Documenting Areas of Importance to Maine Subadult Bald Eagles: Insights from Satellite Telemetry.

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DOCUMENTING AREAS OF IMPORTANCE TO MAINE SUBADULT BALD EAGLES: INSIGHTS FROM SATELLITE TELEMETRY.

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Biodiversity Research Institute (BRI) is a 501(c)(3) non-profit organization located in Gorham, Maine. Founded in 1998, BRI is dedicated to supporting global health through collaborative ecological research, assessment of ecosystem health, improving environmental awareness, and informing science based decision making.

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1.0 EXECUTIVE SUMMARY

While Maine's breeding Bald Eagle population is relatively well-studied, information on daily, seasonal, and annual habitat use and movement patterns of Maine's eagle population is lacking . Habits of immature and subadult eagles from Maine - critical in maintaining population stability – are poorly studied due to their widely roaming nature. We fitted satellite transmitters to nearly-fledged Bald Eagles nestlings to identify areas of presumed importance to Maine's subadult eagle population and to gather information on dispersal timing, use of natal areas, natal habitats, and seabird colonies.

Dispersal Timing: Seasonal timing of dispersal varied widely. The median dispersal date was 18 September, ranging from 21 August to 21 October. Dispersal timing relative to fledging was highly variable, ranging from 6 – 92 days after fledging (mean ± SD = 44.9 ± 23.9 days); The mean age at dispersal ranged from 90 – 176 days; (mean ± SD = 129 ± 23.9 d).

Subadult Visitation of Natal Areas: Maine Bald Eagles showed strong philopatric tendencies on an annual basis. The proportion of satellite-tagged eagles venturing near natal sites appeared to increase with age up to eagles' third year within 5 km and 25 km of the nest site. Over 80% of individuals were detected within 50 km of the nest site within their first through fifth years of age, further supporting relatively low natal dispersal distances for Maine eagles.

Identifying Areas of Importance to Maine Bald Eagles: Numerous areas were documented to be visited independently by multiple transmitter-fitted eagles during 1 April – 1 October including the Lower Sebasticook River, Merrymeeting Bay, as well as other areas, such as the Livermore Falls area of the Androscoggin River, and the Lower Kennebec River. Multiple transmitter-fitted eagles commonly visited several 'artificial' sites throughout the state including the City of Augusta landfill, the Presque Isle landfill, and a poultry farm in Warren, ME. Satellite tracking revealed that many Maine-hatched subadult eagles ventured out of the state during winter months (1 November – 1 March); however, some areas in central and eastern Maine were visited by multiple transmitter-fitted eagles during this period. Most areas used by multiple eagles during the winter period were also used during the summer period with the exception of Canaan Bog, a winter feeding/baiting station in Clinton.

Fidelity to Natal Habitats: Subadult eagles showed fidelity to their natal habitat types while in Maine. Eagles hatched in coastal sites spent 60-78% of their Maine-based days in their natal habitat, while inland-hatched eagles spent 0-23% of their tallied days in Maine coastal habitats. Use of coastal habitats by eagles hatched inland did not appear to be related to the general location or latitude of natal areas, as individuals hatched from nearby lakes varied widely in their extent of coastal habitat use.

Bald Eagle Visitation of Habitat near Great Cormorant Colonies: Only one of 19 subadult eagles (15 deployed at inland sites) was found to visit one of Maine's five Great Cormorant colonies. The 'Vinalhaven eagle' visited the "Little Roberts" Great Cormorant colony and vicinity shortly after fledging. This eagle visited the colony on multiple occasions within- and between seasons during summer and winter months over multiple years.

2.0 INTRODUCTION

Once common throughout its range, Bald Eagle populations throughout North America plummeted to dangerously low levels due to the combined effects of pesticide use (particularly DDT) direct killing, and habitat loss. By the mid 20th century, Bald Eagle populations were drastically reduced in the lower 48 U.S. states. Federal protections for Bald Eagles and their nests, and the banning of DDT were instrumental in reversing the widespread population decline. National recovery efforts implemented by the US Fish and Wildlife Service and partners across the country were successful, leading to the eventual removal of the Bald Eagle from the Federal Endangered Species List in 2007.

The Bald Eagle's plight of near extirpation and subsequent recovery is one of Maine's most notable wildlife management success stories (MDIFW 2004, 2008). Maine's population was estimated at approximately 30-60 pairs in the 1970s. During this time, eagle populations in all other New England states had been fully extirpated and Maine's population represented a regional stronghold. In addition to the banning of DDT, and legal protections for eagles and habitat conservation efforts in the form of voluntary conservation ownership efforts and easements played major roles in the recovery of Maine's population. Today, the Bald Eagle population in Maine exceeds 633 pairs, and over 500 eagle territories are protected, providing a critical 'safety net' for the population (MDIFW 2008).

Throughout the recovery of the Bald Eagle, the preferred approach to managing Bald Eagle populations has slowly shifted from efforts focused on boosting productivity and protecting nest sites, to those targeting a critical component of population stability: survival. Bald Eagle population models indicate changes in Bald Eagle survival rates have a markedly larger impact on population stability compared to changes in reproduction (Young 1968, Grier 1980). As a result, wildlife managers wishing to maintain or increase eagle populations should direct resources toward safeguarding or increasing the survival of individuals already in the population (Grier 1980). While breeding adults were traditionally the focus of such conservation efforts, subadult and non-breeding eagles are increasingly being recognized for their role in maintaining population stability (Grier 1980, Ferrer et al. 2003, Penteriani et al. 2005, 2011). Given Bald Eagles' delayed sexual maturity and territory establishment, subadult and non-breeding eagles likely comprise a significant portion of Maine's overall eagle population – but their numbers are difficult to estimate. Without territories, these eagles often utilize 'settlement areas,' the number and quality of which have themselves also been found impact the stability of overall populations (Penteriani et al. 2003, 2011). As a result, identification and conservation of these areas is an increasing conservation priority (Penteriani et al. 2005, 2011).

Subadult eagles are implicated in the decline of Maine's Great Cormorants (*Phalacrocorax carbo*), which nest colonially on remote islands along the coast. Aggregations of eagles, most commonly subadults, are regularly observed at or near Great Cormorant colonies. While it is generally accepted that eagles are playing a role in the cormorants' decline, little information exists documenting short- or long-term habitat use patterns of Bald Eagles in the vicinity of seabird colonies in Maine.

Despite their demonstrated value in maintaining population stability, the habits of subadult and non-breeding eagles, and the habitats important to them in Maine poorly understood. Such data gaps come at the detriment to making informed decisions about several key conservation issues in Maine such as: (1) anadromous fisheries, which in some areas attract large numbers subadult and non-breeding eagles, (2) proposed industrial facilities such as wind turbines, and (3) management of endangered seabird colonies, which attract and can then be detrimentally impacted by visiting eagles.

The high mobility and roaming nature of non-breeding and subadult Bald Eagles makes them particularly difficult to study. Advancements in wildlife tracking technologies over the past several decades now enables biologists to collect detailed information on wildlife movement patterns that were formerly impractical or cost prohibitive (Kays et al. 2015). In this study, we fitted satellite transmitters to fledgling Bald Eagles to identify habitats used by subadult eagles to gain further perspectives on their ecology. While detailed analyses of eagle use patterns relative to fisheries, wind power installations, and seabird colonies were beyond the scope of this study, we outline preliminary patterns indicated from these instrumented individuals in the context of these conservation issues, which are evolving and pressing in Maine and many regions of the country.

3.0 METHODS

3.1 Definitions and Field Efforts

3.1.1 Bald Eagle Age Classes

For the purposes of this report, we generally follow Bald Eagle age classes as outlined in Millsap et al. (2004). Bald Eagle nestlings (also referred to elsewhere as 'eaglets') are pre-fledged young of the year that are incapable of flight. Nestlings are referred to as fledglings once they have departed the nest but have not yet dispersed. Bald Eagles ≤1 year old are referred to as juveniles after they have dispersed. Subadults are eagles aged 1-5 years. For the purposes of this report, juveniles and subadults are collectively referred to as subadults.

3.1.2 Field Efforts: Bald Eagle Capture and Transmitter Fitting

Bald Eagles were accessed in their nests by tree climbers when nestlings were approximately 8.5-10 weeks of age (fledging occurs at approximately 12-13 weeks). Nestlings were counted and aged during aerial surveys using a fixed-wing aircraft, typically conducted by staff from the Maine Department of Inland Fisheries and Wildlife (MDIFW), the U.S. Fish and Wildlife Service (USFWS) or Biodiversity Research Institute (BRI). Whenever possible, we visited nests once when nestlings were approximately 6 weeks of age to confirm sibling counts and age estimates gathered during aerial surveys and to evaluate the appropriateness of the site for a follow-up visit to fit a transmitter to the largest/most developed nestling captured. All nestlings were banded with uniquely coded red color bands (Figure 1), silver USGS bands issued by the USGS Bird Banding Lab, and sampled for contaminant and other analyses (DeSorbo 2007, Desorbo et al. 2009, Mierzykowski et al. 2013).

We fitted 19 Bald Eagle nestlings with satellite units in 2005-2013 (Table 1). Nearly 75% of transmitters were deployed during 2011-2013. Transmitter deployment sites generally followed a relatively even geographic spacing of approximately 50 km (31 mi) emphasizing central and western Maine (Figure 2). A wide variety of factors, including the number of siblings, tree safety, nestling age, logistical considerations and geographic distribution, were influential to selections of deployment sites.

Figure 1. Nestling Bald Eagle being fitted with solar powered satellite transmitter (top). Bald Eagle nestling fitted with satellite transmitter after being returned to the nest with its sibling (bottom).

Only the antenna of the transmitter is in view on the nestling on the right. Photo credits: Chris Persico (top) and Chris DeSorbo (bottom).

Figure 2. Locations where nineteen Bald Eagle nestlings were fitted with satellite transmitters in Maine, 2006 - 2013.

Table 1. Sites where Bald Eagle fledglings were equipped with satellite transmitters, 2005 – 2013. Deployment locations are shown in Figure 2.

