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Research Article

Habitat Use and Movements of Common Eiders Wintering in Southern New England

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ABSTRACT Little is known about the habitat use patterns and movement ecology of American common eiders (*Somateria mollissima dresseri*) despite potential negative impacts on habitat and eider populations from anthropogenic sources (e.g., oil spills, hunting, offshore wind energy facilities). We used satellite telemetry to quantify migratory phenology, home range size, winter site fidelity, and resource selection of adult female eiders ($n = 24$) from December 2011 to July 2013 that were captured during winter in southern New England, USA. Eiders spent 39% of their annual cycle in southern New England. In spring, eiders took an average of 16 days (range = 2–47) in 2012 and 20 days (range = 1–61) in 2013 to migrate from wintering grounds to summer areas, whereas the duration of fall migration averaged 47 days (range = 7–115). Eiders exhibited high site fidelity to wintering areas, with 83% of birds with active transmitters ($n = 23$) returning to the study area the following winter (2012–2013). Mean individual core use home ranges on wintering grounds averaged 38.5 km^2 and 95% utilization distributions were 199.3 km^2. Based on habitat selection models, eiders preferred shallow, nearshore waters that had relatively fine sediments and a high probability of hard bottom. We estimated that only 3% of our 6,212-km^2 study area had a high relative probability of use by eiders. Future development (e.g., offshore wind energy developments) should avoid shallow, nearshore waters with hard bottoms preferred by eiders to minimize potential impacts.

KEY WORDS common eider, migration phenology, satellite telemetry, site fidelity, *Somateria mollissima dresseri*, southern New England, winter habitat use.

Knowledge of habitat use patterns and movement dynamics of sea ducks of North America is limited; most information about their winter ecology is from studies on the Pacific Coast (Bowman et al. 2015, Savard et al. 2015). In southern New England, USA, the American common eider (*Somateria mollissima dresserri*) is 1 of 5 sea duck species identified as high-priority for study because of population declines or concerns about harvest or habitat limitations (Sea Duck Joint Venture 2014). In addition, eider populations face potential impacts from a variety of anthropogenic and natural sources including offshore wind energy developments (Langston 2013), aquaculture practices (Žydelis et al. 2006), oil spills (Michel et al. 1998), hunting (Gilliland et al. 2009), and disease (Allison et al. 2015). Numerous offshore wind energy developments are in various stages of development along the northwest Atlantic Coast, including the first active offshore wind energy development in North America: a 5-turbine 30-megawatt (MW) facility off Block Island, Rhode Island, USA that was operational by fall 2016 (Bureau of Ocean Energy Management 2012). Research from existing offshore wind energy developments in Europe suggests sea ducks are vulnerable to displacement from foraging habitats (Bradbury et al. 2014), although such displacement may diminish over time (Petersen and Fox 2007). Further, oil spills in winter have had negative impacts on sea duck populations in the region (Michel et al. 1998); thus, understanding spatiotemporal dynamics of eiders in southern New England is important to recognize the potential impacts of future spills. Finally, thousands of common eider were killed on 12 occasions from 1998 to 2013 by a novel orthomyxovirus (i.e., Wellfleet Bay virus) near Cape Cod, Massachusetts, USA, and knowledge of eider movements could inform disease transmission models (Allison et al. 2015).

The common eider is one of the most abundant sea ducks during winter in northeastern North America (Silverman et al. 2013, Bowman et al. 2015), with 3 recognized subspecies: northern common eider (*S. m. borealis*), Hudson Bay common eider (*S. m. sedentaria*), and American common eider (Goudie et al. 2000). American common eiders demonstrate site fidelity to their wintering areas from Newfoundland, Canada to Rhode Island, USA (Merkel et al. 2006, Bowman et al. 2015).

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Fidelity in winter is influenced primarily by prey abundance in rocky sublittoral substrates in nearshore waters <20 m deep (Guillemette et al. 1996, Larsen and Guillemette 2000) where they consume blue mussels (*Mytilus edulis*), crustaceans, and other benthic invertebrates (Goudie et al. 2000, Varennes et al. 2015). Eiders may undertake short (<2 km) offshore movements to roost farther offshore at night (Mackay 1890, Merkel et al. 2006). Although these past studies provide good baseline information about patterns of winter site fidelity and diet, no previous studies of American common eider have used satellite telemetry to determine their spatially explicit resource use patterns during winter, phenology of migratory movements, and the locations of their breeding sites.

Female eiders are of particular conservation interest because they have greater site fidelity than males (Swennen 1990), and adult female survival, dispersal, and productivity largely govern population dynamics (Petersen and Flint 2002, Coulson 2008). Previous studies suggest wintering movements and habitat use are similar between sexes for common eiders (Spurr and Milne 1976, Guillemette et al. 1993, Systad et al. 2000), and thus, our results likely apply to all American common eiders wintering in southern New England.

Our objectives were to assess the movement dynamics of satellite-tagged adult female American common eider that winter in southern New England to quantify movement patterns throughout the annual and diel cycle; determine site fidelity, core home ranges, and utilization distributions on their winter grounds; identify the biotic and abiotic factors associated with habitat selection during winter; and develop a spatially explicit model of the probability of eider use for all nearshore and offshore waters of southern New England.

STUDY AREA

We conducted fieldwork in continental shelf waters off southern New England from Fishers Island, New York, USA to the western edge of Martha's Vineyard, Massachusetts, including Block Island Sound and Rhode Island Sound (6,405 km^2; Fig. 1). Water depths in our study area ranged from 0 m to 65 m, with approximately 19% of the area $\leq$20 m deep. Rocky reefs and scattered blue mussel (*Mytilus edulis*) beds occurred in nearshore waters $\leq$20 m deep that provide excellent foraging opportunities for eiders throughout southern New England (Ydenberg and Guillemette 1991, Theroux and Wigley 1998, Goudie et al. 2000, Loring et al. 2013). The semi-diurnal tidal range is approximately 1 m (Shonting and Cook 1970) and wave heights are generally 1–3 m (Rhode Island Coastal Resources Management Council 2010). During winter, the average daily temperature between December and March is −0.83°C (1901–2000); in contrast, summer average daily temperature from June through September is 19.1° C (1901–2000; National Oceanic and Atmospheric Administration [NOAA] 2017). This area provides key wintering habitat for numerous seaducks including black (*Melanitta americana*), surf (*M. perspicillata*), and white-winged (*M. deglandi*) scoters (Silverman et al. 2013).

METHODS

We used 1.3×18-m^2, 127-mm mesh floating mist nets surrounded by decoys to capture subadult and adult eiders of both sexes ($n = 139$) during November and December 2011 (Brodeur et al. 2008, Beuth 2013). We determined their age and sex by plumage (Carney 1992), measured body mass with a Pesola spring scale (±5 g) and attached a size 7 United States Geological Survey aluminum butt end band to the tarsus. We selected heavier adult female eiders (1,650–2,120 g) to receive an implantable satellite transmitter because adults would have the highest likelihood to survive (Oppel and Powell 2010) and heavier birds would minimize transmitter load. Veterinarians with prior experience with such surgeries implanted 44-g coelomic-implant Platform Transmitter Terminal (PTT) transmitters equipped with external antenna (Microwave Telemetry Inc., Columbia, MD, USA) into the abdominal cavity of 26 females (Korschgen et al. 1996, Iverson et al. 2006). We conducted all captures and methods with approval of the University of Rhode Island Institutional Animal Care and Use Committee (IACUC Protocol #AN 11-09-004).

We programmed transmitters with 2 different duty cycles: period 1 was set for 4 hours on and 24 hours off for 118 duty cycles (median switch date = 27 Apr 2012, range = 3 Apr–5 May 2012) and period 2 was set for 4 hours on and 96 hours off until the end of the battery life (1–1.5 yr). We excluded data collected during the first 14 days following surgeries to minimize any potential biases in assessments of habitat use patterns and movement dynamics due to surgery (Esler et al. 2000). We used data only from location classes (LC) 3 or 2 with estimated accuracies of <250 m and 250–500 m, respectively (Collecte Localisation Satellites 2011, Loring et al. 2014). We ran a hybrid Douglas-Argos Filter to remove unlikely locations and retained the single location with the highest accuracy from each duty cycle in winter and during migration (Douglas et al. 2012). We produced all maps and analyzed telemetry data using ArcGIS 10.0 (Environmental Systems Research Institute, Redlands, CA, USA).

