SURVIVAL OF FEMALE NORTHERN PINTAILS WINTERING IN SOUTHWESTERN LOUISIANA

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Abstract: The North American breeding population of northern pintails (Anas acuta) has reached previously unprecedented low numbers 4 times since 1983. Because pintails show high fidelity to wintering areas, regional survival estimates and identification of factors influencing survival are needed to guide management of wintering pintails. We used radiotelemetry to estimate survival rates of female pintails wintering in southwestern Louisiana. We tested for variation in survival and hunting mortality rates in relation to age (immature or adult), winter (1990–91, 1991–92, 1992–93), time period (prehunting season, first hunting season, time between split hunting seasons, second hunting season, posthunting season), body condition (body mass when released, adjusted for body size), and region (southwestern Louisiana or elsewhere on the Texas–Louisiana Gulf Coast or Mississippi Alluvial Valley). Within southwestern Louisiana, the 147-day (5 Oct–28 Feb) survival rate of adults (0.714 ± 0.045; ± SE) was greater (P = 0.02) than that of immatures (0.550 ± 0.068), primarily because immatures had higher hunting mortality. Female survival was lower ( Ps < 0.01) during hunting than during nonhunting seasons but did not differ between first and second hunting seasons (P = 0.58) or among nonhunting seasons (Ps > 0.25). Survival did not differ in relation to winter or condition (Ps > 0.12). Hunting mortality did not differ (Ps > 0.13) in relation to winter, condition, or region, but hunting mortality of immatures (0.287 ± 0.046) was greater (P < 0.001) than that of adults (0.130 ± 0.025). Despite conservative hunting regulations (30-day seasons and 1 pintail daily), hunting mortality rates of pintails in southwestern Louisiana were high. Pintails in southwestern Louisiana rely on a small number of key refuges for protection but feed almost exclusively in privately owned agricultural fields. If increased winter survival of female pintails in southwestern Louisiana is desired, we recommend that managers increase food availability on refuges.

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Key words: Anas acuta, body condition, hunting, Louisiana, mortality, northern pintail, proportional hazards regression, radiotelemetry, survival, winter.

The continental population of northern pintails (hereafter, pintails) has declined markedly since the 1970s. Numbers of breeding pintails reached previously unprecedented low levels in 1984 (3.0 million), 1985 (2.5 million), 1988 (2.0 million), and 1991 (1.8 million; U.S. Fish and Wildlife Service [USFWS] and Canadian Wildlife Service [CWS] 1997). Despite increases in breeding populations in recent years, pintails in 1997 were the only prairie-nesting dabbling duck below goals of the North American Waterfowl Management Plan (USFWS and CWS 1986, 1997).

The Gulf Coasts of Texas and Louisiana host some of the largest concentrations of pintails wintering in the Central and Mississippi flyways (Howard and Kantrud 1986). Numbers of pintails counted during midwinter surveys during 1950–87 ranged from 0.25 to 1.8 million in Texas and from 0.22 to 1.4 million in Louisiana (Hestbeck 1993a). Using winter banding data, Hestbeck (1993a) found that pintails winter in distinct populations and show high fidelity to the Texas–Louisiana Gulf Coast. Hestbeck (1993b) indicated that a research priority was investigation of relations of management of wintering areas to survival and population size of pintails.

Pintails spend a greater portion of their annual cycle on wintering areas than do most ducks; thus, winter survival may be more important to pintail population dynamics than for other duck species. Survival estimation from annual banding data does not allow mortality to be partitioned into portions of the annual cycle or identification of causes of natural mortality. Radiotelemetry allows hunting mortality rates,
probably the most manageable winter mortality factor, to be estimated for specific regions. Consequently, we estimated winter survival rates and hunting mortality rates of adult (after-hatching-year) and immature (hatching-year) female pintails radiotagged in southwestern Louisiana. We restricted our study to females because sex ratios of pintails are skewed toward males, and thus survival of females has a greater influence on population dynamics than does survival of males. We tested for variation in survival rates in relation to female age, winter, body condition when released (hereafter, condition), and time period in relation to duck hunting seasons. We tested for variation in hunting mortality rates in relation to female age, winter, condition, and region (southwestern Louisiana or elsewhere on the Texas–Louisiana Gulf Coast or Mississippi Alluvial Valley).