Animal Id[a]	ID[b]	Nest[c]	Date	Nest Name, twp	Unit Type / Status[d]
HY01_Brassua	57610	185B	7/11/2006	Little Brassua Lk – Moose River, Sandwich Academy Grant Twp.	Battery Unit / Expired transmitter
HY02_Saco	95935	549B	6/29/2009	Saco River, Dayton	Solar Doppler unit / Active
HY03_Flagstaff	95936	156E	7/15/2009	Flagstaff Lake – Reed Brook, Flagstaff Twp.	Solar Doppler unit / Inactive; injury @ 10 mos.; redeployed
HY04_Wyman	60987	301B	6/24/2010	Wyman Lake – Carrying Place Stream – Henhawk Is, Caratunk	GPS Solar / Active
HY05_Madagascal	60986	620A	6/29/2010	Madagascal Pond – Madagascal Stream, Burlington	GPS Solar / Active
HY06_Winslow	107201	491C	6/27/2011	Kennebec River – Sebasticook River, Winslow	GPS Solar / Active
HY07_Old_Town	107202	527A	6/28/2011	Penobscot River – Stillwater River, Old Town	GPS Solar / Active
HY08_Durham	95936	562B	6/29/2011	Androsoggin River – Salmon Brook, Durham	Solar Doppler /Active
HY09_Rocky_Lake	107200	222D	6/30/2011	Rocky Lake – Northern Inlet, T18 ED BPP	GPS Solar / Active
HY10_Aziscohos	107203	486B	7/18/2011	Aziscohos Lake – Sunday Pond, Errol	GPS Solar / Inactive
HY11_Phippsburg	118879	661A	6/14/2012	The Basin – New Meadows River, Phippsburg	GPS Solar / Active (intermittent)
HY12_Vinalhaven	118880	294B	6/15/2012	Fox Island Thorofare – Perry Cove – Spectacle Island, Vinalhaven	GPS Solar / Active (intermittent)
HY13_Lobster	118875	650B	6/20/2012	Lobster Lake, Northwest Piscataquis	GPS Solar / Active
HY14_Richardson	118876	649A	7/12/2012	Saco River – Runnells Brook, Dayton	GPS Solar / Active
HY15_Madison	118878	514A	6/14/2013	Kennebec River, Madison	GPS Solar / Active
HY16_Ram	118881	295C	6/18/2013	Muscongus Bay – Ram Island, Friendship	GPS Solar / Active
HY17_Bucksport	118877	500C	6/18/2013	Penobscot River, Bucksport	GPS Solar / Active
HY18_Jay	118882	412B	6/19/2013	Androscoggin River, Jay	GPS Solar / Active
HY19_Onawa	118883	722A	6/21/2013	Lake Onawa – Long Pond Stream, Northeast Piscataquis	GPS Solar / Active

[a] Unique ID for each animal. Throughout this report, sites and individuals are referred to using the site name following the underscore.

[b] Platform Transmitter Terminal (PTT) ID number assigned by Argos/CLS America. Not unique as units can be redeployed.

[c] Nest Identification Number as assigned by the Maine Department of Inland Fisheries and Wildlife (MDIFW).

[d] Status as of report date.

3.1.3 Transmitters, Programming and Data Filtering

During 2005-2013, Bald Eagle fledglings were fitted with satellite transmitters (also referred to as Platform Transmitter Terminals, or PTTs) that fixed either GPS and/or Doppler (non-GPS, or 'Argos') locations. Fifteen of the 19 PTTs deployed were 65-70g solar GPS units (North Star Science and Technology, King George, VA) programmed to fix 4-10 GPS locations daily (including 1 midnight fix) from 1 March – 1 October, and 1-4 GPS locations daily during the remainder of the year. One transmitter (deployed on the Brassua nestling) was a battery-powered Doppler unit, and one unit (deployed on the Flagstaff and Durham nestlings) was a solar powered Doppler unit (Table 1).

Location accuracy of GPS fixes acquired by transmitters deployed in this study typically range from 5 – 15 m (K. Lesage, Geotrak, pers. comm.); these locations are typically associated with high accuracy and require little filtering. 'Argos' locations, calculated using Doppler-shift principles, vary widely in accuracy and typically require some filtering. Argos locations are classified into the following seven location classes (LC) by CLS America according to their increasing levels of accuracy: LCZ, LCB, LCA, LC0, LC1, LC2, and LC3 (CLS 2015). We used the 'hybrid' Douglas Argos Filter (Douglas et al. 2012) to remove implausible GPS and Doppler-shift location estimates. User-defined filtering parameters were set to *maxredun* = 5 and *minrate* = 100. Setting the maxredun parameter to 5 increases overall accuracy of locations, but reduces the number of locations retained in the dataset (Douglas et al. 2012). At our chosen filter settings, 68th percentile location errors for Argos location classes have been estimated as follows (in km): LCZ (2.8), LCB (4.3), LCA (2.9), LC0 (5.1), LC1 (2.5), LC2 (1.0), and LC3 (0.4)[1].

3.2 Dispersal Timing and Visitation to Natal Areas

3.2.1 Dispersal Timing

We evaluated dispersal timing for PTT-fitted Bald Eagle fledglings by calculating the median date between the last date an individual was within the general vicinity of the nest, and the first date the individual was in a location outside of the nesting territory in part of a long distance directional movement where the bird remained >3 km away for >3d. GPS locations fixed multiple times daily were preferred over Doppler locations for dispersal timing estimations whenever possible. One individual (HY11_Phippsburg) was excluded from dispersal calculations because this transmitter fixed locations irregularly during the dispersal period (likely due to feather coverage of the unit's solar panel). Age at dispersal was calculated as the difference between the median dispersal date and the bird's hatch date. Hatch dates were back-calculated from ages determined using the measurement of a growing 8th primary feather collected during nestling handling (Bortolotti 1984).

[1] Location errors for LC1, LC2, and LC3 were based on unfiltered data in Douglas et al. (2012).

3.2.2 Visitation to Natal Areas

To evaluate the extent to which eagles returned to their natal areas during the years prior to territory establishment, we evaluated the frequency in which birds fixed satellite locations within 0.20 km (660'), 5 km (3 mi), 25 km (15 mi) and 50 km (31 mi) of their nest site during their first through fifth years of life. We calculated the distance between each filtered location estimate and birds' natal nest sites, and then calculated the minimum daily distance between individuals and their nest sites. Birds with at least one daily location within each of the four distance categories were tallied as travelling within that distance from their nest site. All pre-dispersal locations were removed prior to analysis.

3.3 Identifying Areas Important to Maine Subadult Bald Eagles

It is well-established that Bald Eagles aggregate in areas with ecological value (i.e., typically seasonally abundant food resources) and that visits by individual eagles to such areas can be seasonally habitual. The identification of such areas is a first step in initiating best management and conservation practices for Bald Eagles and other wildlife. Since our sample size of transmitter-fitted individuals limits using actual aggregations of eagles during the same time and place to identify areas of ecological value to Maine's eagle population, we used satellite location data to identify areas of ecological importance based on the assumption that instances where multiple transmitter-fitted eagles were attracted to an area within a season were occurring due to ecological influences as opposed to random chance.

A satellite location estimate in an area implied use or a visit to that area by an eagle for this analysis. We identified areas visited by multiple transmitter-fitted individuals during two seasonal timeframes: 1 April – 1 October (referred to as "extended summer period" and 1 November – 1 March (referred to as "extended winter period"). These broadly encompassing seasons are defined to leave a one-month "gap" between them in order to avoid double-counting individuals in different seasons. As a consequence, location records from eagles fixed during March 2-31 and October 2-31 are excluded from this analysis. We used the Point Statistics Tool in ArcGIS 10.2.2 to analyze all filtered post-dispersal location data. Overlaying the satellite data with an array of 250 m grid cells, we identified the total number of individual Bald Eagles fixing >1 location within a 3 km radius of the each cell.

3.4 Use of Coastal Habitats by Maine Bald Eagles

3.4.1 Fidelity to Natal Habitats

We conducted a coarse, first-time characterization of the extent to which Maine-hatched Bald Eagles used Maine's coastal habitats. Using a filtered dataset containing all post-dispersal location estimates in inland and coastal Maine (n = 50,873), we characterized the proportion of days in which coastal- and inland-hatched fledgling and subadult Bald Eagles used Maine's coastal habitat. A satellite location estimate in an area implied use or a visit to that area by an eagle for this analysis. Location estimates for each individual eagle were categorized into coastal and inland categories for each day (because units fix a different number of locations daily according to numerous factors). We delineated coastal and inland zones of the Maine coast in ArcMap 10.2.2 using the 1:50,000,000 coastline GIS coverage available from naturalearth.com and HUC-12 watershed coverage from the Maine Office of GIS. Locations falling within, or offshore from areas where the HUC-12 watershed boundary intersected the coastline delineation were considered coastal. All other areas were considered inland. On days where individuals fixed locations in both habitat zones, days were assigned to coastal or inland categories if >50% of the locations from that day fell in that habitat zone. We randomly and evenly assigned habitat types to 75 daily location records that contained exactly 50% of locations in each habitat zone.

3.4.2 Bald Eagle Visitation to Maine's Great Cormorant Colonies

During 2012-2013, BRI deployed five transmitters along the Maine coast. These are the first Bald Eagles along coastal Maine to be studied using satellite telemetry. One primary opportunistic goal of focusing satellite deployments on coastal Bald Eagles was to better characterize their use of islands used by nesting seabirds along the Maine coastline. For this report, we focus exclusively on the Great Cormorant, of which there were only five nesting colonies along the Maine coast during 2012-2013 (C. Todd, MDIFW, pers. comm.).

We deployed four solar GPS satellite units on Bald Eagle nestlings from nests in Maine coastal areas: Phippsburg, Vinalhaven Island, Ram Island (Friendship twp), and Bucksport. A fifth unit (a celluar/GSM high resolution GPS transmitter) was deployed on Bois Bubert Island (Millbridge twp), approximately 6 km from a seabird colony of particular management interest on Petit Manan Island. This unit malfunctioned shortly after deployment due to a manufacturer error and thus it has been omitted from this report (including Table 1 and Figure 2). Of the four remaining fledglings instrumented in coastal areas, only the 'Vinalhaven eagle' was recorded in the vicinity of one of Maine's five Great Cormorant colonies. This individual is thus the focal point of this qualitative analysis.

We used GPS and location class 2 (LC2) and 3 (LC3) Doppler location estimates from the transmitter-fitted Vinalhaven eagle to evaluate and describe use of the Little Roberts Great Cormorant colony (roughly 3.4 km [2.1 mi] off the southern tip of Vinalhaven Island and 14.8 km [9.2 mi] south of the natal/deployment site) and surrounding islands. Location estimates within the perimeter of an island, or within 100 m of the shore were considered to be associated with a visit to the respective island. A satellite location estimate in an area implied use or a visit to that area by an eagle for this analysis. We describe the use patterns of the 'Vinalhaven eagle' relative to the vicinity of the colony during 2012, 2013 and 2014.

