

# WINTER SURVIVAL OF FEMALE AMERICAN BLACK DUCKS ON THE ATLANTIC COAST

MICHAEL J. CONROY,<sup>1</sup> U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708  
GARY R. COSTANZO, New York Cooperative Fish and Wildlife Research Unit, Department of Natural Resources, Fernald Hall, Cornell University, Ithaca, NY 14853  
DANIEL B. STOTTS, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708

**Abstract:** We used radio telemetry to monitor the winter survival and cause-specific mortality of 227 female American black ducks (*Anas rubripes*) captured in New Jersey and Virginia, 1983–85. Mean survival rate for 19 December–15 February was 0.65. Survival from hunting and nonhunting risk was 0.84 and 0.78, respectively. Causes of nonhunting mortality included predation and emaciation (winter stress). After-hatch-year (AHY) ducks had a higher probability of survival than hatch-year (HY) ducks (0.73 vs. 0.60); most of this difference was related to survival from nonhunting risk. After-hatch-year ducks with body masses  $\geq$  median had a higher survival probability (0.85) than AHY ducks with  $<$  median body masses (0.61) because of differential survival from hunting risk. Hatch-year ducks had lower body mass than AHY ducks, but among HY ducks body mass was not related to survival. There were no consistent patterns in survivorship in relation to mean daily temperature, although the timing of the onset of low temperatures and storms may have influenced movement patterns. Our estimated survival rates are consistent with estimates from other studies of seasonal and annual survival. It may be possible to manage habitats for population segments at high risk (HY and low body mass birds), and increase black duck survivorship.

*J. WILDL. MANAGE.* 53(1):99–109

Populations of American black ducks have declined from the 1950's to present (Barske 1968, Grandy 1983, Feierabend 1984). Reasons for the decline are unknown but may be related to specific causes of mortality such as hunting (Blandin 1982, Krementz et al. 1988), predation (Ringelman and Longcore 1983), competition from and hybridization with mallards (*Anas platyrhynchos*) (Johnsgard 1961, 1967), and habitat losses (Barske 1968).

Winter is a critical time for black ducks, because of high energetic demands (Albright 1981, Reinecke et al. 1982). Reinecke et al. (1982) demonstrated that immature females achieved adult structural size, but were lighter in weight and had smaller nutrient reserves than did adults during their first winter. Other studies have corroborated a link between age, body condition, and probability of survival. Hepp et al. (1986) reported that the probability of being shot by hunters for mallards in poor condition was higher than for those in better condition. Haramis et al. (1986) reported a direct relationship between the body mass of canvasbacks (*Aythya valisineria*) in early winter and probability of sur-

viving the winter. Although immature black ducks are more vulnerable to hunting (Schierbaum and Foley 1957, Krementz et al. 1988), and have lower annual survival rates than do adults (Blandin 1982, Krementz et al. 1987), whether age-specific mortality persists through winter, or occurs primarily during the postfledging period and early hunting season is unknown. Managers need estimates of winter survival rates and identification of mortality sources to understand black duck population dynamics and assist in the management of black duck populations.

Our objectives were to estimate survival rates of black ducks during winter, examine specific components of mortality, specifically hunting versus nonhunting mortality, and examine variation in survival rates during winter in relation to age, body condition, time, geographic location, and weather conditions.

We appreciate the assistance of E. L. Derleth, N. Dietz, B. Dirks, B. L. Estel, S. Holzman, A. G. Laroche, J. M. Morton, H. H. Obrecht III, S. R. Perin, N. Phelps, H. G. Russell, M. A. Spoden, J. M. Walsh, and G. Wright in the collection of field data. We also thank F. Ferrigno, New Jersey Fish and Game, G. L. Inman and D. L. Beall of Forsythe National Wildlife Refuge, and D. Holland of Chincoteague National

<sup>1</sup> Present address: Georgia Cooperative Fish and Wildlife Research Unit, School of Forest Resources, University of Georgia, Athens, GA 30602.

Wildlife Refuge (CNWR), for their cooperation and assistance in our work on the areas under their supervision. C. M. Bunck and S. R. Winterstein provided valuable statistical advice and C. N. DeCurtis, L. George, and L. A. O'Kelley assisted with computer analyses. We are especially indebted to K. H. Pollock for his insights on the application of the Kaplan-Meier method to radio-telemetry data. We thank T. L. Fields and S. D. Howington for typing drafts of the manuscript. S. Holzman, K. J. Reinecke, and S. R. Winterstein provided helpful comments on earlier drafts. This work was funded by the Division of Refuges and Wildlife, Region V, U.S. Fish and Wildlife Service, and by Cooperative Agreement 14-16-0009-1551, Research Work Order 6 between the University of Georgia and Patuxent Wildlife Research Center.

## STUDY AREAS

We trapped black ducks in 2 locations in southern New Jersey and in coastal Virginia. Brigantine Division, Forsythe National Wildlife Refuge (BNWR) is located on the Atlantic Coast, approximately 8 km north of Atlantic City, New Jersey (39°20'N, 74°42'W). The refuge was characterized by upland areas and coastal wetlands. The latter were dominated by saltmarsh cordgrass (*Spartina alterniflora*), and included high marsh at the upland edge and low marsh interspersed with channels, bays, and small islands at the lower elevations. Two large (225 and 380 ha) freshwater (salinity 2,000–3,000 ppm) to brackish (20,000–30,000 ppm) impoundments were located on the upland-wetland interface, and were the principal trapping locations within BNWR. The Dennis Creek Wildlife Management Area (DCWMA) was located on the Delaware Bay shore of southern New Jersey (30°10'N, 74°52'W), approximately 49 km southwest of BNWR, and was composed of salt meadow (*S. patens*) and saltmarsh cordgrass interspersed with tidal creeks. Trap sites at DCWMA were located in small pannes on the marsh surface. Chincoteague National Wildlife Refuge (CNWR) was located on the Atlantic coast of Virginia (37°53'N, 75°20'W), approximately 190 km southwest of BNWR and 150 km south of DCWMA, on a coastal barrier island bordered by a band of salt marsh (*Spartina* spp.) and containing several large (100–300 ha) freshwater impoundments. Trapping sites for black ducks were located in 2 impoundments at the south end of CNWR.