STUDY AREA AND METHODS

Field Procedures

Our primary study area included all lands within 80 km from the perimeter of Lacassine Pool (Tamisier 1976) on Lacassine National Wildlife Refuge (NWR) in southwestern Louisiana and extended 8 km into the Gulf of Mexico (Fig. 1). We used rocket nets to capture female pintails during 22 October–10 November 1990 (plus 1 additional female on 27 Jan 1991), 30 September–27 October 1991, and 4–25 October 1992. We trapped all pintails during 1990–91, and 3 during 1991–92, on unbaited loafing sites in privately owned agricultural fields. We captured all other pintails on baited sites on Lacassine NWR. We previously described trap sites (Cox and Afton 1994, 1997).

We aged females as adult or immature via cloacal and tail- and wing-feather characteristics (Hochbaum 1942, Carney 1964, Duncan 1985). We weighed (± 5 g) each female and measured (± 0.01 mm) the following: (1) culmen, (2) bill width (at nares), (3) total tarsus (Dzubin and Cooch 1992), and (4) middle toe length. We leghanded and fitted females with 21-g backpack-type radiotransmitters (Dwyer 1972) that had mortality sensors and expected lives of either 100 days (1990–91) or 150 days (1991–92 and 1992–93). We previously described handling procedures (Cox and Afton 1998a). Transmitters initially had minimum ground-to-ground ranges of 7 km to truck-mounted 4-element null-peak antennas, and ground-to-air ranges of 60 km to aircraft at 1,300–1,700 m altitudes. The ventral side of each transmitter was labeled with instructions for hunters to notify us by phone to receive a reward.

We attempted to assess status (alive or dead) of radiotagged females once each day within our primary study area from 26 October 1990 to 26 February 1991, 5 October 1991 to 19 February 1992, and 8 October 1992 to 28 February 1993. Each day that weather permitted, we used aircraft to search the entire primary study area (Gilmer et al. 1981). On days when weather prohibited use of aircraft, we assessed status using ground vehicles and permanent towers. At 1–4-week intervals, we used aircraft to monitor radiotagged pintails located outside our primary study area, which included much of the remainder of Louisiana, eastern Arkansas, western Mississippi and Tennessee, southeastern Missouri, and the rice-prairie region and Gulf Coast of Texas to Matagorda Bay (Fig. 1). We immediately retrieved carcasses and transmitters when activated mortality sensors were detected, except that transmitters in deep water with unconsolidated substrates sometimes required multiple attempts (up to 2 days delay in retrieval). We sent recovered carcasses to the National Wildlife Health Research Center for necropsy when cause of death was not obvious.

Analysis

Body Size and Condition.—We performed principal components analysis (PROC PRIN-
COMP; SAS Institute 1990) on the correlation matrix of the 4 morphometric variables taken from all instrumented females. We subsequently used first principal component scores as a measure of body size (SIZE) for each female (Alisauskas and Ankney 1987). We then used least-squares regression (PROC GLM; SAS Institute 1990) to test for a relation between body mass and SIZE of females. We adjusted body mass of each female for SIZE by adding the overall mean body mass of females to her residual from the regression (Ankney and Afton 1988). We subsequently used size-adjusted body mass of each female when released as an index of body condition (Dufour et al. 1993). We used 2-way analysis of variance (PROC GLM; SAS Institute 1990) to test for differences in condition in relation to age, winter, and age × winter. We used Fisher's LSD test to compare means of significant effects ($P < 0.05$).

**Survival.**—Duck hunting seasons in our primary study area were split into 2 seasons (30 days total length) each winter during which hunters could shoot 1 pintail daily of either sex. We divided each winter into 5 time periods based on duck hunting seasons: (1) prehunting season ([PRE]; maximum range of dates for all winters = 5 Oct–20 Nov), (2) first hunting season ([FHUNT]; 16 Nov–6 Dec), (3) time between split hunting seasons ([SPLIT]; 6–27 Dec), (4) second hunting season ([SHUNT]; 26 Dec–9 Jan), and (5) posthunting season ([POST]; 6 Jan–28 Feb).