4.0 RESULTS AND DISCUSSION

4.1 Field Effort and Data Summary

Between 2005 and 2013, BRI and collaborators (MDIFW, NextEra Energy) deployed 19 PTTs on nestling Bald Eagles[2]. After filtering, 96,648 location estimates collected between deployment and 7 July 2014 remained for analysis. One unit (#95936), initially deployed on a nestling from Flagstaff, was redeployed in Durham the following year after the Flagstaff fledgling was injured at 10 mos. of age. At the time of this report preparation, two of the 19 units deployed through the 2013 season have expired, and two are transmitting intermittently. At present, 16 of the 19 units deployed through the 2013 season are still actively transmitting.

4.2 Dispersal Timing and Visitation to Natal Areas

4.2.1 Dispersal Timing

The median dispersal date for transmitter-fitted fledglings ranged from 8/21 to 10/21 (overall median date = 18 Sept., n = 18). Dispersal timing relative to fledging was highly variable, ranging from 6 – 92 days after fledging (mean ± SD = 44.9 ± 23.9 days); The mean age at dispersal ranged from 90 – 176 days; (mean ± SD = 129 ± 23.9 d).

McClelland et al. (1996) reported the interval between fledging and migration in 15 Montana fledglings ranged from 32-70 days (median = 42d). Wood et al. (1998) reported fledgling Florida Bald Eagles stayed in the natal area (generally within 229 m of the nest) until 105-147 days of age (mean: 126d).

Several individuals in our study dispersed notably quickly after fledging (i.e., Aziscohos, 6d; Winslow, 17d, Durham, 21d). Differences in age at dispersal did not appear to be driven by habitat types (river, lake, coastal) or latitude, but limited sample sizes preclude powerful analyses. Since our age at dispersal estimates are calculated relative to fledging at 12 weeks of age, early- or late-fledging eagles may lessen the accuracy estimates for some individuals.

Overall, the mean age of dispersal for fledglings in our study (129 d) was similar to that reported for Florida nestlings (Millsap et al. 2004). The post-fledging nest dependence period may be more variable, and possibly considerably shorter, for Maine fledglings in some areas compared to well-studied populations elsewhere. A wide variety of factors may influence dispersal and migration timing in Bald Eagles. Other studies indicate that timing of Bald Eagle dispersal and migration departures appear to be functionally-driven, most likely due to changes in resource availability (Hunt et al. 1992, Wood and Collopy 1995, Mcclelland et al. 1996, Wood et al. 1998, Harmata 2002, Millsap et al. 2004, Laing et al. 2005). Satellite telemetry and other developing tracking technologies will undoubtedly refine our understanding of Bald Eagle fledging and dispersal patterns over methods used in the past such as analyses of band encounter data and VHF telemetry. Compared to populations in Florida, Chesapeake

[2] One additional satellite unit was deployed in July 2014 on a nestling on Long Lake in western Maine; and another unit was deployed in July 2015 on Quantabacook Lake (Searsmont); these units were not included in this report.

Bay, and several western populations, much remains to be learned about Maine's eagle population – particularly the subadult age class. Improvements in our understanding of postfledging ecology of Maine's Bald Eagles will be of increasing value as eagle populations and developmental pressures increase in tandem.

4.2.2 Visitation to Natal Areas

Transmitter-fitted Bald Eagles in this study provide first-time characterizations of the extent to which Maine eagles visit areas within the vicinity of natal areas in the years prior to territory establishment. Following dispersal, ten percent (2 of 19) of transmitter-fitted Bald Eagles in our study ventured within 0.2 km of natal areas throughout their first 5 years of life (Figure 3). Following dispersal, one individual was documented ≤0.2 km from the nest during its first year (n = 1) and another during its third year (n = 1). Visits to within 0.20 km of natal nest sites were not documented for birds aged two, four, or five years of age.

Subadult Bald Eagles were documented within 5 km, 25 km, and 50 km of their natal nest sites during their first (hatch through 30 April) through fifth years of life (Figure 3). Across age groups, 42-73% of transmitter-fitted subadults travelled within 5 km of nest sites on at least one day during years 1-5, with birds in their first year being the lowest (8 out of 19 individuals) and birds in their third year (two-year olds) as the highest (8 out of 11 individuals). Subadults in their fifth year (four-year olds) were not documented within 5 km of their natal sites post-dispersal. Fifty-eight to 91% of transmitter-fitted eagles travelled within 25 km of natal nests, and 89-100% travelled within 50 km. Changing patterns of natal area visitation by age class are consistent with findings elsewhere indicating recovery distances of subadult eagles from their natal areas decreased with increasing age, and that the majority of adults were recovered near natal areas (Wood 2009). The highest proportion of individuals was documented within 50 km of natal areas; however, samples sizes (particularly in older age classes) preclude making strong conclusions about this observation.

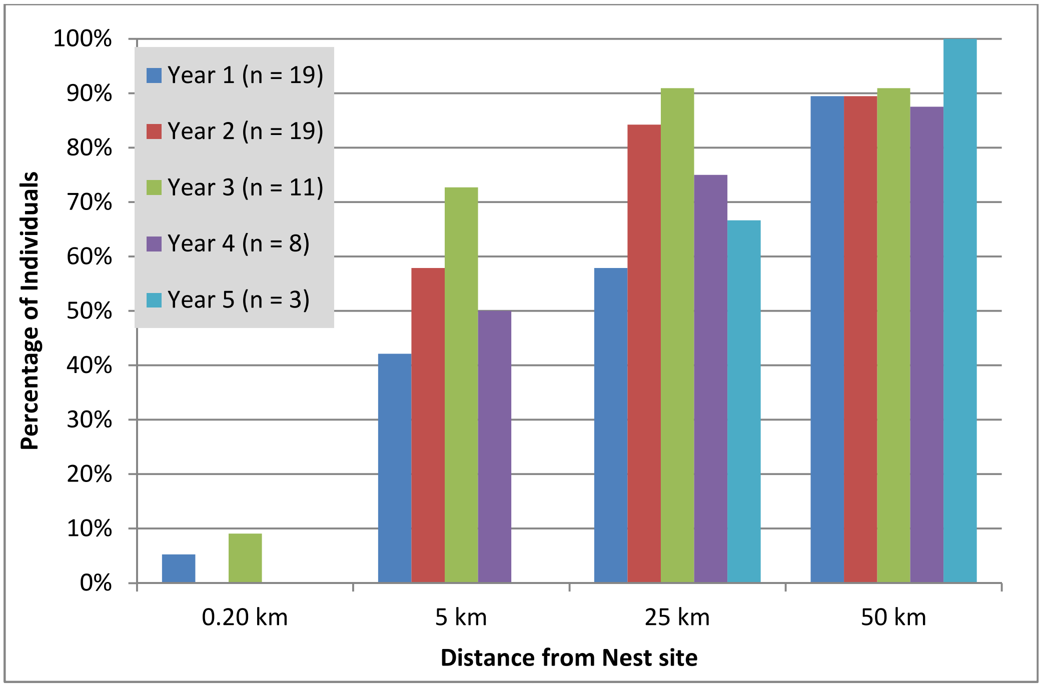

Figure 3. Proportion of transmitter-fitted Bald Eagle fledglings travelling within 0.20 km, 5 km, 25 km, and 50 km of their natal nest site during their first through fifth years of life.

*Year 1 = dispersal – 30 April of the following year. Bird age advances to the next year on 1 May (the average hatch date for Maine nestlings).

Our findings characterize the extent to which Maine subadult Bald Eagles visit the vicinity of natal areas throughout their subadult years. While virtually all transmitter-fitted eagles in our study made long-distance migrations of varying duration to states and provinces throughout the northeast, we found that >50% of eagles in all age classes visited within 25 and 50 km of their natal areas in years prior to breeding (Figure 3).

Further analyses of the mean daily distance individuals travel from natal areas demonstrates a strong attraction of subadults to their natal areas throughout the year; however, Maine subadult eagles varied widely in their habitat use and seasonal migration patterns (Figure 4). At one extreme, some individuals remained in the general vicinity of the natal area for much of the year. In contrast, some individuals made highly regular long-distance movements to northern latitudes for the summer and spent winters near natal areas.

One of the most practical needs for information on use of natal areas by subadult Bald Eagles relates to the insights it provides on natal dispersal. Natal dispersal (the distance between a bird's natal site and the area it uses for breeding; Millsap et al. 2014) is well-studied in some Bald Eagle populations (Buehler 2000, Millsap et al. 2004, 2014, Wood 2009). Using band encounter databases, Millsap et al. (2014) reported that overall natal dispersal for eight Bald Eagle populations (including Maine) was 69.2 km. That study showed a tendency for increasing natal dispersal distances moving from the eastern to the western U.S., and also that the average median natal dispersal distance for females was 78 km farther than that for males. Findings in Millsap's study and others on White-tailed Eagles suggest that natal dispersal distance may decrease with increasing nest density (Whitfield et al. 2009). This may be important in Maine as the population is likely increasing at a minimum of 8% annually (C. Todd, MDIFW, pers. comm.), and nest density varies regionally (MDIFW 2008).

Characterizations of the extent to which subadult Bald Eagles use habitats in their natal region are important given this age group is often overlooked during management considerations due to difficulty in studying them. One study of Bald Eagles banded in Yellowstone National Park found eagles aged 3-4 years experienced the largest proportional decrease in survival compared to other age groups (Harmata et al. 1999), but McCollough (1986) reported survival of first-year, second-year and older eagles was 73%, 84% and 91%.

Information on natal dispersal in eagles is used to inform controversial management decisions such as developing policies to guide issuance of “take” (removal from the wild) permits to a variety of parties (e.g., native American tribes, wind power projects, electric utility distribution facilities) (USFWS 2009, Millsap et al. 2014). Intensive efforts in Maine over the last decade to band nestlings and to fit individuals with satellite units will increasingly enable improved characterizations of the migratory ecology in Maine’s Bald Eagle population to be used toward future conservation and management decisions.

4.2.2 Conclusions

Efforts to track daily movements of Bald Eagles from fledging through adulthood have enabled first-time or improved perspectives on the daily, seasonal, and annual habits of immature and subadult eagles – age classes traditionally overlooked during most studies. Findings in this study refined limited existing dispersal timing estimates, and have demonstrated that young eagles show an annual fidelity to natal areas throughout subadulthood. Future analyses with increased sample sizes enabled by this growing dataset will substantially improve upon the coarse perspectives explored in this study effort.

