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FIRST COMPLETE MIGRATION CYCLES FOR JUVENILE BALD EAGLES (*HALIAEETUS LEUCOCEPHALUS*) FROM LABRADOR

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Abstract.—We documented complete annual migratory cycles for five hatch-year Bald Eagles (*Haliaeetus leucocephalus*) from central Labrador, Canada. We attached backpack-mounted Platform Transmitter Terminals (PTT) to track hatch-year eagle movements from their natal areas. The median departure date from natal areas was 26 October 2002, with the earliest departure occurring on 7 October 2002 and the latest on 12 November 2002. All eagles migrated independently of siblings and spent a mean of 62 d on autumn migration at a mean speed of 45 km/hr with a mean of five stopovers. Eagles travelled north in the spring at an estimated speed of 27 km/hr over 32 d, with a maximum of 11 stopovers. One wintered in the Gulf of St. Lawrence, while the remaining eagles migrated to the northeastern U.S.A. Eagles spent a mean of 76 d on their wintering grounds, with a median date of departure for spring migration of 20 March 2003. Two of the eagles returned to Labrador during their first summer and showed some fidelity to their natal areas. We document migration routes and identify stopover areas.

Key Words: *Bald Eagle*; Haliaeetus leucocephalus; *migration*; *juvenile*; *satellite telemetry*; *stopover*; *dispersal*; *Labrador*.

PRIMEROS CICLOS MIGRATORIOS COMPLETOS PARA INDIVIDUOS JUVENILES DE *HALIAEETUS LEUCOCEPHALUS* DE LABRADOR

Resumen.—En este estudio documentamos los ciclos migratorios anuales completos para cinco individuos de la especie *Haliaeetus leucocephalus* durante su año de eclosión en Labrador central, Canadá. Para seguir los movimientos de las águilas desde su lugar de nacimiento, les acoplamos terminales transmisoras de plataforma por medio de morrales. La mediana de la fecha de partida de las áreas natales fue el 26 de octubre de 2002. El abandono más temprano sucedió el 7 de octubre y el más tardío el 12 de noviembre de 2002. Todas las águilas migraron independientemente de sus hermanos y permanecieron en promedio 62 días en migración de otoño a una velocidad media de 45 km/hr, realizando un promedio de cinco paradas durante la migración. Las aves viajaron hacia el norte en la primavera a una velocidad estimada de 27 km/hr a lo largo de 32 días, con un máximo de 11 paradas. Una de ellas pasó el invierno en el Golfo de St. Lawrence, mientras que las demás migraron al noreste de los Estados Unidos. Las águilas pasaron un promedio de 76 días en sus áreas de invernada, y la mediana de la fecha de partida para la migración de primavera fue el 20 de marzo de 2003. Dos de los individuos regresaron a Labrador en su primer verano y mostraron cierta fidelidad a sus áreas de nacimiento. También documentamos las rutas de migración y las áreas importantes de escala migratoria.

[Traducción del equipo editorial]

A southward migration of post-fledging Bald Eagles (*Haliaeetus leucocephalus*) from northern Canadian natal areas to southern wintering grounds has long been known (Gerrard et al. 1978). Banding and radiotagging eagles have produced limited results (Gerrard et al. 1992). With the advancement of satellite-telemetry technology, information on the ecology and life history of raptors has been greatly expanded beyond what could possibly be gathered during decades of conventional telemetry and banding (Meyburg et al. 1995, Ueta et al. 2000, Hake et al. 2001, Kjellen et al. 2001). Using both

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banding data and conventional telemetry, dispersal behavior, movements, and survival of juvenile Bald Eagles have been documented from Florida (Wood et al. 1998), Saskatchewan (Gerrard et al. 1978, Harmata et al. 1985), Wyoming, California (Hunt et al. 1992), Texas (Mabie et al. 1994), and Colorado (Harmata 2002). Little is known about eagle activities beyond their first winter, limiting our knowledge pertaining to juvenile stopover habitats, migratory flyways (McClelland et al. 1994, 1996), and sources of possible mortality (Buehler et al. 1991). Furthermore, little information is available regarding distribution, nesting chronology, and migration timing and routes on the eastern Canadian population of Bald Eagles in Labrador.