We assessed the length of time eiders spent on the wintering grounds (within our study area), summer areas (breeding or molting sites outside of our study area), and during migration following methods outlined by De La Cruz et al. (2009) and Beuth (2013). In brief, we defined the length of stay on wintering grounds as the period of time between transmitter deployment and spring departure from the study area for the first winter, and as the period between the fall arrival and spring departure date from the study area for the second winter. We defined fall arrival date as the median date between the first location within the study area and the previous location outside the study area, and spring departure date as the median date between the first location outside the study area during spring migration and the previous location within the study area. We added 1 day to the calculated length of stay to account for eiders that were in our study area for part of their arrival or departure dates.

To compare diurnal and nocturnal locations during the winter of 2011–2012, we followed the methods outlined in

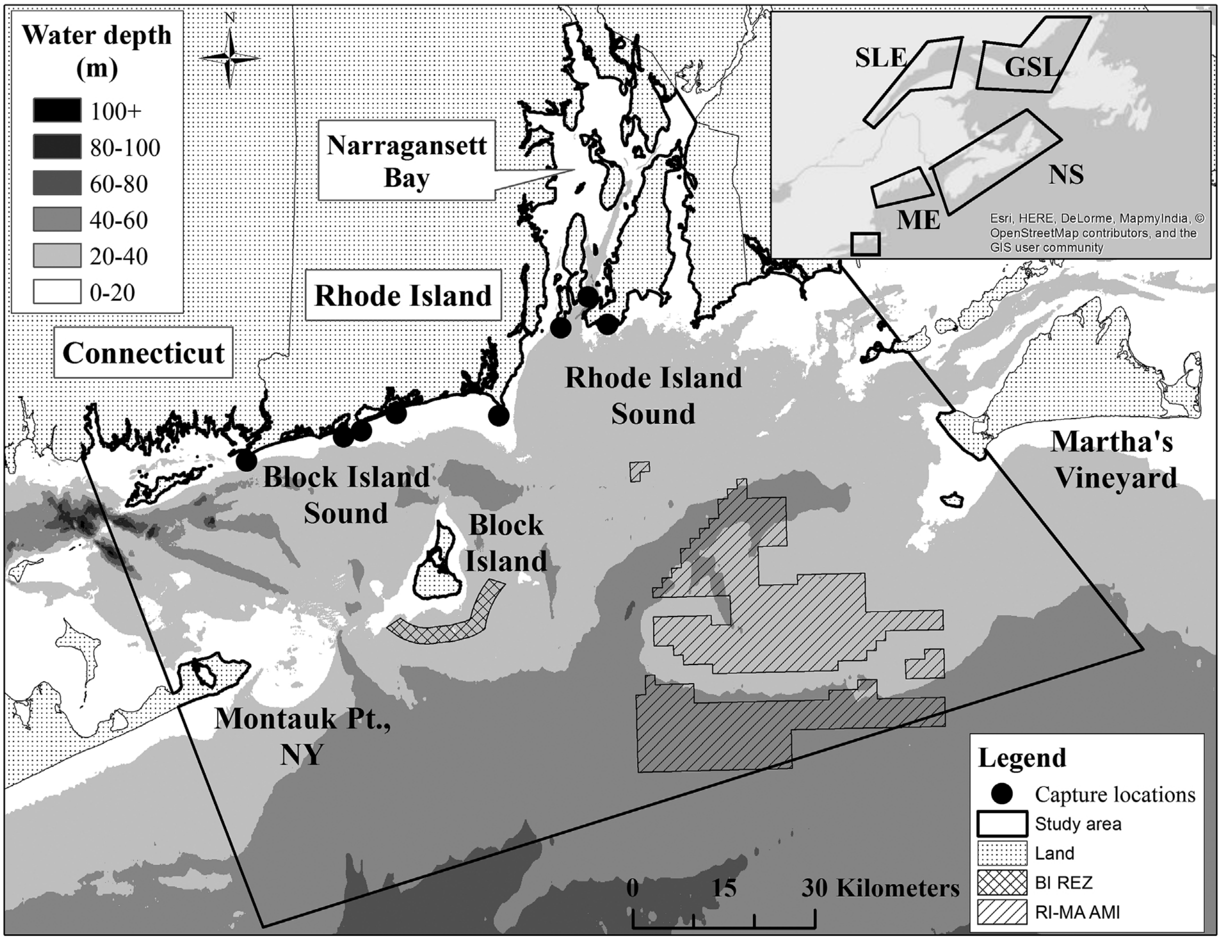

Figure 1. Locations where adult female common eiders ($n = 26$) were captured and implanted with satellite transmitters during November and December 2011 in Rhode Island, USA. The Block Island renewable energy zone (BI REZ) and Rhode Island-Massachusetts area of mutual interest (RI-MA AMI) are depicted. Inset shows areas where eiders were located during summer including Maine (ME), Nova Scotia (NS), St. Lawrence Estuary (SLE), and Gulf of St. Lawrence (GSL).

Beuth (2013). Briefly, we assigned each LC 2 or 3 location to a diel period: dawn (i.e., 1 hr before to 1 hr after official sunrise; U.S. Naval Observatory 2013), dusk (i.e., 1 hr before to 1 hr after sunset), diurnal (i.e., between dawn and dusk), and nocturnal (i.e., between dusk and dawn; Loring et al. 2014). We then averaged diurnal and nocturnal distance to shore and water depth values for each individual bird and used Wilcoxon signed rank tests for paired data to test for differences.

We calculated utilization distributions within our study area by first randomly selecting 50 locations for each individual. We calculated individual kernel utilization distributions with the Gaussian kernel and least squares cross validation bandwidth estimator using Geospatial Modeling Environment (GME; Beyer 2012). We then pooled the 50 locations for individual eiders that spent the entire 2011–2012 winter within the study area ($n = 1{,}050$ locations; 79% were classified as LC 3 and 21% were LC 2) and estimated a composite 95% kernel utilization distribution and 50% kernel core use area. Finally, we calculated the total surface area (km^2) of the individual and composite 95% kernel utilization distributions and 50% kernel core use areas.

We used the composite 95% kernel utilization distributions (available) and 50% kernel core use areas (used) to assess eider habitat selection during winter 2011–2012. We were interested in quantifying habitat selection for the entire diel period; thus, we pooled all locations for this analysis. Following Loring et al. (2014), we used habitat data in raster format to resample 250-m^2 (6.25-ha) cells. To estimate the distance to shore for randomly selected used and available cells, we used Spatial Analyst in ArcGIS to calculate the Euclidian distance (km) of each raster cell to the nearest shoreline (1:24,000, Connecticut Department of Energy and Environmental Protection 2006; range of distance to shore values: 0–10.4 km). We used bathymetry data (NOAA 2012) and sediment size (phi scale) from predictive models of the study area (Poti et al. 2012) to estimate water depth (range = 0–91.3 m) and sediment grain size (range = -1.24 to 4.69), respectively, at used and available cells. To quantify probability of hard bottom, we used a kernel-based probabilistic model of hard-bottom occurrence developed by Loring et al. (2014; range of values = 0–0.77). We calculated the degree slope (range = 0–8) of each raster cell using ArcGIS and the roughness (range = 0.01–2.11) of each cell as the standard deviation of the slope within a 1,000-m radius.

We estimated third-order resource selection (Johnson 1980) by quantifying habitat characteristics within core areas and comparing them to those available within the complete utilization distribution for winter 2011–2012 (sampling protocol A; Manly et al. 2002). The detailed methods for this analysis are outlined in Beuth (2013). Briefly, we used 2,839 points within the available area (17% of total points) and 580 points within the used area (19% of total) to analyze resource selection. We assessed multicollinearity between habitat characteristics by generating variance inflation factors (VIF) and assessed relationships amongst pairs of habitat variables by calculating Pearson correlation coefficients. Correlation between pairs of habitat variables was weak to moderate with all values ≤ 0.619 and VIF values ≤ 2.79. Following Loring et al. (2014), we created generalized linear models with a logit link to generate beta coefficients for the exponential resource selection function (RSF) model (Manly et al. 2002).