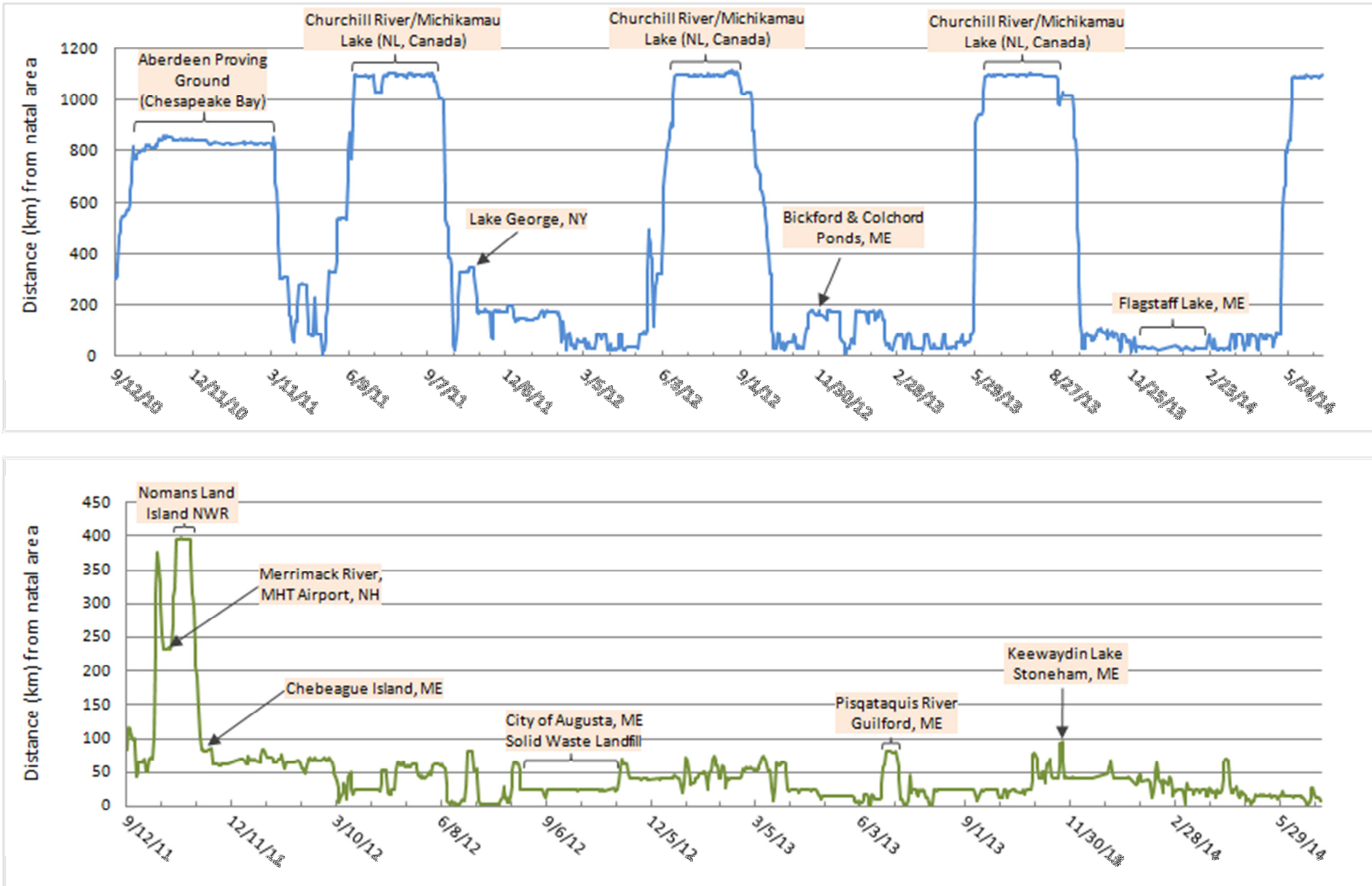

Figure 4. Contrasting migratory strategies of two Bald Eagles fitted with satellite transmitters as fledglings. Post-dispersal movements (km) of the Wyman (top; PTT #60987) and Winslow (bottom; PTT #107201) Bald Eagles relative to their respective natal areas.

4.3 Identifying Areas Important to Maine Subadult Bald Eagles

Our analyses of movements of satellite telemetry data from subadult Bald Eagles highlighted several areas throughout the state that were visited by multiple eagles during both extended summer (1 April – 1 October; Figures 5 and 6) and extended winter (1 November – 1 March; Figures 7 and 8) periods. Analyses highlighted several areas anecdotally known previously to be of importance to Bald Eagles in Maine. Findings in this study demonstrate that even a relatively small sample size of transmitter-fitted eagles (n = 19 eagles at the time of this study preparation) can be effective in identifying areas of ecological importance to the broader population. Such data is increasingly being used in management and conservation decision-making (Millsap et al. 2004, Mojica et al. 2008*a*, Watts and Mojica 2012, Watts et al. 2015).

4.3.1 Extended Summer Period: (1 April – 1 October)

Analyses of transmitter-fitted Bald Eagles during the extended summer period highlighted numerous regions throughout Maine of known or presumed importance to eagles originating from Maine and elsewhere (Figure 5, 6). Analyses highlighted use of the Connecticut River along the NH/VT border, and areas throughout New York, New Brunswick, and Quebec by multiple eagles, but at lower levels compared to those identified in Maine. Links between Maine's eagles and some areas such as northern Quebec and Lake Erie, are previously undocumented. The majority of areas noted to be visited by multiple transmitter-fitted eagles in Maine were focused in central and western Maine, typically in association with prominent lake and river features. Additional areas used by multiple eagles were scattered throughout northern, eastern, and northeastern Maine.

Primary areas in Maine identified in our analyses included:

1. **The Lower Sebasticook River corridor**. The Sebasticook River, running between Benton Falls and Waterville, is regionally unique due to the seasonal river herring run that attracts large aggregations of Bald eagles during the upriver fish run (early May– mid June) and the downriver run (July-October). Forty-seven percent (9 out of 19) of the transmitter-fitted eagles from throughout our deployment region visited the Lower Sebasticook during the extended summer period. More than any other resource in the state, the Lower Sebasticook River likely plays an important role in boosting survival of subadult Bald Eagles originally from Maine or elsewhere.

Case Study Highlight: The Sebasticook River Corridor

Background and History: The Sebasticook River is a unique and ecologically valuable river located in central Maine. With a watershed encompassing about 606,000 acres, it is the largest tributary to the Kennebec River, well-known for harboring prime spawning habitat for anadromous fish such as alewives and blue-back herring (collectively referred to as 'river herring'). Dams have been built at two primary locations along the Sebasticook over the last several centuries. The first, approximately five miles upstream from the confluence of the Kennebec River and the Sebasticook River, was built before the Revolutionary War in the township of Benton Falls. Upper and lower dams in Benton Falls have endured a long history of controversy, demolition, and reconstruction. The 1908, a second dam was built across the Sebasticook River just upstream from the confluence with the Kennebec at the site of a historic outpost – Fort Halifax – in Winslow. Both the Fort Halifax and the Benton Falls dams have intermittently allowed and prohibited migrating fish from reaching their spawning grounds. The Fort Halifax dam stood with no provision for fish passage for 100 years, until late summer 2008 when it was removed after a lengthy litigation process. In 2006, facilities enabling both upstream and downstream fish passage were completed at Benton Falls. While still drastically reduced from historic levels, the Sebasticook River now hosts the largest annual run of river herring in the entirety of New England. During the 2011 fish run, at least 2.7 million river herring swam up the five mile stretch from the former Fort Halifax dam site to the Benton Falls Dam (ME DMR 2012).

Notable aggregations of Bald Eagles are commonly observed on the Lower Sebasticook between mid-May to early-July as they take advantage of this uniquely abundant food resource. Occasional helicopter surveys of the lower corridor detected approximately 60 eagles over the five-mile river stretch (C. Todd, pers. comm.), probably translating to use by a much higher number of eagles. This seasonal aggregation of eagles around a cyclically abundant food source has few other analogs in the northeastern United States. Aggregations of similar proportions have been documented on the Delaware River in southern New York near the Cannonsville Reservoir, where alewives are stocked by the tens of thousands seasonally (Nye 2008). Given its uniqueness, Lower Sebasticook River is increasingly being shown to be an important resource contributing to the recovering bald eagle population in the region. In addition to bald eagles, the abundance of prey is likely valuable to other species such as Great-blue Herons, Ospreys, Double-crested Cormorants, Belted Kingfishers, and river otter. The Black Tern, endangered in the state of Maine, as well as the threatened yellow lamp mussel and Tomah mayfly also rely on the river corridor.

Findings in this study, which demonstrate that multiple Bald Eagles visit of the Lower Sebasticook River during the summer, are consistent with other indications highlighting the value of this area to eagles. During the summer of 2014, BRI and MDIFW conducted both ground- and aerial-based surveys of the Sebasticook River corridor in order to characterize and quantify the extent of Bald Eagle use of the Sebasticook River. Both aerial and ground-based surveys detected notable aggregations of Bald Eagles along the river corridor during the May-July upriver river herring migration (DeSorbo et al. 2015). On the peak day of eagle use, over 60 Bald Eagles were counted along a five-mile stretch of the Lower Sebasticook. This finding confirms this area probably hosts the largest eagle aggregation in New England. Much of the Sebasticook River is in private holdings. Conservation measures to protect this habitat and the fish populations it supports are warranted given demonstrated broad-reaching ecological benefits to regional Bald Eagles and numerous other species.

2. **Sebasticook Lake.** The headwaters for the Sebasticook River. This lake, and agricultural/riverine areas immediately to the north and northeast of the lake harbored seven different transmitter-fitted individuals during the extended summer period. Similar to the Lower Sebasticook River corridor itself, eagles are likely attracted to Sebasticook Lake by the abundance of river herring spawning in the lake. Sebasticook Lake is highly unique compared to other Maine lakes as it is a primary

destination for millions of river herring migrating to its waters to spawn. In 2011, 2.75 million fish were counted at the Benton Falls dam on the Sebasticook River during the upstream fish run.

3. **Merrymeeting Bay and the Androscoggin River in Topsham/Brunswick** . Merrymeeting Bay is an ecologically unique freshwater delta that sits at the confluence of the Androscoggin and Kennebec Rivers. Merrymeeting Bay is well-known to harbor aggregations of Bald Eagles on a year-round basis. Second only to the Sebasticook River, Merrymeeting Bay was among those areas most prominently identified in our analyses during the extended summer period (this area is discussed in further detail below).

