DISPERSAL AND MIGRATORY BEHAVIOUR OF OSPREY AND BALD EAGLES IN LABRADOR

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8 September 2005

A Thesis submitted to the Faculty of Graduate and Post Doctoral Studies of McGill University in partial fulfilment of the requirements of the degree of Master of Science.

Your file Votre référence
ISBN: 978-0-494-22741-1
Our file Notre référence
ISBN: 978-0-494-22741-1

Abstract

This study employed satellite telemetry to document dispersal and migratory behaviour of nine juvenile Bald Eagles (*Haliaeetus leucocephalus*) and two adult and five hatch-year Osprey (*Pandion haliaetus*) from central Labrador between 15 Aug 2002 - 31 Dec 2003. Autumn average departure dates were 20 October 2002 and 13 November 2003 for the eagles and 13 October for both 2002/2003 Osprey, siblings migrating independently. Juvenile Osprey travelled at an average rate of 200 km/d during fall migration; one adult travelled at a rate of 188km/d enroute to the Dominican Republic. Eagles travelled an average distance of 1200 km over 40 days at a rate of 81 km/d, wintering as far south as Virginia. Eagles departed wintering areas by 25 March 2003, travelling at an average rate of 76 km/d using similar waterways, river valleys and corridors as taken in the fall. Eagles and Osprey were not documented travelling overnight or crossing large bodies of water.

Résumé de Thése

Cette étude visait à étudier, grâce à la télémétrie par satellites, les déplacements et activités migratoires de neuf Pygargues à tête blanche (*Haliaeetus leucocephalus*) juvéniles ainsi que de deux adultes et cinq juvéniles Balbuzards pêcheurs (*Pandion haliaetus*) du centre du Labrador entre le 15 août 2002 et le 31 décembre 2003. À l'automne, la date de départ moyenne des pygargues a été le 20 octobre en 2002 et le 13 novembre en 2003. Les jeunes pygargues ont parcouru une distance de 1200 km en 40 jours, à un rythme de 81 km par jour en moyenne, pour hiverner aussi loin que la Virginie. Ils ont quitté les aires d'hivernage avant le 25 mars 2003 et ont parcouru 76 km par jour en moyenne en suivant sensiblement les mêmes rivières, vallées et corridors que durant la migration automnale. En 2002 et en 2003, les balbuzards ont quitté le 13 octobre et les juvéniles ont parcouru en moyenne 200 km par jour pendant la migration automnale. Un des adultes a quant à lui parcouru en moyenne 188 km par jour pour atteindre la République dominicaine. Il a été noté que les frères et les soeurs chez les deux espèces voyageaient de façon indépendante.

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Acknowledgements

There are individuals in your life who create a fork in the road and make you choose between two different paths in life, Mr. Tony Chubbs was the person who introduced me to a life of field biology and told me that I could do it. He was my primary motivator, and his assistance and guidance during this process has been unmatched. This project would not have been possible without his insight, unwavering support and advice. I am also grateful to Matt Solensky for providing me with raptor trapping knowledge (101 uses for monofilament) and encouragement. Geoff Goodyear not only got us to field sites safely but also demonstrated his outstanding ability to support his team by climbing rocks, handling raptors and adding comic relief when needed. Leanne Elson, my colleague and friend, spent hours in the field, in the office, and on the phone with me when the project and I needed it most. Her support and friendship is part of the glue that kept me together over the hours and hours of fieldwork and semesters of school. I can say with great confidence that there is no other friend I'd rather boat out to an Osprey nest with!

From McGill I would like to thank my advisor, Dr. David Bird, for his supervision, editing and writing skills. It was those last minute edits that made the difference! I am grateful to Dr. Rodger Titman, Marcel Gahbauer, Stephanie Bailey, Kate Taillon, Dr. Pierre Dutilleul and Emily Wallace for all of their support, and for making my time at McGill a pleasurable one. Katie Mosher, Elana Jacobs, Emma Plain and Jana Tretina all lent a listening ear and a beer when things were really great, or not so great. All are strong young ladies who made the big hurdles seem like small speed bumps.

Colleagues Debbie Badzinski and Tara L. Crewe also added to the final draft of the thesis and used their red pens relentlessly.

Finally, I must thank my parents who not only provided editorial and emotional support but gave me the encouragement and support when I decided to embark on this project. Thanks for setting such a fine example and helping me through the many moves that got me to where I am today.

Financial support for this project, in its entirety, as well as academic funding, was provided by the Goose Bay Office, Department of National Defence (DND). The following thesis uses data for dispersal and movement pattern research of raptors, as outlined by the MOU shared between DND and McGill University.

Preface

This thesis is presented as a collection of manuscripts in accordance with the regulations set forth by the Faculty of Graduate Studies and Research, McGill University.

Pursuant to these guidelines, the following thesis commences with a literature review followed by two manuscripts. The Bald Eagle manuscript is in press in The Journal of Raptor Research, while the Osprey paper is undergoing review for that same journal. The candidate is the senior author, D. Bird, and T. Chubbs as a junior author. D. Bird and T. Chubbs were involved in the experimental design, implementation and execution of the study and provided analytical and editorial guidance through the preparation of its results. I was intimately engaged in the design, planning, and execution of field research, and was responsible for collecting, compiling and analyzing data and for writing the manuscripts. Formats for manuscript citations follow the guidelines as set by The Journal of Raptor Research, a publication of the Raptor Research Foundation.

Introduction

The overall aim of this thesis is to identify and report the timing, dispersal and migratory movements, site fidelity, and wintering areas of juvenile and adult Osprey (*Pandion haliaetus*) and Bald Eagles (*Haliaeetus leucocephalus*) from central Labrador through use of satellite telemetry. Past studies on these raptors have focused on the birds at either their nesting sites or on their wintering ranges. To date few data detailing the dispersal and migratory patterns between the breeding and wintering grounds exist. Also, Labrador is a centralized area for the North Atlantic Treaty Organization's (NATO) Low Level Jet Fighter training activity. Thus, there is significant potential for fatal interactions between airplane pilots and the birds. Since the flight risk is greatly increased during periods of high migration activity, understanding the general movements of these species within Labrador is considered to be a significant contribution to the preservation of both raptor and human lives. Also, while Osprey and Bald Eagles are not considered to be threatened species in Canada at this time, any information detailing their migratory movements and in particular, key staging areas, is important for their proper management.

Specifically, the objectives of my thesis research are to: 1) study the autumn and spring migratory movements of Bald Eagles and Osprey from central Labrador; 2) analyze timing and movement strategies of Bald Eagles and Osprey enroute to wintering and summering areas; and 3) identify important stopover sites during migration. As part of a Memorandum of Understanding between the funding body, Department of National Defence, and McGill University, the findings will be submitted to scientific journals for publication and made available for consideration by the Department of National Defence in the planning and management of military activity in the area.

Chapter 1: Literature Review

Introduction

The following literature review provides background information on Bald Eagles and Osprey as well as the advancement of satellite technology and its application to research focusing on raptor migration.

Bald Eagles: General Biology

Bald eagles are among the largest birds of prey in North America. Adults are quickly identified by their dark bodies contrasting with a prominent white tail and head, as well as by their broad wings which give them their characteristic soaring flight (Buehler 2000). Prior to reaching sexual maturity, juvenile eagles are a mottled brown with darker eyes and beaks (Gerrard et al. 1978, Palmer et al. 1988, Buehler 2000). By the time they mature at 3 to 5 years their beak and eyes lighten to bright yellow and the tail and head plumage changes from mottled brown to white.

Although variation in size is common among geographical regions, the average adult weighs between 3.0 and 6.3kg, with females being 25% larger than males. Average wingspans range from 168-244cm (Palmer et al. 1988).

Bald Eagles are widely distributed in the northern hemisphere (Wetmore and Gillespie 1976) and nest primarily at the top of coniferous trees (Anthony and Isaacs 1989). Stalmaster (1984) found nest trees to be as high as 60m from tree base to nest bowl, and trunks to be up to 110cm wide. Other studies suggest that the eagles choose sites close to aquatic environments (Chester et al. 1990, Buehler et al. 1991, Chandler et al. 1995) and foraging sites (Dzus and Gerrard 1993, Gende et al. 1997). For example, Driscoll et al. (1999) found that an Arizona eagle population used cliffs for nesting, as trees and higher vegetation were not available. One of the most common denominators with regard to nest site selection is that nest sites are protected from prevailing winds (Buehler et al. 1991, Driscoll et al. 1999).

Eagles mate monogamously with the partner being replaced if one should die (Harmata et al. 1985, Grubb 1988). Once a pair has formed and a nest has been established, egg-laying begins. Timing of egg-laying is dependent on geographical location and latitude with northerly populations laying later than those at lower latitudes (Buehler 2000). On average, 35 days are spent incubating the eggs followed by an average nestling period of 11 to 12 weeks (Wood et al. 1998).

In contrast, Florida eagles have a longer nestling period of 5 to 6 months (Broley 1947, Wood and Collopy 1993, Wood et al. 1998). In Oregon, Bald Eagles commence nesting in March, with young hatching mid-April to mid-May (Anthony and Isaacs 1989). Swenson et al. (1986) found that the Greater Yellowstone Ecosystem (WY) population of eagles began egg-laying in mid-March to mid-April, a month earlier than an Alaskan population, and hatching in early-May to mid June (Hensel and Troyer 1964). In central Labrador the first sightings of hatchlings occur within the last week of May to the first week of June (T.Chubbs, pers comm.). Thus, the timing and duration of nesting by Bald Eagles is affected by latitude and/or location (Buehler 2000).