Wetmore and Gillespie (1976) conducted initial investigations of Bald Eagles in Labrador, and since 1991, the Canadian Department of National Defence (DND) has been monitoring nest sites and productivity through annual surveys (DND 1995). To date, there are some 30–40 known Bald Eagle nest sites in Labrador (T. Chubbs unpubl. data). As part of a larger study investigating the movements of raptors within and out of Labrador (Laing et al. 2002), we implemented a satellite-telemetry program to track five hatch-year Bald Eagles from August 2002–August 2003.

STUDY AREA AND METHODS

Our study took place within the Low Level Training Area (LLTA) for fighter aircraft, covering an area of ca. 130 000 km^2 spanning the Labrador-Québec northeastern border. We searched for occupied raptor nests in the vicinity of the Smallwood Reservoir, ca. 6700 km^2 of central Labrador. This area consists of water bodies, prominent rocky islands, isolated erratics, and rock outcrops. Surrounding the reservoir are shorelines under 1 m of water and that are littered with driftwood, while beyond the waterline are stands of black spruce (*Picea mariana*).

Wetlands in this low subarctic ecoclimate are subject to permafrost. This region has a mean annual temperature of −3°C, a mean summer temperature of −9°C, and a mean winter temperature of −16°C (Meades 1990). Depending on latitude, the mean annual precipitation ranges from 700–1000 mm (McManus and Wood 1991). Bald Eagles typically nest along rivers and large reservoirs in dominant white birch (*Betula papyrifera*), balsam fir (*Abies balsamea*), larch (*Larix laricina*), poplar (*Populus balsamifera*), and black spruce at a height of 15–30 m (Bider and Bird 1983). We have observed eagle nests in all of these tree species in Labrador.

Rock pinnacles and trees are used by nesting Bald Eagles in Labrador. However, due to the inaccessibility and remoteness of tree nests, hatch-year eagles (8–10 wk) were captured from rock nests situated in lakes and reservoirs. Nests were accessed using a ladder or by mountaineering techniques, and birds were removed by hand from the nest to an adjacent area, where birds were processed and banded. Once captured, eagles were fitted with 95-g, battery-powered PTT-100 transmitters (Microwave Telemetry Inc., Columbia, MD U.S.A.) affixed in a backpack harness fashion using Teflon ribbon (Bally Ribbon Mills, Bally, PA U.S.A.). Each transmitter was set with a preset duty cycle to transmit to satellite more frequently (8 hr on, 48 hr off) during possible periods of migration, most frequently during October and March and less frequently during summer and winter months. All eagles were banded with a U.S. Geological Survey aluminium-rivet band on one tarsus and a colored-metal-alphanumeric-rivet band (Acraft Sign and Nameplate Co. Ltd., Edmonton, Alberta, Canada) on the other.

We monitored eagle movements using the Argos Data Collection services (ARGOS 2000). We determined nesting sites, stopover details, wintering areas, and migration routes using the location data received via satellite. Prior to processing, we put location data into a database using a Geographic Information System (GIS), and movement was then analyzed using ESRI® ArcView 3.2 (ESRI, Redlands, CA U.S.A.) in combination with the Animal Movement Extensions program (Hooge and Eichenlaub 1997). The Argos System divides data into different classes based on validation and number of messages received. Location classes (LC) are ranked by accuracy (3>2>1>0>A>B>Z; accurate to least accurate) by Argos; however, we found that several locations per transmission period were sufficient to document raptor movements if reviewed individually. Location validity and accuracy were further determined by comparing consecutive locations to previous locations resulting in a movement estimate. Using this screening method we were able to include more than one transmission per reporting period, independent of location class and quality index Therefore, based on existing literature demonstrating mean juvenile eagle rates of movement (Buehler 2000), we accepted a location if the movement estimate reported for a bird was 0 km/d, but rejected it if the movement estimate was greater than 500 km/d. We then compiled a database comparing the number of locations used for analysis and divided this number by location estimates received to determine a percentage of viable-satellite transmissions (LC Z-transmissions were removed and not used in estimates).

As the transmitters were programmed following a predetermined duty cycle (i.e., September–October 8 hr on and 48 hr off, and November–December alternated between 8 hr on and 72 hr off and 8 hr on and 168 hr off), exact dates of departure from nesting sites and arrivals at wintering grounds are unknown. To estimate dates of arrival we considered that a raptor migrating to an area had arrived by the first date a location was obtained from that area. On departure its location was considered to be the location estimate received from within the area. An area was considered to be a stopover site if we received location estimates from an area for at least 24 hr (Kjellen et al. 2001) and the bird demonstrated concentrated localized movement.