Case Study Highlight: Merrymeeting Bay & The Kennebec Estuary

Background and History: Merrymeeting Bay, and the greater Kennebec Estuary system, is a geographically unique and ecologically important feature on the mid-south coast of Maine. A bay in name, Merrymeeting Bay can be more accurately defined as an inland freshwater tidal delta. At the convergence of six rivers, including two of Maine's largest- the Kennebec and Androscoggin Rivers – fresh water from nearly 40 percent of Maine's land area flows into this semi-impounded body of water. A 280-yard wide gap in the bedrock, known as the Chops, separates the Bay from the Gulf of Maine. Despite this disconnect, Merrymeeting Bay still experiences an average tide of about 5 feet, however the resulting salinity is less than 0.5 parts per thousand. It is one of the few places in the world where major rivers come together to form an enclosed tidal delta (MDIFW 2009). Comprising more than 20 percent of the state's tidal marshes, many sandy beaches, and globally rare pitch pine woodland communities, the Kennebec Estuary supports a biologically rich and productive ecological community. This area provides critical habitat for many state and federally endangered, threatened, and recovering wildlife and plant species. The estuary harbors essential habitat for the state-endangered roseate tern and piping plover. Extensive tidal flats containing beds of submerged and emergent aquatic vegetation, such as wild rice, provide the cover and forage to support thousands of breeding and wintering migratory waterfowl (MDIFW 2009). In the lower portion of the Kennebec Estuary, below the Chops, strong tidal currents and higher salinity keep the water from freezing, offering key winter habitat for waterfowl. Floodplain forests and shrub swamps serve as key stopover sites for neo-tropical passerines (MDIFW 2009). Ten species of anadromous fish, including Atlantic salmon, shortnosed sturgeon, Atlantic sturgeon, shad and alewives inhabit the bay. Despite ever increasing developmental pressures, the land surrounding Merrymeeting Bay and the Kennebec River Estuary has remained relatively undeveloped, thus creating the opportunity for large-scale conservation in a relatively intact estuarine ecosystem.

Merrymeeting Bay is regarded to contain some of Maine's best breeding and wintering habitat for Maine's recovering Bald Eagle population (FoMB 2014). Findings in this study highlight its importance to Maine's subadult Bald Eagles. Continuing efforts to conserve nesting, feeding, and roosting habitats in this area are warranted and would presumably have long-lasting impacts on Bald Eagles and other wildlife in the region.

4. **Lower Kennebec River.** The Kennebec River watershed is an important component of Maine's hydrology and it is a focal point for Maine's growing eagle population. The Lower Kennebec harbors

notable fisheries during the summer months that are of importance to a wide variety of piscivores, especially Bald Eagles.

5. **The Androscoggin River in the Livermore Falls area**. The Androscoggin River watershed is the third largest in the state behind the Penobscot and the Kennebec. Like many Maine Rivers, the Androscoggin has a long and complex history of abuses and a remarkable continuing recovery. Our analyses highlighted the portion of the river in Livermore Falls for harboring 7-9 transmitter-fitted eagles. This area was also identified in Maine's Beginning with Habitat program for its value as Bald Eagle habitat.[3] Eagles in this area are likely attracted to fish using shallow areas below the dam in Livermore Falls. In some areas with moderately abundant food resources, territorial resident eagles may aggressively defend local food resources such as fish runs from other eagles. Bald Eagles have been slow to recolonize the Androscoggin River following the decline. The low density of eagles in this region may lessen territoriality of eagles over this food resource, thereby further attracting eagles to the Androscoggin during fish runs.
6. **Large Lakes** in the Rangeley Lakes vicinity (i.e,. Flagstaff, Aziscohos, Umbagog) and the southern end of Moosehead Lake. Our analyses identified numerous large lakes, primarily in western Maine, that were used by 5-6 different transmitter-fitted eagles during the extended summer period. Many of these lakes are impounded rivers with large amounts of undeveloped shorelines. Foraging habitat on these lakes can be affected by water-level fluctuations to varying degrees depending on water demands for hydroelectric or downstream water supply purposes.
7. **Artificial attractions.** Eagles are regularly observed at several landfills and other facilities throughout the state. Our analyses indicated multiple eagles visited the City of Augusta landfill, the Presque Isle landfill, and a poultry farm in Warren. All three of these areas are known by locals and wildlife agencies for the bald eagle aggregations they encourage. Our knowledge base about artificial food supplies and their use by Maine Bald Eagles is limited. Further analyses evaluating the patterns of use of these areas and risks they might pose to eagles are warranted.

[3] http://beginningwithhabitat.org/the_maps/pdfs/Livermore%20Falls/Livermore%20Falls%20Map%202.pdf

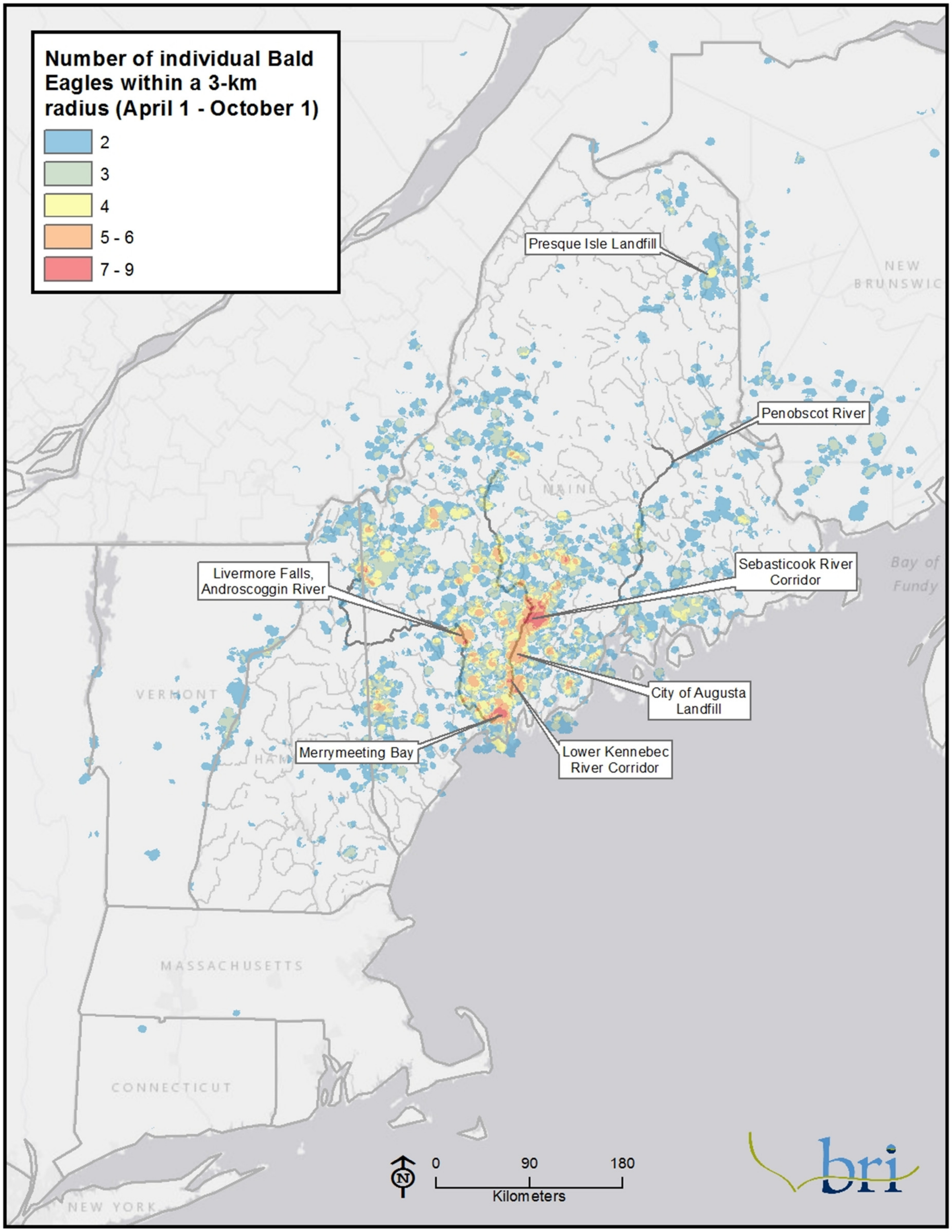

Figure 5. Areas used by multiple (≥2) transmitter-fitted Bald Eagles in New England and portions of Atlantic Canada between 1 April and 1 October.

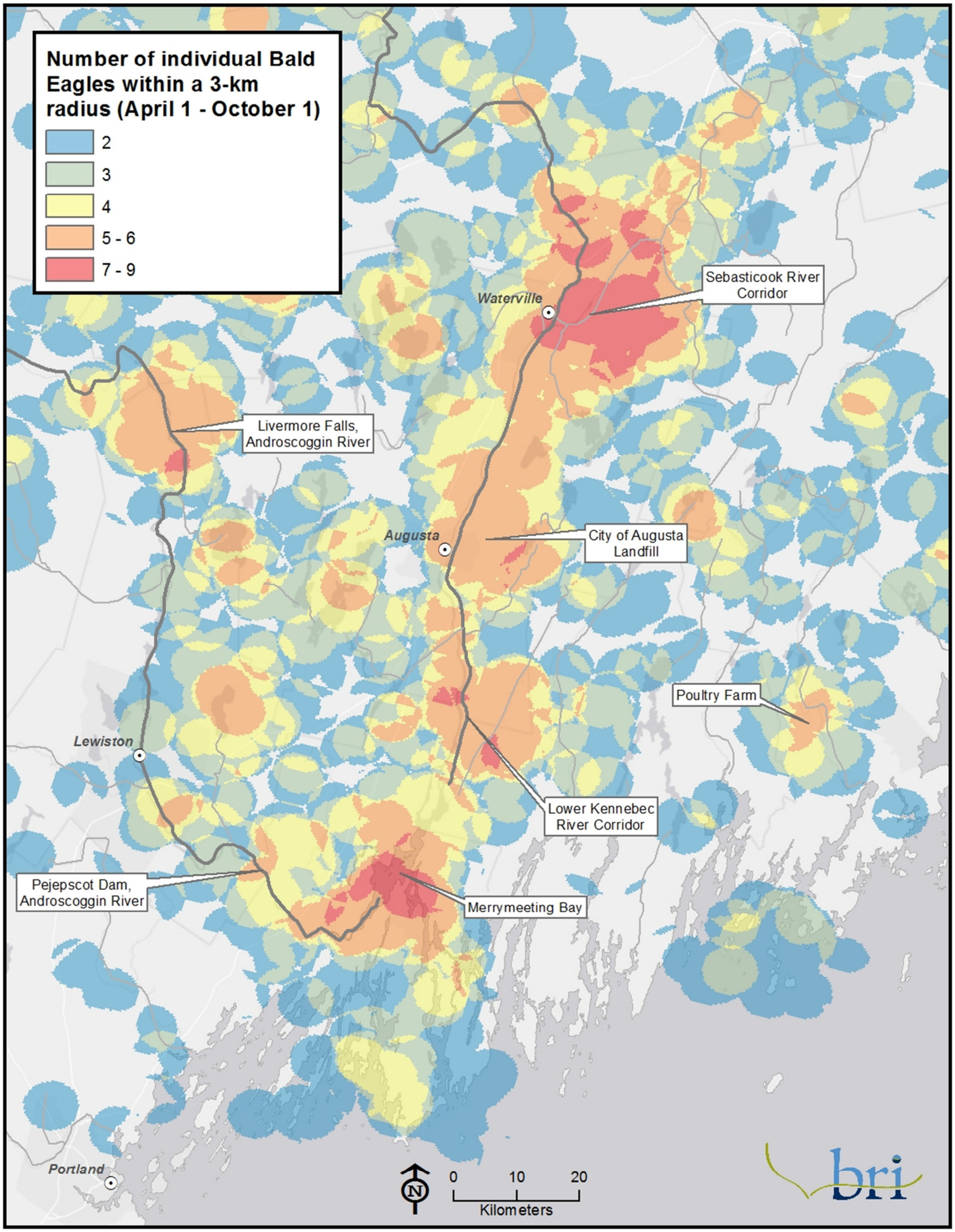

Figure 6. Areas used by multiple (≥2) transmitter-fitted Bald Eagles in the Lower Kennebec River Region between 1 April and 1 October.

