FALL MIGRATION ROUTES, TIMING, AND WINTERING SITES OF NORTH AMERICAN OSPREYS AS DETERMINED BY SATELLITE TELEMETRY

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Abstract. Satellite telemetry was used to determine fall migratory movements of Ospreys (Pandion haliaetus) breeding in the United States. Study areas were established along the lower Columbia River between Oregon and Washington; in north-central Minnesota; on Shelter Island, New York; and in southern New Jersey. Seventy-four adults (25 males, 49 females) were tracked from 1995 through 1999. Migration routes differed among populations but not by sex. Western Ospreys migrated through California and to a lesser degree other western states and wintered in Mexico (88%), El Salvador (6%), and Honduras (6%) (25.9°N to 13.0°N and 108.3°W to 87.3°W). Minnesota Ospreys migrated along three routes: (1) through the Central U.S. and then along the east coast of Mexico, (2) along the Mississippi River Valley, then across the Gulf of Mexico, or (3) through the southeastern U.S., then across the Caribbean. East Coast birds migrated along the eastern seaboard of the U.S., through Florida, and across the Caribbean. Midwestern birds wintered from Mexico south to Bolivia (22.35°N to 13.64°S, and 91.75°W to 61.76°W), while East Coast birds wintered from Florida to as far south as Brazil (27.48°N to 18.5°S and 80.4°W to 57.29°W). Dates of departure from breeding areas differed significantly between sexes and geographic regions, with females leaving earlier than males. Western birds traveled a shorter distance than either midwestern or eastern Ospreys. Females traveled farther than males from the same population, which resulted in females typically wintering south of males.

Key words: migration, Osprey, Pandion haliaetus, satellite telemetry, wintering sites.

INTRODUCTION

Migration routes and wintering localities of North American Ospreys (Pandion haliaetus) have been previously described by various authors using information from band recoveries (Henny and Van Velzen 1972, Poole and Agler 1987), migration count sites (Zalles and Bildstein 2000), and wintering areas (Saggese et al. 1996). These studies show a widespread distribution of Osprey wintering sites and migration...
routes. Winter band recoveries from Ospreys that nest along the East Coast of North America have come mostly from South America and to a lesser degree the West Indies (Poole and Agler 1987). Band recoveries of birds that breed in the midwestern U.S. have been from South and Central America (Niemuth 1991). Band recoveries from western U.S. breeding birds indicate they winter in Mexico and Central America (Melquist et al. 1978, Johnson and Melquist 1991).

Avian migration studies have been enhanced by the recent availability of small, satellite-tracked radios known as platform transmitter terminals (PTTs; Seegar et al. 1996) that have allowed the plotting of migration routes and wintering localities of a variety of birds, including Ospreys (Kjellen et al. 1997, Martell et al. 1998).

Here we report on fall migratory movements of Ospreys breeding in North America as determined by satellite telemetry. Our objectives were (1) to describe routes, distance, and timing of fall migration; (2) to identify wintering localities and arrival dates; and (3) to determine if migration varies by sex or geographic origin.

METHODS
STUDY AREAS
Ospreys were monitored from study areas chosen to represent the eastern, midwestern, and western United States breeding populations (Henny 1983). All study areas were between 46° and 38° north latitude. Birds in the eastern U.S. were trapped on The Nature Conservancy’s Mashomack Preserve and private land on Shelter Island, Suffolk County, New York (on the eastern end of Long Island). Ospreys have been banded and monitored in this area since the early 1900s (Puleston 1972). Additional eastern U.S. birds came from The Wetlands Institute Preserve, Cape May County; the Maurice River, Cumberland County; and Salem County, all in New Jersey.

In the Midwest, Ospreys from a reintroduced population in the Minneapolis-St. Paul, Minnesota, area (Martell 1995) as well as from the forested north-central region around Brainerd, Crow Wing County, Minnesota, were used. Western U.S. Ospreys came from the lower Columbia River (river miles 76–286) bordering Oregon and Washington, and the Willamette Valley in western Oregon. Here the migration study was integrated into ongoing population and contaminant research (Henny and Kaiser 1996).

