WINTER SURVIVAL OF LESSER SCAUP IN EAST-CENTRAL FLORIDA

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Abstract: The North American continental population of lesser scaup (*Aythya affinis*) has been declining since the mid-1980s. Seasonal survival estimates may provide insights about the ecological basis for this decline, but such data are not available. We estimated post-harvest winter survival of lesser scaup in east-central Florida, USA, where 62% of the Atlantic Flyway population winters. The Kaplan-Meier survival estimate from 11 January to 14 March 2002 was 0.95 ± 0.04 (SE) for females and 0.90 ± 0.09 for males. These estimates were not different ($P = 0.64$), and pooled survival was 0.93 ± 0.04. Temporary emigration (movement out of and return to the study area) was exhibited by 25% of the birds during survey periods, but absences were short and were believed to have had little effect on precision of survival estimates. Our findings suggested that natural mortality at Merritt Island National Wildlife Refuge (MINWR) and surrounding estuarine areas was relatively low. Our results also indicate that habitat quality in this portion of east-central Florida was sufficient to meet overwintering requirements and likely contributed to the reported survival rates. Estimating survival during other stages of the annual cycle, as well as an overall winter estimate reflecting harvest mortality, is necessary to determine whether low survival rates are responsible for continental population declines.

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Lesser scaup (hereafter scaup) populations have declined progressively since the mid-1980s and currently are below goals of the North American Waterfowl Management Plan (NAWMP; U.S. Fish and Wildlife Service 1986, 1998). Before managers can develop strategies to curb this trend, they must understand the ecological basis for the decline. An essential step to meet that need is obtaining estimates of survival on both breeding and wintering grounds, with particular emphasis on identifying sources of mortality. The best understanding of survival and sources of mortality comes from harvest trends through the annual U.S. Fish and Wildlife Service's parts collection surveys and band returns (Austin et al. 2000). Annual survival estimates between 1954 and 1969 ranged from 0.44 to 0.87. These estimates were based on band returns; however, since 1969, banding data have been insufficient to estimate survival rates (Austin et al. 2000). Review of the scientific literature yielded no estimates of survival for wintering scaup outside of the hunting season.

Merritt Island National Wildlife Refuge and its adjacent estuarine areas (Banana and Indian Rivers, and Mosquito Lagoon) provide the most valuable habitat for wintering scaup on the Atlantic Flyway (Bellrose 1980). This area harbors up to 62% of all Atlantic Flyway wintering scaup, which constitutes >15% of the continental population (Bellrose 1980, Austin et al. 1998). We estimated winter survival for scaup in east-central Florida from 11 January to 14 March 2002. Estimates were obtained after the hunting season; hence, results represent survival rates of scaup subject only to natural mortality. We also were interested in survival estimates for females because some studies suggest that females have lower annual survival than males (Austin et al. 2000, Afton and Anderson 2001). Differences in local, sex-specific survival would suggest that annual differences might have a winter component. We also evaluated temporary emigration for 2 reasons: (1) understanding the extent of movements outside the study area provides insights on habitat requirements or differential survival (e.g., exposure to other kinds of mortality factors such as harvest); and (2) temporary emigration could lead to elevated variance and low precision of survival estimates (Pollock et al. 1989*a*). We define temporary emigration in our study as the movement of radiomarked scaup outside of the Indian River Lagoon (IRL) complex.

STUDY AREA

We trapped scaup at 9 locations within MINWR, located on the Atlantic Coast approximately 1 km east of Titusville, Florida, USA (28°40′N, 80°46′W). The refuge envelops the John F. Kennedy Space Center (KSC) on Merritt Island,

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covering 55,039 ha of the National Aeronautical and Space Administration's (NASA) 57,000 ha in Brevard and Velusia counties. Our study area was part of the IRL complex, including all waters of the Indian and Banana Rivers and the southern half of Mosquito Lagoon adjacent to MINWR. Merritt Island is a barrier island complex separated from the mainland by the Indian River and from Cape Canaveral by the northern Banana River. The island is composed of sandy beaches, dune systems, hammocks, longitudinal lagoons, and 76 salt marsh impoundments jointly managed by the Brevard Mosquito Control District, National Park Service, NASA, and U.S. Fish and Wildlife Service. Waters tend to be shallow, aeolian lagoons with depths averaging 1.5 m and a maximum of 9 m (dredged regions). Typical salinities ranged from 10 to 42 ppt (Provancha and Sheidt 2000). Estuarine and impounded wetland habitats within our study site were approximately 400 km^2.