We generated 17 *a priori* models using combinations of habitat variables to predict the beta coefficients for the exponential RSF model (Manly et al. 2002) and evaluated relative model fit using Akaike Information Criterion (AIC) values, and selected the most parsimonious of the competing models based on ΔAIC <2 (Burnham and Anderson 2002). We predicted relative probability of habitat use by eiders for 6,212 km^2 of our 6,405-km^2 study area because 193 km^2 of the study area had incomplete spatial coverage of sediment grain size. Within Arc GIS 10.0, we used the geometrical interval function to classify the distribution into 6 equal intervals that partitioned the relative probability of use from unlikely to high (Environmental Systems Research Institute).

To assess the predictive performance of the RSF model, we used a *k*-fold cross validation technique modified by Johnson et al. (2006). To validate the model, we used 10 randomly selected locations from winter 2011–2012 from each individual that were not used to derive individual and composite core use areas or utilization distributions (i.e., test data; Beuth 2013). We removed locations on land and in areas with incomplete spatial coverage, resulting in a mean of 9 (range = 7–10) locations per bird. We conducted a chi-square test on observed and expected proportion of locations within each relative probability of use class. We also used a generalized linear model with a logit link to compare the observed and expected proportions (Johnson et al. 2006). We computed Lin's coefficient of concordance to assess the fit of the RSF model to eider actual use.

To assess site fidelity, we first determined the number of eiders that returned to the study area between the winters of 2011–2012 and 2012–2013. We then determined the number of locations in the winter of 2012–2013 that were within an individual's 2011–2012 core use area (50%) and utilization distribution (95%) using only locations assigned accuracy ratings of LC 3 or 2. We used SAS 9.2 (SAS Institute, Cary, NC, USA) to perform statistical analyses and present mean ± standard error (range), unless otherwise stated.

RESULTS

Two transmitters failed early in the study (after 1 and 39 duty cycles) and were excluded from subsequent analyses. Of the remaining 24 female eiders, all survived for $\geq$12 months, and 17 birds were known to have survived throughout the second winter (Beuth 2013). Overall, we tracked eiders for 545 ± 16 days ($n = 24$), at 196 ± 3 locations, and 89.4% of locations were accurate (LC 3 = 70.9%, LC 2 = 18.5%; Beuth 2013). We documented 3 mortalities: 2 eiders were shot by hunters during winter 2012–2013 and 1 died from severe coelomitis caused by ingestion of a fish hook in late March 2013 (J. R. Ballard, Southeast Cooperative Wildlife Disease Study, personal communication). Six tags ceased transmitting before mid-July 2013 after 157–208 usable locations; temperature sensors indicated normal internal body temperatures during the last duty cycle, which suggests that the transmitters failed.

Movement Chronology

Twenty-one adult females spent the entire first winter (2011–2012) from deployment to spring migration in the study area, with a mean length of stay of 128 ± 3 days (range = 103–152 days; Beuth 2013). During the second winter, 14 eiders remained in the study area for 141 ± 10 days (range = 55–223 days). Mean spring departure from the study area was 4 April in 2012 (range = 17 Mar–13 Apr) and 2013 (range = 18 Mar–20 Apr 2013). Eiders took longer to migrate during fall (47 ± 9 days; range = 7–115 days) than spring 2012 (16 ± 3 days; range = 2–47 days) or spring 2013 (20 ± 5 days; range = 1–61 days). Eiders migrated northward from southern New England to 4 distinct summer areas including Maine, USA ($n = 9$), St. Lawrence Estuary ($n = 4$), Gulf of St. Lawrence ($n = 4$), and Nova Scotia ($n = 4$), Canada; these areas encompass the entire breeding range of this subspecies (Goudie et al. 2000). Mean arrival at breeding areas was 19 April in 2012 (range = 21 Mar–20 May) and 23 April in 2013 (range = 30 Mar–23 May). Eiders spent 168 ± 10 days (range = 93–253 days) on breeding grounds in 2012 and, on average, departed for fall migration on 21 October 2012 (range = 27 Aug–28 Dec). The mean arrival date at the study area was 15 Nov ± 8 days in 2012 (range = 1 Sept 2012–31 Jan 2013).

During winter, 21 eiders averaged 30 ± 2 (13–40) diurnal locations and 42 ± 2 (33–57) nocturnal locations. Eiders were closer to shore during the day; average distance was 0.9 ± 0.1 km for diurnal locations and 1.8 ± 0.2 km (Wilcoxon signed rank test, $P < 0.001$) for nocturnal locations. Water depths at diurnal locations (9.4 ± 1.0 m) were shallower than at nocturnal locations (15.8 ± 1.0 m; Wilcoxon signed rank test, $P < 0.001$).

Habitat Selection During Winter and Site Fidelity

Seventeen eiders had single core use areas (50% kernel) that averaged 38.5 ± 7.9 km^2, whereas 4 eiders had 2 core use areas. Individual utilization distributions (95% kernel) for these 21 eiders averaged 199.3 ± 32.7 km^2. Six of the 21 eiders had a single, continuous utilization distribution, whereas the other 15 eiders had 2–4 separate utilization distributions. For the 21 adult female eiders that spent the entire post-deployment period in the study area, the composite core use area (50% kernel) was 191.2 km^2 and the composite utilization distribution (95% kernel) was

1,042.1 km^2 (Fig. 2). Beuth (2013) presented individual areas and locations of core use and utilization distributions. Three eiders spent an average of 59 ± 17% of the 2011–2012 winter period outside the study area. Core use areas and the utilization distributions for these eiders were 295.2 ± 12.7 km^2 and $1,859.1 \pm 330.8$ km^2, respectively. Two of these 3 eiders had a single core use area, whereas the other eider had 2 separate core use areas.

Eider core use areas were located in areas that were shallower ($\beta = -0.0112 \pm 0.0054$), closer to shore ($\beta = -0.4437 \pm 0.0403$), with a finer sediment grain size ($\beta = 0.4883 \pm 0.0464$), and higher probability of hard bottom ($\beta = 2.8395 \pm 0.2885$) compared to available areas ($\text{intercept} = -2.3075 \pm 0.143$; Table 1).

We used the most supported RSF model to estimate probability of use by eiders for each 250-m^2 cell in the study area. The model with the most support included water depth, distance to shore, grain size, and probability of hard bottom (Table 2). Although models including roughness and slope had some support (i.e., ΔAIC <2), parameters were uninformative (Arnold 2010; Table 2). Validation of the RSF model showed good fit between predictive relative probability of use and actual use ($\chi^2_5 = 0.1607$; $P = 0.9995$, $R^2 = 0.847$). Lin's coefficient of concordance also suggested good fit between predicted relative probability of use and actual use ($\rho_c = 0.919$).

Within the 6,212-km^2 study area, RSF models classified 3,451.5 km^2 (55.6%) as unlikely to be used, 695.1 km^2 (11.2%) as low probability of use, 602.4 km^2 (9.7%) as medium-low probability of use, 650.4 km^2 (10.5%) as medium probability of use, 620.6 km^2 (10.0%) as medium-high probability of use, and 191.7 km^2 (3.1%) as high probability of use (Fig. 3).