Movements of radiotagged pintails outside our primary study area were far-ranging and frequent (Cox 1996). Because we monitored females outside our primary study area less frequently than those located inside, we believe the probability of detecting natural mortality was lower outside the primary study area. Therefore, we performed 2 survival analyses. First, we considered survival from all forms of mortality (hunting, nonhunting) only within our primary study area. We used Cox (1972) proportional hazards regression (PROC PHREG; SAS Institute 1996) to test for differences in survival in relation to female age (adult or immature), winter (1990–91, 1991–92, 1992–93), time period ([PRE], [FHUNT], [SPLIT], [SHUNT], [POST]), and condition at release. We specified time period as a time-dependent variable and reset the time origin for each female to zero at the beginning of each time period. In this model, we right-censored birds while they were outside the study area and reincluded them in the risk set if they returned later. We used backward stepwise procedures to eliminate nonsignificant ($P > 0.05$) terms, beginning with the least significant interactions. Because condition was partially confounded with age and winter (see RESULTS), we further tested for a condition effect by including it as a single predictor of survival.

Our second analysis was designed to identify important sources of variation related to hunting mortality of females. In this analysis, we considered only hunting mortality as the event and included exposure days inside and outside the primary study area. In this model, we right-censored females that died from nonhunting sources of mortality on their dates of death. We used proportional hazards regression to test for differences in hunting mortality in relation to female age, winter, condition, and region (in or out of the primary study area). We again initially included all 2-way interactions and used backward stepwise procedures to eliminate nonsignificant terms. We also further tested for a condition effect as in the previous analysis. In addition to standard assumptions for survival analyses of radiotelemetry data (Pollock et al. 1989), proportional hazards regression further assumes effects are proportional to a baseline hazard function, and that effects of continuous covariates are linear. We examined these latter assumptions in both analyses by examining plots of Schoenfeld residuals and by comparing actual to predicted survival functions for all effects (Allison 1995).

We observed relatively high rates of mortality during the first 4 days of exposure, but we attributed these mortalities to stress related to capture and handling (Cox and Afton 1998a). Accordingly, we excluded the first 4 days of exposure for all females from analyses. Important predictors of mortality during the first 4 days of exposure were number of waterfowl captured in rocket nets, holding time (time from capture until release), and flight quality (scored as poor, moderate, or good) of females upon release (Cox and Afton 1998a). We used proportional hazards regression to test for chronic effects of capture and handling on survival past the initial 4 days of exposure (by considering all mortality sources within the primary study area) and found no evidence that survival differed in relation to number of waterfowl captured (Wald $\chi^2_1 = 0.88$, $P = 0.35$), holding time (Wald $\chi^2_1$
= 0.05, \( P = 0.83 \)) or their interaction (Wald \( \chi^2 \) = 0.22, \( P = 0.64 \)). Survival past the initial 4 days of exposure also did not differ among levels of flight quality (Wald \( \chi^2 \) = 0.02, \( P = 0.88 \)). When the exact date of death was not known, we estimated it as the midpoint between the last date noted alive and the first date the mortality sensor was detected. When a female was known to have departed the primary study area but the departure date was not known precisely, we estimated the departure date by randomly selecting a date from the interval between the last date the bird was known to be in the primary study area and the date the bird was first missed within the primary study area on a complete flight, or the individual was known to be out of the area. We similarly estimated dates for birds returning to the primary study area when exact dates were not known.

Two females were shot and reported to us by hunters after their transmitters had failed; we right-censored these individuals following the last radio contact. We excluded from all analyses 1 additional female accidentally released with an alligator clip attached to the transmitter. We used PROC PHREG (SAS Institute 1996) to calculate product-limit survival estimates (Kaplan and Meier 1958) and 95% confidence limits within time periods and overall. In lieu of retrospective power analyses, we calculated mean survival rates and 95% confidence limits for main effects that were not significant (\( P > 0.05 \)) in our analyses (Steidl et al. 1997); these results are available from RRC upon request. All means are presented ± standard error.

### RESULTS

#### Body Size and Condition

The first principal component explained 49.9% of the overall variation among the 4 morphometric variables. All factor loadings were positive and ranged from 0.26 (bill width) to 0.61 (middle toe length). Body mass of females was positively related to SIZE (\( F_{1,345} = 23.55, P < 0.001; r^2 = 0.06 \)). The equation was

\[
\text{body mass (g)} = 748.8 + 15.9 (\text{SIZE})
\]

Female condition differed among winters (\( F_{2,341} = 18.21, P < 0.001 \)) and between ages (\( F_{1,341} = 16.65, P < 0.001 \)), but the winter × age interaction was not significant (\( F_{2,341} < 0.01, P > 0.99 \)). Condition of females was highest in 1990–91 (least-square \( \bar{z} = 796.6 \pm 12.4 \) g), intermediate in 1992–93 (740.3 ± 6.6 g), and lowest in 1991–92 (709.0 ± 6.4 g; \( P \)-values for pairwise comparisons were <0.001). Adults (771.1 ± 5.8 g) were in better condition than immatures (726.2 ± 8.0 g).