METHODS

Scaup were captured using quick-catch corral traps over baited locations (Joanen 1964, Haramis et al. 1986). We used 9 separate trap locations within MINWR to help increase independence among captured birds. We tried to capture an equal number of both sexes and classified birds via a combination of wing plumage (Carney 1992) and cloacal examination (Hochbaum 1942). Age class of scaup was not assigned because accuracy of techniques has not been verified during midwinter (Hochbaum 1942, Carney 1992).

We surgically implanted (Korschgen et al. 1984, Olsen et al. 1992) radiotransmitters in 60 scaups (34 F, 26 M) from 4 to 7 January 2002. We used intra-abdominal radiotransmitters with an external whip antenna, rather than traditional back-mounted units, due to concerns over behavioral modifications of the latter in scaup (Woakes and Butler 1975, Perry 1981, Olsen et al. 1992, Brook and Clark 2002). Radiotransmitters were implantable model A2310 (Advanced Telemetry Systems, Isanti, Minnesota, USA), had a minimum lifespan of 6 months, and were in the 152.000–153.999 MHz range. Mean mass of transmitters was 18 g, which was ≤2.91% of our lightest bird. Isoflurane (Aerane, Ananquest, Madison, Wisconsin, USA) was used as the anesthetic and delivered into the bird via an Isotec 3 vaporizer (Ohmeda, Madison, Wisconsin, USA). All other surgical procedures followed Olsen et al. (1992).

Prior to release, all birds were given fluids and monitored for >1 hr after surgery. In addition, we banded all birds with U.S. Fish and Wildlife Service aluminum bands. Birds were released at their capture site.

The large size of the study area and intermittent security restrictions associated with the KSC operations prevented us from locating radiomarked scaup every day. Instead, we located radiomarked scaup every 6–7 days using truck-mounted, 6-element dual yagi antennas (Cushcraft, Manchester, New Hampshire, USA) and a null system. We used a model R4000 ATS receiver (Advanced Telemetry Systems, Isanti, Minnesota, USA) to scan all frequencies for 4-sec intervals in a radius of 360°. This process was repeated at a minimum of 25 stops throughout the study area to ensure complete coverage. Radiomarked scaup were routinely located 6–8 km away from the shore due to the open habitat of the IRL complex (Herring 2003).

We used a boat-mounted antenna system to survey the entire area concurrent with the truck survey on 2 days (30 Jan and 26 Feb) to ensure that no birds were missed. Last, we flew 1 aerial survey in a Cessna 172, using strut-mounted radiotelemetry antennas to search for missing scaup and verify ground survey results (14 Feb). Coverage of the aerial survey was from the north end of the Indian River (northern extent of the study site) to 100 km south and 15 km east to west (1,500 km^2).

We chose 11 January as the starting date to estimate winter survival. At that time, all radiomarked scaup had at least 4 days to acclimate to their radiotransmitters. Additionally, prior to beginning data collection, we monitored the activity patterns of 8 implanted birds for >6 hr. Implanted scaup behaved in the same manner as wild adjacent birds, feeding in regular rhythmic patterns and performing other activities (e.g., resting, preening), with no detectable detrimental effects.

We defined the wintering period as 15 December to 15 March, based on the literature (Bellrose 1980) and preliminary migration chronology fieldwork conducted in 2001 (Herring 2003). Mortality was suspected when radiomarked scaup were located in the same area on consecutive surveys. We visited these sites to determine the fate of suspect birds. Examination of the bird's condition was required to separate natural mortality from effects of surgery.

We used a Kaplan-Meier survival model to estimate winter survival (ϕ) for female and male scaup and a pooled estimate for sexes combined (Pollock 1984, Pollock et al. 1989*a*,*b*). Scaup were right censored during weekly survival estimates if

they temporarily emigrated from the region; if scaup returned to the study site, they were included as new at-risk birds. Before we pooled data on sexes, we used a log-rank test to determine whether male and female survival curves differed (Pollock et al. 1989*a*). We also used a *z*-test to compare sex-specific survival at the end of winter. We used a chi-square test to determine whether the frequency distribution of birds that temporarily emigrated from the study area differed between sex. To meet test assumptions (i.e., expected cell values), we grouped the number of individuals, by sex, that emigrated 0–2 times, 3–5 times, and 6–8 times. We assumed, and subsequently verified, that detection probability for radiomarked birds was 1 in the study area. Therefore, birds that were absent during radiotelemetry survey days were treated as temporary emigrants.