4.3.2 Extended Winter Period: (1 November – 1 March)

Analyses documented areas used by multiple transmitter-fitted Bald Eagles during the extended winter period (Figures 7 and 8). Areas identified in analyses during the winter months were more sparsely distributed and were comprised of fewer individuals compared to the extended summer period. This finding is consistent with indications from banding and transmitter tracking data that a significant portion of Maine's subadult Bald Eagles leave the state in the fall and winter months. The majority of areas identified in analyses during the extended winter period were also detected during the extended summer period, highlighting the year-round importance of some areas to the population. Primary areas identified in extended winter analyses included:

1. **Merrymeeting Bay and the Androscoggin River in Topsham/Brunswick.** (see previous section)
2. **The Androscoggin River in the Livermore Falls area.** (see previous section)
3. **The Lower Kennebec River.** (see previous section)
4. **Artificial attractions**: A poultry farm in Warren, City of Augusta Landfill.
5. **Canaan Bog, Canaan.** An artificial winter feeding station in Clinton likely attracts eagles to this area.
6. **Lake habitats between Branch Lake (Ellsworth) west to small ponds east of the Penobscot River corridor:** Jacob Buck Pond, Thurston Pond, Long Pond, Dead River at the head of Alamoosook Lake
7. **Coastal areas west of Harpswell including Maquoit Bay and nearby islands.**

Several areas identified during analyses during the extended winter period were presumably attracted to areas retaining some open water (Merrymeeting Bay, Androscoggin River at Livermore Falls, parts of the Lower Kennebec River), due to natural or artificial processes. Areas used by multiple eagles that were not centered on open freshwater tended to be associated with artificial food resources (i.e., poultry farm, Augusta landfill, Clinton artificial feeding station). The Sebasticook River Corridor, easily the most prominent area used by multiple eagles during the summer period, was not detected as being used by multiple eagles during the winter period. This reflects the seasonal nature of this anadromous fishery resource.

Areas identified in analyses for their importance to eagles are likely strongly influenced by the location of deployment sites. Analyses in this study indicate high philopatry and low natal dispersal distances for this species. However, qualitative evaluations of data from this study also demonstrate that resource availability is a strong, possibly predominant factor influencing subadult eagle use patterns broadly throughout the region. For example, the Rocky Lake eagle from eastern Maine used both Sebasticook Lake and the Sebasticook River corridor heavily, in addition to the Augusta landfill (along with 6 other individuals). Rocky Lake is approximately 234 km (145 mi) from the Sebasticook region, and approximately 195 km (170 mi) from the Augusta region. The Presque Isle landfill is >250 km from the nearest transmitter deployment site; however, the eagles it attracted tended to be from the nearest deployment sites (Madagascal, Lobster, and Madison).

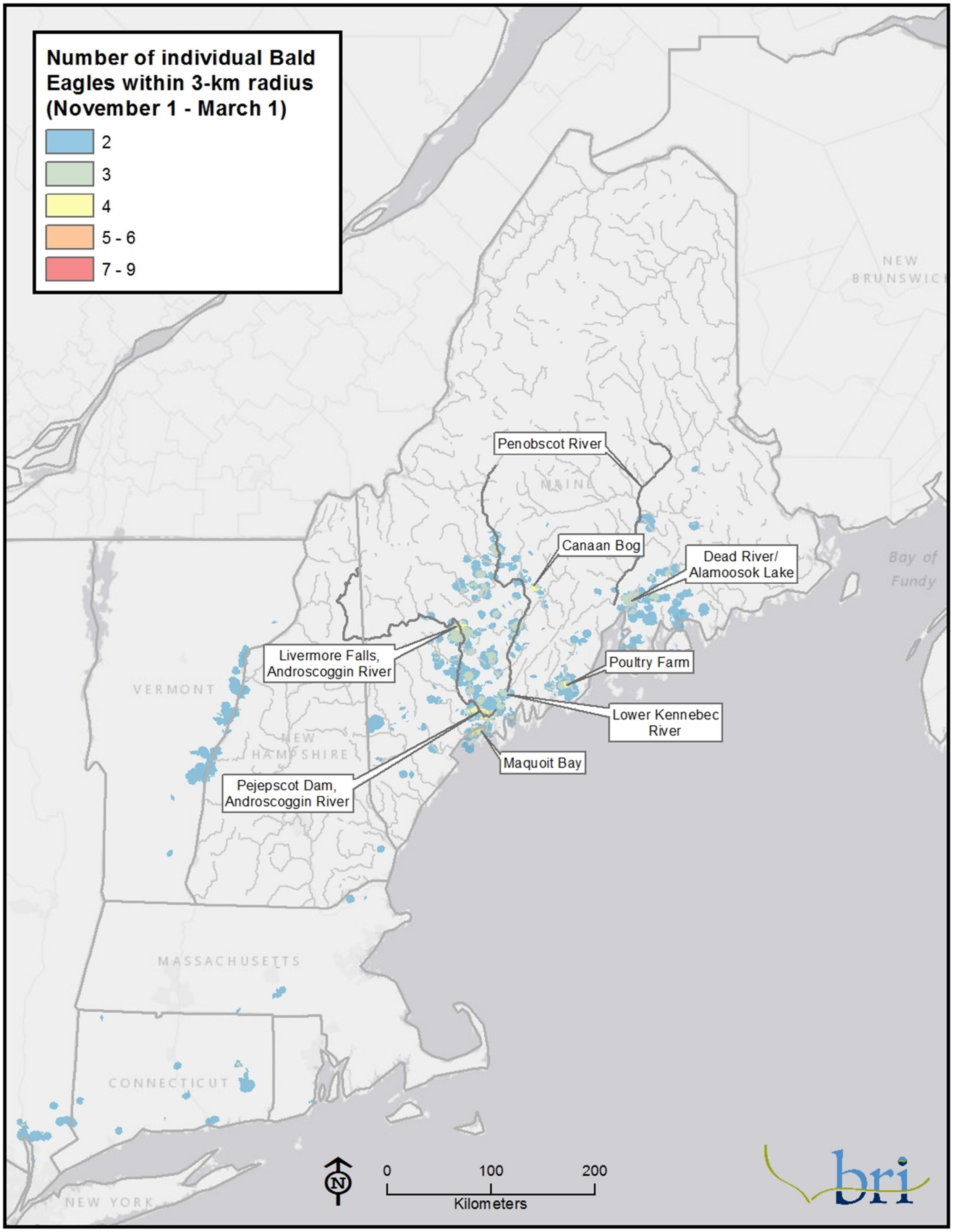

Figure 7. Areas used by multiple (≥2) transmitter-fitted Bald Eagles in New England between 1 November and 1 March.

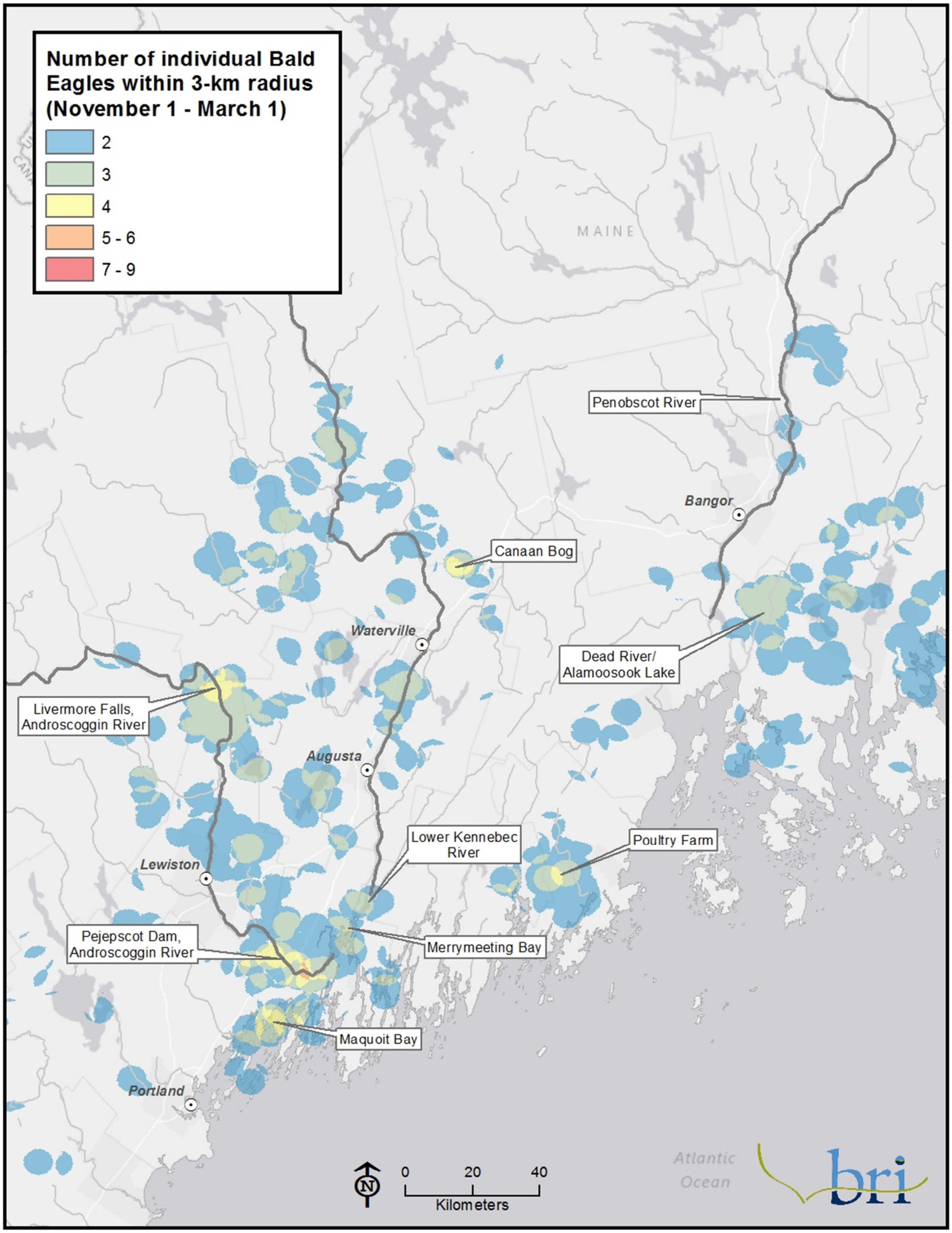

Figure 8. Areas used by multiple (≥2) transmitter-fitted Bald Eagles along three major Maine river corridors between 1 November and 1 March.