### Survival in Southwestern Louisiana—All Sources of Mortality

This analysis included 18,813 exposure days on 320 of the 347 females that we radiotagged. We excluded from analyses those females in the first 4 days of exposure who (1) died (\( n = 23 \)), (2) lost transmitters (\( n = 1 \)), (3) departed our primary study area and never returned (\( n = 2 \)), or (4) we lost contact with (\( n = 1 \)). Our fully specified model contained all main effects and 2-way interactions. Although the overall model was highly significant (\(-2 \text{ log likelihood statistic} = 70.93, \text{df} = 29, P < 0.001 \)), no individual terms initially were significant (\( Ps > 0.19 \)). After fitting the model via backward stepwise procedures, our final model contained only effects of age (Wald \( \chi^2 = 5.48, P = 0.02 \)) and time period (Wald \( \chi^2_2 = 23.30, P < 0.001 \)). Effects of winter, condition, and all interactions were not significant (\( Ps > 0.12 \)). When we further tested for a condition effect, we again found no relation when we included condition as a single predictor of survival (Wald \( \chi^2_1 = 1.37, P = 0.24 \)), or when we controlled for the time-period effect when testing for condition (Wald \( \chi^2_1 = 1.58, P = 0.21 \)). The risk ratio indicated that immatures were 1.8 (95% CI = 1.1–2.8) times more likely to die during winter than were adults. Female survival was lower during hunting than during nonhunting seasons (\( Ps < 0.01 \)), whereas survival did not differ between FHUNT and SHUNT (Wald \( \chi^2_1 = 0.30, P = 0.58 \)) or among nonhunting seasons (\( Ps > 0.25 \); Table 1). Risk ratios indicated that females were 20.9 (95% CI = 2.9–152.7) times more likely to die during FHUNT than during POST, and 17.6 (95% CI = 2.3–134.7) times more likely to die during SHUNT than during POST. The overall survival rate for the 147-day period from 5 October to 28 February was 0.714 ± 0.045 for adults and 0.550 ± 0.068 for immatures (Fig. 2). Of 70 deaths, we confirmed that 43 (61%) were due to legal hunting, 2 (3%) were believed due to legal hunting (transmitters were found near duck blinds or hunting camps with harnesses stretched as if removed by hunters), 1 (1%) was shot illegally, 6 (9%) were killed by mammalian predators, 2 (3%) were killed by avian preda-
Table 1. Estimated survival, hunting mortality, and nonhunting mortality rates by age for female northern pintails in southwestern Louisiana during winters 1990–91 through 1992–93 for each time period and overall (5 Oct–28 Feb).

<table>
<thead>
<tr>
<th>Time period</th>
<th>Days</th>
<th>Age</th>
<th>Survival rate</th>
<th>Hunting mortality rate</th>
<th>Nonhunting mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\hat{r}$</td>
<td>$\hat{r}$ SE</td>
<td>$\hat{r}$ SE</td>
</tr>
<tr>
<td>PRE</td>
<td>47</td>
<td>Adult</td>
<td>0.968 0.013</td>
<td>0 0</td>
<td>0.032 0.013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.980 0.014</td>
<td>0 0</td>
<td>0.020 0.014</td>
</tr>
<tr>
<td>FHUNT</td>
<td>21</td>
<td>Adult</td>
<td>0.878 0.027</td>
<td>0.095$^d$ 0.024</td>
<td>0.030 0.015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.756 0.049</td>
<td>0.223 0.047</td>
<td>0.027 0.019</td>
</tr>
<tr>
<td>SPLIT</td>
<td>21</td>
<td>Adult</td>
<td>0.973 0.015</td>
<td>0.018$^c$ 0.013</td>
<td>0.009 0.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.983 0.017</td>
<td>0 0</td>
<td>0.017 0.017</td>
</tr>
<tr>
<td>SHUNT</td>
<td>15</td>
<td>Adult</td>
<td>0.887 0.047</td>
<td>0.083 0.038</td>
<td>0.033 0.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.799 0.064</td>
<td>0.146 0.060</td>
<td>0.065 0.036</td>
</tr>
<tr>
<td>POST</td>
<td>50</td>
<td>Adult</td>
<td>0.929 0.040</td>
<td>0 0</td>
<td>0.071 0.040</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.957 0.042</td>
<td>0 0</td>
<td>0.043 0.042</td>
</tr>
<tr>
<td>OVERALL</td>
<td>147</td>
<td>Adult</td>
<td>0.714 0.045</td>
<td>0.165 0.034</td>
<td>0.145 0.042</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immature</td>
<td>0.550 0.068</td>
<td>0.315 0.053</td>
<td>0.196 0.077</td>
</tr>
</tbody>
</table>