CAPTURE
Adult birds were trapped on their nesting territories using either a noose carpet placed over the nest, or a modified dho-ghaza, using mist nets with a Great Horned Owl (Bubo virginianus) as a lure (Bloom 1987). We determined the sex of each bird through a combination of plumage, size, and behavior at the nest (Poole 1989). All birds were banded with a U.S. Fish and Wildlife Service band on one leg and a black alphanumeric coded band on the other leg. Wherever possible, subsequent nest success for each trapped individual was monitored along with number of chicks fledged.

TELEMETRY
Two types of PTTs weighing from 30–35 grams (Microwave Telemetry Inc., Columbia, Maryland) were deployed. One type, used in 78 deployments, was battery powered and pre-programmed to turn on for 8-hr periods during varying cycles through the year. This conserved battery power, extending the effective life of the units. Most typical was a cycle that turned the PTT on for 8 hr and then off for 48–72 hr during the anticipated fall and spring migrations and an 8/240-hr cycle during summer and winter. Cycles were adjusted over the course of the study to maximize data collection during migratory periods. Solar-charged units were used on 12 Ospreys in 1999 and were set to transmit for 10 hr followed by 31 hr off. All units were placed on the backs of birds using Teflon ribbon (Bally Ribbon, Bally, Pennsylvania) in a standard backpack configuration (Dunstan 1972, Kenward 1987). Capture, handling, and attachment protocols were reviewed and approved by the Institutional Animal Use and Care Committee at the University of Minnesota.

Birds were located using NOAA satellites with onboard tracking equipment operated by Service Argos Inc. (Landover, Maryland). Locations in latitude and longitude decimal degrees, date, time, location error, and other data were received from ARGOS within 24 hr of satellite contact with a bird. Location error was reported by Service Argos as one of six “location classes” (LC): LC3 = <150 m, LC2 = 150–

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Individuals tagged in</th>
<th>Total deployments</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Years</td>
<td>3 Years</td>
</tr>
<tr>
<td>East</td>
<td>11</td>
<td>16</td>
<td>27</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Midwest</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>3</td>
<td>1</td>
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<tr>
<td>West</td>
<td>4</td>
<td>18</td>
<td>22</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>49</td>
<td>74</td>
<td>35</td>
<td>30</td>
</tr>
</tbody>
</table>

350 m, LC1 = 350–1000 m, LC0 > 1000 m, LCA and B = no location accuracy (Service ARGOS 1996).

RESULTS

THE MARKED POPULATION

Seventy-four adult Ospreys (25 males, 49 females) were trapped and tagged from 1995 through 1999 (Table 1). All were trapped at their nests with the exception of a 1999 New York bird whose nesting status was unknown to us. Eight individuals were tracked in two different years, and four were tracked in three different years resulting in a total of 90 PTT deployments (two in 1995, 16 in 1996, 29 in 1997, 21 in 1998, and 22 in 1999) (Table 1). More females than males were tagged, by design in the West and as a result of trapping bias in the East and Midwest. Both members of 15 nesting pairs were tagged, one in the West, four in the East, and 10 in the Midwest, including one Minnesota pair that was tagged in 2 successive years (1997 and 1998).

Of 8211 locations from the breeding, fall, and winter seasons, 33% were classified as LC = 1, 2, or 3. Due to limited battery life, radio failure, and Osprey mortality, the amount of data collected varied among birds. 54 PTTs (60%) transmitted fall and winter data, 16 PTTs (18%) provided only fall data, 16 PTTs (18%) failed before fall migration, while 4 PTTs (4%) transmitted into a second fall after attachment.

FALL MIGRATION

Migration routes. Fall migration routes differed substantially among the nesting populations studied. Midwest Ospreys showed some overlap with East Coast Ospreys south of 30°N and with West Coast birds south of the U.S.–Mexico border. East and West Coast birds showed no overlap of migratory routes (Fig. 1). Individual Ospreys followed the same routes south in different years in all cases (n = 12).