Eiders exhibited strong site fidelity in winter; 18 of 20 eiders spent the entire 2011–2012 winter on the study area and returned to the study area in 2012–2013, whereas the other 2 eiders moved to Cape Cod Bay, Massachusetts for the 2012–2013 winter. One of 3 eiders that spent considerable time outside of the study area in 2011–2012 returned to the study area for the 2012–2013 winter. Overall, 19 of 23 eiders that migrated to southern New England returned to the study area for winter 2012–2013. Further, 75.9% (±11.8) of winter 2012–2013 locations were within the winter 2011–2012 composite core use area and 96.4% (±16.0) were within the winter 2011–2012 composite utilization distribution (Fig. 4). Most locations during the

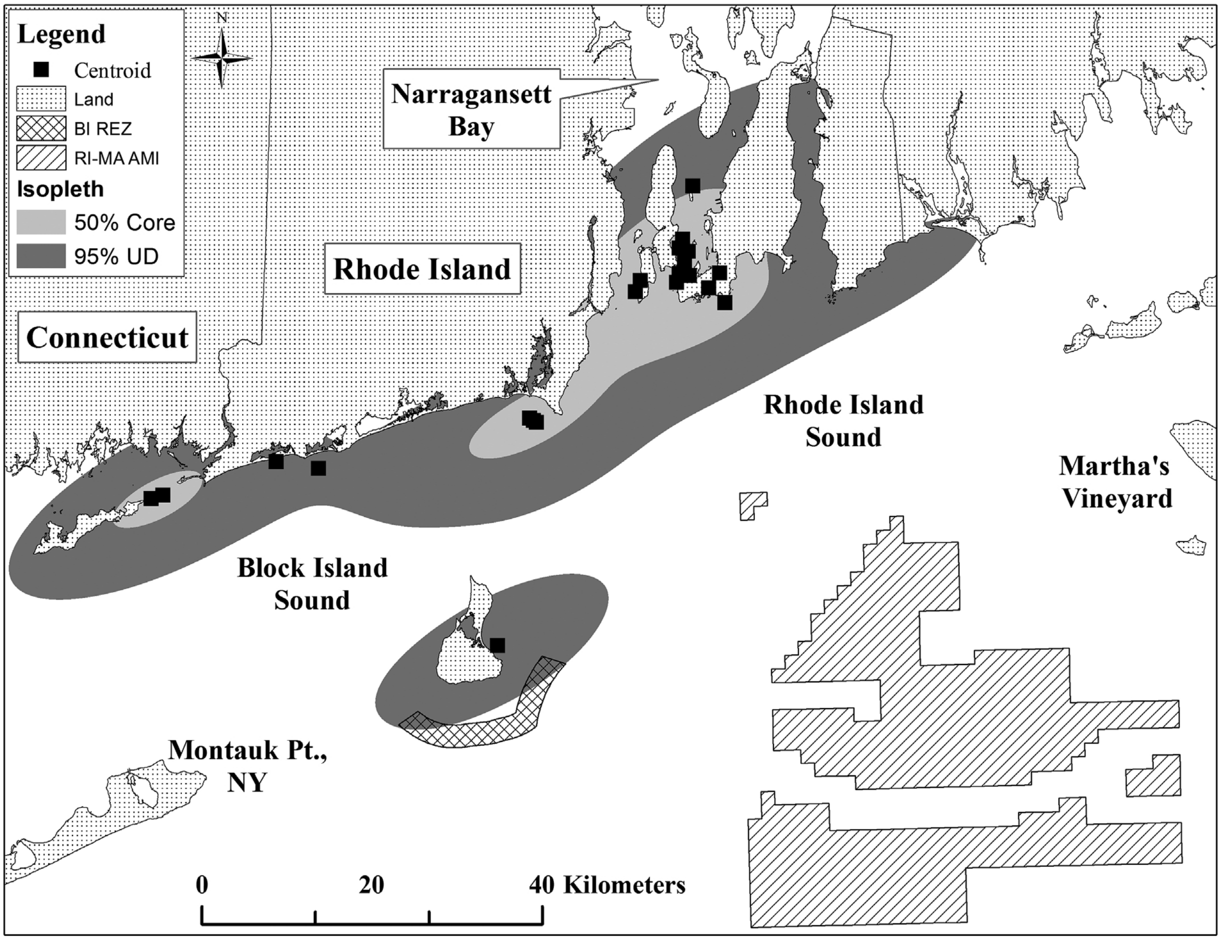

Figure 2. Composite core use area (50% Core) and 95% utilization distribution (95% UD) of 21 adult female common eiders during winter 2011–2012. We implanted eiders with satellite transmitters during November and December 2011 in Rhode Island, USA. Centroids represent the center of each of 21 individual core areas. The Block Island renewable energy zone (BI REZ) and Rhode Island-Massachusetts area of mutual interest (RI-MA AMI) are depicted.

Table 1. Descriptive statistics ($\bar{x} \pm$ SE) for habitat parameters within 95% utilization distributions (available) and 50% core use areas (used) of adult female common eiders in southern New England during winter 2011–2012. Sample size (*n*) is the number of resource units sampled within the composite available and used areas.

	Available			Used		
Habitat variable	$\bar{x}$	**SE**	*n*	$\bar{x}$	**SE**	*n*
Distance to shore (km)	2.94	0.044	3,014	1.57	0.055	580
Water depth (m)	20.38	0.25	3,014	15.45	0.43	580
Grain size (phi scale)	1.34	0.019	2,839	1.76	0.054	580
Hard bottom probability (0–1)	0.2	0.003	3,014	0.3	0.006	580
Slope (degree)	0.53	0.012	3,014	0.7	0.03	580
Roughness[a]	0.33	0.006	3,014	0.42	0.014	580

[a] Roughness of a resource unit is the standard deviation of the slope within a 1,000-m radius.

winter of 2012–2013 were within an individual's winter 2011–2012 core use area (50.6% ± 12.2; $n = 415$ LC 2 or 3 locations) or composite utilization distribution (71.8% ± 16.6).

DISCUSSION

This study provides the first estimates of movement patterns, home ranges, site fidelity, and survival of adult female American common eiders on the Atlantic Coast. Our estimated RSFs and probability of use provide managers with information needed to conserve important marine habitats and make siting decisions for offshore wind energy development and other offshore commercial operations.

Movement Chronology

Eiders spent about 39% of the annual cycle within the southern New England study area, which is comparable to the duration of time spent on wintering areas for other species of sea ducks including northern common eiders in Ungava Bay, Quebec (32%; Savard et al. 2011), black scoters in southern New England (50%; Loring et al. 2014), and king eiders (*Somateria spectabilis*) and Pacific common eiders (*Somateria mollissima v-nigrum*) in Alaska (44% and 40%, respectively; Oppel et al. 2008, Petersen et al. 2012). Eiders that spent the winter in southern New England moved to summer breeding areas throughout the previously reported entire breeding range of this subspecies (Goudie et al. 2000).

The migration chronology that we documented was consistent with that reported by Smith et al. (2015) based on land-based surveys conducted in coastal Rhode Island, and the departure and arrival times of eiders were relatively synchronous regardless of their summer destination. The duty cycles of transmitters in eiders provided relatively few locations during spring and fall migrations; therefore, our estimated durations of migration should be viewed with caution. In general, the average duration of spring migration that we documented (16 days) was shorter, and the fall duration (47 days) longer than estimates from other studies of eiders. For example, northern common eiders breeding in arctic Canada and western Greenland had average spring and fall migratory durations of 27.3 ± 9.8 and 16.1 ± 18.7 days, respectively (Mosbech et al. 2006, Savard et al. 2011).

Eiders migrating between southern New England and northern breeding grounds appeared to use several different routes, although Goudie et al. (2000) suggested that eiders generally migrate along coasts and tend to avoid terrestrial and pelagic routes. Some eiders breeding in the St. Lawrence Estuary, Canada used an overland migration route to migrate to coastal Maine (Gauthier et al. 1976), and Savard et al. (2011) documented eiders flying >1,000 km overwater in Davis Strait between Greenland and northern Labrador, Canada. We observed 1 eider approximately 60 km inland over Quebec that was detected 1 hour later on the eastern shore of the St. Lawrence Estuary. In addition, during the springs of 2012 and 2013, we detected 5 eiders migrating 115–290 km offshore from Cape Cod, Massachusetts to Nova Scotia, Canada (380 km apart). To our knowledge, these are the first documented cases of eiders migrating far offshore during spring migration on the Atlantic coast. The short offshore movements at dusk that we documented in southern New England are similar to those recorded for northern common eiders in Southwest Greenland (Merkel

Table 2. Model selection criteria for logistic regression models used to estimate beta coefficients for an exponential resource selection function for common eiders during winter 2011–2012 in southern New England. Only models with a difference in Akaike's Information Criterion (ΔAIC) <3 are shown. Habitat characteristics used as model parameters include water depth (WD), distance to shore (DS), grain size (GS), relative probability of hard bottom (HBP), roughness (RG), and slope (SL).

