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Winter and Summer Home Ranges of American White Pelicans (*Pelecanus erythrorhynchos*) Captured at Loafing Sites in the Southeastern United States

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**Abstract.**—Satellite telemetry was used to investigate summer and winter home ranges for resident and migrant American White Pelicans (*Pelecanus erythrorhynchos*) captured in the southeastern United States between 2002 and 2007. Home range utilization distributions were calculated using 50% and 95% kernel density estimators with the plug-in bandwidth selector. Mean summer home ranges (95%) varied from 177 to 4,710 km\(^2\) and mean winter home ranges (95%) ranged from 185 to 916 km\(^2\). Mean 50% and 95% home ranges of adult American White Pelicans during summer tended to be larger than those during winter, whereas mean 50% and 95% home ranges of immature pelicans during summer tended to be smaller than those during winter. Home ranges for all American White Pelicans encompassed the latitude range of 24\(^\circ\)-55\(^\circ\) N, including wintering, stop over, and nesting habitat. These data provide baseline movement and home range data for future studies of American White Pelican ecology.

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**Key words.**—American White Pelican, aquaculture, home range, kernel density estimation, movements, *Pelecanus erythrorhynchos*, plug-in bandwidth, satellite telemetry.

The American White Pelican (*Pelecanus erythrorhynchos*; hereafter pelican) is a charismatic and well known species in North America (Anderson and King 2005; Keith 2005), but little is actually known about its general movements, home ranges, and core use areas (Knopf and Evans 2004). Using VHF (Very High Frequency) telemetry, King and Werner (2001) documented daily activity budgets of pelicans captured near aquaculture facilities in the southeastern United States. Logistical constraints involved with the utilization of VHF telemetry, however, precluded its use to effectively address many local, regional, and continental questions concerning pelican ranges and movements (King and Werner 2001). Breeding bird surveys and band recoveries of pelicans have partially identified dispersal patterns (Houston 1972; Strait and Sloan 1975; King and Grewe 2001; Anderson and Anderson 2005) and the location of North American colonies (King and Anderson 2005), but seasonal and regional movements of these wide-ranging birds are of considerable added interest. Recent advances in satellite telemetry have allowed monitoring of animal movements over expansive areas (Lindberg and Walker 2007; Robinson et al. 2009; Hubblewhite and Haydon 2010). Shannon et al. (2002) used satellite telemetry to document American White Pelican soaring flight times, and Izhaki et al. (2002) used satellite telemetry to describe the migratory and ranging behavior of immature Great White Pelicans (*P. onocrotalus*). Further advances have led to the incorporation of a Global Positioning System (GPS) into satellite transmitters, allowing for very precise location data and intensive monitoring of animal movements. For example, Avery et al. (2011) used GPS-technology to document home ranges of...
Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*) in South Carolina, USA, and their migration to central Florida, USA.

To our knowledge, the home range of American White Pelicans has not been previously estimated. The objectives of this study were to: 1) estimate seasonal home ranges and core use areas for pelicans captured in the southeastern United States; and 2) determine effects of season, age, and sex on home range sizes of pelicans. Data from this study provide novel information on local, regional, and continental movements of American White Pelicans and can also be interpreted on a behavioral basis.

**Methods**

**Study Area**

We captured pelicans at loafing sites near aquaculture-intensive areas in Alabama, Arkansas, Louisiana, and Mississippi, USA (Fig. 1) using rocket nets and modified foot-hold traps (King et al. 1998). We fitted pelicans with backpack 70-g solar-powered GPS satellite transmitters (PTT-100, Microwave Telemetry; Dunstan 1972); transmitters were programmed to record one location per hour for the duration of the study and were < 3% of the individual’s body weight. We estimated age (≥ 3 years old = adult; < 3 years old = immature) using plumage and eye and skin color characteristics (D. T. King, unpubl. data) and determined sex by using culmen length (Dorr et al. 2005) for each captured pelican. We released all captured birds at the trap site.

