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ANNUAL ADULT SURVIVAL OF INTERIOR LEAST TERNS

ROCHELLE B. RENKEN AND JOHN W. SMITH

Missouri Department of Conservation
1110 South College Avenue
Columbia, Missouri 65201 USA

Abstract.—During 1987–1990, 194 adult Least Terns (*Sterna antillarum*) were color-banded to estimate the adult annual survival rate for the population in the lower Mississippi River valley. A total of 103 resightings were compiled and 40% (78) of the 194 banded adults was resighted at least once during 1988–1992. Program JOLLY was used to calculate an adult annual survival rate. Model B, which assumes a constant survival rate and time-specific capture probabilities, was the most appropriate model for the data. The estimated adult annual survival rate was 85% (SE = 0.057; 95% CI = 0.73–0.95).

SUPERVIVIENCIA ANUAL DE *STERNA ANTILLARUM* EN MISSISSIPPI

Sinopsis.—De 1987–1990 se marcaron con anillas de colores 194 adultos de la gaviota *Sterna antillarum* para determinar la tasa anual de supervivencia de la población de éstas en la parte baja de valle del Río Mississippi. Se compilaron 103 reavistamientos, y el 40% (78) de las 194 aves marcadas fueron reavistadas al menos una vez durante el período que comprendió 1988-1992. Se utilizó el programa JOLLY para calcular la tasa de supervivencia anual. El modelo B, que asume un tasa de supervivencia constante y una probabilidad de captura tiempo-específica, resultó ser el modelo más apropiado para tratar los datos. El estimado de supervivencia anual fue de 85% (SE = 0.057; 95% CI = 0.73–0.95).

Surveys during the 1970s and 1980s (Downing 1980, Ducey 1981, Sidle et al. 1988, U.S. Fish and Wildlife Service 1985) indicated that interior Least Tern populations had declined throughout most of their historic range. Local breeding populations had been extirpated from the Ohio River, the lower Missouri River, and the upper Mississippi River (Ducey 1981, Hardy 1957, Sidle et al. 1988). As a result of these reports, the interior population of the Least Tern (*Sterna antillarum*) was added to the federal endangered species list in 1985 (U.S. Fish and Wildlife Service 1985).

The cause of the population decline has been the loss of appropriate breeding habitat. Interior Least Terns typically nest in riverine systems on sand and gravel bars that have been scoured free of vegetation by spring floods (Hardy 1957). Extensive channelization, dike construction and damming of these rivers have altered the water flow regime (Downing 1980, Ducey 1981), which has resulted in the loss of sandbars, the encroachment of woody vegetation on islands and the accretion of islands to the riverbank (Smith and Stucky 1988). The subsequent loss and degradation of nesting habitat has resulted in a population decline for Least Terns (Downing 1980, Ducey 1981, Faanes 1983, Sidle et al. 1988).

To remedy this decline, a recovery plan was developed (U.S. Fish and Wildlife Service 1990). The plan identified research needs to achieve recovery, including the need to conduct color-marking studies.

To evaluate the population status of the interior Least Tern, additional data were needed regarding adult annual survival rates. Thompson

(1982) used the small amount of existing band-recovery data to calculate an adult survival rate for all Least Terns banded within the United States. We used capture-recapture data from color-banded birds to estimate an adult annual survival rate for the Mississippi River valley population.

STUDY AREA AND METHODS

The study region encompassed 201 km of the Mississippi River from the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois (36°59'N, 89°08'E) to 36°00'N, 89°43'E, which is approximately at the Missouri/Arkansas/Tennessee border. Interior Least Terns nest on 13–18 sand islands within that river stretch depending upon seasonal levels of the river. Sixteen of those sand islands used as nesting sites by Least Terns have formed within dike fields. Other tern nesting sites within the river basin include a naturally occurring sand island and a sandbar at the tip of a permanent, forest-covered island.

During 1987–1990, adult Least Terns were captured and banded with U.S. Fish and Wildlife Service (USFWS) metal leg bands and individual combinations of Darvic color bands. All color combinations included a dark green Darvic flag, which symbolized a tern caught within our study region. We captured adult Least Terns at nests using T-bar traps (Hill 1985). Banding was conducted under federal permit number 06547.

During 1988–1992, we searched for color-banded terns at all colonies by scanning groups of nesting and loafing birds. To avoid disturbing nesting terns during searches, we hid in portable blinds, waded in the river, or remained in boats near tern loafing areas. When we located color-banded terns for which color bands were missing or metal band numbers were unreadable by spoting scope, we captured them at nests to read USFWS band numbers. When a marked tern was located, we recorded the color-band combination, USFWS metal band number and date.