Distances travelled between summer and winter grounds were calculated by adding the linear distances from the departure point to the arrival location, including distances to and from stopover locations. We calculated radial distances from capture sites using a 95% Kernel home-range estimator, with the Animal Movement Extensions program (Hooge and Eichenlaub 1997), which determined an estimate of the area used by the eagle.

RESULTS

During the 2002 summer field season (15–30 August) five juvenile eagles were captured and fitted with PTTs. We recorded 6472 locations between 15 August 2002–30 August 2003. Of these, 75% were used in analysis. A mean of 966 locations per eagle was collected with only the most-likely locations plotted using GIS (0% Z, 20% B, 19% A, 32% 0, 22% 1, 5% 2, and 2% 3). Of those captured, eagles 37414 and 37413 and eagles 37412 and 37415 were siblings, respectively, and 37411 was captured alone.

Movements before Fall Migration. Eagles remained within their natal area for a mean of 74 d following transmitter attachment, with departures as early as 7 October 2002 and as late as 12 November 2002, and a median departure date of 26 October 2002. Each bird exhibited exploratory flight patterns, and used a mean range of 165 km^2 (97–252 km^2) around original capture sites.

Fall Migration. During autumn migration, the eagles averaged five stopovers prior to reaching their wintering destinations, with stays ranging between 24 hr and 25 d. The eagles took between 5–95 d to reach their wintering areas, with straight-line distances between natal areas and wintering areas ranging from 510–930 km (Fig. 2).

Eagle 37414 (Fig. 1) travelled the shortest linear route south, probably departing its nest site on 13 November 2002. Generally, the relatively infrequent location estimates from Argos were insufficient for tracking the birds' routes, and therefore, there were likely deviations from a straight line. However, during fall (and spring) migrations we received location estimates as often as once every 2 d, suggesting that our estimates represented fair delineations of movement. The next transmission date for eagle 37414, 18 November 2002, was located along the northern coast of the Gulf of St. Lawrence, 472 km from its natal area. This bird wintered, and remained, in the gulf area through the spring migration period. The remaining four eagles stopped along the north shore in Québec, continued southwest, and avoided crossing the Gulf of St. Lawrence.

Eagles 37412 and 37415 (Fig. 1) took similar routes southwest, stopped at Lake Ontario, and wintered in Virginia and West Virginia, respectively. Eagle 37412 had four stopovers before reaching its wintering grounds of Albany, NY, on 1 December 2002, travelling more than 2444 km after leaving its natal area. Eagle 37415 had six stopovers prior to reaching its wintering grounds of Orange County, VA, on 5 February 2003, ca. 1370 km from its natal area.

Eagles 37411 and 37413 (Fig. 1) left the Gulf of St. Lawrence and moved toward the U.S.A. east coast, stopping along the borders of VT and NH. Eagle 37411 made 11 stopovers and travelled ca. 1420 km before reaching its wintering grounds along the Hudson River between Ulster and Dutchess counties, NY. Eagle 37413 travelled ca. 1640 km before settling in Hartford County, CT, with half the number of stopovers.

Movements before Spring Migration. The mean overwintering period was 76 d, (44–124 d), except for 37414 which remained on wintering grounds.

Spring Migration. We defined spring migration as the period of time in which the birds departed from wintering grounds and arrived at summering grounds. Once on the summering grounds, the eagles did exhibit exploratory and nomadic flight behaviour. Eagle 37414 did not migrate in the spring; however, it moved within the same 252 km^2 area for the whole summer and did not venture away from the Gulf of St. Lawrence.

Departure dates for the four remaining eagles were between 11–27 March 2003. The birds had two to six stopovers prior to reaching the Gulf of St. Lawrence. Three of the four eagles (Fig. 2) used similar routes as taken during fall migration to travel north, with the exception of 37415 which travelled more easterly. Eagle 37415 did not stop at Lake Ontario when travelling north in the spring and meandered west of its original autumn route (Fig. 2). All of the eagles were tracked to the Gulf of St. Lawrence; two eagles continued further north to the Québec and Labrador border for the summer. All four birds arrived at the north shore of Gaspé, Québec, between 11–30 April 2003, averaging 32 d on migration.