## METHODS

We trapped black ducks at BNWR and DCWMA during November–December 1983, and at all 3 locations during December 1984 and 1985. We baited large wire-mesh traps with corn and placed them in 20–70 cm of water. We removed ducks from the traps and held them for 8–12 hours to dry and eliminate corn from the crop. Each duck was aged as HY or AHY using plumage and cloacal characteristics and then weighed to the nearest 10 g with a 1,500-g spring balance. We corrected body mass by an index describing the amount of corn remaining in the crop (1–25% = –28.2g, 26–50% = –44.4g, 51–75% = –68.9g, 76–100% = –119.5g) (Albright 1981). Wing lengths were measured from the wrist to the tip of the longest primary on the flattened wing, to adjust body mass for body size.

We attached radio transmitters weighing approximately 30 g with a backpack harness (Dwyer 1972) to 50 female black ducks in 1983 (35 and 15 at BNWR and DCWMA, respectively), 92 in 1984 (52, 20, and 20 at BNWR, DCWMA, and CNWR, respectively) and 101 in 1985 (61, 20, and 20 at BNWR, DCWMA, and CNWR, respectively). We selected equal numbers of AHY and HY females at random at BNWR for radio attachment; this was not possible at DCWMA or CNWR because few ducks were trapped. Ducks with trapping or handling injuries were excluded from the study. We monitored ducks closely for  $\geq 48$  hours following release to determine if they had adapted to the radio packages. One to 3 ducks did not adjust to transmitters and refused to fly or died within this period. These birds were excluded from the study. Remaining ducks appeared to behave normally; i.e., we observed no aversion to flying, swimming, or other normal activities (Greenwood and Sargeant 1973, Wooley and Owen 1978), and they readily associated with other black ducks.

We obtained radio locations daily, if possible, from release until 15 February each year, or until mortality or disappearance of the radio signal occurred. All birds had been released and were adapted to the radio packages no later than 18 December in all 3 years. For later analyses, we considered 19 December to be the initiation date of the survival study interval, and we excluded birds that died or disappeared from the study before that date; 227 of the 243 released birds were monitored from 19 December to 15

February. We used standard techniques to obtain locations of ducks from the ground (Cochran 1980:517-518) using vehicle-mounted and hand-held antenna-receiver systems, and by air (Gilmer et al. 1981) using strut-mounted antennae attached to a Cessna 172. Radio locations were plotted on reduced 7.5-minute topographic quadrangles and transferred to computer files using a digitizer and a microcomputer. Ducks in 1 location for 48 hours were located by foot or boat to determine their status. We estimated time of mortality to the nearest day using field evidence (previous movement patterns and condition of carcass). In instances where little evidence was available, day of mortality was deemed the midpoint of the interval between the last day the duck was known alive, and the day it was determined dead. We performed field necropsies where possible to determine cause of death. We froze intact or partly fleshed carcasses, and later necropsied and fluoroscoped them for the presence of imbedded or ingested shot pellets.

We tested variation in body mass related to age, years, and trap location using a general linear models procedure with wing length as a covariate; a posteriori comparisons were performed using Tukey's test. The hypotheses of no overall variability related to the above factors and of no difference among means were rejected at the 0.05 significance level.

Modifications of the Mayfield method of estimating nesting success (Hensler and Nichols 1981, Bart and Robson 1982) have been used in previous studies to estimate survival rates from telemetry data (Ringleman and Longcore 1983). We believed that  $\geq 2$  critical assumptions of the Mayfield method were violated in our study: daily survival rate (DSR) is constant over the period of interest (19 Dec-15 Feb) and all individuals can be "revisited" and their fates determined with certainty. Because of these violations, we chose not to use the Mayfield method for our analyses.

The Kaplan-Meier (KM) method of analysis of failure times (Kaplan and Meier 1958, Cox and Oakes 1984) is a nonparametric method and empirical survival curves are estimated from sample data. Kaplan-Meier estimates are essentially plots of the changing mortality risk of the population over time and avoid the assumption of constant DSR. Observations are death times, which are the number of days from the initiation of the study (19 Dec) until death or cen-

soring. Censoring occurs when an animal leaves the study, either prematurely (e.g., due to radio failure before 15 Feb) or by surviving through the study period. Thus, KM analysis allows for the inclusion of observations from animals whose ultimate fate may be unknown. These are known to be alive until the time of censoring, and are thereafter removed from the population at risk. Another advantage of the KM method is the availability of procedures for testing the effects of classification variables (e.g., age, location) and of continuous covariates (e.g., body mass) (Pollock et al. 1989).

Kaplan-Meier estimates were computed for the entire sample for each year using the PHGLM procedure (Harrell 1983). We obtained estimates of survival rate (S) for 19 December-15 February as the 58-day KM estimate and computed standard errors (Cox and Oakes 1984:51). We computed estimates separately for survival from hunting risk by considering non-hunting mortalities as censored observations; conversely, survival from nonhunting mortality was obtained by censoring hunting mortalities. Although these estimates for cause-specific mortality are not independent (S. R. Winterstein, Michigan State Univ., pers. commun.), we believe they represent good approximations to the relative risk from hunting and nonhunting sources. We examined variability of survival rates relative to trap location, year, age, and body mass using tests in which samples grouped on the appropriate discrete variable or combination of variables (e.g., age, location) were compared using a Gehan-Wilcoxon Chi-square statistic (Therneau 1983). We constructed tests of specific contrasts between groups (e.g., AHY  $\geq$  median body mass vs. HY < median body mass) using the proportional hazards model and a likelihood-ratio test (Harrell 1983). We performed further testing of the above factors with body mass treated as a continuous variable and wing length as a covariate using a stepwise procedure in PROC PHGLM. We rejected tests of significance at the 0.10 level, but report the actual probability.

