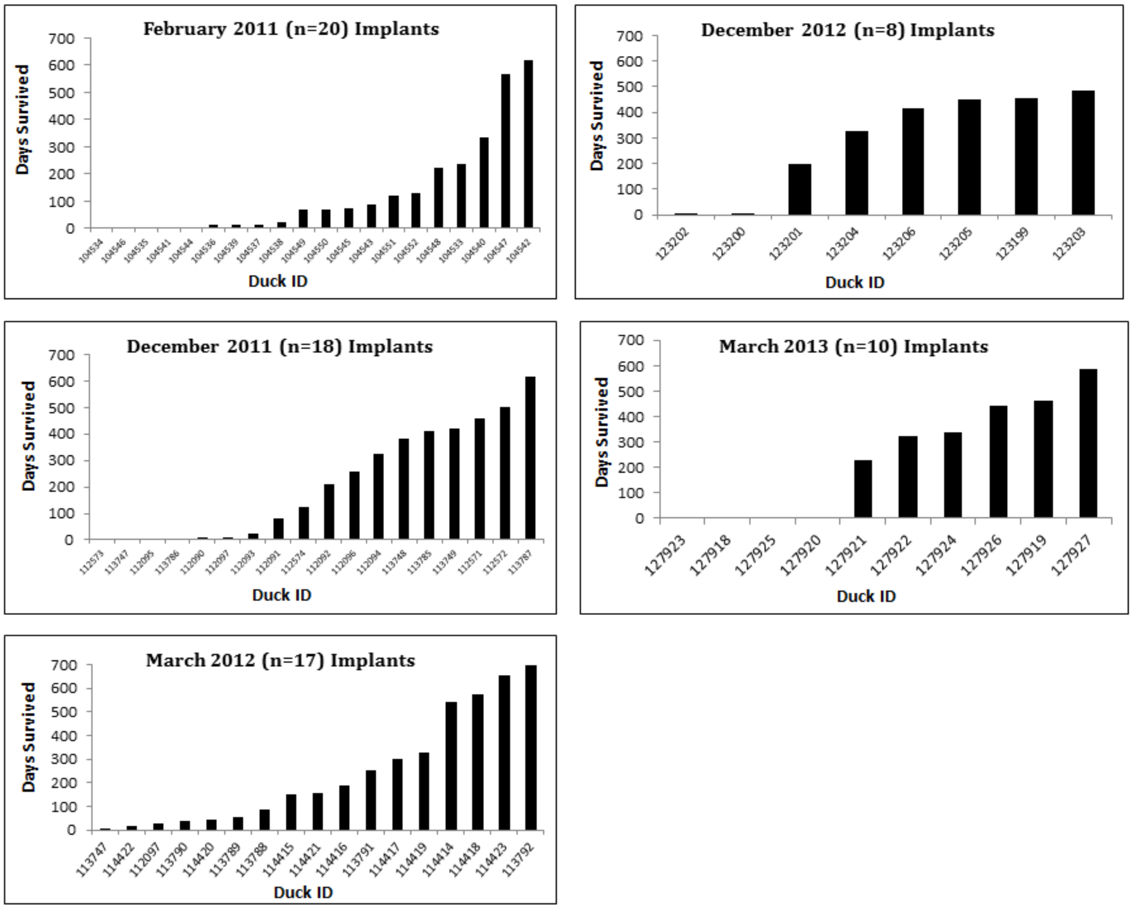


Figure 18. Number of days that long-tailed ducks captured at Lake Ontario survived / transmitted data after being implanted with satellite transmitters.

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 19. Spring staging areas used by adult long-tailed ducks (n = 29 females, 8 males) marked at Lake Ontario.

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 (Fig. 20). 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. 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.