Eagle 37413 left its wintering ground first on 10 March 2003, travelling northeasterly for 1100 km with three stopovers and arriving at the Gulf of St. Lawrence on 21 April 2003. Comparatively, eagles 37412 and 37415 left their wintering grounds at similar times and travelled 1955 km and 1600 km to arrive at the Gulf of St. Lawrence on 21 and 26 April 2003, respectively. Eagle 37411 left its winter-

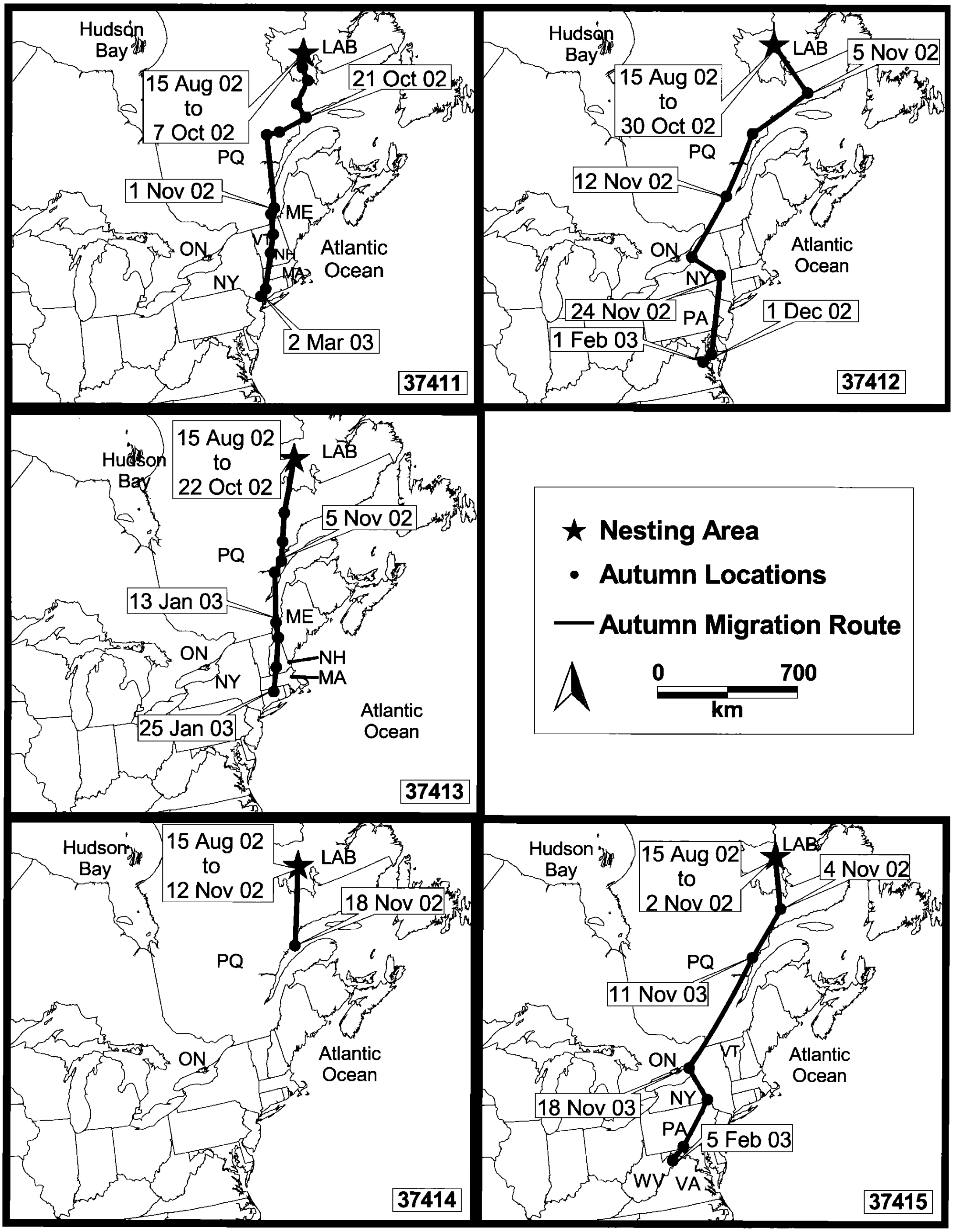

Figure 1. Fall migratory routes of juvenile Bald Eagles from their natal sites in Labrador to their wintering grounds as tracked by satellite in 2002.