We also examined the effects of mean daily temperature on survival of our radio-marked ducks. We obtained data from monthly summaries for Atlantic City, New Jersey (BNWR and DCWMA) and Wallops Island, Virginia (CNWR) from the National Oceanic and Atmospheric Administration (1983-85). We chose mean daily temperature as the best indicator of

Table 1. Body mass (g) of female black ducks radiotagged at Brigantine Division, Forsythe National Wildlife Refuge (BNWR), and Dennis Creek Wildlife Management Area (DCWMA), New Jersey, and Chincoteague National Wildlife Refuge (CNWR), Virginia, 1983–86.

	After-hatch-year			Hatch-year			All ducks		
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n
BNWR	1,211	13	69	1,104	13	70	1,157	10	139
DCWMA	1,202	35	11	1,127	16	37	1,144	15	48
CNWR	1,158	28	13	1,058	21	27	1,091	18	40
Total	1,203	11	93	1,102	9	134	1,143	8	227

weather severity. Daily temperature was compared to survival rates using a proportional hazard model (Harrell 1983).

## RESULTS

### Condition

Mean body mass for the 227 female black ducks trapped during November–December, and alive at 19 December 1983–85, was 1,143  $\pm$  8 (SE) g (Table 1). There was variability in body mass (adjusted for wing length) related to age ( $P = 0.001$ ), and trap location ( $P = 0.04$ ) but not year ( $P = 0.23$ ). After-hatch-year birds had greater ( $P < 0.05$ ) body masses than did HY birds (Table 1). Ducks trapped at BNWR and DCWMA had greater ( $P < 0.05$ ) body masses than did birds trapped at CNWR; BNWR and DCWMA birds were not different. The most pronounced differences in body mass were due to age. After-hatch-year birds were structurally larger than HY birds ( $\bar{x}$  wing length 272.6

vs. 265.6 mm;  $P = 0.0001$ ), but mass corrected for structural size was also significantly greater, suggesting that HY black ducks have smaller nutrient reserves in early winter than do AHY ducks (Reinecke et al. 1982).

### Survival

Ninety-one (40%) of 227 ducks alive on 19 December survived until 15 February, 32 (14%) died from hunters, 38 (17%) were killed by causes other than hunting, and 66 (29%) could not be followed until 15 February (Table 2). Most (82%) of the ducks that could not be followed occurred in 1984–85 because transmitters began to fail in mid-January. Failure was coincidental with a series of storms in New Jersey, Delaware and Maryland. The 66 ducks that were not followed to 15 February were treated as censored observations; i.e., ducks were alive up to the time of radio failure or harness breakage, and had unknown fates beyond that time.

Table 2. Status on 15 February of female black ducks radiotagged at Brigantine Division, Forsythe National Wildlife Refuge (BNWR) and Dennis Creek Wildlife Management Area (DCWMA), New Jersey, and Chincoteague National Wildlife Refuge (CNWR), Virginia, and monitored 19 December–15 February, 1983–86.

Year	Trap location	Total	n alive	n dead			Unknown <sup>a</sup>
				Total	Hunting	Nonhunting	
1983	BNWR	34	14	14	7	7	6
	DCWMA	15	10	3	2	1	
	All areas	49	24	17	9	8	8
1984	BNWR	48	0 <sup>b</sup>	19	5	14	29 <sup>b</sup>
	DCWMA	15	0	3	2	1	12
	CNWR	20	2	5	3	2	13
	All areas	83	2	27	10	17	54
1985	BNWR	57	38	17	7	10	2
	DCWMA	18	13	5	3	2	0
	CNWR	20	14	4	3	1	2
	All areas	95	65	26	13	13	4
1983–85	BNWR	139	52	50	19	31	37
	DCWMA	48	23	11	7	4	14
	CNWR	40	16	9	6	3	15
	All areas	227	91	70	32	38	66

<sup>a</sup> Includes ducks whose status could not be determined because of radio failure or loss.

<sup>b</sup> Yr in which most radio failures or losses occurred, resulting in a very few ducks known to be alive 15 Feb.

Kaplan-Meier estimates for  $S$  were computed for hunting and nonhunting risk, and for overall survival (Table 3). Overall survival rates ranged from 0.54 (1984–85) to 0.72 (1985–86); the pooled estimate was 0.65. Survival from hunting and nonhunting risks were nearly equal in 1983 (0.78 and 0.77, respectively) and 1985 (0.86 and 0.84, respectively), whereas survival from nonhunting risk was lower in 1984 (0.86 and 0.63, respectively), which was a winter of sustained low temperatures and extensive icing. Estimates for  $S$  also were computed under 2 extreme assumptions about the fate of censored animals: that all ducks censored early in the study survived until 15 February, and that all ducks censored died at the time of censoring. These estimates give rise to logical upper and lower boundaries on the estimates of  $S$  (Table 3). However, we assume that all ducks whose radios failed or had harnesses that broke survived at the same mean rate as the radio-marked population, and thus, that the overall estimate is valid for all ducks. Possibly, ducks with a greater likelihood of disappearing (e.g., because of movement from the study area or radio failure) had different mortality rates; i.e., their censoring probabilities were not independent of survival probability (an assumption of the KM method [Pollock et al. 1989]). If this were the case, actual  $S$  may have been somewhat lower than  $\hat{S}_{\text{overall}}$ , but probably closer to  $\hat{S}_{\text{overall}}$  than to  $\hat{S}_{\text{upper}}$  or  $\hat{S}_{\text{lower}}$ . In particular,  $\hat{S}_{\text{lower}}$  was practically zero in 1984; and it is unlikely that actual survival was that low.