Our model assumptions were as follows: (1) birds were selected independently within sexes; (2) birds have independent survival times (i.e., the fate of 1 bird is not related to another [e.g., paired birds]); (3) the radiomarking method does not affect survival (radiotransmitter implant surgery and carrying the transmitters throughout the winter period); (4) death times are known exactly; (5) censoring is random and independent of survival; and (6) we had a well-defined time origin for the study (Pollock et al. 1989*a,b*). We evaluated these assumptions in the following manner:

Birds were Selected Independently within Sexes.—Trapping and subsequent capture of female and male scaup occurred over 4 days at 9 locations. Independent selection of birds was assumed for the following reasons: (1) by capturing birds from several sites in a short period, birds had less time to develop any bait response; (2) more birds (>150) were captured than required to meet the goal of 60 implanted scaup; and (3) only 1 bird was recaptured, suggesting that new birds were continually caught.

Independent Survival Times.—Lesser scaup do not begin to form pair bonds until late winter (Bellrose 1980, Austin et al. 1998). Accordingly, the fate of 1 bird will not be related to another.

Marking Method does not Affect Survival.—Woakes and Butler (1975), Perry (1981), and Olsen et al. (1992) showed that implanted radiotransmitters resulted in no detectable adverse effect on the behavior or survival of canvasbacks (*Aythya valisineria*). Furthermore, Brook and Clark (2002) also observed no mortalities or impairment of behavior as a result of radiomarking scaup. However, Brook and Clark (2002) used subcutaneous transmitters. In a recent study of mallards (*Anas platyrhynchus*), >2,000 transmitters were implanted over 5 years with no detectable effect on survival or indication of impairment of reproductive capacity (J. Devries, Ducks Unlimited Canada, personal communication).

Death Times are Known Exactly.—As part of a concurrent project, radiotelemetry locations of scaup were being collected between weekly data collection periods. Therefore, we considered the assessment of time of death for individual birds to be accurate.

Censoring is Random and Independent of Survival.—Statistical tests showed that temporary emigration occurred at similar rates for both sexes. In addition, we found censoring to be independent of survival because all birds that were censored (temporarily emigrated) were later observed on the study site during the 10-week winter period.

Well-defined Time Origin for the Study.—The period for which survival was to be determined was assigned prior to initiation of the study.

RESULTS

We collected survival data for 30 female and 24 male radiomarked scaup. Five implanted scaup were never detected in a 1,500-km^2 aerial search area; hence, we assumed the radiotransmitters failed or the birds left the area completely. A hunter shot the other radiomarked scaup within 2 days of the radiotransmitter being implanted (1 day remained in the waterfowl hunting season when radiomarked birds were released). The aerial and boat surveys conducted to verify ground telemetry resulted in the same radiomarked scaup being either absent or present from the study area as in the ground survey; confirming that detection probability = 1.

Cumulative survival estimates were 0.95 ± 0.04 (SE) for females and 0.90 ± 0.09 for males. Estimates were not different ($z = -0.52$, $P = 0.3$, df = 1), nor were the survival curves ($\chi^2 = 0.11$, $P = 0.64$, df = 1). Pooled survival was 0.93 ± 0.04 (Table 1). Of 3 deaths recorded during the study, 2 were likely caused by avian predation and did not occur until the week of 8–14 March. We could not determine the cause of the third death but suspect that it was related to the surgery procedure.

Seventy-two percent of all radiomarked scaup temporarily emigrated at least once during the study. We found no significant differences in the number of times males and females temporarily emigrated from the study area ($\chi^2 = 3.71$, $P = 0.16$, df = 2). Mean apparent temporary emigra-

Table 1. Pooled survival estimates for male and female lesser scaup in a Florida wintering area, from 11 Jan to 14 Mar 2002; returning temporary emigrants are treated as new at risk birds.

Period	Dates	No. risk[a]	No. deaths[b]	No. censored[c]	New added[d]	Cumulative survival	95% CI
1	7 Jan–11 Jan	54	0	13	0	1.00	1.00 to 1.00
2	12 Jan–17 Jan	41	1[e]	5	13	1.00	1.00 to 1.00
3	18 Jan–26 Jan	48	0	17	5	1.00	1.00 to 1.00
4	27 Jan–1 Feb	36	0	14	17	1.00	1.00 to 1.00
5	2 Feb–7 Feb	39	0	10	14	1.00	1.00 to 1.00
6	8 Feb–14 Feb	43	0	19	10	1.00	1.00 to 1.00
7	15 Feb– 21 Feb	34	0	18	19	1.00	1.00 to 1.00
8	22 Feb–1 Mar	35	0	24	18	1.00	1.00 to 1.00
9	2 Mar–7 Mar	29	0	21	24	1.00	1.00 to 1.00
10	8 Mar–14 Mar	32	2	33	21	0.93	1.00 to 0.85

[a] Number of individual radiomarked scaup that were located during this survey and are the basis of the associated survival estimate.
[b] Number of deaths between the previous and current period.
[c] Number of radiomarked scaup that were not detected during this survey; temporary emigrants.
[d] Temporary emigrants from the previous survey that are added as new birds at risk.
[e] Mortality of unknown nature, not included in survival estimates.

tion of pooled sexes during weekly survey periods was 24.9 ± 3.8%. Temporary emigration increased toward late winter (Table 1).