Bald Eagles faced significant declines in the 1970's due to the after effects of the DDT era (Buehler 2000). Although the status of Labrador eagles during this time was not tightly monitoried, the lower Great Lakes region has been intensely monitored since the birds population crash in the 1980's (Laing and Badzinski, 2005). The population in this region has since been protected through government regulations and numbers have been on the incline and productivity for this area has increased from less than 1 to 1.7 (Laing and Badzinski, 2004).

Diet

Compiling an average for 20 studies, Stalmaster (1987) found that fish constituted 56% of the diet for nesting Bald Eagles. Birds, mammals, and other identifiable items comprised 28%, 14% and 2%, respectively. Todd et al. (1982) reported that over 75% of the diet of inland breeding Bald Eagles is composed of fish but the coastal populations have more bird and mammal components.

Bald Eagle populations in the Pacific northwest feed largely on spawning salmon in fall and winter (Hodges et al. 1987). Comparatively, the analysis of 22 Bald Eagle nests in Placentia Bay, Newfoundland showed that fish, avian, and mammalian prey occurrences averaged 64, 29 and 7%, respectively (Dominguez et al. 2003). An analysis of diets of Bald Eagles in Labrador has not been made, however some eagles have been observed feeding on carrion in the Goose Bay area after the water had been frozen (T. Chubbs pers. comm.).

Bald Eagles are opportunistic and will also scavenge easily accessible prey items (Stalmaster and Gessaman 1984); their movement patterns are largely affected by their dietary needs (Buehler 2000).

Habitat Use

Breeding sites of this species seem to be largely determined by old growth forests with some habitat edge, that are located within 2km of open or promising foraging opportunities (Buehler 2000). According to Wood et al. (1998), areas which have substantial human activity along the shoreline will force eagles to move nests inland and nests located along the shorelines are often in sites of lower development. Anthony and Isaacs (1989) and Livingston et al. (1990) have also found that woodlot size does affect Bald Eagle nesting locations, with most preferring a larger woodlot.

Both Stalmaster (1987) and Livingston et al. (1990) concluded that an eagle's nest location is characterized by isolation from human disturbance, suitable nesting substrate and proximity to a large water body or continually present food source. Of 115 nests in Maine only 8 nests were the exception to the above noted qualities (Livingston et al. 1990). They were either more than 1 km from a water body of sufficient size or fisheries information was unavailable.

Habitat requirements during breeding are slightly different and stricter than those required on migration.

However, foraging opportunities remain the common key requirement (Buehler 2000).

Migratory Behaviour

A combination of factors contributes to the complex migratory pattern of this species. Age, location, food availability, and even climate at the original natal grounds influence Bald Eagle migration.

Movement strategies of this species seem to be largely affected by changes in prey availability (Buehler 2000). Eagles feed predominantly on live and dead fish, therefore their movement patterns often lead them to areas in which fish are most available, including river valleys, waterways, and other areas of open water.

Buehler (2000) suggested that eagles breeding north of the 40°N latitude head south between August and January with juveniles leaving first and often travelling the farthest. In comparison, populations breeding south of 40°N latitude are less likely to migrate at all and tend to remain close to natal nest sites if ample food is accessible (Broley 1947, Buehler et al. 1991, Wood and Collopy 1993, Wood et al. 1998, Ueta et al. 2000, Harmata 2002).

Of the northern migrating populations, those in Alaska appear to move in relation to the timing of foraging opportunities (Knight and Skagen 1988). Individuals move south along the west coast, coincidental with salmon runs, arriving on the wintering grounds in the coastal north-western US mid-November to early December (Hodges et al. 1987).

The annual salmon run within Glacier National Park creates an abundance of readily available food for migrating scavengers which has become a traditional stop for Bald Eagles migrating south. According to McClelland et al. (1996), northern populations (including those in the Northwest Territories, Alberta, and Saskatchewan) usually move through this area between September and December.

Although Bald Eagle populations are largely migratory north of 40°N, ample food sources available year-round may permit adults to forego migration and remain as residents in a particular nesting habitat (Swenson et al. 1986). Banded Eagles nesting in the Greater Yellowstone Ecosystem were observed through late winter, suggesting they were a more sedentary than migratory population (Swenson et al. 1986).

Regardless of whether they coincide with foraging opportunities, adults of the west/central region of the continent generally arrive on the wintering grounds between November and December, with juveniles appearing a month or so later (Harmata et al. 1985, Buehler 2000). Although date comparisons of more northern populations seem to demonstrate a similar period of movement, routes and migratory tendencies can vary. Gerrard et al. (1978) observed that Saskatchewan eagles utilized shorelines, rivers, and lakes while migrating south. Harmata (2002) found similar results with Colorado eagles and added that the birds avoided over-water crossings. Others have noted similar tendencies towards variable flight patterns (Buehler et al. 1991, McCollough et al. 1994).

According to Buehler (2000), Bald Eagles are generally solitary migrants, possibly congregating enroute at popular foraging sites, but moving further as individuals. He further added that immature eagles migrate nomadically and that such behaviour can be attributed to inexperience and exploratory flights.

Flight speeds also vary. While few reliable studies demonstrate flight speeds, Harmata et al. (1985) recorded juveniles travelling at speeds of 33km/d and adults at rates of 180km/d.

Osprey: General Biology

Within the Northern Hemisphere, the Osprey represents one of the most widely distributed bird species. Although this species can tolerate human disturbance at low levels (Poole 1989, Thomas 1998, Trimper et al. 1998), Osprey experienced a population crash similar to that of the Bald Eagle during the DDT era. By 2000 however, cleaner and safer environments supported significant population increases (Poole et al. 2002); this rebound was well documented by Palmer et al. (1988) and Poole (1989).

Osprey weigh approximately 1200-2000g and have a wingspan of 150-180cm, with the adult female (1,700-2,000g) being significantly larger than the male (1,200-1,500g, Flook and Forbes 1983). Characteristically appearing mostly white from a distance, the male can be quickly distinguished from a female by the female's distinctive brown-speckled necklace. In comparison, the male's breast is white and free of prominent streaking; however both sexes have dark brown upper and back wing coverts. Their heads are predominantly white with a prominent dark line horizontally across the eye. The juveniles have an orange-red iris which darkens with age. Pale blue-gray legs and cere are also a definitive characteristic of the adult Osprey (Flook and Forbes 1983).

Osprey mate monogamously and tend to breed in temperate areas between 40° and 70° latitude, migrating long distances to southern and tropical regions during the winter (Poole 1989, Hake et al. 2001, Martell et al. 2001). Similar to the Bald Eagle, the breeding range of this species is largely dependent on availability of fish (Bent 1937, Flook and Forbes 1983, Palmer et al. 1988, Poole 1989). Consequently, most Osprey construct large stick nests on top of Black Spruce (*Picea mariana*) and other conifers (Wetmore and Gillespie 1976) adjacent to, or near, aquatic areas. Osprey have also been recorded using power lines, platforms (Houghton and Rymon 1997, Chubbs and Trimper 1998), offshore duck-hunting blinds (Henny and Van Velzen 1972), and other artificial locations (Poole 1989).

Poole (1989) generalized that pair bonds are formed at nest sites in mid-March. Once on the nest, egg-laying commences. Some laying occurs as late as mid-May with most incubating for 35-43 days.

Diet

Fish comprise 99% of the Osprey's diet (Chubbs and Trimper 1998). According to Flook and Forbes (1983) Osprey do not demonstrate a preference for a particular species of fish but instead feed on the most widely available fish species. For example, Van Daele and Van Daele (1982) reported that Osprey hunting in west-central Idaho took mostly bullheads (*Ameiurus nebulosus*) and salmonids, the most common fish in the area. In another study, Osprey in Yellowstone Lake were seen to feed on immature cutthroat trout (*Onchorhynchus clarki*) (Swenson 1978). If a shift in prey availability does occur, most Osprey will select the next most available fish species (Poole 1989).

Similar to Bald Eagles, Osprey exploit the fish species available within that particular geographic area. For instance, on Canada's east coast Greene (1987) recorded alewives (*Clupius harengus*), polluck (*Pallachius virens*) and smelt (*Osmerus mordax*) in the diet of Osprey. Osprey will hunt in both saltwater and freshwater environments (Buehler 2000).

Osprey fish in shallow waters as they can only dive within a meter of the water's surface (Poole et al. 2002). Swenson (1981) concluded that these birds need shallow, clear water for hunting. However, a Florida study suggested that while adults prefer to hunt in shallow water, fledged young have no preference (Edwards 1989)

Habitat Use

Osprey prefer to nest within 1-2 km of water, however if these no nesting substrates sites are not available they will move inland, upwards of 14 km from a main foraging site (Greene 1987). According to Poole et al. (2002), Osprey will use good nest sites up to 10-20 km from water, which may even include hydro poles (Ewins 1997).

Osprey habituate quite easily to human activity and will take advantage of artificial nest sites even if areas are settled by humans (Poole et al. 2002). Poole et al. (2002) summarized the common features of a successful Osprey nest as close proximity to water, feeding areas, open and easy access to nest, and safety from ground predators (high over the ground). On occasion Osprey will occupy channel markers (Poole et al. 2002).