Model parameters	No. parameters	ΔAIC	Relative likelihood	w_i[a]
−WD, −DS, +GS, +HBP	4	0.00[b]	1.00	0.40
−WD, −DS, +GS, +HBP, −RG	5	1.48	0.48	0.19
−WD, −DS, +GS, +HBP, +SL	5	1.80	0.41	0.16
−DS, +GS, +HBP	3	2.20	0.33	0.13
−WD, −DS, +GS, +HBP, +SL, +RG	6	2.69	0.26	0.11

[a] Akaike weight.
[b] AIC = 2,675.67.

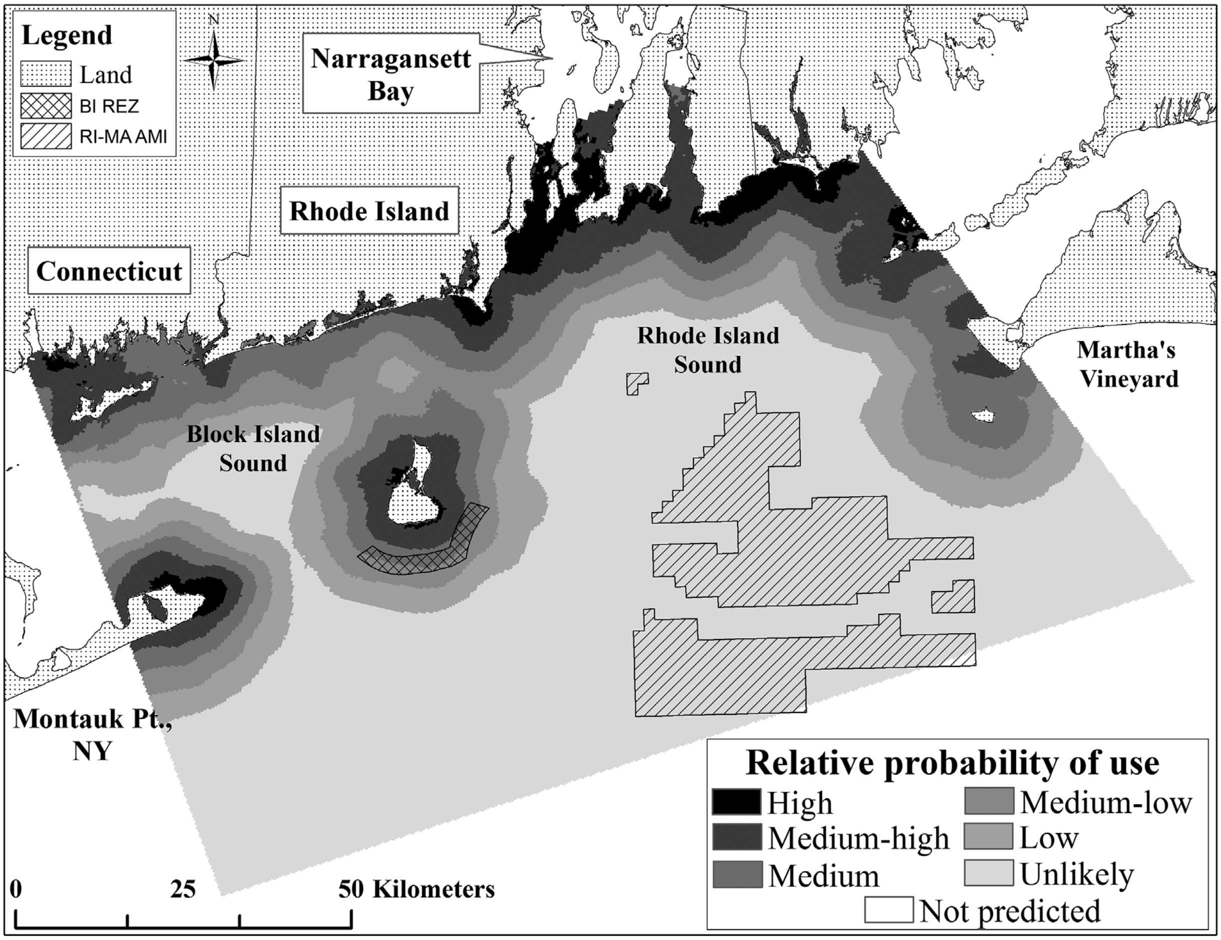

Figure 3. Relative probability of use of nearshore and offshore waters by adult female common eiders during winter 2011–2012 in relation to the Block Island renewable energy zone (BI REZ) and the Rhode Island-Massachusetts area of mutual interest (RI-MA AMI). We derived relative probability from the top-ranked logistic regression model and mapped probability of use using a resource selection function of the β coefficients from the top-ranked model.

et al. 2006). At Nantucket, Massachusetts, Mackay (1890) reported eiders flying offshore to roost at night and returning to nearshore waters at dawn. Smith et al. (2015) recorded eiders flying offshore at dusk; however, they were unable to determine the location of offshore roosts. During capture efforts, we rarely encountered eiders at nearshore capture locations during pre-dawn hours; however at dawn, eiders started to fly inshore apparently from offshore roosts (J. M. Beuth, University of Rhode Island, unpublished data).

Winter Home Ranges and Site Fidelity

Eiders in southern New England were relatively sedentary and had generally smaller core use areas but larger utilization distributions compared to other sea ducks (Merkel et al. 2006, Savard et al. 2011). However, many factors may influence the size of core use areas and utilization distributions of sea ducks during winter such as the inclusion of juveniles in a study, tracking method, transmitter duty cycles, data quality, method of home-range estimation, and the duration of the study (Reed and Flint 2007, Oppel et al. 2008, Loring et al. 2014). Savard et al. (2011) documented core use areas 13% smaller and utilization distributions 276% larger for northern common eider ($n = 1$ adult M, 14 adult F) in Greenland than those in our study. Conversely, despite similar numbers of core use areas, eider core use areas in this study averaged 4.75 times larger and utilization distributions averaged 2.97 times larger than mean core use areas ($8.1 \pm 1.3\,\mathrm{km}^2$) and utilization distributions ($67.8 \pm 8.3\,\mathrm{km}^2$) for northern common eiders ($n = 32$) wintering in southwest Greenland (Merkel et al. 2006). However, Merkel et al. (2006) derived core use areas and utilization distributions from an average of 39 tracking days, which was far fewer than the 128 days we tracked birds. Therefore, caution should be used when comparing these results.

Adult female common eiders during this study exhibited high intra- and inter-annual fidelity to southern New England. Philopatry of adult female eiders to specific breeding areas has been well documented (Swennen 1990); however, to our knowledge we present the first evidence supporting high fidelity of American common eiders to wintering areas. Similarly, Petersen et al. (2012) reported that 18 of 19 Pacific common eiders demonstrated site fidelity and, of those that returned, 95% used the same home range as the previous winter. However, the high levels of fidelity we observed for eiders were greater than those reported for harlequin ducks (*Histrionicus histrionicus*; 62% F and 77% M; Robertson et al. 2000) and black scoters (Loring