### Causes of Mortality

In most cases hunting mortality was documented by hunter reports of transmitters on shot ducks, or by tracking transmitters to hunters' residences. In a few instances hunting mortality was inferred when, for example, a transmitter was found in the vicinity of a duck blind with the harness wires cut. In 1 instance we found the remains of a duck that had been killed by an otter (*Lutra canadensis*). Upon subsequent examination we determined that the bird had a wing fracture caused by a pellet, and was a cripple when killed by the otter; we classified this death as a hunter-kill.

Of the 38 mortalities classified as nonhunting, we could identify probable cause of mortality for 21. Of these, 12 apparently were killed by predators, primarily raccoon (*Procyon lotor*) and red fox (*Vulpes fulva*). Most (9 of 12) of the

Table 3. Survival rates ( $\hat{S}$ ) of female black ducks radiotagged in New Jersey and Virginia and monitored from 19 December to 15 February, 1983–85.

Year	Source of risk	$\hat{S}$	SE	95% CI
1983				
	Hunting <sup>a</sup>	0.779	0.089	0.603–0.955
	Nonhunting <sup>b</sup>	0.770	0.090	0.594–0.945
	Overall	0.599	0.089	0.424–0.774
	Upper limit <sup>c</sup>	0.653	0.091	0.475–0.831
	Lower limit <sup>d</sup>	0.347	0.066	0.217–0.476
1984				
	Hunting	0.857	0.047	0.765–0.950
	Nonhunting	0.632	0.090	0.455–0.809
	Overall	0.542	0.086	0.372–0.711
	Upper limit	0.675	0.091	0.497–0.852
	Lower limit	0.024	0.012	0.001–0.047
1985				
	Hunting	0.857	0.039	0.780–0.934
	Nonhunting	0.843	0.041	0.763–0.923
	Overall	0.723	0.047	0.630–0.815
	Upper limit	0.726	0.047	0.634–0.819
	Lower limit	0.684	0.048	0.591–0.778
1983–85				
	Hunting	0.842	0.031	0.780–0.903
	Nonhunting	0.776	0.037	0.704–0.848
	Overall	0.653	0.038	0.578–0.728
	Upper limit	0.692	0.038	0.616–0.767
	Lower limit	0.370	0.032	0.308–0.432

<sup>a</sup> Survival from hunting risk obtained by treating nonhunting mortalities as censored.

<sup>b</sup> Survival from nonhunting risk obtained by treating hunting mortalities as censored.

<sup>c</sup> Logical upper bound to overall survival estimate; censored (e.g., radio failed) animals assumed to live until 15 Feb.

<sup>d</sup> Logical lower bound to overall survival estimate; censored animals assumed to die at date of last observation.

apparent predator kills were of HY black ducks. One HY black duck trapped at CNWR and killed by a fox in January 1985 had an ingested lead pellet in the gizzard; sublethal lead poisoning thus may have contributed to the death of this duck. Two black ducks radioed in 1985 (1 at BNWR and 1 at DCWMA) were killed in muskrat (*Ondatra zibethicus*) traps (at BNWR and in N.C., respectively).

We classified 3 mortalities (2 AHY and 1 HY) as starvation and/or hypothermia. All 3 deaths occurred during January 1985 near BNWR when a series of storms occurred in New Jersey, freezing the impoundments and most saltmarsh habitats by 10 January. Following this freeze, approximately 50 black ducks using saltmarsh habitats near BNWR were found dead or could not fly and were easily captured. Fourteen black ducks, including 1 marked bird, were collected and sent to the National Wildlife Health Laboratory (NWHL) for diagnosis. Ten were di-

Table 4. Sources of variation in survival rates ( $\hat{S}$ ) of female black ducks radiotagged in New Jersey and Virginia and monitored from 19 December to 15 February, 1983–86.

Risk source Source of variation	1983			1984			1985			1983–85		
	$\chi^2$	df	P	$\chi^2$	df	P	$\chi^2$	df	P	$\chi^2$	df	P
All risk												
Location (Loc)	1.62	1	0.20	1.77	2	0.41	0.88	2	0.64	3.56	2	0.17
Age	0.04	1	0.84	5.97	1	0.02*	0.99	1	0.32	4.46	1	0.04*
Body mass	7.10	1	0.01*	0.33	1	0.57	1.98	1	0.16	6.21	1	0.01*
Yr										0.81	2	0.67
Age–body mass	7.61	3	0.06*	6.81	3	0.08*	6.58	3	0.09*	10.33	3	0.02*
Loc–body mass	6.83	3	0.08*	4.33	5	0.50	3.58	5	0.61	11.27	5	0.05*
Loc–age	1.90	3	0.59	11.92	5	0.04*	3.01	5	0.70	10.82	5	0.06*
Hunting risk												
Loc	0.71	1	0.40	0.60	2	0.74	0.28	2	0.87	0.21	2	0.90
Age	1.49	1	0.22	2.73	1	0.10*	0.12	1	0.73	0.05	1	0.83
Body mass	4.68	1	0.03*	1.28	1	0.26	0.01	1	0.92	3.82	1	0.05*
Yr										0.69	3	0.71
Age–body mass	9.63	3	0.02*	3.35	3	0.34	4.58	3	0.21	6.32	3	0.10*
Loc–body mass	3.96	3	0.27	4.25	5	0.51	1.15	5	0.95	3.37	5	0.27
Loc–age	2.67	3	0.45	3.42	5	0.64	4.11	5	0.53	3.93	5	0.56
Nonhunting risk												
Loc	0.97	1	0.33	3.95	2	0.14	2.48	2	0.29	7.52	2	0.02*
Age	1.41	1	0.24	3.27	1	0.07*	3.49	1	0.06*	8.36	1	0.00*
Body mass	2.41	1	0.12	0.14	1	0.71	4.86	1	0.03*	2.39	1	0.12
Yr										2.19	2	0.33
Age–body mass	2.61	3	0.54	3.53	3	0.32	5.52	3	0.14	9.51	3	0.02*
Loc–body mass	3.57	3	0.31	5.39	5	0.37	7.67	5	0.18	10.77	5	0.06*
Loc–age	3.68	3	0.30	18.52	5	0.00*	8.35	5	0.14	26.81	5	0.00*

\* Gehan-Wilcoxon test rejected ( $P < 0.10$ ).

agnosed as having died from starvation; i.e., the pectoral muscles were atrophied and there were no deposits of subcutaneous, abdominal, mesenteric, or cardiac fat. The pectoral muscles of the radio-marked black duck were atrophied, but the duck contained subcutaneous, mesenteric, and cardiac fat. Two other marked ducks found dead near BNWR were not sent to NWHL; our examination showed that their pectoral muscles were severely atrophied and that no fat depots were present, suggesting that starvation caused mortality.