East Coast Ospreys (n = 20) took similar routes south with only minor deviations in the northern hemisphere (Fig. 1). Ospreys nesting
on eastern Long Island began their migration by flying west along the island before moving south. Most crossed the Delaware and Chesapeake Bays, staying east of the Appalachian Mountains while continuing in a broad front through the eastern half of Virginia and the Carolinas. Their route narrowed over the Georgia coast into Florida. In Florida, birds moved both along the Atlantic coast and across the peninsula to the Gulf Coast near Sanibel Island.

Migrating East Coast Ospreys crossed the Florida Keys to the north coast of Cuba, 100 to 250 km west of Havana. They moved southeast through Cuba, crossing over to Hispaniola, then flew approximately 600 km across the Caribbean to South America making landfall between Santa Marta, Colombia, and Lake Maracaibo, Venezuela. The main migration front then moved to the southeast through Venezuela and into Brazil, with final destinations variable.

Midwest-nesting Ospreys ($n = 27$) moved along one of three routes (Fig. 1). The first route (Central America) took them south through central Iowa and Missouri, then southwest through Oklahoma and Texas to the Gulf Coast of Mexico. Migration continued along the coast over Veracruz, Mexico, across the state of Chiapas, Mexico, down the west coast of Honduras, El Salvador, and Nicaragua, crossing to the Caribbean coast of Costa Rica and Panama and into Colombia. The second route (Gulf of Mexico) followed the Mississippi River Valley south, across the Gulf of Mexico to the Yucatan Peninsula, and then south through Central America and into Colombia. The third route (Caribbean Islands) went southeast through Illinois, across Kentucky, Tennessee, Alabama, and Georgia, and into Florida. These birds continued south along the Gulf Coast to the Florida Keys, then followed the route described earlier for East Coast birds across the Caribbean Islands (Fig. 1). One Midwest male varied from the norm in 1997 by moving from Cuba to Jamaica before continuing to South America.

Midwestern males and females used all three routes; the land route through Central America was used by 59% of all Midwest birds (9 males, 7 females), followed by the Caribbean route (2
males, 5 females; 26% of Midwest birds), and the Gulf of Mexico route (3 males, 1 female; 15%). In only two of seven Midwest pairs did the male and female follow the same routes south, and these were on different schedules.

West Coast Ospreys (n = 15) moved south along a broad front through the western United States (Fig. 1). Eleven Ospreys nesting on the west side of the Cascade mountain range traveled directly south along the foothills of the Cascade and Sierra Nevada mountain ranges, then through central California to the west coast of Mexico. Two birds nesting on the west side of the Cascades and three birds nesting on the east side of the range headed in a more dispersed southeasterly direction through Nevada, Utah, and Arizona, with one bird moving as far east as eastern Utah and New Mexico. These routes took them to both the Pacific and Gulf coasts of Mexico. Most birds wintered in coastal Mexico, while some continued into Central America as far south as El Salvador.

**Departure dates.** Dates of departure from breeding areas occurred over a 10-week period, ranging from 12 July to 1 October (Table 2). Departure dates differed significantly by geographic origin and sex. Significant differences were found among geographic areas when both males and females were included in the analysis ($F_{2,45} = 5.8, P < 0.001$), and when only females were analyzed ($F_{1,45} = 5.1, P = 0.01$). The median departure date of 19 August for East Coast females ($n = 22$) was 12 and 21 days earlier than the median departure dates for Midwest ($n = 12$) and West Coast ($n = 14$) females, respectively (Table 2). Differences in departure dates between the East and West Coasts were significant ($t = 2.0, P = 0.05$). No significant differences were found between the Midwest birds and either the East or West Coast birds.

Median departure dates for females were significantly earlier than for males in the East and Midwest ($t_{1,53} = 16.2, P < 0.001$; the sample size of males in the West was too small for analysis). Within mated pairs, females departed before their mates in all cases ($n = 11$). The mean difference in departure dates within mated pairs was 22 days (range 7 to 39 days). Departure dates of individual Ospreys in different years varied by 1–16 days ($n = 14$). Nest failure did not affect departure date within geographic or sex groups.