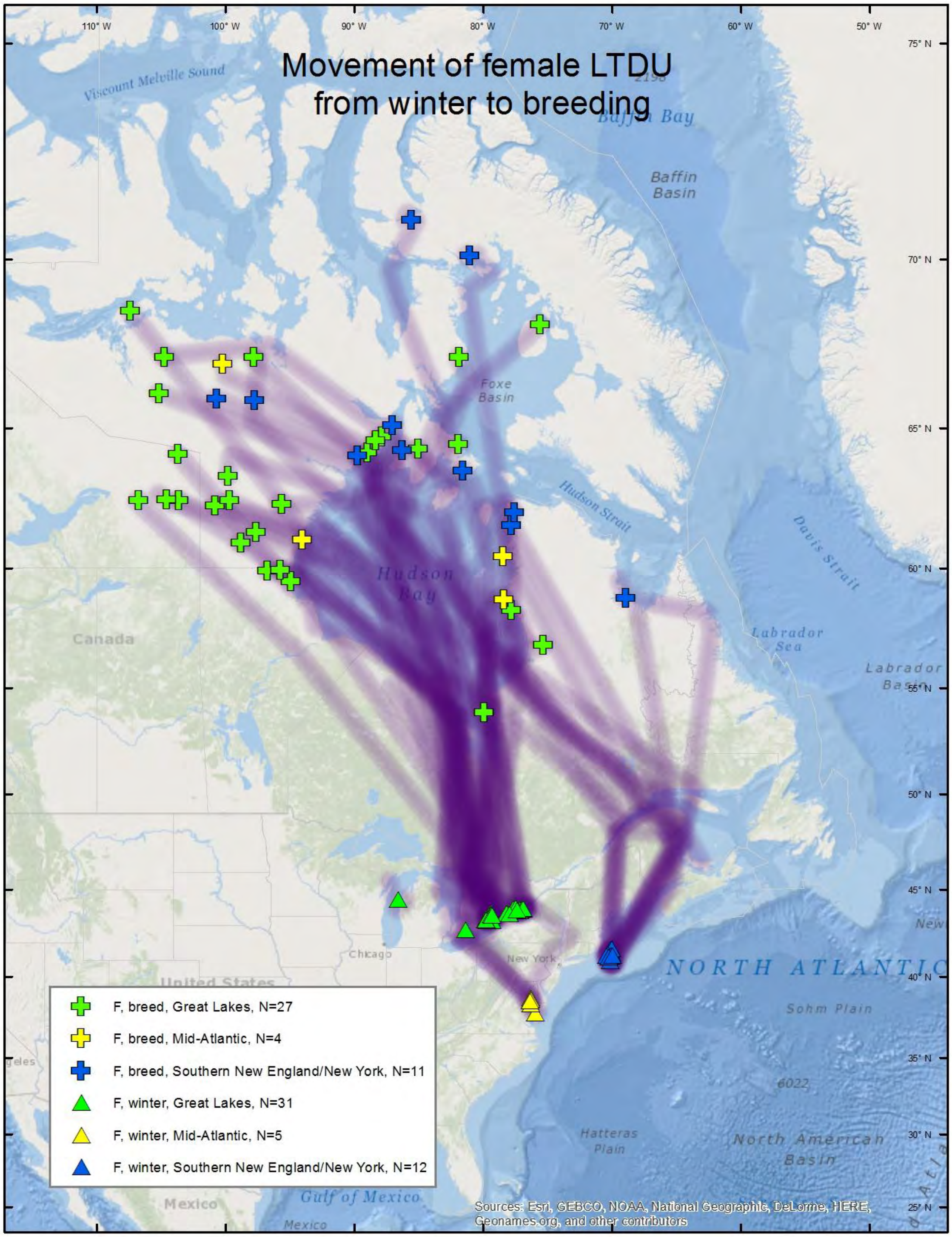


Figure 20. Spring migration patterns for 48 adult female long-tailed ducks marked during winter along the Atlantic coast and at Lake Ontario. Numbers reflect unique animals that contributed to the map. Dashed lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration path. Map includes all locations through 22 October 2014.