We used program JOLLY (Pollock et al. 1990) to estimate Least Tern adult annual survival rates from capture-recapture data for the period of 1987–1992. We examined the fit of models A, B and D (Pollock et al. 1990) to determine which model best fit the data. In brief, model A is the full Jolly-Seber model that allows for time-specific survival rates and capture probabilities. Models B and D are reduced-parameter models that assume constant survival rates (model B), or constant survival and capture probabilities (model D) during the study period. We selected the best model for our data based upon the appropriateness of model assumptions to Least Tern biology and Chi-squared tests of goodness-of-fit. Best-fitting models not only have low Chi-squared values, but also have the fewest number of parameters (Pollock et al. 1990). Pollock et al. (1990) recommend that if the full model (model A) and a reduced-parameter model (models B or D) both fit the data (have low Chi-squared values), the best model is the reduced-parameter model. Our goal was to select the simplest model.

TABLE 1. Capture-recapture summary statistics for adult Least Terns in the Mississippi River valley. Definitions of variables are taken from Pollock et al. (1990).

Period	Date	n_i	m_i	R_i	r_i	z_i
1	1987	37	—	37	16	—
2	1988	37	3	37	19	13
3	1989	73	14	73	41	18
4	1990	104	40	104	22	19
5	1991	24	24	23	5	17
6	1992	22	22	22	—	—

n_i = Total number of animals captured in the ith sample (includes captured and resighted birds).
m_i = Number of marked animals captured in the ith sample (resighted birds).
R_i = Number of n_i that are released after the ith sample.
r_i = Number of R_i released at i that are captured again.
z_i = Number of animals captured before i, not captured at i, and captured again later.

RESULTS

During 1987–1991, 194 adult Least Terns were color-banded. Forty percent (78) of the 194 adults were resighted at least once following banding. In all, we compiled 103 resightings of color-banded adults. The data used in JOLLY are defined in Table 1.

The results of goodness-of-fit tests suggest that model B was the best fitting model for our data (Table 2). Model B was best for estimating Least Tern adult annual survival rates because it is a simpler model than model A, and the assumptions of time-specific capture probabilities and a constant survival rate were realistic for this population. Model D did not fit the data (Table 2) and had assumptions that could not be met. The estimate of Least Tern adult annual survival was 85% (SE = 0.057; 95% CI = 0.73–0.95) during 1987–1992.

DISCUSSION

The 85% adult annual survival rate we calculated for the period 1987–1992 is the same as that calculated by Thompson (1982) using band recovery data for Least Terns in the United States and is similar to the 88% survival rate calculated by Massey et al. (1992) for California Least Terns.

TABLE 2. Goodness-of-fit test results for JOLLY models A, B and D for Least Tern data (1987–1992).

Test	χ^2	df	*P*
Goodness-of-fit to model A	3.09	7	0.877
Goodness-of-fit to model B	7.5	10	0.675
Goodness-of-fit to model D	28.04	14	0.014
Model B versus model A	4.4	3	0.218
Model D versus model B	20.7	4	0.0004
Model D versus model A	24.9	7	0.0008

Least Terns can be long lived; two terns banded as chicks in our study region prior to this study were 15 and 17 yr old when we recaptured them. The oldest known Least Tern was 21 yr old (Massey and Atwood 1978).

During our breeding-season studies, adult Least Terns died from several different causes. At least eight adult terns were killed by Barred Owls (*Strix varia*) at one colony during 1988. We identified the predators from foot tracks at kill sites. Another three adult terns were shot in 1991 and another adult was killed by an all-terrain vehicle in 1984. Lingle (1993) observed adult Least Tern mortality from similar causes in the Platte River valley. He reported that adults were killed by Great Horned Owls (*Bubo virginianus*), gunshot, hail, dogs and an all-terrain vehicle.

During the non-breeding season, Least Terns migrate to and winter in Central and South America (U.S. Fish and Wildlife Service 1990). It is not known what mortality factors affect adult Least Terns in that region, but incidental hunting and pesticides may pose threats to the survival of adults on the wintering grounds (Whitman 1988).

The nest step in research and management of Mississippi River valley Least Terns is to model the population with our estimates of adult annual survival and productivity (Smith and Renken 1993) to determine the long-term status of this population. Kirsch (1992) has already done modeling for the interior Least Tern population in the Platte River valley. She reported that this population appears to be stable given the current estimates of mortality and natality. Our estimates of mortality (this study) and natality (Smith and Renken 1993) are similar to those used in her analysis. If we are to meet recovery-plan goals successfully and manage for an enduring tern population in the Mississippi River valley, we need to examine the present population trend and determine what demographic parameters can be affected to ensure long-term population viability.

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