### Sources of Survival Rate Variation

Survival rate did not vary among locations within years, but was different among locations for survival from nonhunting risk when data were pooled across years (Table 4). Variation in  $\hat{S}$  was related to age (AHY vs. HY) for overall survival and survival from hunting and nonhunting risk in 1984, but not in the other 2 years. Survival was related to body mass (< median vs.  $\geq$  median) for overall risk and hunting risk in 1983, and for nonhunting risk in 1985. The combined effects of age and body mass were associated with survival in all 3 years for overall

risk, 1983 for hunting risk, and 1985 for nonhunting risk. The results of the proportional hazards models, in which body mass (adjusted for wing length as a covariate) was treated as a continuous variate, are generally consistent with these results (Table 5). Most of the differences related to these factors were consistent across years, and the survival curves were not different ( $P > 0.10$ ) among years (Table 4); thus, we present survival summary statistics (Table 6) based on the pooled data for 1983–86.

Survival rates were lower at BNWR than at DCWMA or CNWR, primarily as a function of higher nonhunting mortality rates at BNWR (Table 6); survival from hunting risk was similar among locations. After-hatch-year ducks had higher overall  $\hat{S}$  and survival from nonhunting risk; again, survival between ages from hunting risk was similar. Ducks having greater body mass had higher overall  $\hat{S}$ , mostly related to differences in hunting mortality. Survival from nonhunting risk of ducks having  $\geq$  median body masses was also greater, but the difference was not statistically significant. Survival was related to body mass in AHY birds, but not HY birds, again mostly survival from hunting risk. After-

hatch-year birds with  $\geq$  median body mass survived at higher rates from hunting and non-hunting risk, than did birds with  $<$  median mass (Table 6).

To avoid possible interactions between trap location and the effects of body mass and age on survival (Table 4), we tested the effects of body mass and age for each trap location separately. Because of small adult sample sizes, there were inadequate data at DCWMA (AHY  $n = 11$ ) and CNWR (AHY  $n = 13$ ) and we were able to test those effects for BNWR ducks only. We present the results for BNWR ducks pooled over years (Fig. 1). We also performed analyses for each year; the results were similar to the pooled analyses, but were not statistically significant. After-hatch-year ducks with  $\geq$  median body masses had higher  $S$  from all risk than did HY ducks ( $P = 0.01$ );  $\geq$  median AHY birds also had higher survival than  $<$  median AHY ducks, but the difference was not significant ( $P = 0.17$ ). Survival from hunting risk was higher ( $P = 0.10$ ) for AHY ducks having  $\geq$  median body mass than for AHY ducks with  $<$  median mass (Fig. 1). The survival from hunting risk of HY  $<$  median body mass birds was higher than the other 3 groups, but was not statistically different from that of HY  $>$  median ducks ( $P = 0.18$ ). Body mass did not appear to influence survival from nonhunting mortality; AHY ducks survived at higher rates than did HY ducks ( $P = 0.02$ ), but the effects of body mass within age class were negligible.

Daily temperature was not related consistently to survival probability. Daily temperature was related ( $P < 0.10$ ) to hazard (negative slope, with decreasing temperatures related to increasing hazard) in 1983. Slopes were negative but nonsignificant for nonhunting risk in 1984 and overall, and positive ( $P < 0.05$ ) for several other comparisons (e.g., all risk 1984 and 1985, hunting risk 1984). These results suggest a weak relationship between daily temperature and probability of survival.

### DISCUSSION AND MANAGEMENT IMPLICATIONS

Age and early winter physical condition of black ducks were predictive of overwinter survival. Our observations that AHY birds with lower body masses have higher vulnerability to hunting mortality are consistent with earlier work on canvasbacks (Haramis et al. 1986) and mallards (Hepp et al. 1986). Age-related differ-

Table 5. Effects of body mass (g), age, and trap location on survival rates ( $\hat{S}$ ) of female black ducks radiotagged in New Jersey and Virginia, 1983-85.

Independent variables	All risk			Hunting risk			Nonhunting risk					
	$\hat{b}$	SE	$\chi^2$	$p^b$	$\hat{b}$	SE	$\chi^2$	$P$	$\hat{b}$	SE	$\chi^2$	$P$
Body mass <sup>c</sup>	-0.002	0.001	3.83	0.05*	-0.001	0.002	0.56	0.45	-0.003	0.002	4.08	0.04*
Age	0.522	0.257	4.11	0.04* <sup>d</sup>	-0.096	0.360	0.07	0.79	0.933	0.382	5.98	0.02* <sup>e</sup>
Body mass   age <sup>e</sup>	-0.002	0.001	1.85	0.17	-0.001	0.002	0.70	0.40	-0.002	0.002	1.14	0.28
Age   body mass	0.473	0.304	2.42	0.12	-0.175	0.429	0.17	0.68	1.077	0.443	5.92	0.02*
Body mass   age												
Location yr	-0.002	0.001	3.18	0.07*	-0.002	0.002	0.74	0.38	-0.003	0.002	2.40	0.12
Age   Body mass												
Location yr	0.500	0.310	2.60	0.11	-0.268	0.441	0.37	0.54	1.211	0.451	7.13	0.01*

<sup>a</sup> Slope of relationship between independent variables and hazard function.  
<sup>b</sup>  $\chi^2$  test of  $H_0: b = 0$  (no relationship); critical value of  $P = 0.10$  selected for rejection (\*).  
<sup>c</sup> Body mass adjusted for wing length (mm) as a covariate.  
<sup>d</sup> Selected by a stepwise procedure ( $P = 0.05$ ).  
<sup>e</sup> Body mass adjusted for age and wing length.