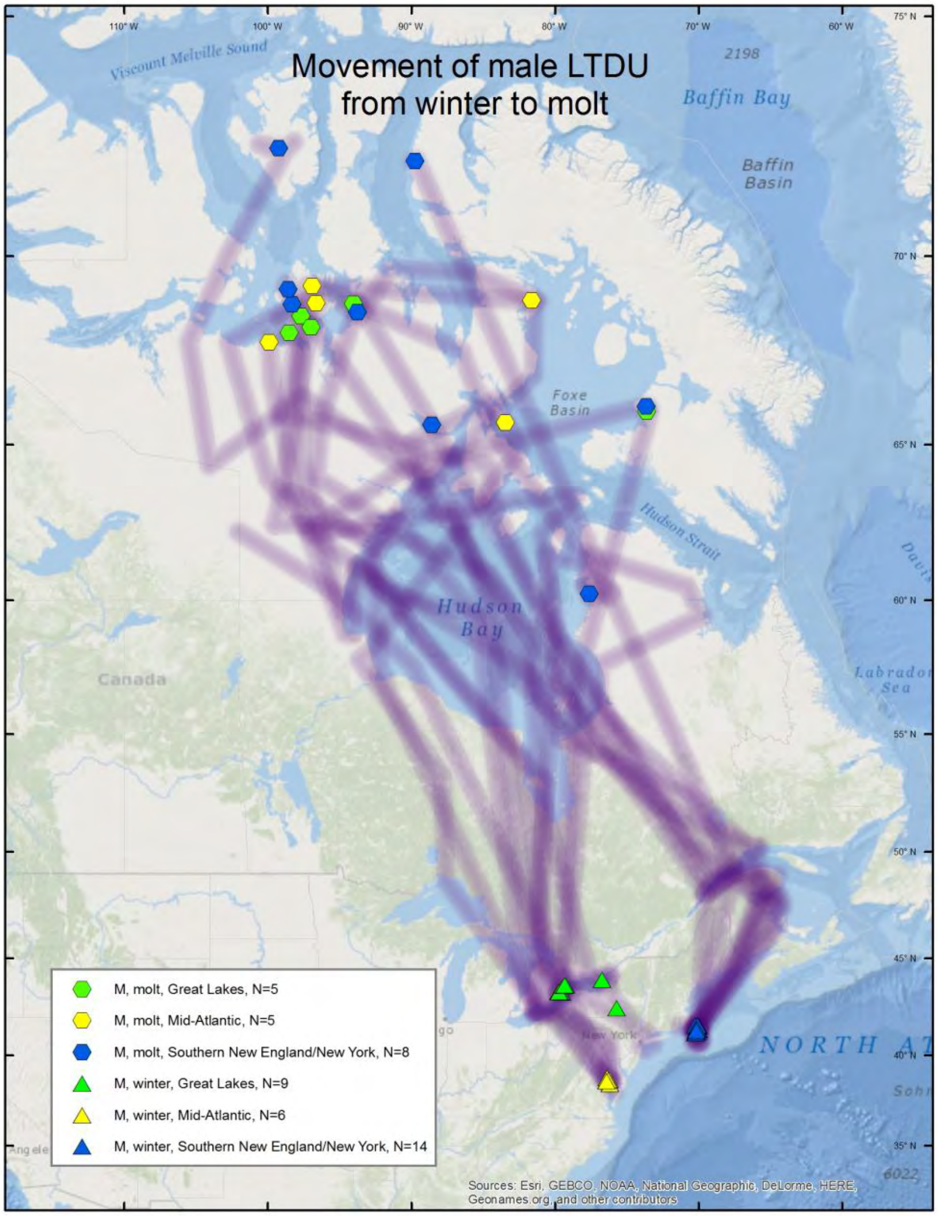


Figure 21. Spring migration patterns for 29 adult male long-tailed ducks marked during winter along the Atlantic coast and at Lake Ontario. Numbers reflect unique animals that contributed to the map. Dashed lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration path. Map includes all locations through 22 October 2014.

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 Lake Ontario once they settle 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 along the

Atlantic coast (Fig. 20). However, sample sizes are small and additional marking would provide additional insight.

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 (Fig. 21). 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 (Fig. 20). There seems to be no apparent difference in pattern of use of molting areas between birds marked at Lake Ontario or the Atlantic coast.

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 (Figs. 22-23), where they staged from 10 days to 2 months before continuing their migration. Long-tails 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 marked at Chesapeake Bay returned to Chesapeake Bay. Most of the Cape Cod/Nantucket ducks flew directly back to the wintering area from the Belchers, 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 back to Lake Ontario to complete wintering prior to spring migration.