Migratory Behaviour

Martell et al. (2001) used satellite telemetry to document the movements of Osprey from three distinct regions of North America (west, central, and east). Prior to Martell et al. (2001), Henny and Van Velzen (1972) and Poole and Agler (1987) were able to determine Osprey movements using band recoveries that yielded similar results.

The general consensus is that Osprey depart for autumn migration by August (Poole 1989, Martell et al. 2001) with some populations departing in September (Henny and Van Velzen 1972). Failed breeders often depart for autumn migration first (Restani 2000).

Martell et al. (2001) elaborated on the departure dates of Osprey in North America, characteristic of geographic regions with eastern North American populations departing from their nest sites by a median date of 19 August. Furthermore, the average North American autumn migratory period of this species can range from mid-July to early November with most arriving on wintering grounds by 26 September.

Martell et al. (2001) also established intersexual differences in the timing, routes, distance, and wintering and breeding sites of Osprey. In general, Osprey are solitary migrants (Poole 1989) and, weather permitting, can travel for an average of 9 hrs during daylight (Kjéllen et al. 1997). Martell et al. (2001) reported that Osprey travel at an average rate of 230km/day within eastern North America. They also documented western and central North American populations travelling at 296km/day and 230km/day, respectively. Comparatively, Swedish Osprey were observed migrating at speeds upwards of 413km/d (Kjéllen et al.

1997), females departing before males in all geographic contexts (Martell et al. 2001).

For North American breeders, wintering locations are typically Central and South America (Martell et al. 2001). While Henny and Van Velzen (1972) and Poole and Agler (1987) relied on band recoveries, both studies suggest that Osprey travel in the fall as far south as South America. Spring arrivals at breeding locations range between late February in Minnesota (Martell et al. 2001), late March-early April in New England (Henny and Van Velzen 1972), and late April to early May in central Labrador (Trimper et al. 1998).

Poole (1989) postulated that Osprey likely choose the same routes of migration in spring as in fall and more recent evidence has supported his hypothesis (Meyburg et al. 1995, Hake et al. 2001, Kjéllen et al. 2001, Martell et al. 2001). Furthermore, Osprey appear to prefer to travel along coastlines, and avoid over-water crossings of more than 10-15km.

Telemetry

Satellite telemetry has become a widely used tool for investigating the patterns and behaviour of migrating wildlife. The focus of data collection capability provided by this technology eliminates the variable and inconsistent results of traditional research methods, e.g. banding, observation, and counts.

This emerging technology has developed considerably since its first experimental application in the 1970s (Buechner et al. 1971; Meyburg et al. 1995). As initial transmitter units were relatively large and bulky, early studies were primarily focused on large terrestrial (Craighead and Craighead 1972, Curatolo 1986) and marine mammals (Priede and French 1991, Frost et al. 2001). Although useful, the transmitter's bulky attributes offered only short-term results and limited applicability for smaller organisms.

Since then, advanced technology has led to the miniaturization of transmitters allowing smaller organisms such as Peregrine Falcons (*Falco peregrinus*) (Fuller et al. 1998, McGrady et al. 2002), murres, and puffins (Hatch et al. 2000) to be studied over vast landscapes for prolonged periods. In the last 10 years transmitters have even become small enough to implant in species such as the Spectacled Eider (*Somateria fischeri*)(Petersen et al. 1995). Although small units are gaining increasing popularity, larger more robust units are still being used on bigger species.

For example, Blouin et al. (1999) used two different satellite transmitters for his Snow Geese (*Anser caerulescens*) study. A 116g backpack-mounted transmitter was compared in effectiveness to a 99g neck-collar mounted transmitter. Both weights represented the standard accepted transmitter weight ratio of 3.5-2.5% of total body mass. The authors concluded that both transmitters were effective, however the smaller transmitter provided more quality locations.

Satellite telemetry does, however, have its disadvantages. The initial costs of this type of tracking are expensive in the primary stages, but long-term maintenance costs are grossly reduced. As well, this type of technology is less accurate than ground-truthing locations. Fancy et al. (1989) revealed that satellite technology at that time could only produce estimates within 900m of a known location (with a suggested mean error of 480m). Two years later, Keating et al. (1991) tested the accuracy of satellite telemetry and concluded that in comparison to actual locations, accuracy can vary from 150m to numerous kilometres away. They suggested that caution be taken when requiring small-scale accuracies.

Studies of far-ranging migratory species on a larger scale (Martell et al. 2001, McGrady et al. 2002, Laing *et al.* 2003) are thought to be less susceptible to these small-scale inaccuracies, as their requirement for fine detail is less important than the "where and when" components of the study.

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CONNECTING STATEMENT

Chapter 1 reviewed the pertinent literature required to best understand the diet, habitat use and migratory behaviour of Bald Eagles and Osprey, as well as satellite telemetry, the latest technology used to study avian migratory movements. Chapter 2 reports on movements, timing, and popular stopover locations of Bald Eagles from central Labrador as investigated via satellite telemetry. Migration routes for Bald Eagles breeding in Labrador, both southward and northward, have never been recorded previously. The manuscript, which is in press, has been formatted for the Journal of Raptor Research.

Chapter 2: FIRST COMPLETE MIGRATION CYCLES FOR JUVENILE BALD EAGLES *HALIAEETUS LEUCOCEPHALUS*, FROM LABRADOR

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 important stopover areas.

KEY WORDS: Bald Eagle; *Haliaeetus leucocephalus*; migration; juvenile; satellite telemetry; stopover; dispersal; Labrador.

INTRODUCTION

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, Kjéllen et al. 2001). Using both banding data and conventional telemetry, dispersal behaviour, 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 and 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 for fighter aircraft, covering an area of approximately 130 000 km^2 spanning the Newfoundland and

Labrador-Québec northeastern border. We searched for occupied raptor nests in the vicinity of the Smallwood Reservoir, approximately 6700 km^2 of central Labrador. This area consists of water bodies, prominent rocky islands, isolated erratics and rock outcrops. Surrounding the reservoir are shallow shorelines (<1 m deep) littered with driftwood, while above the waterline, stands of Black Spruce (*Picea mariana*) are the predominant forests type.

Wetlands in this low subarctic ecoclimate are subject to underlying 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 (age 8--10 wk) were captured from rock substrate nests situated along 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 had a preset-duty cycle to transmit to satellite more frequently during possible periods of migration in October and March and less frequently during summer and winter months(September--October 8 hr on and 48 hr off, November--December alternated between 8 hr on and 72 hr off and 8hr on and 168 hr off) All eagles were banded with a U.S. Geological Survey aluminum-rivet band on one tarsus and a coloured-metal-alphanumeric-rivet band (Acraft Sign & Nameplate Co. Ltd., Edmonton, Alberta, Canada) on the other.

We monitored eagle movements using the Argos Data Collection services (ARGOS 2000). We determined natal 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 accuracy was 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 an estimated excess maximum travelling speed of 500 km/d (P. Nye, pers. comm.). 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 estimate).

As the transmitters were programmed to follow a predetermined duty cycle, 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 (Kjéllen et al. 2001) and the bird demonstrated concentrated localized movement.

Distances travelled between summering and wintering 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 initial 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 and 37411 was captured independently of its sibling. Of those captured, eagles 37414 and 37413 and eagles 37412 and 37415 were siblings, respectively, and 37411 was captured alone. 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).

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 northern coast of the Gulf of St. Lawrence, 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, approximately 1370 km from its natal area.

Eagles 37411 and 37413 (Fig. 1) left the Gulf of St. Lawrence and moved toward the U.S. east coast, stopping along the borders of Vermont and New Hampshire. Eagle 37411 made 11 stopovers and travelled approximately 1420 km before reaching its wintering grounds along the Hudson River between Ulster and Dutchess Counties, NY. Eagle 37413 travelled about 1640 km before settling in Hartford County, CT, with 6 stopovers.

MOVEMENTS BEFORE SPRING MIGRATION

The mean overwintering period was 76 d, (44--124 d), except for 37414 which remained at the wintering site through August 2003.

SPRING MIGRATION

We defined spring migration as the period of time in which the birds departed from wintering grounds and arrived at the summering grounds. Once on the summering grounds, the eagles did exhibit exploratory and nomadic flight behaviour. While eagle 37414 did not migrate in the spring, it did move within the same 252 km^2 area for the whole summer but 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 inland 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 and 1600 km to arrive at the Gulf of St. Lawrence on 21 and 26 April 2003, respectively. Eagle 37411 left its wintering 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 State on 15 May 2003. It then travelled north on 8 June 2003 and returned to the Gulf of St. Lawrence. On 12 August 2003, this bird began moving south to New York State.

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 towards the Gulf of St. Lawrence prior to dispersing enroute 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 later in the season (median = 26 October).

All of our eagles travelled independently of one another, migrating in a similar direction, 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 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. 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). Non-breeding 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.

ACKNOWLEDGMENTS

This project would not have been possible without the funding support of the Goose Bay Office, Department of National Defence, Canada. We also acknowledge the support of McGill University, Gary Humphries, and the Department of Tourism, Culture and Recreation (Endangered species and Biodiversity Section). We would also like to thank M. Solensky for demonstrating proper transmitter attachment techniques and for assisting in the field. We thank L. Elson, G. Goodyear, and P. Trimper for their help in the field. We are grateful to Capt. (N) K.D. Laing for his

editorial assistance. We also thank M. Fuller, M. Restani, and M. Goldstein for comments that greatly improved the manuscript.