Table 6. Survival rates ( $\hat{S}$ ) of female black ducks radiotagged in New Jersey and Virginia and monitored from 19 December to 15 February, 1983–85; data pooled across years.

	All risk		Hunting risk		Nonhunting risk	
	$\hat{S}$	SE	$\hat{S}$	SE	$\hat{S}$	SE
Location <sup>a</sup>						
BNWR	0.602**	0.048	0.850	0.036	0.709*	0.049
DCWMA	0.734	0.079	0.834	0.065	0.880	0.064
CNWR	0.754	0.073	0.834	0.067	0.904	0.053
Age						
AHY	0.729**	0.058	0.851	0.045	0.857**	0.050
HY	0.599**	0.048	0.835	0.038	0.718**	0.048
Body mass						
<median	0.580**	0.053	0.793**	0.048	0.732	0.053
≥median	0.728**	0.051	0.890**	0.034	0.818	0.047
Age–body mass						
AHY						
<median	0.612**	0.087	0.764**	0.077	0.801	0.082
≥median	0.846**	0.064	0.934**	0.037	0.906	0.052
HY						
<median	0.640	0.061	0.884	0.044	0.725	0.060
≥median	0.547	0.075	0.782	0.060	0.701	0.078
Location–body mass						
BNWR						
<median	0.537*	0.065	0.795*	0.053	0.676	0.068
≥median	0.665*	0.066	0.903*	0.041	0.737	0.065
DCWMA						
<median	0.612*	0.135	0.765	0.093	0.800	0.108
≥median	0.856*	0.087	0.893	0.078	0.958	0.040
CNWR						
<median	0.711	0.106	0.884	0.078	0.804	0.099
≥median	0.791	0.097	0.791	0.097	1.000	0.000
Location–age						
BNWR						
AHY	0.725**	0.064	0.834	0.047	0.869**	0.053
HY	0.486*	0.065	0.864	0.050	0.564**	0.069
DCWMA						
AHY	0.729	0.155	1.000	0.000	0.729	0.155
HY	0.733	0.085	0.780	0.082	0.939	0.042
CNWR						
AHY	0.746	0.125	0.821	0.116	0.909	0.083
HY	0.758	0.088	0.841	0.073	0.902	0.067

<sup>a</sup> Brigantine Division, Forsythe National Wildlife Refuge, N.J. (BNWR); Dennis Creek Wildlife Management Area, N.J. (DCWMA); Chincoteague National Wildlife Refuge, Va. (CNWR).

<sup>b</sup> Different (\* =  $P < 0.10$ , \*\* =  $P < 0.05$ ) from  $\hat{S}$  of other group(s); e.g.,  $S_{BNWR} < S_{DCWMA}$ ,  $S_{BNWR} < S_{CNWR}$  (all risk).

ential vulnerability to nonhunting risk is consistent with the observation by Reinecke et al. (1982) that HY female black ducks have lower nutrient reserves in their first winter. Hatch-year ducks were, as a group, in poorer condition than AHY ducks; but variability in body mass among HY ducks was not predictive of survival.

We do not know why HY ducks were in poorer condition, or why low body mass ducks survived at lower rates. Conroy et al. (1987) examined the movements of radio-tagged black ducks near BNWR, and found that HY ducks having <

median body masses used the BNWR impoundments less frequently, and spent more time foraging in saltmarsh habitats, than did AHY or HY ducks having ≥ median body masses. Hatch-year ducks may be less efficient foragers than AHY ducks, perhaps through inexperience, and may spend more time in energetically costly activities (e.g., foraging flights) than AHY ducks.

We speculate that weather is important in influencing overwinter survival; however, our analyses revealed no apparent relationship between average daily temperature and survival



probability. Overall environmental conditions were most severe (prolonged low temperatures, extensive icing) in 1983-84 ( $\bar{x}$  temp = -1.19 and 0.96 C for N.J. and Va., respectively; 32 and 22 days of temp <0 C for N.J. and Va., respectively), compared to 1984 and 1985 ( $\bar{x}$  temp = 1.46 and 1.76 C for N.J. and Va., respectively; 22.5 and 21.5 days <0 C for N.J. and Va., respectively) but we observed the greatest amount of starvation and hypothermia during 1984-85, especially at BNWR. One possibility is that the timing of the onset of icing on feeding areas is the critical component, rather than overall severity of winter. Freeze-up in New Jersey occurred on 19 December 1983, 10 January 1985, and 29 December 1985. Nichols et al. (1983) suggested that wintering mallards exhibit a threshold migration response to ice cover, rather than a gradual shift based on decreasing temperature. Our observation of black duck movements suggested that more dispersal, including long-distance migration, occurred in years when freeze-up occurred earlier (1983 and 1985) than later (1984-85).

Survival rates of ducks trapped at BNWR were lower than those at DCWMA or at CNWR. Parts of BNWR and CNWR were not hunted. Mean winter temperatures at BNWR and DCWMA are similar, but temperatures at CNWR were generally warmer than in southern New Jersey. A possible explanation for difference in survivorship is the influence of the freshwater impoundments at BNWR. Our observations suggest that many black ducks are attracted to the freshwater impoundments and may be held longer into the winter than would occur in the absence of the impoundments. If extensive icing occurs later in winter, as happened 1984-85, birds that are attracted by the impoundments may be at more risk from nonhunting mortality. Most of the differences in mortality among locations were from greater nonhunting mortality at BNWR, and most of that was associated with periods of severe icing and below normal temperatures in late December-mid-January.