The summer season included locations from 1 June-31 August, and the winter season included locations from 1 November-15 April. A pelican’s home range for a given season/year was computed only if there were > 50 locations and if those locations were logged during > 50% of the time period. We identified 1 June the year following capture as the date when a bird tagged as a 2-year-old immature would be considered an adult. We defined migration as seasonal movements from wintering areas in the southern United States to breeding and summering areas in the north central United States and southern Canada. Because a few individuals exhibited nomadic behavior when flying north in the spring, but never reached breeding colonies, we identified 36"
30° N latitude as the dividing line and 15 June as the
cutoff date for individuals to either be classified as resi-
dents or migrants.

Statistical Analysis

We used kernel density estimation (KDE) to es-
timate summer and winter 50% (i.e., core area) and
95% (i.e., overall use area) utilization distributions for
pelicans. We used the second generation plug-in band-
width selection method because our GPS data set had
numerous locations (i.e., 50-24,000 per season) that of-
ten caused first generation methods to fail (Gitzen et al.
2006; Walter et al. 2011). First generation methods such
as least squares cross-validation failed to converge with a
large number of identical or very tight clustered points
(Hemson et al. 2005; Gitzen et al. 2006; Pellerin et al.
2008) or had a tendency to grossly over-smooth the data
(default or reference bandwidth; Worton 1995; Sea-
man and Powell 1996; Hemson et al. 2005). The plug-
in bandwidth selection method is data-based, uses an
equation to directly estimate the ‘ideal’ bandwidth, and
estimates pilot bandwidths to tune the performance of
the covariance estimator (Jones et al. 1996; Duong and
Hazelton 2003; Duong 2007). We calculated KDE plug-
in home ranges in the R language for statistical com-
puting (R Development Core Team 2012) using the ks
package (Duong 2007).

We used mixed-effect models to detect effects of
season, age, and sex on home range sizes of pelicans
with animal ID as a random effect variable to account
for temporal autocorrelation because of repeated ob-
servations of the same individual (R Development Core
Team 2012). If the estimate of variance for animal ID
was 0.00, we used analysis of variance to compare home
range sizes by age, sex, season, and their interactions at
the significance level of 0.05. In preliminary analyses, ef-
effects of year were not significant (P > 0.10). Therefore,
we pooled our data over years in subsequent analyses.

We tested for effects of fixed-effect variables (age,
sex, and season) and their interactions with: 1) all pos-
sible combinations of two-factor interactions; and 2)
three-factor interaction. We conducted backward model
selection at the significance level of 0.05. We conducted
multiple comparisons of least square means (lsmeans)
or sliced lsmeans of home ranges with the Tukey adjust-
ment using the SAS procedure MIXED with the slice
option (Littell et al. 2006). We conducted linear model
or mixed-model analysis for 50% and 95% KDE home
range sizes, with home range sizes log transformed for
the normality assumption.

Results

From 19 April 2002-4 April 2007, we cap-
tured 39 pelicans (3-17 per year) and fit-
ted them with transmitters. We captured 34
males (5 adults, 29 immatures) and 5 imma-
ture females. These birds were tracked from
19 April 2002-29 October 2007. Transmitters
(n = 39) operated an average of 17.3 months
(± 1.5 SE; Range = 1-52), excluding birds
that were known to be killed (shot under depreda-
tion permits at aquaculture facili-
ties) within 3 weeks of release. We obtained
an average of 2,299 (± 271.8 SE) locations
per bird, some of which were represented
by captured immatures reaching adulthood
(male: n = 17; female: n = 4).

Mean 50% and 95% home ranges of adult pelicans during summer tended to
be larger than those during winter, whereas
mean 50% and 95% home ranges of immu-
rate pelicans during summer tended to be
smaller than those during winter (Table 1).
Estimated mean 95% home ranges for all
pelicans covered the latitude range of 24°-
55° N, including wintering, stop over, and
nesting habitat. Mean 50% summer home
ranges for migrating pelicans were located
in the northern part of the species’ range
(i.e., summer nesting habitat; Fig. 2). The