4.3.3 Artificial Attractions

Our analyses highlighted that several 'artificial' sites were visited by multiple subadult Bald Eagles during both extended summer and winter seasons. Primary sites noted include: (1) the City of Augusta Landfill, (2) the Presque Isle Landfill, (3) a Poultry Farm in Thomaston, ME, and an eagle baiting/feeding station in Clinton, ME. Aggregations of Bald Eagles have been previously reported at all of these locations (Figure 9). Data collections by transmitter-fitted eagles provide further insights on the regularity and seasonality of use of such areas.

Figure 9. An aggregation of Bald Eagles at an artificially supplemented feeding station in Clinton (top). Aggression between eagles is often common at such stations (bottom) and can lead to injury or mortality.

Artificial feeding of Bald Eagles (which is illegal in one county of Maine and elsewhere in the U.S.), such as bait piles, are generally associated with increased aggression and regular combat-induced injuries in eagles. Aggression is often less severe in areas where food is plentiful (i.e., anadromous fish runs), but piracy (intra-species) and kleptoparasitism (inter-species) is common in Bald Eagles due to their generally opportunistic foraging strategy (Stalmaster 1987, Buehler 2000). Industries, such as poultry farms, or landfills providing large quantities of carrion or other food that attracts eagles, may be functionally equivalent to eagle baiting stations. Such areas may expose eagles to a variety of risks (i.e., entanglement, exposure to contaminants, poisoning, increased electrocution hazards due to proximity of utility poles relative to the food resource;) that predispose them to injury beyond what might occur in natural settings. Further case-by-case investigations of risks at sites identified in this study are warranted.

Figure 10. A winter aggregation of Bald Eagles at the Augusta Landfill.

Photo credit: Jeanne Marie Coleman Photography.

4.3.4 Insights for Wind Power and other Facilities

Like many numerous other states in New England, Maine is faced with a large number of proposals to construct land-based wind energy facilities throughout the state. Bald Eagles represent a significant management challenge between wind project developers and wildlife agencies because the Bald and Golden Eagle Protection Act prohibits killing, injuring, or harassing Eagles. The U.S. Fish and Wildlife Service considers information on habitat use and natal dispersal when establishing limits to “take” permits to windpower developers and other parties in the event that eagles are inadvertently killed (USFWS 2009, Millsap et al. 2014).

Data collected during this study document areas of demonstrated importance to Maine’s Bald Eagle population. Many of the areas identified in this study likely represent those of particular importance to the subadult eagle age class, whose survival is critical to maintaining population stability (Grier 1980). We suggest areas of importance to Bald Eagles and associated travel corridors should be considered in future risk evaluations for the construction of wind power or other large-scale facilities in Maine. Such an approach could be advantageous to developers and conservation entities alike. Further efforts to model landscape and other factors influencing Bald Eagle movement patterns of adult breeding Bald Eagles using high resolution GPS technology are currently underway (B. Massey, UMASS). Such studies will likely provide first-time, site-specific information on animal movements that will improve assessments Bald Eagle collision risks associated with proposed wind energy projects.

4.3.5 Conclusions

Analyses based on 19 transmitter-fitted Bald Eagles further confirm that data collected from satellite tracked individuals can be effectively used to identify areas of importance to Maine's subadult Bald Eagle population. Satellite-tracked individuals in our study reiterated the ecological value of areas already known to harbor eagle aggregations, but also provided insights on both natural and manmade areas likely undervalued for their role in supporting eagles in Maine. Areas such as the Lower Sebasticook River corridor, parts of Merrymeeting Bay, and numerous other regions, were highlighted in this study for their importance to subadult eagles. Such areas likely provide survival benefits to the subadult portion of the population, and conservation efforts targeting these areas may have overall population benefits. Our study also identified several 'artificial areas', regularly visited by a substantial portion of eagles tracked in this study, such as feeding stations and landfills. These areas may be associated with risks to eagles, and they may require further investigation. Areas of importance to Maine Bald Eagles, and their associated travel corridors, should be considered during proposals to build large-scale industrial facilities such as wind turbines. Data collected by satellite transmitters is commonly used toward a variety of management purposes, including identifying communal roost areas, lessening electrocution hazards, characterizing landfill use by eagles (Watts and Mojica 2012, Turrin et al. 2015, Watts et al. 2015) and documenting migration patterns, survivorship and fecundity for populations (Wood 1992, Millsap et al. 2004, Mojica et al. 2008*b*). Our sample size of satellite-tagged eagles is limited in number and spatial extent. Further efforts to deploy transmitters in northern and eastern Maine will likely reveal additional areas of similar or greater importance to Maine's eagle population while also enabling more robust analyses to support conservation and management needs.

4.4 Use of Coastal Habitats by Maine Bald Eagles

The Maine coastline is unique in character, with thousands of miles of shoreline and over three thousand islands. Roughly half of Maine's Bald Eagle population nests along the coast. Efforts by state and federal agencies, land trusts and numerous conservation partners to conserve coastal nesting habitats significantly contributed to the continuing recovery of Maine's Bald Eagle population.

Much remains unknown about the ecology of the coastal-dwelling portion of Maine's Bald Eagle population. This data gap is particularly prevalent for post-dispersal (i.e., juveniles and subadults) movements of eagles, because their widely roaming habits make them very difficult to study until they establish a territory and become sexually mature around roughly five years of age. Improvements in our understanding of habitat use patterns of Maine's coastal eagles would help inform wildlife management decisions related evaluating risks of proposed construction projects along the coast (i.e, inshore and offshore wind power facilities, other industrial facilities), seabird management, and other subjects. Here, we conducted coarse, preliminary analyses on data from Bald Eagles fitted with satellite transmitters to: (a) characterize the extent to which post-fledged coastal- and inland-hatched Bald Eagles (aged 3 mos. – 5 years) used coastal vs. inland habitats, and (b) characterize the extent to which eagles visited Maine's five remaining Great Cormorant Colonies.

4.4.1 Fidelity to Natal Habitats

Bald Eagles hatched in strictly coastal areas (n = 3; Phippsburg, Vinalhaven, Ram Isl; Figure 2) spent 60-78% of their Maine-based days using habitat along the Maine coast. The Bald Eagle fitted with a transmitter in Bucksport, which could be arguably categorized as inland or coastal due its close proximity to Penobscot Bay and extensive freshwater systems, spent only 7% of its Maine-based days using coastal habitats. Bald Eagles from inland sites throughout Maine (n = 15, those not mentioned above; Figure 2) spent 0-23% of their Maine-based days using coastal habitat. Of the 15 transmitter-fitted eagles from inland sites, 33% were never documented using Maine coastal habitat (n = 5; Brassua, Aziscohos, Richardson, Madison, Jay), while the remaining 66% (n = 10; Flagstaff, Rocky Lake, Lobster, Old Town, Saco, Winslow, Onawa, Madagascal, Wyman, Durham) spent between 1 – 23% of their Maine-based transmitter days using coastal habitats. We found no evidence suggesting that natal latitude had a strong influence on birds' tendency to use the coastal environment. Bald Eagles from Flagstaff Lake and Lobster Lake in northwestern Maine were among birds spending the highest proportion of Maine-based days using the Maine coast of all inland-based nests, while eagles from neighboring Aziscohos, Richardson and Brassua were never documented using the Maine coast. Knowledge of high philopatry and a relatively low natal dispersal distance in eagles suggests that coastal-hatched eagles will likely spend an increasing amount of time in their natal habitat type with increasing age (Wood et al. 1998, Millsap et al. 2014) as long as suitable nesting habitat and food resources exist.

4.4.2 Bald Eagle Visitation to Maine's Great Cormorant Colonies

Background: Maine is the only U.S. state to support a breeding population of Great Cormorants (*Phalacrocorax carbo*). On 1 August, 2014, MDIFW recommended a review of the current status of Great Cormorants as Threatened on Maine's Threatened and Endangered Species List due to concerns of declining populations. Only discovered breeding on the Maine coast in 1984, the number of breeding Great Cormorants in Maine has declined significantly in recent years. The suspected peak of the population was 260 pairs in 1992. By 2003, the population declined by 66% (141 nests at 8 sites), in 2011 only 72 pairs nested on five islands, and in 2013 the nesting population was reduced to 48 pairs in five colonies (C. Todd, MDIFW, pers. com.). While managers are trying to understand all of the factors influencing this decline, it is apparent through field observations that depredation by eagles is playing a major role in that decline. Observations of small aggregations of Bald Eagles at or near nesting colonies are regularly noted (B. Allen, MDIFW, pers. comm.). Bald Eagle visits to cormorant colonies can be highly disruptive during all stages of the nesting cycle. Bald Eagles have been observed predating Great Cormorant eggs and developing young. Adult eagles have been observed predating adult Double-crested

Cormorants. Great Cormorant eggs typically hatch in late May / early June. Eagle disturbances resulting in the fleeing of incubating cormorants has been observed to result in increased egg predation by gulls (L. Welch, USFWS, pers. comm.). Great Cormorant fledglings are learning to fly by mid-August, which coincides with the post fledge period for a large proportion of Maine Bald Eagles (MDIFW 2004). Nestling cormorants are defenseless during this time and are therefore highly vulnerable to predation by eagles.

Of the four satellite transmitters deployed in coastal areas (Phippsburg, Vinalhaven, Ram Island, Bucksport) and the 15 deployed inland (all remaining; see Table 1 and Figure 1) by the time of our data cutoff for this report, only the eagle from Vinalhaven fitted with a PTT ('Vinalhaven eagle hereafter') ventured into the vicinity of one of five of Maine's remaining Great Cormorant colonies. This colony, (Coastal Island Registry [CIR] # 63-175 "Roberts Island - west" – aka, "Little Roberts" in this report), south of Vinalhaven Island (Figure 11), located off the southern shore of Vinalhaven Island in Knox County, represents the southern periphery of the range of Great Cormorants in Maine. We describe the movements of the Vinalhaven eagle relative to the vicinity of the Little Roberts cormorant colony below.