*PRE = prehunting season; FHUNT = first hunting season; SPLIT = time between split hunting seasons; SHUNT = second hunting season; POST = posthunting season.

$^b$ Maximum number of days per time period in any winter.

$^c$ Note that hunting mortality rate and nonhunting mortality rate cannot be summed to estimate mortality rate from both sources (1 - survival rate).

$^d$ Includes 1 suspected hunter-killed female.

$^e$ Includes 1 suspected hunter-killed female and 1 illegally killed female.

Fig. 2. Survival rate (5 Oct–28 Feb; 147 days) of radiotagged female northern pintails (adults = circles; immatures = squares) in southwestern Louisiana during winters 1990–91 through 1992–93, considering all sources of mortality. Dashed lines (adults) and dotted lines (immatures) denote 95% confidence intervals. Maximum widths of first hunting seasons (FHUNT) and second hunting seasons (SHUNT) among winters are denoted by vertical lines.
tors, and 16 (23%) were killed by unknown causes.

Hunting Mortality
This analysis included 52 hunting mortalities in 27,198 exposure days on 322 radiotagged females, including all those in the previous analysis plus the 2 females that departed the primary study area in the first 4 days of exposure and never returned. Our final fitted model contained only age effects (Wald $\chi^2_1 = 11.69$, $P < 0.001$). Effects of winter, condition, region, and all interactions were not significant ($Ps > 0.13$). When we tested for an effect of body condition alone, we again found no relation to condition (Wald $\chi^2_1 = 1.44$, $P = 0.23$). Immatures were 2.6 (95% CI = 1.5-4.5) times more likely to be shot by hunters than adults. Hunting mortality rates were $0.130 \pm 0.025$ for adults and $0.287 \pm 0.046$ for immatures.

DISCUSSION
Our overall (147-day) winter survival estimates for female pintails in southwestern Louisiana were low compared to most other telemetry-based estimates for wintering female dabbling ducks (Table 2), but the long time interval (147 days) over which our estimates were calculated should be considered when comparing to other studies. Hunting and nonhunting mortality rates for female pintails in southwestern Louisiana were markedly higher than those reported for female pintails in other regions (Table 2). Survival rates of pintails in southwestern Louisiana were lower than those of mallards (Anas platyrhynchos) elsewhere (Table 2). Our estimate of hunting mortality of adult female pintails in southwestern Louisiana (16.5%) was as high as that of American black ducks (Anas rubripes) in New Jersey and Virginia, which previously was the highest reported for wintering adult female dabbling ducks. Estimated hunting mortality of immature female pintails in southwestern Louisiana (31.5%) was considerably higher than the next highest estimate for wintering immature female dabbling ducks (19% for mallards; Reinecke et al. 1987; Table 2).

The timing of hunting mortality for female pintails in southwestern Louisiana differed from that of pintails in other regions. Hunting mortality of female pintails in Sinaloa, Mexico, was highest early in the hunting season (Migoya and Baldassarre 1995). In contrast, hunting mortal-