Our observed *S*, and the differential between HY and AHY ducks, can be related to the annual life cycle of black ducks by considering available annual and seasonal survival estimates (Table 7). We caution that these rates are approximations, and represent overlapping periods (e.g., hunting season and winter overlap). In Table 7, we consider only nonhunting mortality in our winter estimate, because the independent esti-

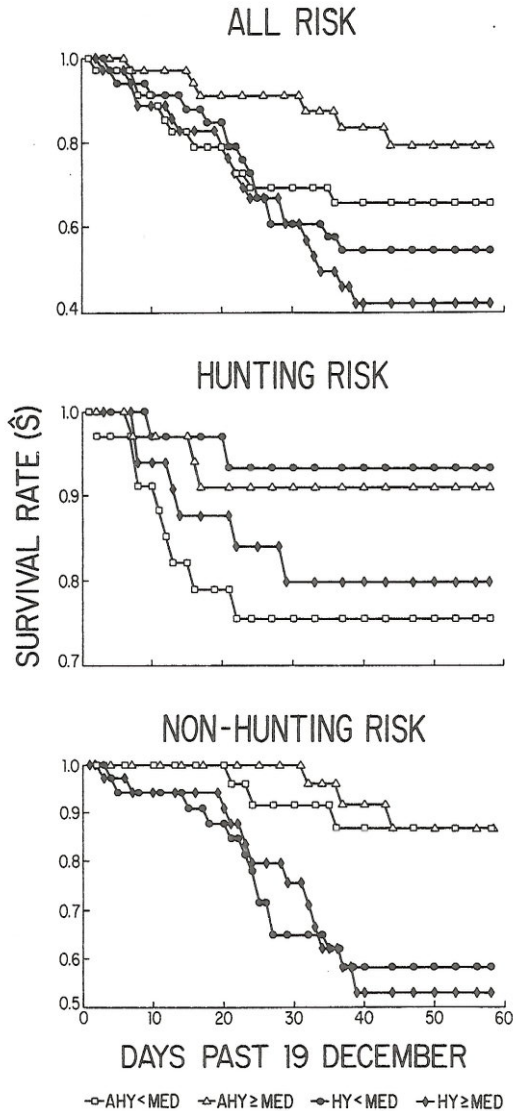


Fig. 1. Survival probabilities from all risk factors, hunting risk, and nonhunting risk for female black ducks radiotagged at Brigantine National Wildlife Refuge, New Jersey and monitored from 19 December to 15 February 1983-85; by age (after-hatch-year [AHY] and hatch-year [HY]) and body mass classes (< median [med] body mass and ≥ median body mass).

mate of survival from hunting risk includes exposure to hunting during winter. The products of the separate estimates ( $H \cdot W \cdot B \cdot P$ , Table 7) are in close agreement with the estimated annual survival rates of 0.45 and 0.35 for AHY and HY black ducks, respectively; suggesting, that our estimates of winter nonhunting mortality are at least consistent with estimates of total annual survival and seasonal survival rates from other studies. Overall, hatch-year ducks

Table 7. Estimates of survival rates (S) by age for female black ducks during different seasons.

Period	After-hatch-year	Hatch-year
Hunting season (H)	0.82 <sup>a</sup>	0.71 <sup>a</sup>
Winter (W)	0.86 <sup>b</sup>	0.72 <sup>b</sup>
Breeding (B)	0.74 <sup>c</sup>	0.74 <sup>c</sup>
Postbreeding (P)	0.95 <sup>d</sup>	0.95
Annual	0.45 <sup>a</sup>	0.35 <sup>a</sup>
H·W·B·P	0.50	0.36

<sup>a</sup> Estimated from band-recovery data (Krementz et al. 1988).

<sup>b</sup> Present study, Table 6 (nonhunting risk only).

<sup>c</sup> Ringelman and Longcore (1983), assuming equal survivorship for second yr and later birds.

<sup>d</sup> For mallards (Kirby and Cowardin 1986).

are more vulnerable to hunting than AHY ducks, but this differential vulnerability seems to diminish by winter, as evidenced by similar survival rates from hunting risk for AHY and HY ducks (Table 6). Our data for BNWR ducks show that differential vulnerability may be maintained through winter by higher risk of HY ducks to mortality other than hunting.

The radio transmitters may have affected S of our radio-marked sample. We noticed no differences in the behavior or movement patterns of radioed black ducks and other ducks at BNWR, DCWMA, or CNWR. Radioed ducks were shot by hunters 500 km south (N.C.) and 600 km north (Que.) of our trapping sites. The hunters who shot our radioed ducks reported no behavioral anomalies or apparent lack of wariness. We also noted no differences in wariness of radioed black ducks and other ducks during our efforts to collect black ducks in March–April. However, G. R. Costanzo (unpubl. data) found losses of 16–18% of body mass over December–March for radioed ducks collected in March, compared to 5–7% body mass differences observed in December and March trapped samples; the relative mass changes were similar for HY and AHY ducks. These results suggest that radio packages may have lowered S for our sample, compared to the remainder of the population. We believe the effect on S to be small, and that our comparative inferences regarding S are still valid. Our estimates of S (Table 7), although possibly biased (low), are generally consistent with evidence from the remainder of the life cycle of female black ducks.

Our results may have important implications for the management of black ducks during winter. We were able to predict differential survivorship from the age and early winter body mass of female black ducks. Preliminary evidence

from our telemetry study (Conroy et al. 1987; G. R. Costanzo, unpubl. data) suggests that black ducks in different age and condition categories use habitats differently: spatially, temporally, or both. Management might be directed toward maintenance of habitats used by the most vulnerable segments of the population (low body mass and HY ducks). These results may have important implications for harvest management because HY ducks, which are more vulnerable to hunting than AHY ducks, may respond to hunting in an additive fashion (Krementz et al. 1988), and are more vulnerable to nonhunting mortality. Identification and protection of important wintering habitats for these vulnerable segments may be a management tool for enhancing overall survival of black ducks.