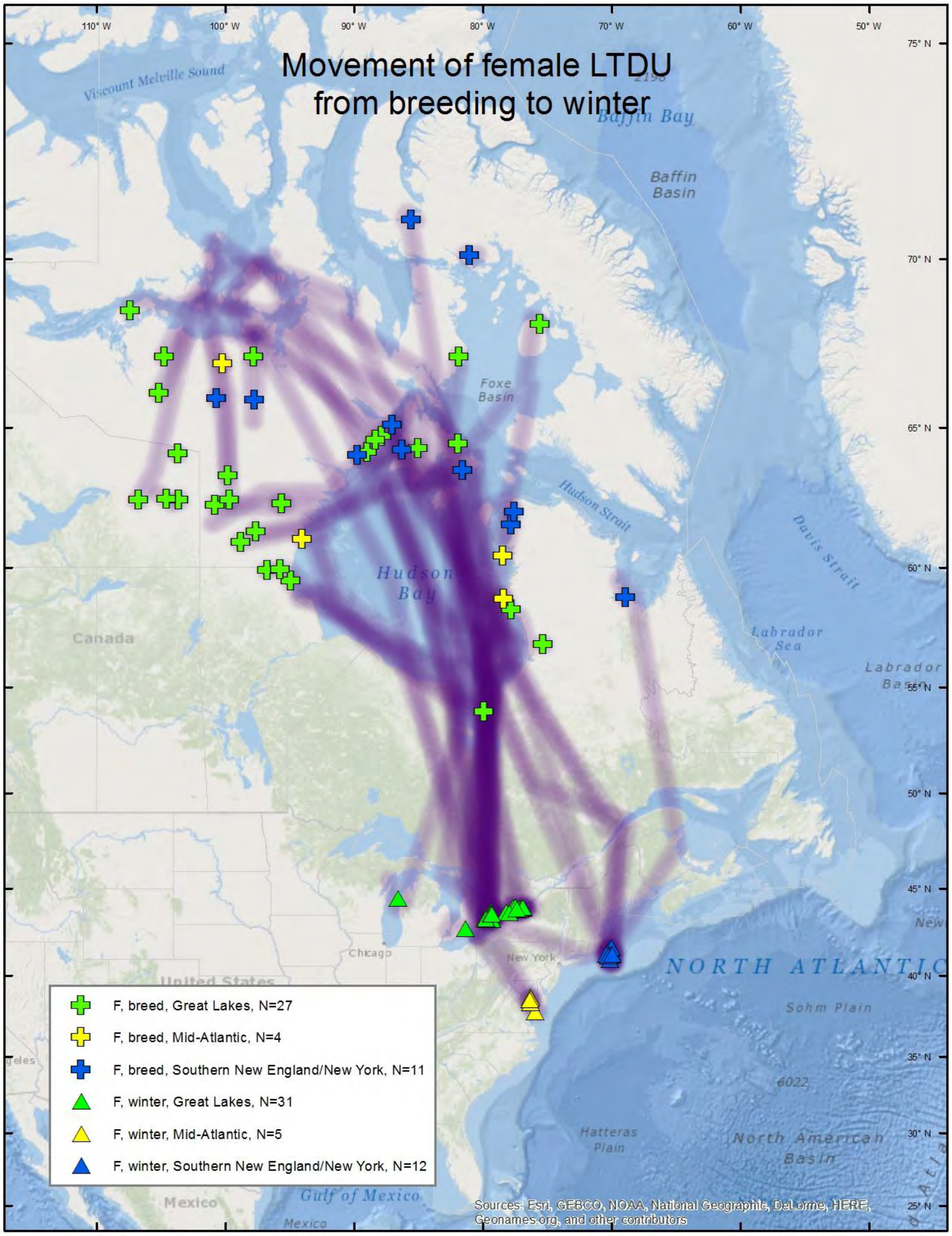


Figure 22. Fall migration patterns for 42 female long-tailed ducks marked during winter along the Atlantic coast and on Lake Ontario. Shaded lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration paths. Map includes all locations through 22 October 2014.

Wintering areas

Both male and female long-tailed ducks exhibited site fidelity to wintering areas. One bird initially marked in Lake Ontario migrated to New York in the fall where it stayed for 2 months before returning to its wintering site Lake Ontario. Also note that there are no locations between the two winter deployment locations of Chesapeake Bay and Nantucket/Cape Cod (Figs. 22 and 23).

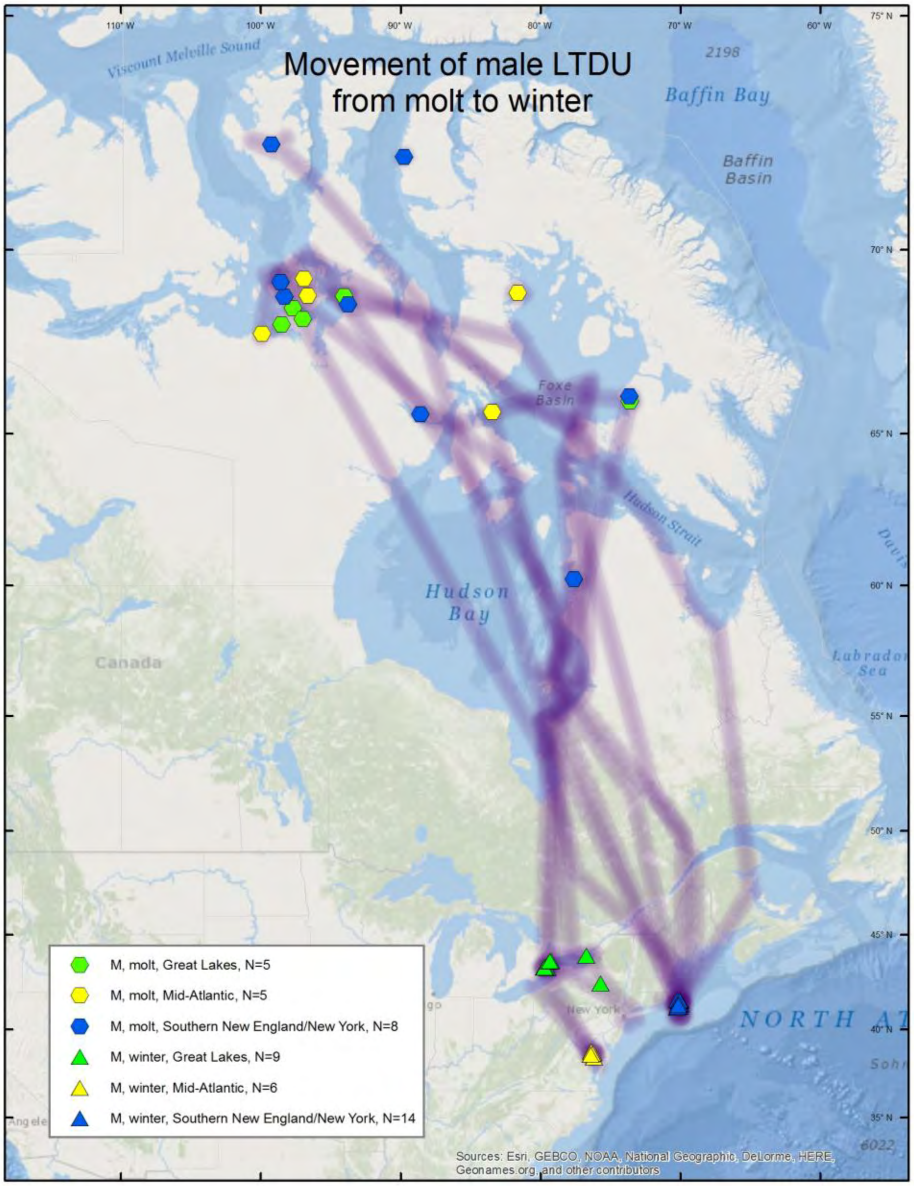


Figure 23. Fall migration patterns for 18 adult male long-tailed ducks marked during winter along the Atlantic coast and on Lake Ontario. Numbers reflect unique animals that contributed to the map. Dashed lines between points represent a direct line between consecutive locations, but do not necessarily represent actual migration path. Map includes all locations through 22 October 2014.