**Distance.** Total distance traveled by individual birds ($n = 49$) varied from 1890 km for an East Coast male that in 1999 traveled from Shelter Island, New York, to Ft. Pierce, Florida, in 5 days, to 8720 km for an East Coast female that traveled from Shelter Island to the Pantanal area of Brazil in 38 days. Mean distance traveled by Ospreys from different study areas was significantly different ($F_{2,48} = 6.1, P < 0.001$) with West Coast birds (3824 ± 862 km, $n = 16$) traveling less distance than either East Coast (5134 ± 1964 km, $n = 20$) or Midwest (5872 ± 1780 km, $n = 16$) Ospreys. Females showed an even greater difference ($F_{2,29} = 15.3, P < 0.001$) with West Coast females traveling less distance (3784 ± 705 km, $n = 13$, range 2713–5008 km) than females from the East Coast (6015 ± 1297 km, $n = 11$, range 3762–8720 km) or Midwest (6623 ± 1855 km, $n = 8$, range 3031–8405 km). We found no significant difference between distances traveled by Midwest vs. East Coast Ospreys. Males from the East Coast (4057 ± 2165 km, $n = 9$) and Midwest (5122 ± 1435 km, $n = 8$) traveled significantly less distance than females.

### Table 2. Fall departure and winter arrival dates of satellite tracked Ospreys by sex and region.

<table>
<thead>
<tr>
<th>Region</th>
<th>Median departure date</th>
<th>Range of departure dates</th>
<th>n</th>
<th>Median arrival date</th>
<th>Range of arrival dates</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Coast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>19 Aug</td>
<td>12 July–9 Sep</td>
<td>22</td>
<td>11 Sep</td>
<td>30 Aug–3 Oct</td>
<td>15</td>
</tr>
<tr>
<td>Male</td>
<td>7 Sep</td>
<td>27 Aug–3 Oct</td>
<td>8</td>
<td>8 Oct</td>
<td>3 Sep–18 Nov</td>
<td>7</td>
</tr>
<tr>
<td>Midwest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>31 Aug</td>
<td>1 Aug–12 Sep</td>
<td>12</td>
<td>2 Oct</td>
<td>7 Sep–11 Oct</td>
<td>8</td>
</tr>
<tr>
<td>West Coast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>9 Sep</td>
<td>28 Aug–24 Sep</td>
<td>14</td>
<td>19 Sep</td>
<td>7 Sep–14 Oct</td>
<td>14</td>
</tr>
<tr>
<td>Male</td>
<td>1 Sep</td>
<td>—</td>
<td>1</td>
<td>22 Sep</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>
FIGURE 2. Wintering locations of North American Ospreys as determined by satellite telemetry.

\( F_{3,34} = 9.0, P = 0.05 \). Too few West Coast males (4082 km, \( n = 2 \)) were available for comparisons.

The number of days spent on fall migration ranged from 5 days for an East Coast male that wintered in Florida, to 68 days for an East Coast male that spent 20 days in Cuba before wintering in central Brazil. A significant difference was found in the number of days traveled among Ospreys from different study areas \( (F_{2,48} = 8.4, P < 0.001) \). West Coast birds traveled fewer days \( (13 \pm 4, n = 13) \) than East Coast \( (31 \pm 16, n = 22) \) or Midwest Ospreys \( (26 \pm 11, n = 17; t = 2.0, P = 0.05) \). We found no significant difference in number of days traveled between males and females in the East \( (31.0 \text{ days, } n = 6 \text{ for males, } 31.3 \text{ days, } n = 15 \text{ for females}) \) and Midwest \( (23 \text{ days, } n = 10 \text{ for males, } 28.4 \text{ days, } n = 7 \text{ for females}) \). No significant difference was found for between-year differences in the same individuals.

