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SURVIVAL AND MOVEMENT OF POSTFLEDGING JUVENILE HARLEQUIN DUCKS

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ABSTRACT.—Age specific survival and movement are important components of demography and population

My objectives were to use radio marking to estimate survival and movement of juveniles during their first winter and to allow separation of mortality from emigration, to use capture-mark-recapture (CMR) analysis to compare local survival among sex-age classes, to determine whether age specific mortality rates

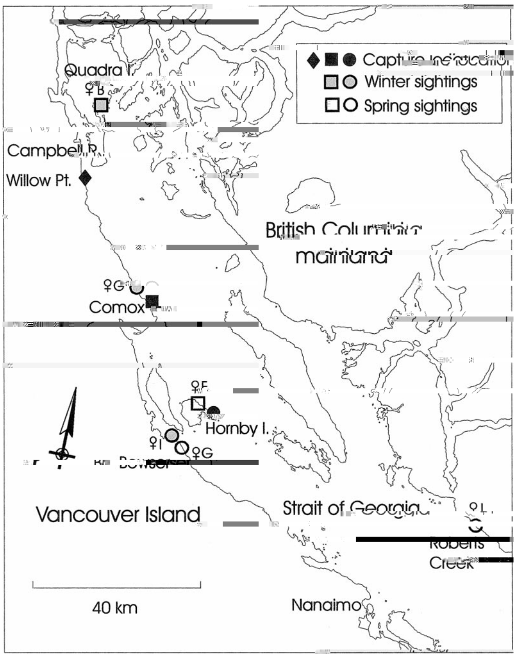

FIG. 1. Four of eight juvenile female Harlequin Ducks marked with external radio transmitters moved . 10 km from their capture location in the northern Strait of Georgia, British Columbia, Canada, 2000–2001. Capture locations are shown as solid symbols; winter (mid-October through February) and spring (March) sighting locations of females that moved . 10 km are shown as partially filled and unfilled symbols, respectively, with the type of symbol indicating the capture location from which the individual originated. Individual females are identified with letters (see also Table 2).

weeks during fall, and 1–4 weeks during spring. From September to December 2000, I located juveniles with radio transmitters from land, or with fixed-wing aircraft. I conducted three telemetry flights in October and November and covered the northern Strait of Georgia, from the northern end of Quadra Island to Nanaimo (Fig. 1) at least once, and most areas at least twice. I determined distances individuals had moved from capture locations using a handheld GPS unit or from measurements taken from marine charts. I report records during winter (mid-October through February) separately from those during spring (March) because movement during spring can be associated with aggregation at herring spawning sites (Rodway et al. 2003b). I could not compare movement distances between radio-marked males and females due to small sample size of surviving males (see results). However, I was able to compare philopatry between the sexes by comparing proportions of all marked juveniles (captured before 2000) observed at their capture location during their second winter at the coast.

I was able to monitor survival of most juveniles carrying transmitters from September through November, until batteries failed or transmitters were lost, after which juveniles were resighted opportunistically. I confirmed the death of radio-marked juveniles by pinpointing their transmitters to small areas (several m^2) of dense shoreline vegetation (two cases), or by retrieving the carcass (one case).

I estimated local survival rates and tested hypotheses that they differed by sex and by age (juvenile and postjuvenile) using sightings of all juveniles marked with bands (21 females, 13 males) and the CMR program MARK (White and Burnham 1999). I devel-

TABLE 1. Candidate models ranked in order of increasing QAIC$_c$ indicate that survival rate differs by age (juvenile versus postjuvenile) and resighting rate differs by season (fall versus spring) for banded Harlequin Ducks, captured as juveniles, in the northern Strait of Georgia, British Columbia, 1995–2000. AIC$_c$ values were adjusted for $\hat{c}$ of 1.24.