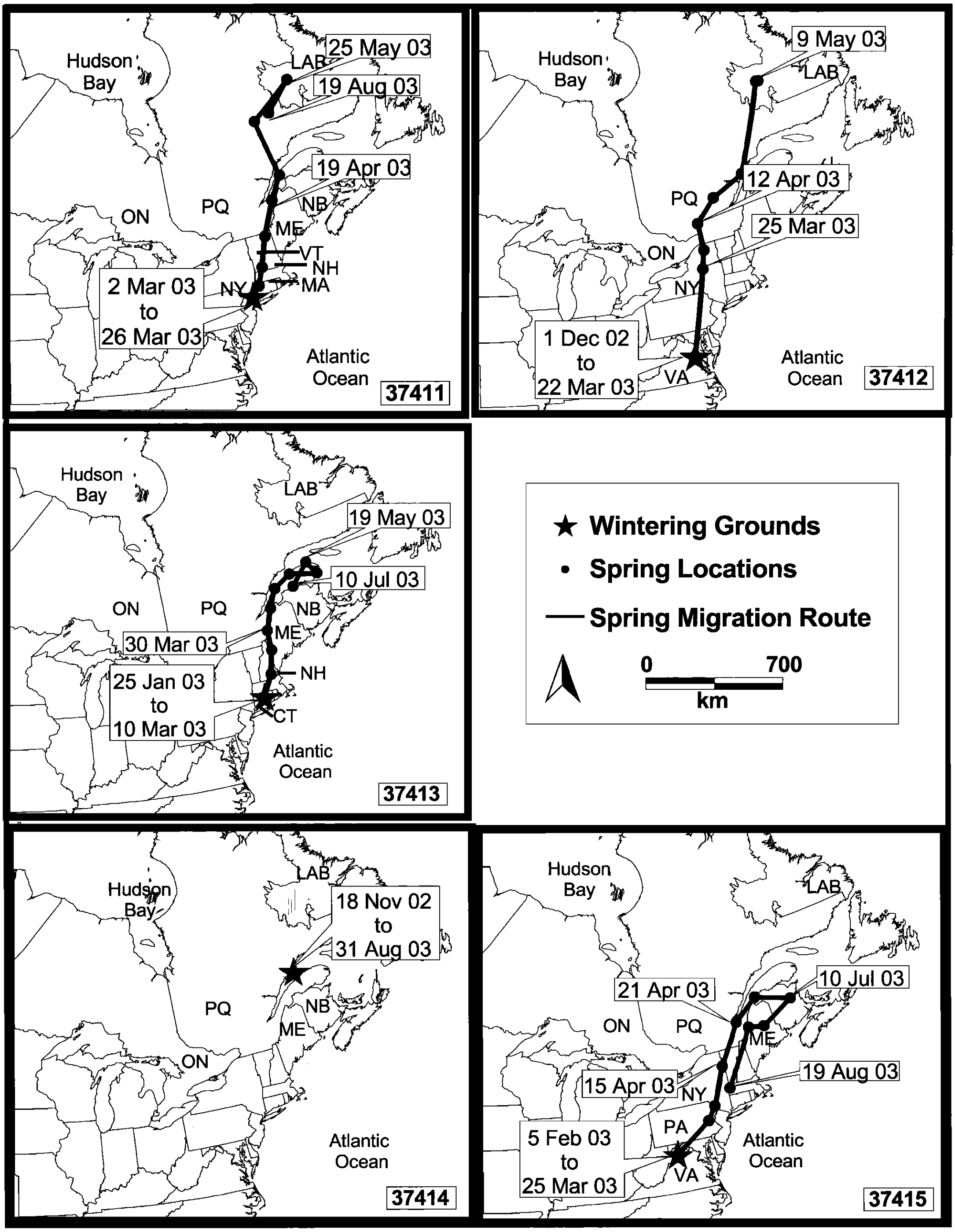

Figure 2. Spring migratory routes of juvenile Bald Eagles from their wintering sites to their summering grounds as tracked by satellite in 2003.

ing grounds the latest (26 March 2003), and travelled 790 km to its summering grounds with three stopovers to arrive at the Gulf of St. Lawrence on 9 April 2003.

Eagle 37413 divided its summer activities between the Gulf of St. Lawrence and New York State. Eagle 37415 was located on the Québec and New Brunswick borders on 1 May 2003 (Fig. 2) and moved south again to New York on 15 May 2003. It then returned to the Gulf of St. Lawrence on 8 June 2003. On 12 August 2003, this bird began moving south to New York.