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. While the overall strategy for delineating long-tailed duck populations in eastern North America was based on capturing and marking birds throughout wintering areas, there are long-tailed ducks that winter in northeastern Canada (e.g., Hudson Bay, Hudson Strait, Frobisher Bay), southeastern Canada (e.g., Gulf of St. Lawrence in Quebec, coastal Newfoundland and Maritimes Provinces) and possibly in Greenland, Iceland and the British Isles, that originate from breeding areas in Canada. While overall numbers in these areas may constitute a small proportion of the overall Atlantic wintering population, we should acknowledge that 1) current sampling will 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 eastern Canada or Greenland.

Recommendations for future work on long-tailed ducks:

1. Focus deployment of transmitters in under-sampled wintering areas (Lake Erie, ON; Delaware Bay, New Jersey coastline, Maine, and Nantucket/Cape Cod) to better ensure that the sample is geographically representative of the population.

2. Investigate options for marking wintering long-tailed ducks in the Great Lakes west of Lake Ontario to better ensure that the entire Great Lakes population is represented. A pilot capture effort in March 2015 by Kevin Kenow (USGS) and crew was successful and suggests that capturing and marking long-tailed ducks is indeed feasible in Lake Michigan.

3. Choose birds for implantation that appear to be in the relatively best possible body condition to increase their probability of survival. For those caught in the Chesapeake Bay, the ducks caught later in winter were in the best body condition compared to birds caught earlier in winter. Conversely, ducks captured at eastern Lake Ontario were in better body condition during December captures than ducks captured in western Lake Ontario during March captures.

4. Consider testing newer technologies, such as 5-12 g solar powered backpack transmitters, on captive long-tailed ducks to assess attachment techniques, behavioral response, and transmitter performance. If it works this would reduce the handling time, the need for anesthesia, and reduce the weight of transmitters.

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, and links to maps for all species and all elements of this study, including individual bird maps that are updated daily by seaturtle.org. The site also contains important information for partners, including the most updated study plan, SOPs, equipment lists, generic data recording forms, trapping techniques, and project task lists.

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

Wells-Berlin, Alicia M., Ronald E. Therrien, Timothy D. Bowman, and Keith McAloney. 2011. A Sea Duck Joint Venture Management Board priority: compiling and archiving all satellite telemetry data for landscape scale analyses and monitoring.

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.

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	9-10 March 2011
Spatial and temporal distribution, abundance and flight ecology of birds in inshore and offshore waters of RI	Kris Winiarki	Carol Trocki, Peter Paton, Scott 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,	Carol Trocki, Peter Paton, Jay Osenkowski, Scott McWilliams, Pamela Loring	5th North American Ornithological Conference	Aug 2012
Developing a framework to monitor sea ducks for offshore wind developments	Scott McWilliams	Peter Paton	5th North American Ornithological Conference	Aug 2012

Atlantic and Great Lakes Sea Duck Migration Study	Alicia Berlin	Therrien, Perry, Bowman, Gilliland, Savard, Lepage, Allison, McAloney, McBride, Vormwald, Osenton	Microwave Telemetry Avian and Marine Tracking Conference	March 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
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. Savard, E. Reed, D. Saalfeld and M. Perry	6th North American Duck Symposium	Jan 2013

Synopsis

The study is yielding results that are both interesting and will be useful for management purposes. The study is greatly improving our understanding of migration patterns and range affiliations for sea ducks in eastern North America. Some of the more notable results include:

1. Documentation of a previously unknown major breeding area for black scoters west of Hudson Bay.
2. Confirmation of separate Atlantic and Pacific populations of black scoters.
3. The importance of James Bay for spring and fall staging sea ducks.
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, and the most recent wintering at Lake Ontario.
5. Relatively low fidelity of scoters to molting areas
6. Further documentation of Chaleur Bay and St. Lawrence Estuary as staging areas for large proportions of all species marked so far (exception of Lake Ontario marked long-tailed ducks).

7. Lake Erie may be a key staging area for long-tailed ducks wintering in Chesapeake Bay.
8. Belcher Islands in Hudson Bay appears to be a key stopover for surf scoters during fall and during the spring and fall for long-tailed ducks.

Capture and marking efforts have been highly successful for black scoters, and most objectives have largely been met for this species. The focus has now shifted to the other three species (surf and white-winged scoters, and long-tailed ducks). Efforts to trap these other species of sea ducks along the mid-Atlantic coast fell short of objectives in 2010-2014, and mortality of marked birds has been high. We do not fully understand the reasons for these shortfalls. Mortality of marked surf scoters and long-tailed ducks remains higher than we would like, and calls into question how representative the behavior of surviving birds is relative to unmarked wild birds. Similarly, the strength and accuracy of inferences should be viewed with some caution due to possible transmitter effects.

The SDJV has asked the Harvest Management and Habitat Conservation subcommittees for more explicit guidance about what level of detail (i.e., geographic scale) and precision is necessary to address questions related to harvest management and habitat conservation. Re-evaluation of overall study objectives and sampling plan, including required sample sizes, will continue before and after the each trapping season.