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Season</th>
<th>50%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Adult</td>
<td>Summer</td>
<td>2,818 ± 1,418</td>
<td>28,487 ± 10,147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>916 ± 228</td>
<td>12,632 ± 3,140</td>
</tr>
<tr>
<td></td>
<td>Immature</td>
<td>Summer</td>
<td>326 ± 124</td>
<td>5,275 ± 2,175</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>681 ± 162</td>
<td>11,410 ± 2,994</td>
</tr>
<tr>
<td>Female</td>
<td>Adult</td>
<td>Summer</td>
<td>4,711 ± 2,794</td>
<td>65,880 ± 28,866</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>186 ± 29</td>
<td>1,329 ± 248</td>
</tr>
<tr>
<td></td>
<td>Immature</td>
<td>Summer</td>
<td>177 ± 66</td>
<td>2,089 ± 557</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>342 ± 79</td>
<td>4,960 ± 814</td>
</tr>
</tbody>
</table>
extents of mean 50% and 95% home ranges of summer residents (i.e., non-migrants) were similar to those of winter home ranges (Figs. 3 and 4).

50% Kernel Home Range

The estimate of variance for animal ID was 0.00 when including animal ID as a random effect. Therefore, we compared 50% kernel home ranges using analysis of variance. No comparisons of 50% kernel home range sizes by age, sex, and season were significant ($P > 0.10$).

95% Kernel Home Range

In the mixed model, the age-sex-season interaction was significant ($F_{4,75} = 4.82, P = 0.002$). Female adults had larger home ranges in summer than in winter ($t_{75} = 3.28$, Tukey adjusted $P = 0.03$), with the least square mean of log transformed 95% kernel home range sizes being 10.4 and 7.06, respectively. Moreover, female adults had larger home range sizes than did male immatures during summer ($t_{75} = 3.6$, adjusted $P = 0.01$), with the least square mean of log transformed 95% kernel home range sizes being 10.4 and 7.21, respectively. Female home range sizes did not differ from those of adult males.

Discussion

Migratory birds make seasonal movements between wintering and summer nesting habitats to take advantage of available resources in different locations to meet habitat and nutritional requirements (Pulido 2007; Ramenofsky and Wingfield 2007). Mean 50% kernel home ranges (i.e., core home ranges of summer residents).
ranges) of pelicans were spatially unconnected (Figs. 2 and 4). The northern boundary of winter 95% kernel home ranges probably represents the northern boundary of pelican wintering habitat (Fig. 4). For migrating pelicans, the lower latitude limit of the range of summer core or 50% kernel home ranges was approximately the same as that of known breeding colonies (Fig. 2; King and Anderson 2005). Therefore, our estimated summer and winter core home ranges probably delineate the lower latitude limit of nesting habitat and upper latitude limit of wintering habitat respectively, providing insight for future studies of habitat selection and requirements by nesting and wintering American White Pelicans.

Habitat, food abundance, and bird reproductive condition may affect bird movement distance and home range sizes (McNab 1963; Weimerskirch et al. 1994). More abundant food resources may result in smaller home ranges of animals (McNab 1963). Home ranges of adult pelicans during winter tended to be smaller than those during summer (Table 1). Additionally, home range size of female adults in summer was greater than that in winter. Wintering pelicans feed on fish at commercial aquaculture facilities, such as catfish (*Ictalurus punctatus*) ponds, in the southeastern United States (King et al. 2010). Catfish aquaculture in the southeastern United States was estimated to produce a total of 1,626,401,709 kg of fish during our study period (National Agricultural Statistics Service 2013). Abundant fish at commercial aquaculture facilities improves the body condition of pelicans (King et al. 2010) and may reduce winter home range sizes of pelicans. During the breeding season, egg incubation and provision feeding by adults are energetically demanding with nesting birds often
making long foraging trips to meet these energetic demands (Behle 1958; Johnson and Sloan 1978; Weimerskirch et al. 1994; Findholt and Anderson 1995).

When compared to peak years, the aquaculture industry in the USA has undergone a 54.6% reduction in total catfish water surface acres and a 55.6% reduction in the number of commercial catfish farms due to foreign imports and rising feed costs (Hanson and Sites 2014). It has been speculated that the remaining commercial catfish farms will suffer increased predation losses and disease risk as pelicans concentrate their foraging efforts on fewer facilities, which could also restrict pelican winter home ranges to smaller areas. This information will be important to catfish farmers to help them better understand the threat that changes in American White Pelican distribution represents, allowing farmers to concentrate control and harassment efforts during the appropriate months to increase efficiency and reduce predation losses. These data can be used as baseline movement and home range data for future studies of American White Pelican ecology.

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