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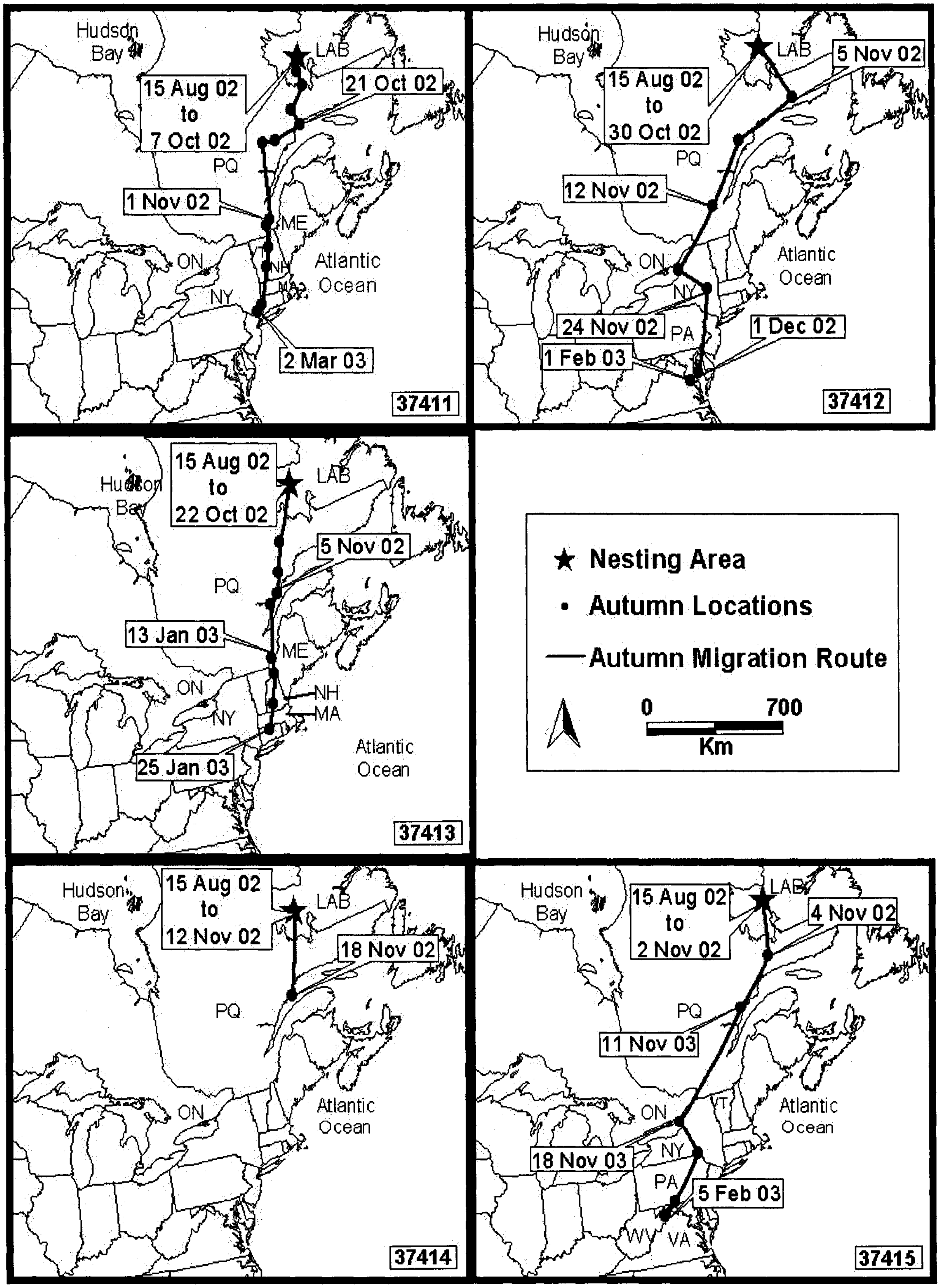
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1 Feb 03
37412
15 Aug 02 to 22 Oct 02
Hudson Bay
LAB
5 Nov 02
PQ
13 Jan 03
ME
ON
NH
NY
MA
Atlantic Ocean
25 Jan 03
37413
Nesting Area
Autumn Locations
Autumn Migration Route
0
700
Km
Hudson Bay
15 Aug 02 to 12 Nov 02
LAB
18 Nov 02
PQ
ON
Atlantic Ocean
37414
Hudson Bay
15 Aug 02 to 2 Nov 02
LAB
4 Nov 02
PQ
11 Nov 03
ON
VT
Atlantic Ocean
18 Nov 03
NY
PA
5 Feb 03
WV
VA
37415

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.

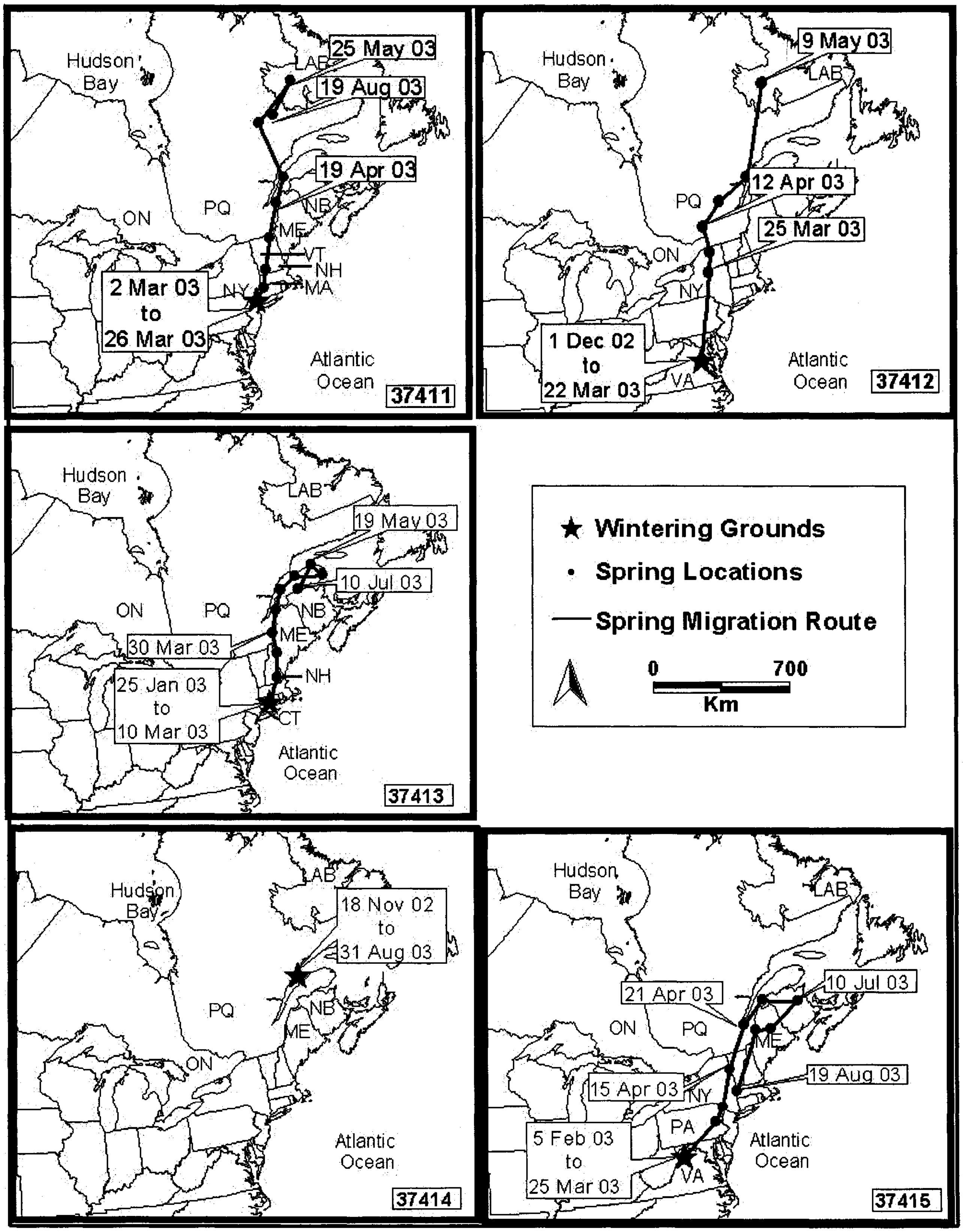
Hudson Bay
LAB
25 May 03
19 Aug 03
19 Apr 03
ON
PQ
NB
ME
VT
NH
MA
NY
2 Mar 03
to
26 Mar 03
Atlantic Ocean
37411
Hudson Bay
9 May 03
LAB
PQ
12 Apr 03
25 Mar 03
ON
NY
1 Dec 02
to
22 Mar 03
VA
Atlantic Ocean
37412
Hudson Bay
LAB
19 May 03
10 Jul 03
ON
PQ
NB
ME
30 Mar 03
25 Jan 03
to
10 Mar 03
NH
CT
Atlantic Ocean
37413
Wintering Grounds
Spring Locations
Spring Migration Route
0
700
Km
Hudson Bay
LAB
18 Nov 02
to
31 Aug 03
PQ
NB
ME
ON
Atlantic Ocean
37414
Hudson Bay
LAB
21 Apr 03
10 Jul 03
ON
PQ
ME
19 Aug 03
15 Apr 03
NY
PA
5 Feb 03
to
25 Mar 03
VA
Atlantic Ocean
37415

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

CONNECTING STATEMENT

Chapter 2, elaborated on the movements, timing, and popular stopover locations of Bald Eagles from Central Labrador. Chapter 3 focuses on the movements, dispersal, timing, and popular stopover locations of Osprey from central Labrador. To date these aspects of Labrador Osprey populations have not been studied previously. The following manuscript is formatted for the Journal of Raptor Research.