Currently, the plan for 2015 is to 1) mark white-winged scoters and long-tailed ducks at wintering areas in southern New England; and 2) consider a capture effort for long-tailed ducks in Lake Michigan as early as fall 2015.

Capture events are providing biologists with an unprecedented opportunity to collect tissues samples that can be used to examine relationships among populations based on genetics and stable isotopes, screen for diseases, and determine contaminant loads (e.g., mercury). Some of these samples have already been analyzed (e.g., mercury), other samples are being archived for future analyses.

The partnership is growing, and in 2012 a significant new partnership was formed with the Bureau of Ocean Energy Management (BOEM) to deploy additional transmitters in surf scoters along the mid-Atlantic coast (North Carolina, Chesapeake Bay, and Delaware Bay) to better evaluate habitat use and potential risk associated with development of offshore wind energy projects. These two projects have overlapping objectives and are complementary. The SDJV and BOEM have similar needs for data management and synthesis and are jointly funding a database manager and GIS-related support for the SDJV and BOEM sea duck and sea bird telemetry projects.

For more information on this project please visit: http://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study/

Literature Cited

Brook, R. W., K. F. Abraham, K R. Middel, and R. K. Ross. 2012. Abundance and habitat selection of breeding scoters (Melanitta spp.) in Ontario's Hudson Bay Lowlands. Canadian Field-Naturalist 126:20-27.

Canadian Wildlife Service Waterfowl Committee. 2013. *Population Status of Migratory Game Birds in Canada: November 2013*. CWS Migratory Birds Regulatory Report Number 40.

Douglas, D. C. 2006. The Douglas Argos-filter algorithm. Version 7.03. U.S. Geological Survey, Anchorage, Alaska. Available at http://alaska.usgs.gov/science/biologiy/spatial/douglas.html

Douglas, D. C., R. Weinzierl, S. C. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution. doi: 10.1111/j.2041-210X.2012.00245.x

Falardeau, G. and J.-P. L. Savard. 2003. Migration printanière des macreuses sur la Côte-Nord et dans la baie des Chaleurs. Sainte-Foy, Québec, Environnement Canada, Service canadien de la faune, région du Québec**:** 47.

Heath, J., and the community of Sanikiluaq. 2011. People of a Feather. Sanikiluaq Running Pictures.

Hochbaum, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Transactions Seventh North American Wildlife Conference, 1942: 299-307.

Korschgen, C. E., K. P. Kenow, A. Genron-Fitzpatrick, W. L. Green, and F. J. Dein. 1996. Implanting intra-abdominal radio transmitters with external whip antenna in ducks. J. Wildl. Manage. 60:132-137.

Lepage, C., and J.-P. L. Savard. 2013. White-winged Scoter, pp. 167-170 in Lepage, C. and D. Bordage, eds. Status of Quebec Waterfowl Populations, 2009. Technical Report Series No. 525, Canadian Wildlife Service, Environment Canada, Quebec Region, Quebec City.xiii + 243 pp.

Lindberg, M. S. and J. Walker. 2007. Satellite telemetry in avian research and management: sample size considerations. Journal of wildlife management 71:1002-1009. URL: http://www.bioone.org/doi/abs/10.2193/2005-696.

Loring, P. H. 2012. Phenology and Habitat Use of Scoters along the Southern New England Continental Shelf. M.Sc. Thesis, University of Rhode Island. 97 pp.

Loring, P. H., P. W. C. Paton, J. E. Osenkowski, S. G. Gilliland, J-P. L. Savard, S. R. McWilliams. 2014. Habitat Use and Selection of Black Scoters in Southern New England and Siting of Offshore Wind Energy Facilities. The Journal of Wildlife Management 78:645-656.

Mallory, M. L., J. Akearok, N. R. North, D. V. Weseloh, and S. Lair. 2006. Movements of long-tailed ducks wintering on Lake Ontario to breeding areas in Nunavut, Canada. Wilson Journal of Ornithology 118:494-501.

Mather, D. D. and D. Esler. 1999. Evaluation of bursal depth as an indicator of age class of harlequin ducks. Journal of Field Ornithology 70:200-205.

Mulcahy, D. M., D. Esler, and M. K. Stoskopf. 1999. Loss from harlequin ducks of abdominally implanted radio transmitters equipped with percutaneous antennas. Journal of Field Ornithology 70:244-250.

Olsen, G. H., S. Ford, M. C. Perry, and A. M. Wells-Berlin. 2010. The use of Emeraid Exotic Carnivore Diet improves postsurgical recovery and survival of long-tailed ducks. Journal of Exotic Pet Medicine. 19: 165-168.

Perry, M., G. Olsen and A. Wells-Berlin. 2008. Effects of Surgically Implanted Transmitters with Percutaneous Antennae on Breeding Behavior of Captive Lesser Scaup Used as Surrogates for Wild Seaducks. Sea Duck Joint Venture Annual Project Summary #90. http://seaduckjv.org/science-resources/previous-and-ongoing-studies/

Peterson, S. R. and R. S. Ellarson. 1978. Bursae, reproductive structures, and scapular color in wintering oldsquaws. Auk 95:115-121.