<table>
<thead>
<tr>
<th>Species</th>
<th>Region</th>
<th>Days</th>
<th>Age*</th>
<th>Survival rate</th>
<th>Nonhunting mortality rate</th>
<th>Hunting mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern pintail</td>
<td>Mexico</td>
<td>107</td>
<td>Ad</td>
<td>0.91</td>
<td>0.48-0.103</td>
<td>0.049</td>
</tr>
<tr>
<td>Northern pintail</td>
<td>California</td>
<td>180</td>
<td>Ad</td>
<td>0.574</td>
<td>0.200-0.293</td>
<td>0.030</td>
</tr>
<tr>
<td>Northern pintail</td>
<td>Louisiana</td>
<td>147</td>
<td>Ad</td>
<td>0.714</td>
<td>0.395-0.866</td>
<td>0.036</td>
</tr>
<tr>
<td>Mallard</td>
<td>Mississippi, Arkansas</td>
<td>70</td>
<td>Imm</td>
<td>0.790</td>
<td>0.570-1.000</td>
<td>0.180</td>
</tr>
<tr>
<td>Mallard</td>
<td>Texas</td>
<td>100</td>
<td>Ad</td>
<td>0.773</td>
<td>0.570-0.970</td>
<td>0.210</td>
</tr>
<tr>
<td>Mallard</td>
<td>Arizona</td>
<td>30</td>
<td>Ad</td>
<td>0.983</td>
<td>0.770-1.000</td>
<td>0.018</td>
</tr>
<tr>
<td>Mallard</td>
<td>New Jersey, Virginia</td>
<td>59</td>
<td>Imm</td>
<td>0.759</td>
<td>0.590-0.900</td>
<td>0.114</td>
</tr>
<tr>
<td>American black duck</td>
<td>Maine, New Brunswick</td>
<td>76</td>
<td>Imm</td>
<td>0.593</td>
<td>0.390-0.800</td>
<td>0.292</td>
</tr>
</tbody>
</table>

*Ad = adult (hatching year); Imm = immature (hatching year)
ity of radiotagged adult female pintails in the Sacramento Valley of California occurred late in the continuous 79-day hunting season of 1987–88, and only during the second hunting seasons of 1988–89 and 1989–90 (Miller et al. 1995). In our study, hunting mortality of female pintails was high throughout the first and second hunting seasons. This finding is consistent with our observations and interviews with hunters (n = 43) who shot radiotagged pintails (Cox 1996), which indicated hunter effort in southwestern Louisiana was consistently high throughout hunting seasons (USFWS 1991–97).

Miller et al. (1995) speculated hunting mortality of adult female pintails in the Sacramento Valley of California was low, in part because females reacquainted themselves with refuges during the nearly 2 months between arrival and beginning of hunting seasons. Pintails arriving closer to the start of, or during, hunting season were suggested to be at greater risk from hunting and natural mortality (Miller et al. 1995). Large numbers of pintails did not arrive in southwestern Louisiana until mid- to late October, and most of our radiotagged females were captured in late October, only 3 weeks before hunting seasons began in mid-November. Further, pintails in California established routines of roosting diurnally on refuges and feeding nocturnally in agricultural areas before the start of hunting seasons (Miller 1985). In contrast, diurnal nonrefuge areas (67%) by female pintails in southwestern Louisiana was twice as high as that of refuges (33%) prior to hunting seasons (Cox and Afton 1997). Thus, greater familiarity with refuges and use of them prior to hunting seasons may partly explain lower mortality rates of pintails in California compared to those in southwestern Louisiana.

Pintails roosting diurnally in large concentrations on Lacassine NWR, the primary roost site of females during our study, spend virtually no time feeding (Tamisier 1976), which suggests food resources are limited there. In contrast, pintails on NWRs in the Sacramento Valley typically feed >10% of daylight hours (Miller 1985). Thus, greater food availability on diurnal roosts also may contribute to greater survival of adult female pintails in California.

We found no effect of body condition on survivorship either when we tested for condition effects simultaneously with other covariates or when we tested for condition effects alone. Similarly, survival of adult and immature female pintails in Mexico was not related to body condition (Migoya and Baldassarre 1995), and survival of adult female pintails in California was not related to body mass (Miller et al. 1995), although relatively low mortality rates in these studies resulted in lower power for testing condition effects. One reason for failure to detect condition effects in studies of wintering pintails may be that birds in the poorest condition arrive later on wintering areas, or perhaps fail to arrive on wintering areas altogether because of hunting mortality in more northern areas or because of mortality during migration. Consequently, our study and others may have failed to find body mass or condition effects on wintering pintails because birds captured very soon after arrival on southern wintering areas may represent a sample of individuals in high body condition (possibly above a condition threshold). Alternatively, body mass and condition of pintails can increase rapidly after arrival on wintering areas (Miller 1986), and tests for condition effects on female pintail survival have relied on a single measure of condition taken while birds were being handled, soon after pintails arrived on wintering areas (Migoya and Baldassarre 1995, Miller et al. 1995, this study). Thus, we are reluctant to conclude that survival of pintails is not related to condition, because condition of females upon arrival may not accurately reflect their condition status later in winter.