Chapter 3: DISPERSAL MOVEMENTS OF OSPREY *Pandion haliaetus* MIGRATING FROM LABRADOR NATAL AREAS

ABSTRACT

We documented dispersal behaviour of five hatch-year and two adult Osprey (*Pandion haliaetus*) from central Labrador, Canada. Satellite telemetry was used to track the fall migration of Osprey from natal sites in late August 2002 and 2003. Mean juvenile departure dates from natal areas were 3 October (n=3), with a range of 28 September (in 2002) to 8 October (in 2003). Juveniles migrated independently of siblings, travelled up to 308km/d, and followed coastlines and waterways. One adult was tracked for its entire autumn migration (18 October to 23 November 03. It travelled at an average rate of 184km/d; transmissions recorded movements occurring only during the day.

Key words: Osprey, *Pandion haliaetus*, migration, stopover, Labrador, satellite telemetry

INTRODUCTION

Osprey (*Pandion haliaetus*) are a widely distributed bird of prey in the Northern Hemisphere, breeding in temperate areas between 40° and 70° latitude and migrating long distances to southern and tropical regions during winter (Poole 1989, Hake et al. 2001). In Canada, Osprey are present during breeding and migration from April to October (Jamieson et al. 1983). Osprey are distributed throughout North America, but the species reaches the northern limit of this part of their range Labrador (Wetmore and Gillespie 1976). Northern-nesting Osprey commonly nest in the tops of Black Spruce (*Picea mariana*), Balsam Fir (*Abies balsamiea*), and on power poles (Wetmore and Gillespie 1976, Chubbs and Trimper 1998).

Research within the Labrador region thus far has focused on the distribution and productivity of Osprey (Wetmore and Gillespie 1976), food habits (Chubbs and Trimper 1998), and the influence of low-level jet aircraft noise on nesting Osprey (Thomas 1998, Trimper et al. 1998). While activities at Osprey nest sites have been documented in Labrador (Wetmore and Gillespie 1976, DND 1995, Chubbs and Trimper 1998, Thomas 1998, Trimper et al. 1998), little is known about dispersal and migration behaviour in this population.

Migration routes, stopover and wintering sites of Osprey in other parts of their range have been studied using conventional banding methods (Henny and Velzen 1972, Poole and Agler 1987) and more recently using satellite telemetry (Hake et al. 2001, Martell et al. 2001). Analyses of band recovery data analyzed by Poole and Agler (1987) showed that there are both resident and migratory populations of Osprey in the United States (Poole et al. 2002. Furthermore, birds breeding in the Midwestern United States winter in South America (Poole and Agler 1987). This latter finding was further supported through the use of satellite telemetry (Martell et al. 2001).

While banding recoveries only support two confident locations, one in which the bird was banded and the second where it was retrieved dead or recaptured, satellite telemetry can delineate a detailed account of a bird's movement. Martell et al. (2001) tracked the movements of 74 adult Osprey (25 males, 49 females) and found that on average, fall migration began in August (although this varied by location), and that the birds favoured large tributaries, open waterways, and river valleys. Other satellite tracking studies have also revealed that Osprey apparently do not migrate at night, travel independently (Kjéllen et al. 1997), and make extensive overwater crossings (Martell et al. 2001). In fact, Osprey travelling southward on the east coast of North America do make large crossings over water from Florida to Cuba (Martell et al. 2001). Therefore, I suspected that birds from northern Labrador would travel southward along the eastern coast of the United States, possibly as far south as Cuba.

As a preliminary study examining dispersal and migratory movements of Osprey breeding in Labrador, this study describes the fall migration of one adult Osprey and partial dispersal movements and timing of 5 juvenile one adult Osprey.

STUDY AREA AND METHODS

The study took place near the Labrador-Québec north-eastern border, specifically the Smallwood Reservoir (53° 30'N; 64° 00'W) in central Labrador in August of 2002 thru December 2002 and 2003 thru December 2003. The study area was composed of water bodies, prominent rock islands, isolated erratics and rock outcrops. The dominant forest type was Black Spruce (*Picea maria*) with other species interspersed (Bider and Bird 1983). Due to the low sub-arctic ecoclimate, wetland areas are subject to underlying permafrost. This region has relatively cool summers and very cold winters with a mean summer (May-August) temperature of 9°C and a mean winter (December-February) temperature of -16°C. Mean annual precipitation varies according to latitude with an annual range of 700-1000 mm (Env. Can. unpubl. data).

Due to the inaccessibility and remoteness of tree nests, only rock nests were accessed. Juvenile Osprey (age 8-10wk) were captured by climbing rocks supporting Osprey nests and removing young by hand (Chubbs et al. 2005). Two adult males were caught, on separate occasions, using a modified noose carpet placed over the nest (Anderson and Hamerstrom 1967). We attached an 17.5-22cm brook trout (*Salvelinus fontinalis)*to the top of the noose dome to attract the adults back to the nest(Chubbs and Trimper 1998).

Once in hand, each Osprey was moved to an adjacent area (<50m away) for processing and banding. All captured birds were fitted with a transmitter in the same manner as described by Martell et al. (2001). Osprey were fitted with 35g solar-powered, harness mounted, satellite transmitters (termed platform transmitting terminals, or PTT) affixed in a back-pack harness fashion using Teflon ribbon (Bally Ribbon Mills, PA). The duty cycle on the PTTs transmitted for 8 hr every 24 hr period. All Osprey were banded with a U.S. Fish and Wildlife Service rivet band on one tarsus and a blue colour rivet band on the other.

We monitored Osprey movements using the Argos Data Collection services (ARGOS 2000). We determined natal sites, departure and arrival times, 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. We used locations found to be most valid in relation to the location class quality index, i.e. all location class values between 0 and 3.

Departure from one location and arrival dates at the next were determined by comparing the last transmission at the location of origin to the first transmission at a new location. An area was considered to be a stopover site if the bird staged for at least 24 hr (Kjėllen et al. 2001) and demonstrated localized movement <30km between points. Distances between summering and wintering grounds were calculated between stopovers, and measured in a linear fashion to establish successive and cumulative distance measurements between points (Laing et al. 2005).

All location data collected prior to initial southward migration movements were combined for home range analysis. Data were analyzed using GIS and the Animal Movement Extension for Kernel Analysis, available for Arcview GIS 3.2 (ESRI, Redlands, CA). Using this method, a 95% home range was calculated for each bird using movement data collected 1-18 September (2002 and 2003).

Transmission loss was determined by comparing activity sensor output of the birds, explained thoroughly by our service provider(Argos 2000). Using the algorithms provided by Argos (2000), we could determine inconsistencies and low activity output of transmitters. The low activity could be a result of a dead non-moving bird or a faulty transmitter; therefore confident dates of death or survival rates cannot be determined. Poor transmissions were collected until PTTs ceased transmission all together.

RESULTS

Between 3 and 4 September 2002, four juvenile Osprey from two nests (2 males, 2 females) were captured and fitted with PTTs (Table 1). In August 2003, one female juvenile and two adult male Osprey were captured (Table 1).

Inexplicably, six of the seven transmitters ceased transmission, three (37416, 37417, and 40581) prior to recording dispersal from their natal territories (Table 1). However, three fledged birds (37418, 40580, 40582) were tracked during the onset of their autumn migration to gain dispersal data and one adult Osprey continued to transmit through autumn migration and on the wintering grounds until 31 December 03 (Table 2).

A total of 942 locations was collected from the 2002 captured birds (n=4), 53% of which were ranked as accurate (i.e. location >0). There were a higher than average number of inaccurate locations because of days with poor transmissions just prior to transmitter loss. Percentages of locations collected include: Z=4%, B=13%, A=18, 0=36%, 1=22%, 2=6%, and 3=1%; only locations classed 0, 1, 2, and 3 were used in analysis.

As of 31 December 2003, captured birds (n=3) transmitted 1652 locations with 88.3% of locations estimated as accurate. Percentages of locations used were: Z=10%, B=13%, A=14%, 0=35%, 1=18%, 2=8%, and 3=2%.

Captured Birds in 2002

Two birds from different nests, were not recorded on migration. The transmitter of 37416, juvenile female, and sibling of 37418, ceased transmission on 28 September 2002 (Table 1). Based on 60 transmssions all movement was within 8.3km^2 of its natal area, at a rate of 25km/d. Female 37419, a juvenile and sibling of 37417, transmitted up to 30 September 2002 (Table 1). Over 250 locations were sent, all within 23.5km^2 of its natal area and indicating an average travel rate of 33km/d.