Petrie, S. and M. L. Schummer. 2002. Waterfowl response to zebra mussels on the lower Great Lakes. Birding. August 2002:346-351.

Petrie, S.A., S.S. Badzinski, K.R. Ross, and N.R. North. 2006. Great Lakes winter sea duck survey (SDJV #83). Site: http://seaduckjv.org/studies/pro3/pr83.pdf. Sea Duck Joint Venture. 2012.

Rail, J.-F. and J.-P. L. Savard. 2003. Identification des aires de mue et de repos au printemps des macreuses (*Melanitta sp.*) et de l'Eider à duvet (*Somateria mollissima)* dans l'estuaire et le golfe du Saint-Laurent. Série de rapports techniques n° 408. Sainte-Foy, Québec, Environnement Canada, Service canadien de la faune, région du Québec**:** 54.

Sea Duck Joint Venture. 2010. Sea Duck Joint Venture Implementation Plan for April 2012 through March 2015. Report of the Sea Duck Joint Venture. Available at U.S. Fish and Wildlife Service, Anchorage, Alaska and Environment Canada, Sackville, New Brunswick. Also available at http://seaduckjv.org/science-resources/#planningdocuments

Sea Duck Joint Venture Management Board. 2014. Sea Duck Joint Venture Strategic Plan 2014-2018. U.S. Fish and Wildlife Service, Anchorage, Alaska, USA; Canadian Wildlife Service, Sackville, New Brunswick, Canada.

Silverman, E. D., J. B. Leirness, D. Saalfeld, M. Koneff, and K. D. Richkus. 2012. Atlantic coast wintering sea duck survey, 2008-2011. U.S. Fish and Wildlife Service, Laurel, Maryland. 27 pages. Also available at http://seaduckjv.org/pdf/studies/pr109.pdf .

Ware, L. L., B. T. Naumann, P. L. Wilson, S. A. Petrie, and M. L. Schummer. 2013. A lift-net method for capturing diving and sea ducks. Wildlife Society Bulletin 37:877-880.

White, T. P., R. R. Veit, and M. C. Perry. 2009. Feeding Ecology of Long-tailed Ducks Clangula hyemalis wintering on the Nantucket Shoals. Waterbirds 32: 293-299.

Worton, B. J. 1989. Kernel methods for estimating utilization distribution of home-range studies. Ecology 70: 164-168.

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	27	0	3	45
Female deployed	2	6	19	19	2	4	52
Total deployed	**13**	**10**	**19**	**46**	**2**	**7**	**97**
Male lost or died >60d	9	3	0	24	0	1	37
Female lost or died >60d	2	4	15	18	2	3	44
Total lost or died >60d	**11**	**7**	**15**	**42**	**2**	**4**	**81**
Male died <=60d[1]	0	1	0	2	0	2	5
Female died <=60d[1]	0	1	3	1	0	1	6
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	2	5
Female lost or died <=60d	0	2	3	1	0	1	7
Total lost or died <=60d	**0**	**3**	**3**	**3**	**0**	**3**	**12**
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	67	11
% F lost or died <=60d	0	33	16	5	0	25	13
% Total lost or died <=60d	**0**	**30**	**16**	**7**	**0**	**43**	**12**

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 malfunction.

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**	**summer 2006**	**winter 2011**	**winter 2012**	**winter 2013**	**winter 2010**	**summer 2010**	**fall 2012**	**fall 2013**	**TOTAL**
Male deployed	0	0	1	5	7	0	16	12	12	4	6	15	2	0	7	1	1	0	0	89
Female deployed	1	4	0	0	0	4	5	7	4	0	3	0	1	1	4	0	0	26	53	113
Total deployed	**1**	**4**	**1**	**5**	**7**	**4**	**21**	**19**	**16**	**4**	**9**	**15**	**3**	**1**	**11**	**1**	**1**	**26**	**53**	**202**
Male still transmitting	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	0	0	0	0	6
Female still transmitting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	14	17
Total still transmitting	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**14**	**23**
Male lost or died >60d	0	0	1	2	5	0	10	8	9	3	1	7	1	0	2	1	0	0	0	50
Female lost or died >60d	1	3	0	0	0	4	2	1	3	0	0	0	1	1	0	0	0	13	17	46
Total lost or died >60d	**1**	**3**	**1**	**2**	**5**	**4**	**12**	**9**	**12**	**3**	**1**	**7**	**2**	**1**	**2**	**1**	**0**	**13**	**17**	**96**
Male died <=60d[1]	0	0	0	1	1	0	5	4	3	1	2	7	0	0	1	0	1	0	0	26
Female died <=60d[1]	0	1	0	0	0	0	2	3	1	0	3	0	0	0	1	0	0	4	16	31
Male lost <=60d[2]	0	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	5
Female lost <=60d[2]	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	6	16
Male lost or died <=60d	0	0	0	2	1	0	6	4	3	1	3	8	1	0	1	0	1	0	0	31
Female lost or died <=60d	0	1	0	0	0	0	3	3	1	0	3	0	0	0	1	0	0	13	22	47
Total lost or died <=60d	**0**	**1**	**0**	**2**	**1**	**0**	**9**	**7**	**4**	**1**	**6**	**8**	**1**	**0**	**2**	**0**	**1**	**13**	**22**	**78**
Male missing data	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Female missing data	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
Total missing data	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
% M lost or died <=60d	0	0	0	40	14	0	38	33	25	25	50	53	50	0	14	0	100	0	0	35
% F lost or died <=60d	0	25	0	0	0	0	60	43	25	0	100	0	0	0	25	0	0	50	42	42
% Total lost or died <=60d	**0**	**25**	**0**	**40**	**14**	**0**	**43**	**37**	**25**	**25**	**67**	**53**	**33**	**0**	**18**	**0**	**100**	**50**	**42**	**39**

[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 malfunction.