Movements of the 'Vinalhaven eagle' – PTT #118880 – deployed 6/15/2012.

Post-fledging period: Satellite data indicated the Vinalhaven eagle visited the Roberts Island area between fledging and dispersal during 2012, its natal year (Figure 11). The eagle visited the Roberts Island area on several excursions in 2012 as a fledgling. On 1 August, very shortly after fledging, the eagle fixed 2 GPS locations, 1 hour apart, on nearby Otter Island. It subsequently returned to Vinalhaven Island for the rest of the day on 1 August and remained in the general vicinity of the nest site through the morning of 17 August, when it returned to the Roberts Island area. Over the next three days (17 - 19 August), the eagle fixed locations on Otter Island, Carvers Island, Roberts Island and Little Roberts Island. The eagle then returned to the natal area again and remained there for approximately two days. On the afternoon of 21 August, the fledgling returned to the Roberts Island vicinity again. Satellite data suggest it remained there until 3 September, visiting Little Roberts Island on at least three occasions and making frequent trips between Otter Island and Roberts Island as well as visits to Hay Island and Carvers Island. During this 13-day period, the Vinalhaven eagle was documented returning to Vinalhaven Island on a minimum of three occasions, each for <24 hours.

In total, satellite data from fall 2012 suggests the Vinalhaven fledgling made visits to Little Roberts on a minimum of 6 occasions (Aug 18-19, 27-29), Roberts Island a minimum of 21 occasions (Aug 17-18, 21-25, 27-30, Sep 1-2), and Otter Island a minimum of 32 occasions (Aug 1, Aug 17-19, Aug 21-Sep 3). Additional locations were also fixed on the southern shoreline of Vinalhaven and numerous other islands in the Roberts Island vicinity during this time (Figure 9).

Post-dispersal, 2012-2015: After spending the winter of 2012/2013 in western Connecticut / New York, the Vinalhaven eagle returned to Maine and made several brief visits the Roberts Island area during April and June 2013, including one visit to Little Roberts Island on 19 June for a minimum duration of 1 hour. Satellite transmissions largely ceased between 21 June and 12 December 2013, presumably due to feather coverage over the transmitter unit's solar panel. Unfortunately, this negated any further insights on Bald Eagle habitat use patterns during the remainder of the 2013 Great Cormorant nesting season. Satellite fixes confirmed visits to southern and western portions of Vinalhaven Island, February through mid-April 2014. After this period, the eagle did not appear to visit the Roberts Island area again before another lapse in transmissions limited insights again starting late April 2014. The Vinalhaven eagle transmitted from throughout the Vinalhaven/North Haven region January through April, 2015[4]. As of July 2015, the last transmissions were fixed in the Medomak River/Bremen region on April 24, 2015.

Satellite tracking data from this study only confirms that one of the two fledglings from the Spectacle Island Bald Eagle nest on Vinalhaven spent numerous days and nights in the immediate vicinity of the Little Roberts Great Cormorant colony in August - September. Post-fledging Bald Eagles in eastern Maine have been found to be entirely dependent on their parents for food 35-67 days prior to dispersal (McCollough 1986). It is therefore likely that at least one of the adult eagles from the Spectacle Island pair, and quite possibly the Vinalhaven eagle's sibling, were present for a portion or all visits to the Roberts Island vicinity. Field observations of small groups of eagles, are common at Great Cormorant colonies (B. Allen, MDIFW, pers. com., L. Welch, USFWS pers. com.). Habitat use patterns of the Vinalhaven eagle as indicated by satellite telemetry may be indicative of those for other individuals locally.

Aggregations of eagles are commonly observed at sites throughout Maine where abundant seasonal food resources such as anadromous fish runs, artificial food supplies, seal pupping areas, and others exist (Elliot et al. 2004, DeSorbo et al. 2015). Our dataset of 19 tracked subadult eagles summarized in this study demonstrate that highly regular, seasonal visits to targeted areas are common among subadult Bald Eagles (Figure 4, Figure 11). Prior to the widespread population decline of the Bald Eagle, the diet of the coastal-dwelling population was likely predominated by river herring, Menhaden, and several species of groundfish (i.e., cod, haddock, sculpin) stranded in intertidal areas by Maine's extreme tides. The precipitous decline of these fish stocks likely caused a dietary shift in eagles toward one predominated by birds (i.e., gulls, cormorants, eiders). In the absence of dominant fisheries, seabird colonies may currently represent a seasonally abundant food supply for eagles, who are well-established opportunistic foragers. Colonies may be especially attractive to subadults, who tend to avoid territorial adults and may have poor hunting skills. Once discovered, colonies likely attract eagles annually. Findings from limited satellite tracking data in this study suggest that predation pressures on this particular seabird nesting colony will likely increase with the continuing recovery of Maine's Bald Eagle population. Proximity to the mainland is likely an important factor influencing predation eagle pressure on seabird colonies. Colonies such as Little Roberts will likely receive higher regular predation pressures compared to those located further offshore, as eagles are generally not well-suited for long, overwater journeys[5].

4.4.3 Conclusions

[4] Data from 2015 was beyond the data cutoff for analyses in this report, and thus 2015 data was not included in Figure 10. We mention 2015 movements here to further demonstrate the strong annual site fidelity to the area.

[5] Note however, several dozen eagles have been annually observed at Gray Seal birthing areas far offshore in March.

Data from satellite-tracked subadult eagles in this study confirm that Maine-hatched subadult eagles have a fidelity to their natal habitat while in the state. Our findings revealed that the Little Roberts Great Cormorant colony was likely among the first places the eagle visited following fledging. Findings also demonstrated a general fidelity to the area and the colony in years subsequent to dispersal and migration. Based on the limited perspectives provided from this single eagle, we would expect predation pressures on this colony to increase over time. Further efforts documenting the seasonal and annual habitat use patterns of Bald eagles breeding in the vicinity of this and other seabird nesting colonies would improve our understanding of the pressures eagles exert on sensitive seabird nesting colonies. Rapid advancements in tracking technologies, such high resolution GPS, automated telemetry, and others, would likely provide higher resolution perspectives on the habitat use patterns of Bald Eagles in the coastal environment than those collected opportunistically during our broader study effort. Such information would be useful in developing and evaluating the efficacy of potential management strategies.

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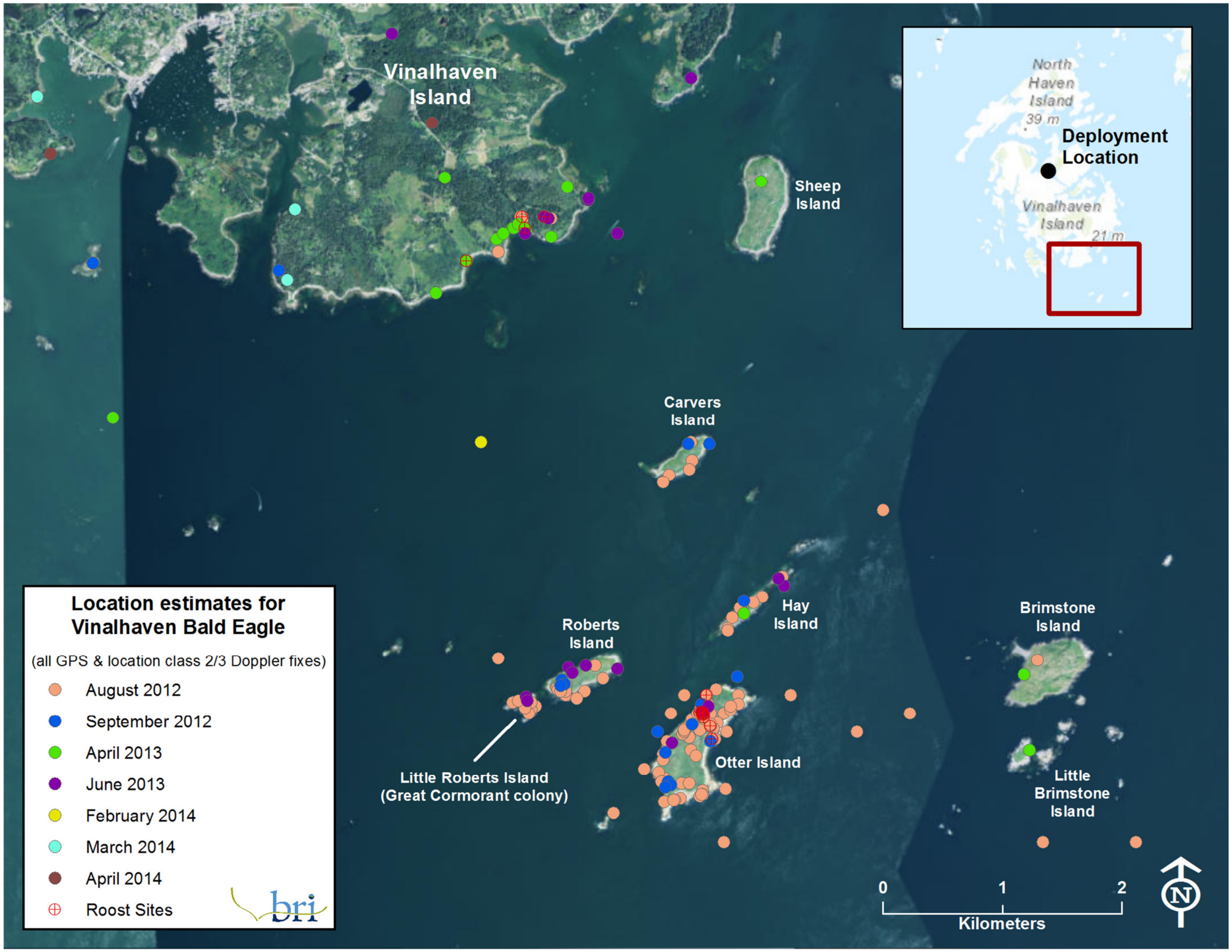

Figure 11. Locations of Vinalhaven Bald Eagle PTT# 118880 in the vicinity the Great Cormorant colony on Little Roberts Island, Penobscot Bay, Maine.

The transmitter fixed to this eagle received limited communications during summer seasons of 2013-2014. Thus, perspectives on use of the area shown during the Great Cormorant nesting periods for 2013-14 are limited and biased toward spring and winter months.

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