Juvenile male Osprey 37417 was recorded on its natal grounds until 8 October 2002 (Table 1), travelling to the north shore of the Gulf of St. Lawrence by 9 October 2003 (Fig. 8). This bird's PTT sent 324 signals indicating use of an estimated area of 23.5km^2 around its natal area. This bird flew at a rate ranging between 308km/d and 198km/d at the onset of migration (Table 2). Its signal was lost on 15 October 2002 along the north shore of the Gulf of St. Lawrence (Fig. 3).

Juvenile male, Osprey 37418, used an area of $13.4km^2$ around its natal area, moving at a calculated average rate of 1.2km/d. This bird had six distinct stopovers during its major movement between 29 September 2002 and 9 October 2002 (Fig. 3) and moved a cumulative distance of almost 3500km from its natal area (Table 2). Both Osprey tracked on migration made stops along the Gulf of St. Lawrence (Fig. 3).

All siblings studied moved independently, with only the two juvenile males transmitting during the onset of migration.

CAPTURED BIRDS IN 2003

Two of the 2003 captured birds were caught at the same nest, a juvenile (40581) and the adult male (40580). Osprey 40581 was not tracked on migration due to transmitter failure on 21 September 2003 (Table 1). However, it had been recorded flying a cumulative distance of 1769km at an average rate of 14km/d on daily excursions near its natal area. Within the one-month period the bird had sporadic transmissions (n<140), estimating a dispersal range area of $58.7km^2$. Osprey 40580 had 558 reliable transmissions before its transmitter failured on 19 October 2003. Osprey 40580 was recorded travelling within $1.6km^2$ of its nest site prior to departing southward on 8 October 2003, travelling 732km before transmission was lost. The bird was recorded travelling at an average rate of 180km/d while on migration. The bird was last recorded on the north shore of Quebec.

The adult male Osprey 40582, captured in the Smallwood Reservoir 27 August 2003, was lost until 31 December 2003. Between date of capture and its departure on 18 October 2003 it used a $2.8km^2$ range, centered over its nest area, travelled at an average rate of 13km/d while in its breeding area. This male made 15 short (<24hr) layovers and travelled at an average rate of 189km/d prior to reaching its wintering area on 23 November 2003 in the Isle of Beata, Dominican Republic (Table 1, Table 2 and Fig. 4).

DISCUSSION

Satellite telemetry has become a valuable tool in predicting Osprey movement in comparison to traditional banding and observational practices, and can provide valuable insight into the fall migration of adult Osprey and the first month after fledging of juvenile Osprey. The most critical time period for raptors is the first month after a chick fledges from the nest (Poole et al. 2002). Most young birds remain within close proximity of the nest during the day and frequently return to the nest at night (Henny and Wight 1969). Consistent with the literature, all five juvenile Osprey involved in this study nomadically travelled areas within 8-58km^2 of original natal areas.

Juvenile Osprey survival rate is very low, often only 60% surviving in their first year (Poole 1989, Poole et al. 2002). Late fledging (Poole 1989) and underdeveloped foraging skills (Edwards 1989, Poole 1989) have been suggested as the cause for juvenile Osprey mortalities. In the weeks following fledging, in both 2002 and 2003, transmitter signals of four of the seven tagged Osprey were lost prior to migratory movements. Ceased transmission could be linked to mechanical difficulties, or early mortality. General failure rates have not been intensely documented.

Results from our study record an adult Osprey in Labrador used an area of approximately 3 km^2, which is consistent with existing literature (Poole et al. 2002). Due to the nesting location of these birds in Labrador around the Smallwood Reservoir, it is likely that they were able to exploit fish resources adjacent to nest sites. Adult breeding ranges are often characterized by foraging availability and commuting distances (Poole et al. 2002); however available literature on the breeding range of Osprey is limited. Breeding adults are recorded to use a smaller area near the nest site in comparison to nomadically moving non-breeders. The latter travel upwards of 10-20 km for optimal foraging opportunities but concentrate daily movements within 1.5km of their nest site. Therefore, further management plans should consider that Osprey of Labrador are using similar- sized ranges near their nest sites as seen in other North American Osprey populations (Poole et al. 2002).

Juvenile Osprey tracked from Labrador departed their natal areas between 29 September 2002 and 9 October 2002, travelled independently of siblings from original natal areas, and followed river valleys and larger water bodies, similar to the populations studied by Martell et al. (2001). The adult male Osprey in our study departed natal areas at the same time (8 October 2003) or after (18 October 2003) juveniles, however differences in departure are likely partially linked to weather or foraging opportunities (Martell et al. 2001). Although full migratory cycles for juvenile Osprey were not recorded, their travelling paths reveal movements independent of a sibling from natal areas.

Literature suggests that departure times may differ between sexes, female adult Osprey usually depart nesting areas before adult males and adult males depart before juveniles (Bent 1937, Henny and Van Velzen 1972, Kjéllen et al. 1997, 2001, Hake et al. 2001, Martell et al. 2001, Poole et al. 2002). Dispersal typically begins in August (Poole and Agler 1987, Martell et al. 2001, Poole et al. 2002) but can range between mid-July to early November (Poole et al. 2002). Martell et al. (2001) speculated that the early departure of the females could be attributed to the fact that females travel farther south than males on migration and thus may depart earlier.

The tagged Osprey from Labrador followed river valleys and large water bodies, reflective of typical foraging behaviour with few stopovers (Martell et al. 2001). Martell et al. (2001) found that eastern North American Osprey had a tendency to follow the eastern seaboard down into the southernmost part of Florida, crossing over into the West Indies and/or South or Central America. The fall movements of my adult Osprey showed the same movement pattern. He reached the Dominican Republic in 36 days, travelling along the eastern seaboard at a rate of 189km/d, comparable to that recorded by Martell et al. (2001). Therefore, Osprey populations in Labrador travel similar routes and winter in locations common to other North American Osprey populations. The adult Osprey male in our study crossed the Atlantic Ocean at the southernmost tip of Florida and arrived at the northernmost point in Cuba after which it eventually wintered in the Dominican Republic, a popular location for migratory North American Osprey (Henny and Van Velzen 1972, Poole and Agler 1987, Martell et al. 2001, Poole et al. 2002). Martell et al. (2001) and Hake et al. (2001) both stated that Osprey will make extensive crossings over water while on migration, even water bodies as large as the Mediterranean Sea (Kjéllen et al. 1997, Hake et al. 2001), the Caribbean Sea and the Gulf of Mexico (Martell et al. 2001). Alternatively, adults may be departing to reduce competition for food with their young within nesting territories.

Banding recovery data, pre-1972, showed that 15.5% of east coast Osprey winter in the West Indies (Henny and Van Velzen 1972). Satellite telemetry has since recorded wintering Osprey spending time in both South America (89%) and the West Indies (11%)(Martell et al. 2001. The Labrador adult Osprey moved in a "marathon" fashion, versus the "sprint" fashion, travelling in a straight line to its wintering grounds. The "sprint" fashion implies travel of shorter distances with more stops on the way, while the "marathon" pattern refers to constant long distance migration, with foraging on the way (Martell et al. 2001). Osprey wintering farther from nests make more non-stop flight segments than those travelling a shorter distance (Kjéllen et al. 1997, 2001, Martell et al. 2001) and often depart original nest sites earlier to ensure a timely arrival on wintering grounds (Martell et al. 2001). The adult Osprey migrating from Labrador made the journey in 36 days at a rate of 100 km/day, similar to the rates of other eastern North American Osprey flying at rates of 111-380 km/day (Martell et al. 2001) and Swedish Osprey (Kjéllen et al. 1997) at 159-413 km/day.

In summary, Osprey migrating from Labrador appear to have similar patterns of movement and flight strategies as other eastern North American populations of Osprey (Martell et al. 2001). Despite transmitter failure in several of our birds, our study does provide a preliminary look into post-fledging dispersal of juvenile Osprey from Labrador and also documents the first known migration of an adult male from central Labrador to the Dominican Republic. Further satellite tracking is required to fully understand the migratory behaviour of both juvenile and adult Osprey residing in Labrador.

ACKNOWLEDGEMENTS

We acknowledge the support of the Goose Bay Office, Department of National Defence, McGill University, and the Department of Tourism, Culture and Recreation (Endangered species and Biodiversity Section). Extended thanks go to M. Solensky for his guidance in the field and L. Elson and P. Trimper for their help in the field. We would also like to acknowledge the editorial assistance of Capt. (N) K.D. Laing, an anonymous external reviewer, T.L. Crewe and D. Badzinski.