We found that immature female pintails in southwestern Louisiana survived at lower rates than adults, primarily because hunting mortality of immatures was greater. Lower annual survival rates of immatures versus adults commonly are reported in banding and mark–resighting studies of dabbling ducks (Johnson et al. 1992, Arnold and Clark 1996). Our findings also are consistent with the conclusion of Johnson et al. (1992) that large age-specific differences in survival rates occur primarily between August and February, which includes fall migration and hunting periods. Immature females were in poorer condition, on average, than were adults, but survival did not differ in relation to condition. Cox and Afton (1997) detected no difference in use of habitats in southwestern Louisiana between age classes of female pintails. In total, these findings suggest immatures were more vulnerable to hunting because they were more naive (i.e., less wary) to hunting than were adults, and not because they were in poorer
condition or because they used habitats differently.

We found no evidence of differential hunting mortality of females within versus outside our primary study area. However, statistical power for testing region effects was relatively low because 76% of female pintail exposure days prior to 20 January (latest possible date for hunting seasons) occurred inside our primary study area. Thus, our estimate of hunting mortality that included both regions may be more representative of southwestern Louisiana than the remainder of the Texas–Louisiana Gulf Coast and Mississippi Alluvial Valley.

Annual survival rates of adult female pintails throughout the Gulf Coasts of Louisiana and Texas, estimated from winter bandings, were 67% during 1964–66 and 70% during 1976–78 (Hestbeck 1993b), which is only slightly lower than our 147-day estimate (71%) for adult females in southwestern Louisiana. If we assume annual survival rates during our study were similar, survival rates during March–September (218 days) would be 94–98%. These estimates seem unrealistically high given substantial mortality of female dabbling ducks on breeding areas (e.g., Johnson and Sargeant 1977). The apparent discrepancy between annual survival estimates for adult female pintails of Hestbeck (1993b) and those based on our estimates of winter survival may be due to (1) temporal decline in annual survival rates from the 1960s and 1970s to the early 1990s, which would coincide with population declines over these intervals; (2) marked heterogeneity of winter survival rates among regions within the Mississippi Alluvial Valley and Gulf Coast; or (3) underestimated winter survival rates in our study, possibly due to radio effects. Clearly, further investigations of these relations are needed.

Overall, our study indicates that southwestern Louisiana is an area of high hunting and nonhunting mortality of female pintails, particularly immatures. We believe there is little potential for management of nonhunting mortality factors (primarily predation) of female pintails in this region. Legal hunting, the most manageable winter mortality factor in our study, accounted for the majority of total mortality of both age classes of female pintails in southwestern Louisiana. However, the high hunting mortality of female pintails that we documented occurred under conservative regulations (30-day season, 1 pintail daily). Further restriction of bag limits, short of closing the season, is not likely.

**MANAGEMENT IMPLICATIONS**

Although several large waterfowl refuges are located in southwestern Louisiana, pintails use only 2 extensively: Lacassine NWR and Amoco Pool (Cox and Afton 1998b). Pintails use these areas primarily during the day during hunting seasons (apparently to escape hunting pressure), and they feed almost exclusively at night in nearby privately owned agricultural fields (Tamisier 1976, Cox and Afton 1997). If food resources are limited on major diurnal concentration areas in southwestern Louisiana (Tamisier 1976; Cox and Afton 1996, 1997), we believe increasing the availability of foods on these areas may decrease hunting mortality rates of female pintails in this region. Further, we believe high hunting mortality of female pintails reflects a strong tradition of duck hunting in southwestern Louisiana (Reisner 1991). Consequently, hunter effort and success (USFWS 1991–97), hunter knowledge of pintail movements and habits, hunter preference for pintails as table fare, and skill levels of hunters (identification, calling, shooting, etc.) are high. Many of the dedicated hunters that shot radiotagged pintails had adopted a strategy of shooting a limit of ducks as soon as possible after legal hours began in the morning, believing that leaving hunting areas (largely agricultural fields) undisturbed for the majority of the day allowed them to successfully hunt the same field or blind regularly (often daily) throughout the season. This practice may encourage indiscriminate shooting of pintails with regard to sex. If so, there is potential for shifting at least some of the hunting mortality of females to males through hunter education, incentives, or mandates via regulations. However, winter survival rates of male pintails in southwestern Louisiana are not known and should be estimated before and after adopting such programs.

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