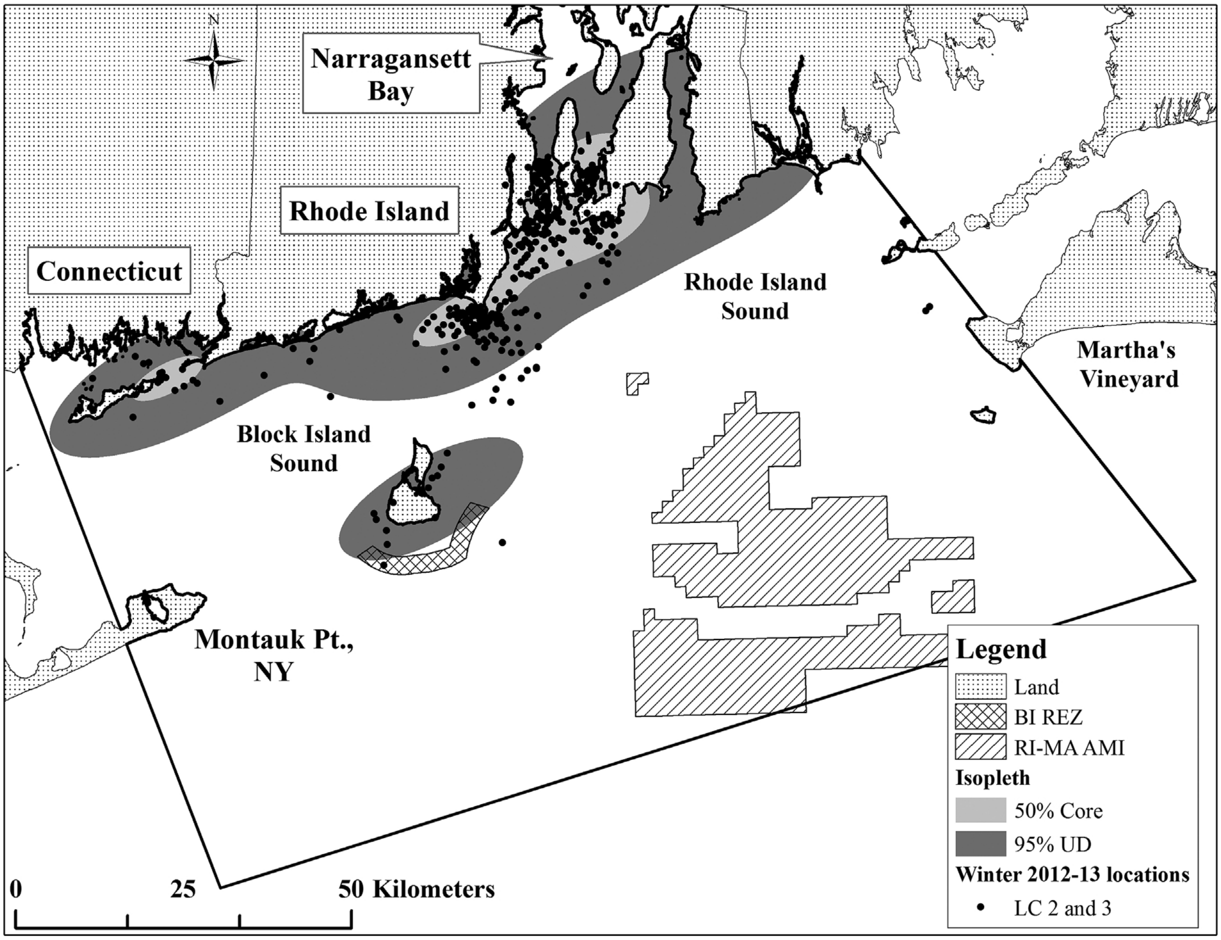

Figure 4. Site fidelity of adult female common eiders to the southern New England wintering areas. We present high quality (location class 2 and 3; LC 2 and 3) point locations of 19 satellite-tagged eiders during winter 2012–2013 overlaid onto the composite utilization distribution (95% UD) and core use areas (50% Core) derived from locations of 21 eiders during winter 2011–2012. The Block Island renewable energy zone (BI REZ) and Rhode Island-Massachusetts area of mutual interest (RI-MA AMI) are depicted.

et al. 2014). Robertson and Cooke (1999) suggest that local knowledge of food resources and predator avoidance may influence high fidelity to wintering areas. In addition, eiders pair relatively early in the wintering period and breeding females have been observed with the same mate in consecutive years (Spurr and Milne 1976). High site fidelity of eiders to their wintering area facilitates early reestablishment of pair bonds and may minimize costs associated with pair bonding and competition (Ashcroft 1976, Spurr and Milne 1976) during winter. Winter already has high energetic demands because of shorter day length resulting in less time foraging and lower temperatures (Beuth et al. 2016*b*).

On the other hand, high site fidelity may repeatedly expose eiders to diseases such as Wellfleet Bay virus, which has killed hundreds to thousands of eiders annually since 1998 on the wintering area in Cape Cod Bay, Massachusetts (Allison et al. 2015). Exposure to disease on the wintering areas is less likely to affect entire breeding colonies because eiders from many breeding areas mix throughout the winter range (Goudie et al. 2000) as we report. However, the transmission of diseases such as Wellfleet Bay virus is not well understood and the potential exists for disease to severely affect large flocks that congregate in certain areas on the wintering grounds.

Survival of Satellite-Tagged Female Eider

Previous studies have suggested implant transmitters affect sea duck survival (Iverson et al. 2006, Fast et al. 2011) and behavior (Latty et al. 2010), which could influence habitat use and movement patterns. Survival estimates (Dec 2011–2012) of radio-marked adult female American common eiders ($n = 24$ of 26 birds) during this study were similar to estimates derived from banding studies of Pacific common eiders (89%; Wilson et al. 2012) and transmittered king eiders (94%; Oppel and Powell 2010), and higher than other species of satellite-tagged sea ducks (Fast et al. 2011, Loring et al. 2014).

Mortality of common eider in our study may have been less than in other published studies because we marked only heavy adults. Adult sea ducks have higher survival than juveniles (Oppel and Powell 2010) and heavier individuals (>1,650 g) are likely in better condition (Beuth et al. 2016*a*, *b*) and may be better able to tolerate a 44-g transmitter.

However, age, condition, and sex-specific transmitter effects are unknown and warrant further examination. Unusually warm fall 2011 temperatures may have also contributed to higher survival rates. Specifically, temperatures during November 2011 were the warmest on record (1895–2014) and averaged 8.8° C, which was 3.5° C warmer than the long-term average of 5.3° C; temperatures in December 2011 averaged 3.9° C, which was the third warmest December on record (NOAA 2017).

Habitat Use and Resource Selection

Habitat characteristics important for eider included sites that were closer to shore with shallower water depths, a higher probability of hard bottom, and relatively fine sandy substrates. This corroborates findings by Winiarski et al. (2014) and Flanders et al. (2015) that eiders are most abundant in areas with water depths <25 m; thus, much of Rhode Island and Block Island sounds were too deep to provide important foraging habitat for eiders. Overall, 3% and 10% of the study area was classified as high and medium high probability of use, respectively, which often included rocky headlands in the southern portion of Narragansett Bay (McKinney et al. 2006). Benthic communities of lower Narragansett Bay are predominately mussel beds (Schwartz 2009, Loring et al. 2013), which provide preferred foraging opportunities for eiders, thus explaining the frequent detections and high abundance counts in previous studies (Smith et al. 2015) and the high level of use observed in our study.

Effects of disturbance and displacement in our study area likely will be localized to areas of high probability of use (Fig. 3). However, relatively large winter utilization distributions of this long lived, gregarious, and highly site-faithful species may lead to conflicts with commercial operations (e.g., aquaculture, oil drilling) and offshore wind energy development. For example, 63.7% of the wind turbine footprint under construction within the Block Island Renewable Energy Zone (Fig. 3) was classified as medium-high or medium probability of use suggesting this development may affect the local wintering population of common eiders. Eiders fly through the study area during spring or fall migration or while moving locally throughout the winter, presenting a potential collision risk for offshore wind development.

Research in Europe reported that collision risk with offshore wind turbines is minimal for sea ducks (Desholm and Kahlert 2005) and increased flight distance and times resulting from deflection were trivial and unlikely to have significant impacts (Masden et al. 2009). However, based on research conducted at European offshore wind farms, we suspect that the construction of offshore wind turbines in this region could displace some eiders from foraging habitat (Larsen and Guillemette 2007) and could increase flight times between foraging and roosting sites (Desholm and Kahlert 2005, Masden et al. 2009). Displacement, however, may be relatively short-term given that sea ducks, such as black scoters in Europe, may habituate to wind turbine structures and eventually reoccupy the development's footprint (Petersen and Fox 2007). Developments offshore and in deeper water such as the proposed Rhode Island-Massachusetts area of mutual interest, which is classified as unlikely to be used by eider (Fig. 3), may avoid negative impacts such as displacement during the wintering period. Regardless, monitoring of eider movement during and after construction of offshore wind turbines would allow any effects on sea ducks wintering in southern New England to be quantified.