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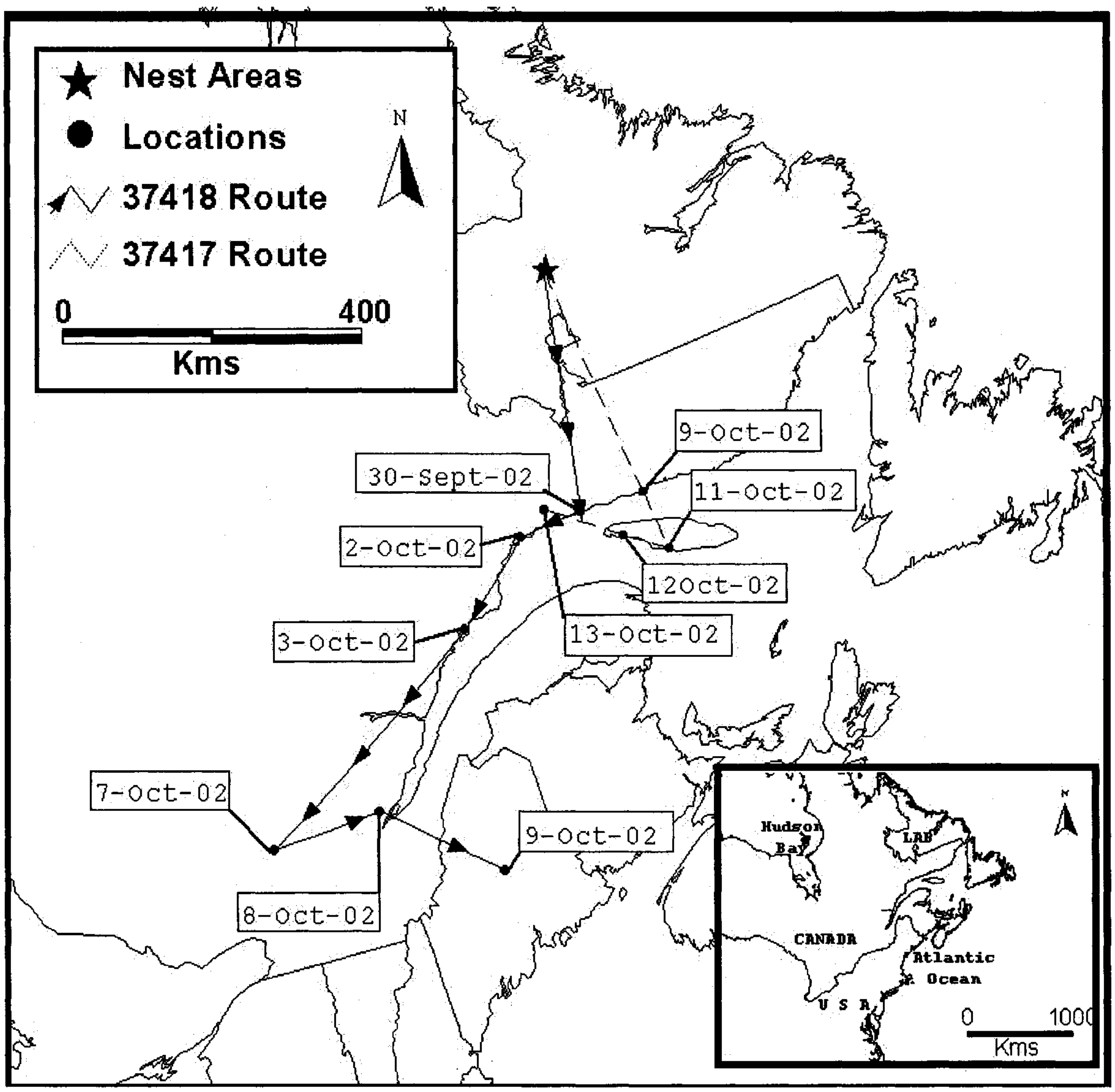
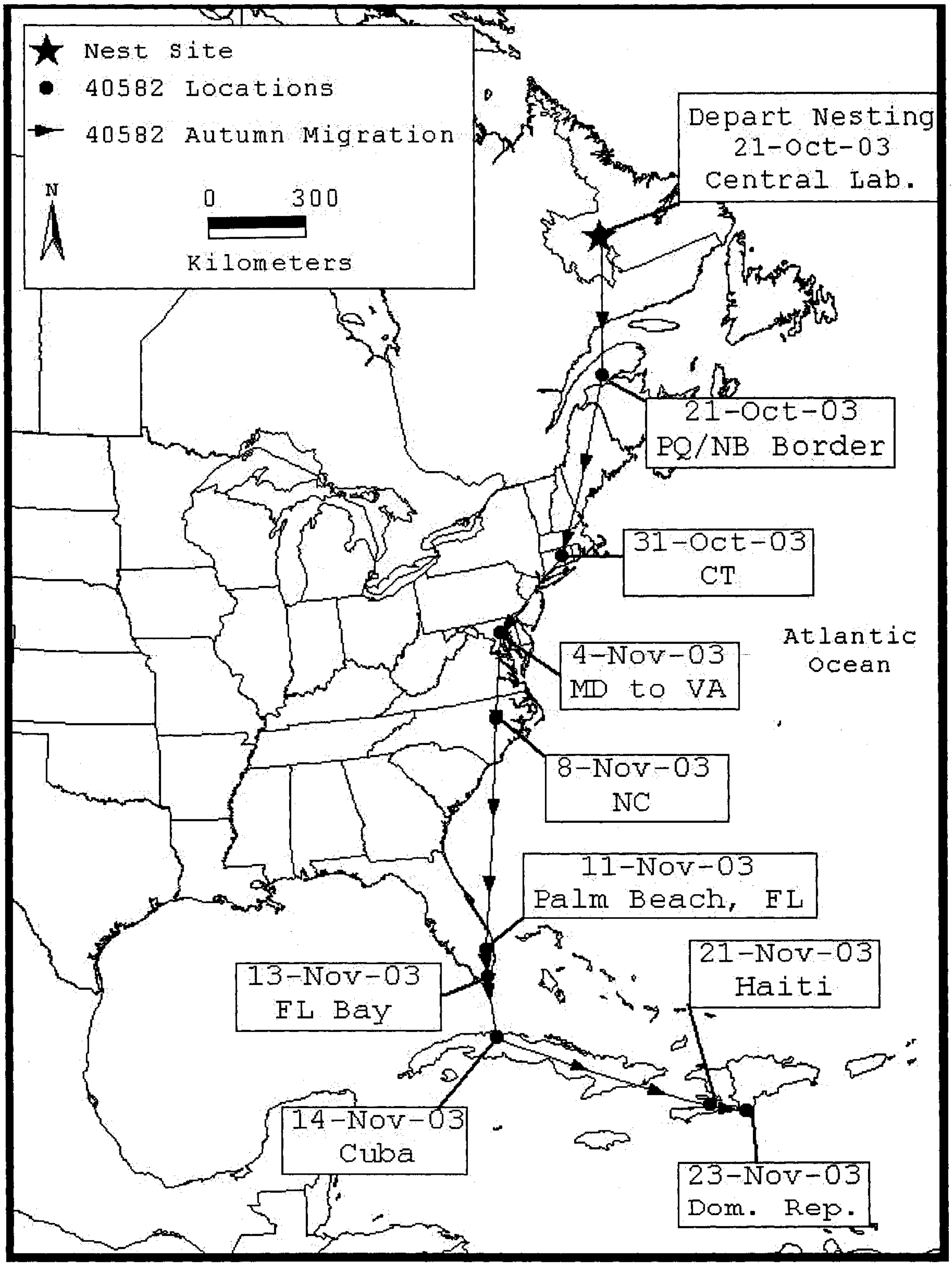


Nest Areas
Locations
37418 Route
37417 Route
0
400
Kms
N
9-Oct-02
30-Sept-02
11-Oct-02
2-Oct-02
12Oct-02
13-Oct-02
3-Oct-02
7-Oct-02
9-Oct-02
8-Oct-02
Hudson Bay
LAB
CANADA
Atlantic Ocean
U S A
0
1000
Kms

Fig. 3. Fall migration routes of juvenile Osprey 37418 and 37417 from Labrador, 2002. 37417 travelled over-water to Anticosti Island and back to the mainland in Québec.



Nest Site
40582 Locations
40582 Autumn Migration
N
0 300
Kilometers
Depart Nesting
21-Oct-03
Central Lab.
21-Oct-03
PQ/NB Border
31-Oct-03
CT
Atlantic
Ocean
4-Nov-03
MD to VA
8-Nov-03
NC
11-Nov-03
Palm Beach, FL
21-Nov-03
Haiti
13-Nov-03
FL Bay
14-Nov-03
Cuba
23-Nov-03
Dom. Rep.

Fig. 4. Complete fall migration route of adult male Osprey 40582 from Labrador to the Dominican Republic, 2003.

Table 1: Transmitter summary for all seven Osprey fitted with transmitters between August 2002 and 2003. Approximate coordinates (decimal values) are given for transmitted locations.