Eagles 37411 and 37412 left the Gulf of St. Lawrence between 3–6 May 2003 (Fig. 2). Eagle 37411 flew 400 km to the Caniapiscau Reservoir (Québec) and later spent time at the Ossokmanuan Reservoir (Labrador). Eagle 37412 travelled 617 km north and spent its summer at the Smallwood Reservoir.

All eagles moved sporadically during the summer period, with most location estimates indicating activities on the north shore of the Gulf of St. Lawrence.

DISCUSSION

The departure of juvenile Bald Eagles from their natal nest sites in Labrador has become more predictable with the application of satellite technology. Juvenile Bald Eagles from Labrador migrated south or southwest, consistent with previous juvenile Bald Eagle migration reports (Gerrard et al. 1978, 1992, Hunt et al. 1992, McClelland et al. 1994, 1996, Harmata et al. 1999, Harmata 2002). Autumn movement was south toward the Gulf of St. Lawrence prior to dispersing en route to wintering areas.

We know from previous studies that juvenile migration may be initiated by changes in foraging opportunities (Hodges et al. 1987, Hunt et al. 1992, McClelland et al. 1994, Restani et al. 2000, Hoffman and Smith 2003), with birds departing an area if prey is not readily available. Hunt et al. (1992) suggested that eaglets first leave on exploratory or foraging flights and return to nest sites throughout the day for possible food provisioning by adults. What specific cue triggers migration in Labrador eagles is not known. In the weeks following fledging, all five juvenile eagles remained in natal areas and exhibited exploratory flights within a 40-km radius of original nest areas, occasionally returning to the nest.

Autumn departure may have been partially linked to weather or foraging opportunities. Because all five eaglets were captured at the same latitude and longitude, they were exposed to many of the same weather conditions. Therefore, weather characteristics such as the first snow fall or frost event could have contributed by triggering the initiation of migration of individuals. Conversely, Harmata et al. (1999) stated that juveniles may exhibit movement that is individually characteristic of the juvenile and exclusive of foraging opportunities.

Montana juvenile eagles (McClelland et al. 1996) departed their natal territories between 22 August–5 October (median = 9 September, N = 5), Saskatchewan juveniles left at the beginning of October (Gerrard et al. 1978), and a population in southern California departed between 19 July–22 August (Hunt et al. 1992). More northern studies have documented movement from northern Saskatchewan as late as 3 November (Harmata et al. 1999). Generally, Labrador eagles migrated south late in the season (median = 26 October).

While the four eaglets travelled independently of one another, some went in a similar direction (i.e., southwest of natal areas), moving between lakes and rivers and exploiting aquatic environments. They made several stopovers along the way, most near larger water-bodies such as the Gulf of St. Lawrence, Lake Ontario, and Lake Champlain. Gerrard et al. (1978) believed that juveniles followed rivers and were found near lakes as these areas represented favourable habitat. Montana eagles also made stops, sometimes for weeks at a time, enroute to wintering areas (McClelland et al. 1994, 1996). These stops provided an opportunity for eaglets to replenish nutrients lost during migration. Restani et al. (2000) elaborated on the functional response on stopovers made by migrant Bald Eagles through Montana. They found that the eagles stopped while passing through a corridor, 80–130 km wide, around the Hauser Reservoir, Glacier National Park. The eagles detected conspecifics foraging from 40–65 km away and then travelled into the area to feed. The birds used this reservoir as a stopover during both northward and southward migrations. We documented the use of the St. Lawrence River and the Gulf of St. Lawrence as both spring and autumn migration stopovers for Labrador juvenile eagles. The mean travelling distance from wintering to summering grounds was 350 km less than the distances travelled from natal areas to winter grounds. We suspect that Labrador eagles gained experience during their autumn migration, and that their flight routes and strategies were more defined and less nomadic in the spring. Eagles may improve their sense of direction on northern flights through visual cues, mentally catalogued stopovers (Hake et al. 2001), and increased flight experience.

Spring departure of juveniles occurred between 11–27 March 2003, and the four migrating eagles used the Gulf of St. Lawrence fall stopover (median = 21 April 2003) prior to arriving at summering grounds (between 3–6 May 2003). Nonbreeding birds are more apt to spend time away from optimal nesting areas and focus on favourable foraging sites rather than establishing a breeding territory (Jenkins et al. 1999). Based on the survival of our five PTT-tagged birds, the Gulf of St. Lawrence was a suitable stopover site, and provided adequate foraging habitat for travelling Bald Eagles.

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