Model description	Number of parameters	QAIC$_c$	Delta QAIC$_c$	QAIC$_c$ weight
Survival rate differs by age, sighting rate differs by season	4	114.26	0.00	0.4552
Survival rate differs by sex, sighting rate differs by season	4	115.28	1.02	0.2728
Survival rate differs by age and sex, sighting rate differs by season	6	115.88	1.62	0.2020
Survival rate differs by age, sex, and season for the juvenile age class, sighting rate differs by season	8	119.21	4.95	0.0382
Survival rate differs by age, sex, and season for the juvenile age class and for postjuvenile females, sighting rate differs by season	9	120.17	5.91	0.0237
Survival rate differs by age, sex, and season for both age classes, sighting rate differs by season (general model)	10	122.32	8.06	0.0081
Survival and sighting rates are constant	2	138.56	24.30	0.0000
Survival rate differs by age, sighting rate is constant	3	139.65	25.39	0.0000
Survival rate differs by sex, sighting rate is constant	3	140.21	25.95	0.0000
Survival rate differs by sex and age, sighting rate is constant	5	142.07	27.81	0.0000

in their capture location. I set type I error rate at 0.05.

RESULTS

Among radio-marked juveniles, a greater proportion of males died (50%, *n* 5 6) than did females (0%, *n* 5 9; Fisher's exact test, *P* 5 0.044). All deaths occurred within 46 days after capture. Two of the males that died were unusually light at capture (males N and O, Table 2). The death of the third male 46 days after capture (male K, Table 2) most likely was due to predation; four days earlier he had been observed 2 km from his capture location, feeding alongside two juvenile females. Based on sightings during and after the study period, I determined that $8 of the 9 radio-marked females survived the winter.

I contrasted 10 models in CMR analysis to test hypotheses that local survival rates differed by sex and age, and to estimate sex and age specific local survival rates (Table 1). Bootstrap goodness-of-fit testing with 1,000 simulations revealed adequate model fit; the probability of a deviance as great or greater than that of the most general model was 0.12, and the variance inflation factor, $\hat{c}$, was estimated at 1.24. Three models had similar QAICcs (differing by , 2), thus they were fairly similar in their abilities to describe the data in a parsimonious manner and I drew inferences from this subset of models (Lebreton et al. 1992, Anderson and Burnham 1999). The most saturated of the three models estimated separate 6-month local survival rates for juvenile males (0.58 6

derson 1988, Anderson et al. 1992), and assumptions of male-biased dispersal in young Harlequin Ducks (Cooke et al. 2000), proportions of banded male and female juveniles resighted at their capture locations during their second winter did not differ, suggesting equal dispersal rates. Third, radio marking in combination with CMR analysis indicated that first-winter survival of juvenile Harlequin Duck females was high, providing further evidence that female winter survival may be similar among age groups. Conclusions pertaining to female survival rates must, however, be treated with caution due to sample size limitations.

Results of this study also suggest that juvenile male Harlequin Ducks may be more likely to die than juvenile females. However, inferences regarding differences in survival between the sexes are weak due to small sample sizes of radio-marked birds. Although lower survival of juvenile males relative to the other sex-age classes also was supported by CMR analyses, the local survival rates estimated by CMR analysis reflect a combination of mortality and emigration, and large confidence intervals surrounding point estimates limit confidence in apparent differences. The male dispersal distances, possibly in combination with higher death rates, could account for lower local survival of male than female juveniles.

Results of this study have implications for genetic and demographic population structure of Harlequin Ducks. Juvenile Harlequin Ducks are believed to leave inland breeding areas and arrive at coastal wintering areas in family groups accompanied by their mothers, at least when families are intact at the time of fledging (Regehr et al. 2001). In this study, juveniles of both sexes dispersed from their coastal capture locations, suggesting that both sexes likely contribute to gene flow among populations. Also, dispersal of females in addition to males increases the potential for demographic connection among populations because successful recolonization or rescue of extinct or reduced populations are dependent upon female movement (Avise 1995). Further study is required to test the idea that low local survival rates of juvenile males may be partly due to higher death rates, to resolve potential sex differences in juvenile dispersal distances, and to investigate what factors affect differences in dispersal strategies among individuals of the same sex. Exceptions to patterns of sex-bias in subsets of populations can aid in our overall understanding of the evolutionary forces shaping dispersal patterns.

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