TT	Age	Sex	Date Tagged	Location Tagged Latitude/ Longitude	Transmitter Failure	Depart	Latitude/ Longitude	Arrive	Difference (hrs)	Distance (km)	Rate (km/hr)	Average Rate (km/hr)
416	Juv	F	3 Sept 02	53.8137N/63.7944W	28 Sept 02	-	-	-	-	-	-	-
417	Juv	M	4 Sept 02	53.7497N/63.5997W	15 Oct 02	8 Oct 02	53.759N/63.585W	9 Oct 02	29.37	377.50	12.85	13
418	Juv	F	3 Sept 02	53.8137N/63.7944W	3 Nov 02	29 Sept 02	53.806N/63.593W	30 Sept 02	29.73	377.50	12.70	
						1 Oct 02	50.305N/64.743W	2 Oct 02	21.97	110.90	5.05	
						3 Oct 02	48.235N/69.127W	4 Oct 02	21.12	256.80	12.12	
						7 Oct 02	46.856N/73.686W	8 Oct 02	24.00	162.60	6.78	
						8 Oct 02	46.600N/69.274W	9 Oct 02	22.10	102.90	4.66	8
419	Juv	F	4 Sept 02	53.7497N/63.5997W	30 Sept 02	30 Sept 02	53.803N/63.316W	-	-	-	-	-
580	Ad	M	15 Aug 03	53.697N/63.7944W	19 Oct 03	8 Oct 03	52.919N/63.931W	9 Oct 03	24.28	159.20	6.56	
						14 Oct 03	51.737N/65.590W	15 Oct 03	25.35	205.70	8.11	
						15 Oct 03	49.522N/69.198W	16 Oct 03	23.58	203.60	8.63	
						17 Oct 03	47.854N/70.175W	18 Oct 03	23.85	163.40	6.85	7.5
581	Juv	F	27 Aug 03	53.697N/63.7944W	21 Sept 03	21 Sept 03	53.743N/63.763W	-	-	-	-	-
582	Ad	M	27 Aug 03		-	18 Oct 03	53.778N/64.072W	19 Oct 03	26.23	367.00	13.99	
						20 Oct 03	50.706N/66.449W	21 Oct 03	32.22	263.40	8.18	
						21 Oct 03	48.258N/67.148W	22 Oct 03	31.33	385.60	12.31	
						24 Oct 03	44.007N/70.041W	25 Oct 03	34.22	110.10	3.22	
						29 Oct 03	42.841N/71.701W	31 Oct 03	32.73	134.70	4.12	
						31 Oct 03	41.630N/72.400W	1 Nov 03	29.60	126.70	4.28	
						2 Nov 03	40.817N/74.365W	3 Nov 03	29.92	139.50	4.66	
						7 Nov 03	36.758N/77.449W	8 Nov 03	25.25	122.00	4.83	
						9 Nov 03	35.636N/77.804W	10 Nov 03	33.08	667.40	20.17	
						10 Nov 03	30.127N/81.537W	11 Nov 03	33.27	347.40	10.44	
						12 Nov 03	26.212N/80.567W	13 Nov 03	29.82	106.00	3.56	
						13 Nov 03	25.238N/80.592W	14 Nov 03	29.62	262.00	8.85	
						19 Nov 03	21.594N/78.327W	20 Nov 03	32.52	138.70	4.27	
						20 Nov 03	20.005N/74.628W	21 Nov 03	27.00	260.00	9.63	
						22 Nov 03	18.413N/72.828W	23 Nov 03	30.70	167.00	5.44	7.8

Table 2. Total time, distance and average speed of migration of four male Osprey[1] recorded by satellite tracking.

	37417	37418	40580	40582
Age	Juvenile	Juvenile	Adult	Adult
Migration Period[2]	8-9 Oct 02	29 Sept- 9 Oct 02	8-18 Oct 03	18 Oct- 23 Nov 03
Transmission Failures	15 Oct 02	3 Nov 02	19 Oct 03	N/A
Total time (days)[3]	1	12	10	36
Total distance (km)[4]	377	1011	732	3597
Average Speed (km/d)	377	84	73	100

[1]Three of the Osprey transmitters failed prior to recording movement from original natal areas. The siblings of 37417 and 37418, 37419 and 37416, respectively, ceased transmission by 30 Sept 02 and the offspring of 40580 (40581) ceased transmission by 21 Sept 03.
[2]Period includes all movements recorded away from original natal area before transmitter failure
[3]Time recorded for duration of movements, prior to transmission failure.
[4]Distances measured linearly between positions using only the first and last position in each 8-h transmitting interval.

Conclusion

Central Labrador is home to two of North America's migratory raptors, the Bald Eagle and Osprey. The focus of this thesis was to use satellite telemetry to study the timing, migratory movements, site fidelity, and wintering ranges of juvenile and adult Osprey and Bald Eagles from central Labrador.

Our tracking data indicate that Bald Eagles disperse from central Labrador in the fall between 7 October and 8 December at an average rate of 80km/d, and in the spring, head north from their wintering areas between 15 February and 22 March at an average travelling speed of 75km/d. Juvenile Osprey departed between similar periods, 29 September and 8 October, but travelled at a faster average rate (229km/d). One tracked adult departed Labrador by 18 October, travelling 188km/d to reach the Dominican Republic in 36 days.

Raptors travelled directly from the Smallwood Reservoir to the Gulf of St. Lawrence, with most scattering among smaller lakes and tributaries at the southernmost entrance of the Gulf of St. Lawrence. One eagle remained throughout the winter at the Gulf of St. Lawrence from 18 November 2002, with the others wintering in New York State, Maryland, and Virginia. The eagles demonstrated exploratory flight once on wintering grounds and utilized similar routes north in the spring as taken in the fall.

Our data suggest that these migrants are likely dispersing in larger numbers along Labrador river valleys and waterways focusing activities near aquatic environments at the south-central region of Labrador during late September to late November.

Therefore, future management strategies for this species from central Labrador, particularly those pertaining to the low-level military jet training activities, should consider the timing in which these raptors begin migratory movements, their important flyways, as well as identified stopover areas (i.e. Gulf of St. Lawrence, Smallwood Reservoir) documented in this thesis.

Appendix A

Animal Care Committee-Approved Form

Guidelines for completing the form are available at www.mcgill.ca/rgo/animal

McGill University
Animal Use Protocol – Research

For office use only
Protocol #: 4661
Investigator #: 391
Approval End Date: NOV. 30, 2003
Facility Committee: AGR

Title: Migration Routes, Timing and Fidelity of Osprey and Bald Eagles as they relate to Military Aircraft Training in Labrador

New Application: YES **Renewal of Protocol: #** **Pilot:** **Category** *(see section 11)*: B

1. Investigator Data:

Principal Investigator: Dr. David M. Bird **Phone #:** (514) 398-7760
Department: Avian Science and Conservation Center **Fax#:** (514) 398-7990
Address: **21,111 Lakeshore Road, Ste. Anne de Bellevue, Que.** **Email:** bird@nrs.mcgill.ca

2. Emergency Contacts: Two people must be designated to handle emergencies.

Name	Work #	Emergency #
Tony E. Chubbs	(709) 896-6900 ext 7811	(709) 896-2691
Perry G. Trimper	(709) 896-5860	(709) 896-5898

3. Funding Source:

External: Yes
Source (s): Department of National Defence
Peer Reviewed: YES
Status: Approved
Funding period: 5 Sept. 2002- 5 Sept. 2004

Internal:
Source (s) :
Peer Reviewed:
Status:
Funding period:

For Office Use Only:

ACTION	✓	DATE
CCa	✓	Dec 17 '02
CB		
APPROVED		

**** All projects that have not been peer reviewed for scientific merit by the funding source require 2 Peer Review Forms to be completed e.g. Projects funded from industrial sources. Peer Review Forms are available at www.mcgill.ca/rgo/animal**

Proposed Start Date of Animal Use (d/m/y): 01/05/03 **or ongoing:**

Expected Date of Completion of Animal Use (d/m/y): 31/10/04 **or ongoing:**

Investigator's Statement: The information in this application is exact and complete. I assure that all care and use of animals in this proposal will be in accordance with the guidelines and policies of the Canadian Council on Animal Care and those of McGill University. I shall request the Animal Care Committee's approval prior to any deviations from this protocol as approved. I understand that this approval is valid for one year and must be approved on an annual basis.

Principal Investigator's signature: **Date:** Oct 19/02

Chair, Facility Animal Care Committee: **Date:** 11/12/2002

University Veterinarian: **Date:** Dec 11, 2002

Chair, Ethics Subcommittee (as per UACC policy): **Date:**

APPROVED ANIMAL USE PERIOD START: Dec. 1, 2002 END: NOV. 30, 2003

DEC 17 2002

May 2002

Manuscript Permits

Junior Author

```
-----Original Message-----
From: Tony Chubbs [mailto:techubbs@cablelab.net]
Sent: 30 August 2005 10:38
To: Dawn Laing
Subject: RE: ms edits
```

This is note conveys my approval to permit manuscripts to which I am a participating co-author as outlined as my role in the introduction of the thesis entitled:

"DISPERSAL AND MIGRATORY BEHAVIOR OF OSPREY AND BALD EAGLES IN LABRADOR"

by

Dawn Kelly Laing, Department of Natural Resource Sciences, (Wildlife Biology), McGill University-MacDonald Campus, Montréal, Québec.

I am the junior author of both the Bald Eagle and Osprey papers and I have had a role in much of the project development, data collection, and publication and review process.

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-----Original Message-----
From: JAMES BEDNARZ [mailto:JBEDNARZ@astate.edu]
Sent: 30 August 2005 11:47
To: Dawn Laing
Cc: Journal Raptor Research
Subject: Use of JRR article in thesis

Dawn,

No problem. Use of your JRR article in your thesis is consistent with the mission of the Raptor Research Foundation, Inc.

Thus, I, on behalf of the Raptor Research Foundation, Inc., grant Dawn K. Laing permission to reproduce the article, "First complete Migration Cycles for Juvenile Bald Eagles from Labrador" (*Journal of Raptor Research* 39:11-18) as part of her M.Sc. Thesis on behalf of the Raptor Research Foundation, Inc. If you need further documentation of this permission, please let me know.

James C. Bednarz
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Journal of Raptor Research

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