Mean distance traveled per day by individuals varied from 111 km day\(^{-1}\) for an East Coast male that spent 10 days in Cuba followed by 14 days in the Dominican Republic (while sitting out Hurricane Georges), to 380 km day\(^{-1}\) for a West Coast female that wintered near Tampico, Mexico. A significant difference was found in distance traveled per day between Ospreys from different study areas \( (F_{2,49} = 6.3, P < 0.001) \). West Coast Ospreys \( (296 \pm 55 \text{ km day}\(^{-1}\), \( n = 14) \) traveled farther per day than either Midwest \( (230 \pm 61 \text{ km day}\(^{-1}\), \( n = 17) \) or East Coast Ospreys \( (214 \pm 81 \text{ km day}\(^{-1}\), \( n = 21; t = 2.0, P < 0.05) \). No significant difference in the distance traveled per day was found between males and females for the East and Midwest.

WINTERING LOCATIONS
Ospreys from this study wintered in 11 countries from the United States (Florida) and Mexico (Sinaloa) in the north, to Brazil, Bolivia, and Peru in the south (Fig. 2, Table 3). The most southerly wintering bird was an East Coast female that in 1996 wintered in the Pantanal area shared by Bolivia and Brazil, at 18.49°S, 57.42°W. West Coast birds \( (n = 16) \) wintered from 22.4°N to 13.7°S, and 91.7°W to 61.8°W in eight countries (Table 3) ranging from Mexico to Brazil. Sixty-nine percent of the Midwest birds wintered in South America, the remainder in Central America and Mexico. East Coast birds \( (n = 19) \) wintered from 27.5°N to 18.5°S and 80.4°W to 57.3°W. East Coast Ospreys wintered mainly in northern South America (89%), with two wintering in Cuba and one in Florida. West Coast birds \( (n = 15) \) showed the tightest distribution, wintering from 25.9°N to 13.0°N and 108.3°W to 87.3°W. Fourteen West Coast Ospreys (87.5%) wintered in Mexico, but none wintered
TABLE 3. Wintering localities by country of Ospreys from three North American breeding populations (East Coast, Midwest, and West Coast). Individuals at sites in more than one year counted only once.

<table>
<thead>
<tr>
<th>Wintering area</th>
<th>Range of latitude</th>
<th>Range of longitude (°W)</th>
<th>East Coast</th>
<th>Midwest</th>
<th>West Coast</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>27.4°N</td>
<td>80.4</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Mexico</td>
<td>25.9–15.1°N</td>
<td>108.3–91.3</td>
<td>-</td>
<td>2</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Cuba</td>
<td>21.9–22.3°N</td>
<td>83.1–79.3</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>El Salvador</td>
<td>13.3°N</td>
<td>88.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Honduras</td>
<td>13.0°N</td>
<td>87.3</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>13.0–11.7°N</td>
<td>87.3–85.8</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Colombia</td>
<td>10.7–8.8°N</td>
<td>75.0–74.5</td>
<td>2</td>
<td>3</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Venezuela</td>
<td>10.8–8.3°N</td>
<td>71.4–62.7</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.5–18.4°S</td>
<td>73.8–49.6</td>
<td>8</td>
<td>2</td>
<td>-</td>
<td>10</td>
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<tr>
<td>Peru</td>
<td>3.8–11.7°S</td>
<td>74.3–70.2</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>3</td>
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<tr>
<td>Bolivia</td>
<td>11.1–13.6°S</td>
<td>66.6–61.7</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>4</td>
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<tr>
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<td>19</td>
<td>16</td>
<td>15</td>
<td>50</td>
</tr>
</tbody>
</table>

in Baja California or along the northern two-thirds of the Sea of Cortez where a substantial resident breeding population lives (Henny and Anderson 1979). One bird wintered in El Salvador and one in Honduras. There was overlap in winter ranges of Midwest and East Coast, and Midwest and West Coast Ospreys, but not of West Coast and East Coast Ospreys (Fig. 2).