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

	Boston Harbor	Chaleur Bay	Lake Ontario	Long Island Sound	Maine	Rhode Island	St. Lawrence River		
ADULT BIRDS (>1 YR OLD)	winter 2013	Apr/May 2009	winter 2013	winter 2014	winter 2011	winter 2010	summer 2010	summer 2012	TOTAL
Male deployed	0	2	0	0	1	1	16	12	32
Female deployed	3	0	2	3	0	0	3	5	16
Total deployed	3	2	2	3	1	1	19	17	48
Male still transmitting	0	0	0	0	0	0	0	1	1
Female still transmitting	0	0	0	1	0	0	0	0	1
Total still transmitting	0	0	0	1	0	0	0	1	2
Male lost or died >60d	0	0	0	0	1	1	11	9	22
Female lost or died >60d	2	0	1	2	0	0	3	5	13
Total lost or died >60d	2	0	1	2	1	1	14	14	35
Male died <=60d	0	0	0	0	0	0	4	2	6
Female died <=60d	1	0	0	0	0	0	0	0	1
Male lost <=60d	0	0	0	0	0	0	1	0	1
Female lost <=60d	0	0	1	0	0	0	0	0	1
Male lost or died <=60d	0	0	0	0	0	0	5	2	7
Female lost or died <=60d	1	0	1	0	0	0	0	0	2
Total lost or died <=60d	1	0	1	0	0	0	5	2	9
Male missing data	0	2	0	0	0	0	0	0	2
Total missing data	0	2	0	0	0	0	0	0	2
% M lost or died <=60d	0	0	0	0	0	0	31	17	22
% F lost or died <=60d	33	0	50	0	0	0	0	0	12
% Total lost or died <=60d	33	0	50	0	0	0	26	12	19

	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 malfunction.

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				
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**	**TOTAL**
Unk deployed	0	0	0	0	0	0	0	1	0	0	0	1
Male deployed	0	6	0	0	20	3	0	7	11	4	10	61
Female deployed	1	4	10	1	19	22	10	3	3	6	9	88
Total deployed	**1**	**10**	**10**	**1**	**39**	**25**	**10**	**11**	**14**	**10**	**19**	**150**
Male lost or died >60d	0	4	0	0	11	1	0	4	4	1	6	31
Female lost or died >60d	0	0	6	0	9	16	6	2	1	5	4	49
Total lost or died >60d	**0**	**4**	**6**	**0**	**20**	**17**	**6**	**6**	**5**	**6**	**10**	**80**
Unk died <=60d	0	0	0	0	0	0	0	1	0	0	0	1
Male died <=60d	0	2	0	0	7	1	0	3	6	2	4	25
Female died <=60d	1	3	3	1	7	6	0	1	2	1	4	29
Male lost <=60d	0	0	0	0	2	1	0	0	1	1	0	5
Female lost <=60d	0	1	1	0	3	0	4	0	0	0	1	10
Unk lost or died <=60d	0	0	0	0	0	0	0	1	0	0	0	1
Male lost or died <=60d	0	2	0	0	9	2	0	3	7	3	4	30
Female lost or died <=60d	1	4	4	1	10	6	4	1	2	1	5	39
Total lost or died <=60d	**1**	**6**	**4**	**1**	**19**	**8**	**4**	**5**	**9**	**4**	**9**	**70**
% U lost or died <=60d	0	0	0	0	0	0	0	100	0	0	0	100
% M lost or died <=60d	0	33	0	0	45	67	0	43	64	75	40	49
% F lost or died <=60d	100	100	40	100	53	27	40	33	67	17	56	44
% Total lost or died <=60d	**100**	**60**	**40**	**100**	**49**	**32**	**40**	**45**	**64**	**40**	**47**	**47**

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

Appendix I. Summary of SDJV and partner contributions ($1000s) to the Atlantic and Great Lakes Sea Duck Migration Study, 2010-2014.

SDJV Fiscal	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)
Year		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	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)
Year		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**		

Appendix I (Continued). Summary of SDJV and partner contributions ($1000s) to the Atlantic and Great Lakes Sea Duck Migration Study, 2010-2014.

SDJV Fiscal	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)
Year		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	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)
Year		Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind	
2013	194.24									
2013						12.00	20.85			EC - Canadian Wildlfe 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		

Appendix I (Continued). Summary of SDJV and partner contributions ($1000s) to the Atlantic and Great Lakes Sea Duck Migration Study, 2010-2014.

SDJV Fiscal	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)
Year		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		