DISCUSSION

Although our estimates of survival do not include the first 3 weeks of winter, they cover the period during which numbers of scaup on the wintering grounds are highest (Bellrose 1980, Herring 2003). The pooled winter-period survival estimate in our study (0.93 ± 0.04) was within the range of other duck species under similar circumstances (i.e., no harvest pressure). For example, winter survival of canvasbacks in Chesapeake Bay was 0.89 (Haramis et al. 1993), whereas winter survival for mallards in Arkansas ranged from 0.96 to 0.99 (Dugger et al. 1994). Differences in survival in our study between males and females were not significant. Notwithstanding low precision, our findings suggest that sex-specific differences in annual survival (Austin et al. 2000, Afton and Anderson 2001) probably stem from differential survival elsewhere (e.g., nesting females; Koons 2001).

We believe that temporary emigration had a negligible effect on precision of our survival estimates. Estimates of cumulative survival were based on 10 "recapture" occasions occurring at intervals of 5–7 days, a temporal scale much broader than the daily activity schedule exhibited by scaup. The absence of scaup from the study area was usually brief, often lasting <24 hr (Herring 2003). Zehfuss et al. (1999) demonstrated that model estimates generally were unbiased if animals had a high probability of returning to the study site after temporary emigration. When the probability of being absent is constant, then temporary emigration simply reduces capture probabilities and estimates are less precise (Zehfuss et al. 1999). We surmised that our sampling scheme provided multiple opportunities to detect birds if they were in the area. In telemetry studies, detection probability is almost always 100% when animals remain in the study area (White and Garrott 1990, Williams et al. 2002). Moreover, our coverage of the area was extensive and included ground, boat, and aerial surveys. Temporary emigration increased toward late winter. A plausible explanation for this pattern probably is related to the onset of migration (e.g., migratory restlessness). We still contend that our estimates of survival were reliable because radiotelemetry survey efforts remained consistent throughout the study, suggesting that we did not simply miss birds.

Temporary movements could have resulted from birds using different areas for foraging, loafing, and obtaining access to fresh water. Of these possibilities, we believe that the latter was the most likely. Home-range analyses suggested that scaup regularly flew inland to freshwater systems (Herring 2003). Adair et al. (1996) showed that scaup wintering in coastal Texas traveled inland primarily to obtain fresh water critical to birds wintering in saline systems (Kiel 1957, Mitchell et al. 1992, Woodin 1994). Scaup wintering in east-central Florida experience similar conditions (Herring 2003).

Because available annual survival estimates precede the onset of decline (1954–1969) and were based on band recovery data—which often are plagued by low recovery rates and precision—these estimates for scaup (0.57–0.71; Austin et al. 2000)

seem of little value in ascertaining the underlying reasons for the recent decline of this species. Seasonal survival needs to be estimated throughout the annual cycle to determine when the species is most vulnerable and whether management can be prescribed to enhance survival. Our work yields the first critical evaluation of winter survival of scaup in east-central Florida. Our findings suggest that natural mortality at MINWR and surrounding estuarine areas is relatively low. Further, our findings indicate that habitat quality in the area was sufficient to meet overwinter requirements for high survival (e.g., foraging opportunities and related nutrient reserves; Herring 2003).

MANAGEMENT IMPLICATIONS

Apparent high survival at MINWR reflects the importance of high-quality wintering habitats for scaup. Maintaining these areas may be essential to minimize winter mortality and prevent it from contributing to current declines. Survival rates and mortality sources often are spatially heterogeneous, which emphasizes the need to examine scaup survival in other wintering sites. Prominent wintering areas, such as Florida and Louisiana, are susceptible to both natural and human-induced changes and should be selected for vital parameter assessments.

Temporary emigration underscored the importance of multiple habitats for scaup, which need access to habitats that provide freshwater after foraging in saline systems. In a larger context, temporary emigration may contribute to lower period survival due to increased exposure to harvest pressure, and the possibility of such an interaction should be evaluated to adjust wintering conservation strategies accordingly.

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