## LITERATURE CITED

- ALBRIGHT, J. J. 1981. Behavioral and physiological responses of coastal wintering black ducks (*Anas rubripes*) to changing weather in Maine. M.S. Thesis, Univ. Maine, Orono. 72pp.
- BARSKE, P., editor. 1968. The black duck. Evaluation, management and research: a symposium. Atl. Waterfowl Council and Wildl. Manage. Inst. 193pp.
- BART, J., AND D. S. ROBSON. 1982. Estimating survivorship when the subjects are visited periodically. *Ecology* 63:1078–1090.
- BLANDIN, W. W. 1982. Population characteristics and simulation modelling of black ducks. Ph.D. Thesis, Clark Univ., Worcester, Mass. 345pp.
- COCHRAN, W. W. 1980. Wildlife telemetry. Pages 507–520 in S. P. Schemnitz, ed. Wildlife management techniques. Fourth ed. Wildlife Soc. Inc., Washington, D.C.
- CONROY, M. J., G. R. COSTANZO, AND D. B. STOTTS. 1987. Winter movements of American black ducks in relation to natural and impounded wetlands in New Jersey. Pages 31–45 in W. R. Whitman and W. H. Meredith, eds. Waterfowl and wetlands symposium: proceedings of a symposium on waterfowl and wetlands management in the coastal zone of the Atlantic Flyway. Del. Coastal Manage. Prog., Del. Dep. Nat. Resour. and Environ. Control.
- COX, D. R., AND D. OAKES. 1984. Analysis of survival data. Chapman and Hall, New York, N.Y. 193pp.
- DWYER, T. J. 1972. An adjustable radio-package for ducks. *Bird-banding* 43:282–284.
- FEIERABEND, J. S. 1984. The black duck: an international resource on trial in the United States. *Wildl. Soc. Bull.* 12:128–134.
- GILMER, D. S., L. M. COWARDIN, R. L. DUVAL, C. W. SCHAFFER, AND V. B. KUECHLE. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Fish and Wildl. Serv. Resour. Publ. 140. 19pp.
- GRANDY, J. W. 1983. The North American black

- duck (*Anas rubripes*): a case study of 28 years of failure in American wildlife management. Int. J. Stud. Anim. Problems Suppl. 4: 35pp.
- GREENWOOD, R. J., AND A. B. SARGEANT. 1973. Influences of radio packages on captive mallards and blue-winged teal. J. Wildl. Manage. 37:3-9.
- HARAMIS, G. M., J. D. NICHOLS, K. H. POLLOCK, AND J. E. HINES. 1986. The relationship between body mass and survival of wintering canvasbacks. Auk 103:506-514.
- HARRELL, F. E. 1983. The PHGLM procedure. Pages 267-294 in S. P. Joyner, ed. SUGI supplemental library user's guide. SAS Institute, Inc., Cary, N.C.
- HENSLE, G. L., AND J. D. NICHOLS. 1981. The Mayfield method of estimating nesting success: a model, estimators, and simulation results. Wilson Bull. 93:42-53.
- HEPP, G. R., R. J. BLOHM, R. E. REYNOLDS, J. E. HINES, AND J. D. NICHOLS. 1986. Physiological condition of autumn-banded mallards and its relationship to hunting vulnerability. J. Wildl. Manage. 50:177-183.
- JOHNSGARD, P. A. 1961. Wintering distribution changes in mallards and black ducks. Am. Midl. Nat. 66:477-484.
- . 1967. Sympatry changes and hybridization incidence in mallards and black ducks. Am. Midl. Nat. 77:51-63.
- KAPLAN, E. L., AND P. MEIER. 1958. Nonparametric estimation from incomplete observations. J. Am. Stat. Assoc. 53:457-481.
- KIRBY, R. E., AND L. M. COWARDIN. 1986. Spring and summer survival of female mallards from northcentral Minnesota. J. Wildl. Manage. 50: 38-43.
- Krementsz, D. G., M. J. Conroy, J. E. Hines, and H. F. Percival. 1987. Sources of variation in survival and recovery rates of American black ducks. J. Wildl. Manage. 51:689-700.
- , ———, ———, and ———. 1988. Effects of hunting on survival rates of American black ducks. J. Wildl. Manage. 52:214-226.
- NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. 1983-85. Local climatological data, monthly summaries for Atlantic City, N.J. and Wallops Island, Va. Natl. Climatic Data Cent., Asheville, N.C.
- NICHOLS, J. D., K. J. REINECKE, AND J. E. HINES. 1983. Factors affecting the distribution of mallards wintering in the Mississippi alluvial valley. Auk 100:932-946.
- POLLOCK, K. H., S. R. WINTERSTEIN, AND M. J. CONROY. 1989. Estimation and analysis of survival distributions for radio-tagged animals. Biometrics. In Press.
- REINECKE, K. J., T. L. STONE, AND R. B. OWEN, JR. 1982. Seasonal carcass composition and energy balance of female black ducks in Maine. Condor 84:420-426.
- RINGELMAN, J. K., AND J. R. LONGCORE. 1983. Survival of female black ducks, *Anas rubripes*, during the breeding season. Can. Field-Nat. 97:62-65.
- SCHIERBAUM, D. C., AND D. D. FOLEY. 1957. Differential age and sex vulnerability of the black duck to gunning. N.Y. Fish and Game J. 4:88-91.
- THERNEAU, T. M. 1983. The SURVTEST procedure. Pages 343-346 in S. P. Joyner, ed. SUGI supplemental library user's guide. SAS Institute, Inc., Cary, N.C. 402pp.
- WOOLEY, J. B., AND R. B. OWEN, JR. 1978. Energy costs of activity and daily energy expenditure in the black duck. J. Wildl. Manage. 42:739-745.

Received 2 September 1987.

Accepted 2 August 1988.