East Coast and Midwest females tended to winter farther south than males from the same regions. This tendency was most pronounced in Midwest birds, where 63% of females (n = 8) wintered south of all males (n = 8). The area between latitudes 8°N and 9°N seemed to define this split, with 66% of the East Coast and Midwest males (n = 15) wintering north of 9°N and 68% of the females (n = 19) wintering south of 8°N. We did not have a sample of West Coast males large enough for comparison. In 7 of 9 pairs, the female wintered south of the male. All individuals (n = 9) tracked in more than one year returned to the same wintering area.

Arrival dates (Table 2) on wintering areas ranged from 30 August to 18 November. Arrival dates for birds from different geographic areas varied significantly (F2, 19 = 9.6, P < 0.001) with Midwest Ospreys arriving later than either East or West Coast birds. East Coast and Midwest females arrived on their wintering areas significantly earlier than males (F1, 38 = 17.6, P < 0.001). From the East Coast, 60% of females and only 25% of males arrived by the median arrival date for that population. In the Midwest, 75% of females and 45% of males arrived by the median arrival date for that population. Within pairs, females tended to arrive on their wintering areas before their mates (recall that females always departed before males). In six pairs, the female arrived an average of 37 days (range 20–70 days) ahead of its mate, while in three pairs the male arrived an average of 9 days (range 2–20 days) before the female.

Individuals arrived on their wintering sites an average of 10 days apart in different years (n = 7, range 0–20 days). Mean difference in arrival dates between years was 12.6 days (n = 3) for males, and 6 days (n = 4) for females.

DISCUSSION

Osprey migration from North America has broad spatial and temporal variation, as shown in this study as well as from band recoveries (Henny and Van Velzen 1972, Poole and Agler 1987). This variability, or differential migration (Alers-tam and Hedenstrom 1998), was found among the geographic groups we studied as well as between the sexes.

It is notable that the breeding pairs of Ospreys in this study did not migrate or winter together. Females from the East Coast and the Midwest, as a group and within each pair, departed on migration before the males, often leaving the breeding territory before their young were independent. In Sweden, satellite-tagged females at two nests left around the end of July while males were still feeding the young (Kjellen et al. 1997). Females’ earlier departure from the breeding areas may be due to the greater distance they travel on migration (females tend to winter south of males), or, possibly, to reduce competition for food with their young on the nesting territory.
Female Ospreys also tended to migrate farther than males from the same geographic group. However, this difference was not seen between groups: West Coast females travelled less distance and wintered north of many Midwest and East Coast males. Wintering separation of the sexes is found in other avian species (Cristol et al. 1999), as well as in Ospreys in Africa, where separation occurs along an east-west gradient (Kjellen et al. 2001). Explanations for separation include body size differences, dominance hierarchies, and facilitating the males’ quick return in spring for territorial defense (Cristol et al. 1999).

Although we did not find any difference in departure dates between birds whose nests had failed and those that succeeded, it is interesting to note that the earliest departure dates we recorded (mid-July) were from an East Coast female whose nest failed in both 1997 and 1998. Other birds whose nests failed either stayed in the general vicinity of their nesting territory, or moved away from the area but did not begin migration. Birds from Shelter Island, New York, whose nests failed were found on eastern Long Island, as well as in Connecticut and as far north as Massachusetts. These areas were used for up to a month before the birds left on migration. A similar situation was described by Kjellen et al. (1997) for a female Osprey from Sweden.

In addition to the effects that geographic origin and gender have on migration timing, routes, and wintering areas, individuals within groups also showed variations based on factors not obvious to us. Ospreys nesting close to each other (on Shelter Island for example) wintered far apart, as noted also for Swedish birds (Kjellen et al. 1997). Individuals showed strong fidelity to their wintering areas, similar to their fidelity to breeding territories (Poole 1989). This breeding-site fidelity allows individuals to obtain all of the advantages conferred by familiarity with foraging and roosting areas; we suggest that similar advantages come from fidelity to wintering areas and migration routes.