MANAGEMENT IMPLICATIONS

In general, nearshore (<2 km) waters <20 m deep with hard, sandy substrates are suitable for common eiders. Our site-specific results allow managers to 1) focus sampling of birds for diseases including Wellfleet Bay virus, 2) consider zone-specific harvest regulations, 3) prioritize response to oil spills to areas likely to include eiders, and 4) restrict or regulate aquaculture practices in areas identified as suitable or high probability of use for common eiders in our study area. Eiders in our study spent approximately 40% of the annual cycle on the wintering grounds, and demonstrated site fidelity; thus, preferred habitat characteristics and critical habitats identified in our study area should be carefully considered when planning any marine development including offshore wind energy development.

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LITERATURE CITED

Allison, A. B., J. R. Ballard, R. B. Tesh, J. D. Brown, M. G. Ruder, M. K. Keel, B. A. Munk, R. M. Mickley, S. E. J. Gibbs, A. P. A. Travassos da Rosa, J. C. Ellis, H. S. Ip, V. I. Shearn-Bochsler, M. B. Rogers, E. Ghedin, E. C. Holmes, C. R. Parrish, and C. Dwyer. 2015. Cyclic avian mass mortality in the Northeastern United States is associated with a novel orthomyxovirus. Journal of Virology 89:1389–1403.

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's information criterion. Journal of Wildlife Management 74:1175–1178.

Ashcroft, R. E. 1976. A function of the pair bond in the common eider. Wildfowl 27:101–105.

Beuth, J. M. 2013. Body composition, movement phenology and habitat use of common eider along the southern New England coast. Thesis, University of Rhode Island, Kingston, USA.

Beuth, J. M., P. W. C. Paton, J. E. Osenkowski, and S. R. McWilliams. 2016*a*. Validating the deuterium dilution method to assess body composition of common eider. Wildlife Society Bulletin 40:456–463.

Beuth, J. M., P. W. C. Paton, J. E. Osenkowski, and S. R. McWilliams. 2016*b*. Body composition dynamics of common eider during winter: an application of the deuterium dilution method. Wildlife Society Bulletin 40:464:469.

Beyer, H. L. 2012. Geospatial Modeling Environment (v. 0.7.2.0). <http://www.spatialecology.com/gme>. Accessed 25 Jan 2016.

Bowman, T. D., E. D. Silverman, S. G. Gilliland, and J. B. Leirness. 2015. Status and trends of North American sea ducks: reinforcing the need for better monitoring. Pages 1–27 *in* J.-P. L. Savard, D. V. Derksen, D. Esler, and J. M. Eadie, editors. Ecology and conservation of North American sea ducks. Studies in Avian Biology. CRC Press, New York, New York, USA.

Bradbury, G., M. Trinder, B. Furness, A. N. Banks, R. W. G. Caldow, and D. Hume. 2014. Mapping seabird sensitivity to offshore wind farms. PLoS ONE 9:e106366.

Brodeur, S., G. H. Mittelhauser, J.-P. L. Savard, P. W. Thomas, R. D. Titman, and D. Comeau. 2008. Capture methods for migrating, wintering and molting sea ducks. Waterbirds 31:133–137.

Bureau of Ocean Energy Management. 2012. Commercial wind lease issuance and site assessment activities on the Atlantic outer continental shelf offshore Rhode Island and Massachusetts. Office of Renewable Energy Programs, U.S. Department of the Interior, Washington, D.C., USA.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer, New York, New York, USA.

Carney, S. M. 1992. Species, age and sex identification of ducks using wing plumage. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Collecte Localisation Satellites. 2011. Argos user's manual. <http://www.argos-system.org/manual/>. Accessed 25 Jan 2016.

Connecticut Department of Energy and Environmental Protection. 2006. Northeastern United States State Boundary Line (1:24,000). Connecticut Department of Energy and Environmental Protection, Hartford, Connecticut, USA.

Coulson, J. C. 2008. The population dynamics of the eider duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525–543.

De La Cruz, S. E. W., J. Y. Takekawa, M. T. Wilson, D. R. Nysewander, J. R. Evenson, D. Esler, W. S. Boyd and D. H. Ward. 2009. Spring migration routes and chronology of surf scoters (*Melanitta perspilillata*): a synthesis of Pacific coast studies. Canadian Journal of Zoology 87:1069–1086.

Desholm, M., and J. Kahlert. 2005. Avian risk at an offshore wind farm. Biology Letters 1:296–298.

Douglas, D. C., R. Weinzierl, S. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3:999–1007.

Esler, D., D. M. Mulcahy, and R. L. Jarvis. 2000. Testing assumptions for unbiased estimation of survival of radiomarked harlequin ducks. Journal of Wildlife Management 64:591–598.

Fast, P. L. F., M. Fast, A. Mosbech, C. Sonne, H. G. Gilchrist, and S. Descamps. 2011. Effects of implanted satellite transmitters on behavior and survival of female common eiders. Journal of Wildlife Management 75:1553–1557.

Flanders, N. P., B. Gardner, K. J. Winiarski, P. W. C. Paton, T. Allison, and A. O'Connell. 2015. Key seabird areas in southern New England identified using a community occupancy model approach. Marine Ecology Progress Series 533:277–290.

Gauthier, J., J. Bédard, and A. Reed. 1976. Overland migration by common eiders of the St. Lawrence Estuary. Wilson Bulletin 88:333–344.

Gilliland, S. G., H. G. Gilchrist, R. F. Rockwell, G. J. Robertson, J-P. L. Savard, F. Merkel, and A. Mosbech. 2009. Evaluating the sustainability of harvest among northern common eiders *Somateria mollissima borealis* in Greenland and Canada. Wildlife Biology 15:24–36.

Goudie, R. I., G. J. Robertson, and A. Reed. 2000. Common eider (*Somateria mollissima*). No. 546 *in* A. Poole and F. Gill, editors. The birds of North America online. The Birds of North America Inc., Philadelphia, Pennsylvania, USA.

Guillemette, M., J. H. Himmelman, C. Barette, and A. Reed. 1993. Habitat selection by common eiders in winter and its interaction with flock size. Canadian Journal of Zoology 71:1259–1266.

Guillemette, M. J., J. H. Himmelman, and A. Reed. 1996. Availability and consumption of food by common eiders wintering in the Gulf of St. Lawrence: evidence of prey depletion. Canadian Journal of Zoology 74:32–38.

Iverson, S. A., W. S. Boyd, D. Esler, D. M. Mulchay, and T. D. Bowman. 2006. Comparison of effects and performance of four types of radiotransmitters for use with scoters. Wildlife Society Bulletin 34:656–663.

Johnson, C. J., S. E. Nielsen, E. H. Merrill, T. L. McDonald, and M. S. Boyce. 2006. Resource selection functions based on use-availability data: theoretical motivation and evaluation methods. Journal of Wildlife Management 70:347–357.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.

Korschgen, C. E., K. P. Kenow, A. Gendron-Fitzpatrick, W. L. Green, and F. J. Dein. 1996. Implanting intra-abdominal radiotransmitters with external whip antennas in ducks. Journal of Wildlife Management 60:132–137.

Langston, R. H. W. 2013. Birds and wind projects across the pond: A UK perspective. Wildlife Society Bulletin 37:5–18.

Larsen, J. K., and M. Guillemette. 2000. Influence of annual variation in food supply on abundance of wintering common eiders *Somateria mollissima*. Marine Ecology Progress Series 201:301–309.

Larsen, J. K., and M. Guillemette. 2007. Effects of wind turbines on flight behavior of wintering common eiders: implications for habitat use and collision risk. Journal of Applied Ecology 44:516–522.

Latty, C. J., T. E. Hollmen, M. R. Petersen, A. N. Powell, and R. D. Andrews. 2010. Abdominally implanted transmitters with percutaneous antennas affect the dive performance of common eiders. Condor 112:314–322.

Loring, P. H., P. W. C. Paton, S. R. McWilliams, R. A. McKinney and C. A. Oviatt. 2013. Densities of wintering scoters in relation to benthic prey assemblages in a north Atlantic estuary. Waterbirds 36:144–155.

Loring, P. H., P. W. C. Paton, J. E. Osenkowski, S. G. Gilliland, J.-P. L. Savard, and S. R. McWilliams. 2014. Habitat use and selection of black scoters in southern New England and siting of offshore wind energy facilities. Journal of Wildlife Management 78:645–656.

Mackay, G. H. 1890. *Somateria dresseri*, the American eider. Auk 7:315–319.

Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Second edition. Kluwer Academic Publishers, Dordrecht, Netherlands.

Masden, E. A., D. T. Haydon, A. D. Fox, R. W. Furness, R. Bullman, and M. Desholm. 2009. Barriers to movement: impacts of wind farms on migrating birds. International Council for the Exploration of the Sea. Journal of Marine Science 66:746–753.

McKinney, R. A., S. R. McWilliams, and M. A. Charpentier. 2006. Waterfowl-habitat associations during winter in an urban North Atlantic estuary. Biological Conservation 132:239–249.

Merkel, F. R., A. Mosbech, C. Sonne, A. Flagstad, K. Falk, and S. E. Jamieson. 2006. Local movements, home ranges and body condition of common eiders *Somateria mollissima* wintering in southwest Greenland. Ardea 94:639–650.

Michel, J., F. Csulak, D. French, and M. Sperduto. 1998. Natural resource impacts from the *North Cape* oil spill. International Oil Spill Proceedings 1997:841–850.

Mosbech, A., G. Gilchrist, F. Merkel, C. Sonne, A. Flagstad, and H. Nyegaard. 2006. Year-round movements of northern common eiders *Somateria mollissima borealis* breeding in arctic Canada and West Greenland followed by satellite telemetry. Ardea 94:651–665.

National Oceanic and Atmospheric Administration [NOAA]. 2017. National Centers for Environmental Information. Climate at a Glance: U.S. Time Series, Average Temperature. <http://www.ncdc.noaa.gov/cag/>. Accessed 10 May 2017.

National Oceanic and Atmospheric Administration [NOAA]. 2012. National Geophysical Data Center. <http://www.ngdc.noaa.gov/mgg/bathymetry/relief.html>. Accessed 25 Jan 2016.

Oppel, S., and A. N. Powell. 2010. Age-specific survival estimates of king eiders derived from satellite telemetry. Condor 112:323–330.

Oppel, S., A. N. Powell, and D. L. Dickson. 2008. Timing and distance of king eider migration and winter movements. Condor 110:296–305.

Petersen, I. K., and A. D. Fox. 2007. Changes in bird habitat utilization around the Horns Rev 1 offshore wind farm, with particular emphasis on common scoter. National Environmental Research Institute, Denmark.

Petersen, M. R., D. C. Douglas, H. M. Wilson and S. E. McCloskey. 2012. Effects of sea ice on winter site fidelity of Pacific common eiders (*Somateria mollissima v-nigrum*). Auk 129:399–408.

Petersen, M. R., and P. L. Flint. 2002. Population structure of Pacific common eiders breeding in Alaska. Condor 104:780–787.

Poti, M., B. P. Kinlan, and C. Menza. 2012. Surficial sediments. Pages 33–58 *in* C. Menza, B. P. Kinlan, D. S. Dorfman, M. Poti, and C. Caldow, editors. A biogeographic assessment of seabirds, deep sea corals and ocean habitats of the New York Bight: science to support offshore spatial planning. NOAA National Center for Coastal Ocean Science Technical Memorandum 141, Silver Spring, Maryland, USA.

Reed, J. A., and P. L. Flint. 2007. Movements and foraging effort of stellar's eiders and harlequin ducks wintering near Dutch Harbor, Alaska. Journal of Field Ornithology 78:124–132.

Rhode Island Coastal Resources Management Council. 2010. Rhode Island Ocean Special Area Management Plan: OceanSamp, volume 1. Rhode Island Coastal Resources Management Council, Wakefield, Rhode Island, USA.

Robertson, G. J., and F. Cooke. 1999. Winter philopatry in migratory waterfowl. Auk 116:20–34.

Robertson, G. J., F. Cooke, R. I. Goudie, and W. S. Boyd. 2000. Spacing patterns, mating systems and winter philopatry in harlequin ducks. Auk 117:299–307.

Savard, J.-P. L., D. V. Derksen, D. Esler, and J. M. Eadie, editors. 2015. Ecology and conservation of North American sea ducks. Studies in Avian Biology No. 46. CRC Press, Boca Raton, Florida, USA.

Savard, J.-P. L., L. Lesage, S. Gilliland, G. Gilchrist, and J.-F. Giroux. 2011. Molting, staging and wintering locations of common eiders breeding in the Gyrfalcon Archipelago, Ungava Bay. Arctic 64:197–206.

Schwartz, M. L. 2009. Estuarine habitats of Narragansett Bay. Pages 89–106 *in* K. B. Raposa and M. L. Schwartz, editors. An ecological profile of the Narragansett Bay National Estuarine Research Reserve. Rhode Island Sea Grant, Narragansett, USA.

Sea Duck Joint Venture. 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.

Shonting, D. H., and G. S. Cook. 1970. On the seasonal distribution of temperature and salinity in Rhode Island Sound. Limnology and Oceanography 15:100–112.

Silverman, E. D., D. Saalfeld, J. B. Leirness, and M. D. Koneff. 2013. Wintering sea duck distribution along the Atlantic Coast of the United States. Journal of Fish and Wildlife Management 4:178–198.

Smith, A. D., S. R. McWilliams, K. J. Winiarski, C. L. Trocki, B. Harris, J. E. Osenkowski, and P. W. C. Paton. 2015. Using land-based surveys to assess sea duck abundance and behavior in nearshore water of southern New England, USA. Waterbirds 38:252–259.

Spurr, E., and H. Milne. 1976. Adaptive significance of autumn pair formation in the common eider *Somateria mollissima*. Ornis Scandinavica 7:85–89.

Swennen, C. 1990. Dispersal and the migratory movements of eider *Somateria mollissima* breeding in the Netherlands. Ornis Scandinavica 21:17–27.

Systad, G. H., J. O. Bustnes, and K. E. Erikstad. 2000. Behavioral responses to decreasing day length in wintering sea ducks. Auk 117:33–40.

Theroux, R. B., and R. L. Wigley. 1998. Quantitative composition and distribution of the macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States. Northeast Fisheries Science Center, NOAA Technical Report NMFS 140. National Marine Fisheries Service, NOAA, Woods Hole, Massachusetts, USA.

U.S. Naval Observatory. 2013. Astronomical applications rise and set for the sun for 2012. <http://www.usno.navy.mil/USNO/astronomical-applications/data-services>. Accessed 21 Oct 2013.

Varennes, E., S. A. Hanssen, J. C. Bonardelli, and M. Guillemette. 2015. A large molluscivore bird (common eider, *Somateria mollissima*) is able to discriminate quality of blue mussels (*Mytilus edulis*) based on size and provenance. Canadian Journal of Zoology 93:655–663.

Wilson, H. M., P. L. Flint, A. N. Powell, J. B. Grand, and C. L. Moran. 2012. Population ecology of breeding Pacific common eiders on the Yukon-Kuskokwim Delta, Alaska. Wildlife Monographs 182:1–28.

Winiarski, K. J., D. L. Miller, P. W. C. Paton and S. R. McWilliams. 2014. A spatial conservation prioritization approach for protecting marine birds given proposed offshore wind energy development. Biological Conservation 169:79–88.

Ydenberg, R., and M. Guillemette. 1991. Diving and foraging in the common eider. Ornis Scandinavica 22:349–352.

Žydelis, R., D. Esler, W. S. Boyd, D. L. Lacroix, and M. Kirk. 2006. Habitat use wintering surf and white-winged scoters: effects of environmental attributes and shellfish aquaculture. Journal of Wildlife Management 70:1754–1762.

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