We documented Ospreys regularly making long-distance water crossings over the Caribbean Sea and Gulf of Mexico, and shorter ones across the Delaware and Chesapeake Bays. Long water crossings are typically avoided by most Falconiformes (Kerlinger 1985), although European Ospreys also make long water crossings over the Mediterranean (Kjellen et al. 1997, Hake et al. 2001). It is of interest that Ospreys crossing the Caribbean used both Cuba and Hispaniola as “stepping stones,” with individual birds spending up to 23 days in Cuba (Rodriguez et al. 2001). However, we did not see birds continue island hopping through Puerto Rico and smaller islands to the southeast which would have reduced the need for a longer water crossing between Hispaniola and Venezuela.

Ospreys in this study were found across most of the previously reported wintering range of North American Ospreys (Poole and Agler 1987, Poole 1989). Our East Coast Ospreys wintered in the West Indies (11%) and South America (89%), similar to band recovery data showing 15.5% of East Coast birds (n = 71) wintering in the West Indies (Henny and Van Velzen 1972). In this study however, a higher percentage of East Coast (55%) and Midwest Ospreys (43%) wintered south of the equator than was found in band recovery analysis (26% of East Coast and 22% of Midwest band returns south of the equator, Poole and Agler 1987). We suspect that band recovery analysis incorrectly classified some birds that died on migration in northern South America as wintering, and that fewer bands are reported from more southerly areas.

Ospreys in this study made either a relatively short, quick migration or a longer, slower journey. This “sprint” vs. “marathon” strategy is reflected in the variability seen in departure dates, distance traveled, and speed of travel. Ospreys from the West employed the sprint strategy while Midwest and Eastern birds typically made marathon journeys. Western Ospreys traveled, on average, significantly less distance than either Midwest or East Coast Ospreys; differences that were even greater when comparing only females. West Coast Ospreys also spent significantly fewer days on migration than either Midwest or East Coast Ospreys, and traveled significantly farther per day (296 km) than either Midwest or East Coast Ospreys. The mean distances traveled per day in this study (111–380 km day⁻¹) are similar to findings for Swedish Ospreys (Kjellen et al. 1997, 2001) that traveled between 159 and 413 km day⁻¹.

Some individuals from the Midwest and East also utilized a sprint strategy rather than the marathon strategy. Seven individuals, four from the East (three males, one female) and three from the Midwest (two males, one female) traveled less than 4000 km (similar to the distance...
covered by West Coast Ospreys). These birds spent an average of 12 days on migration covering 327 km day⁻¹, data more similar to West Coast Ospreys than the other Midwest and East Coast birds.

Different migration strategies were also reflected in times of departure from breeding areas. While departure dates can certainly be affected by nesting phenology (Poole and Agler 1987); in this study we noted no differences in egg laying dates among the study areas (all occurred between mid-April and mid-May). Thus, nesting phenology does not seem to explain the differences in departure dates among these populations. It is apparent that birds travelling greater distances departed earlier, perhaps to insure timely arrival on the wintering area. West Coast Ospreys in this study can apparently remain on their breeding grounds later than East Coast birds before making a quick, short flight to their wintering areas.

The marathon strategy may result from the need of long distance migrants to hunt during migration. Alternatively, the sprint strategy may be made possible when individuals are able to utilize wintering grounds close to their nesting areas. The energetic demands faced by Ospreys on migration are not well known, but Candler and Kennedy (1995) produced models showing it possible for Ospreys migrating through the western United States to complete their journeys without feeding. Information on Ospreys foraging during migration is mostly anecdotal (Kerlinger 1985); however, fall reports of Osprey numbers increasing at reservoirs and other sites outside of the nesting range (Castrale et al. 1998) suggest that some regularly feed on migration. Swedish Ospreys are thought to feed at stopover sites on migration (Kjellen et al. 2001).

Migratory behavior and wintering locations of North American nesting Ospreys vary among geographic regions and by sex. Thus, the strategies employed by any individual bird are influenced by its nesting origin and gender. However, there are still differences among individuals within any group. Competition for resources, particularly food, on the wintering ground and probably during migration, may ultimately shape the strategies employed by individual birds.

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