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Supplementary material

Appendix 1

Fig. A1. Partial range map for Snow Buntings, illustrating wintering areas featured in this study. Birds in the Great Lakes region and eastward breed in Greenland, birds wintering west of the great lakes breed in the Canadian Arctic (see Macdonald et al. Animal Migration, cited in main text). Note that the full range for this species includes Arctic and north-temperate zones worldwide. Shapefiles of range obtained from BirdLife International and NatureServe (2014) (BirdLife International, Cambridge, UK and NatureServe, Arlington, USA).

Detailed geolocator deployment methods and analyses of potential effects on birds

Geolocators were attached to Snow Buntings by a custom-fit leg-loop harness made of 2.5mm-wide Teflon ribbon. In 2010 we used British Antarctic Survey MK12S models with 5mm stalk, and in 2011 and 2012, we used MK20AS; both models weighed 0.8g, or 1.1g including the harness. Geolocators were deployed on adult breeding birds in all years. In 2010 we also deployed 20 geolocators on fledged hatch-year birds; none of these birds returned in 2011, and neither did any of 47 banded-only hatch year birds from the same year. Hatch-year birds were not included in analyses of return rates because of their inherently low survival probability (range of 0-12% return rate, overall rate of 3.5%, at EBI based on 313 hatch-year birds banded between 2007-2012). In 2010 and 2011, males of nesting pairs were trapped during egg-laying, and both members of the pair were re-trapped during late nestling provisioning. Geolocators were attached to adults after breeding was completed (i.e. post-fledging; 15-30 July in 2010 and 7-24 July in 2011). In 2012 geolocators were deployed earlier (starting 5 June, most deployed between 19-25 June) on birds that were known to breed at East Bay (recaptures from previous years) or birds showing signs of pairing/nesting (first egg dates ~mid-June) to avoid deploying tags on transient birds. Geolocators were retrieved from returning birds as early as possible, and usually before nesting and soon after arrival at the study site.

Geolocator return rate by size, sex, and age

Negative effects of geolocators are assumed to relate to their added weight, which can result in higher wing-loading and thus more energy required for flight. This is especially thought to be an issue for relatively small birds, often characteristic of first-year breeders and females. The geolocators deployed on Snow Buntings during this study (n = 83) weighed 1.1g (including

harness), or approximately 3.01 ± 0.25 % of the mean weight of males (n = 310) and 3.23 ± 0.32 % of the mean weight of females (n = 213) at our study site. We tested for effects of age, sex, and size (mass) on the likelihood that geolocator-wearing birds returned to our study site. We could not compare return rates of geolocators birds to birds that were only banded since nearly all breeding birds at our study site received geolocators. Comparisons to return rates in other years were also not possible because of additional handling and sampling of birds during deployment years for concurrent studies, and natural yearly variation in return rates (Love unpubl. data).

To test if returning birds were those that were larger, or from a specific age or sex class, we used generalized linear models with recapture status as the binomial response (returned or did not), and age, sex, size and year as predictors. Wing length and mass were positively correlated ($r = 0.46$, $P < 0.001$). Therefore, we only included mass in further analysis, as compared with wing, it accounted for more variation explained in the models compared. First we used a mixed-effects model with year as a random factor, however year had no significant effect (0 variance explained) therefore we continued with standard generalized linear models with binomial error distribution. We used the R package lmerTest to generate p-values for model estimates.

Return rate of geolocator birds overall was 29% (Table 1), which is within the normal range at our study site (27-43%; unpubl. data). We found that returning birds with geolocators were not significantly bigger when they were tagged relative to birds that did not return (estimate 0.25 ±0.18, $z = 1.39$, $P = 0.16$) (Fig. A2), neither were males more likely to return than females (estimate -1.29 ±0.90, $z = -1.44$, $P = 0.15$) (Fig. A3). Second-year birds were not more

likely to return than adults overall (estimate -0.48 ±1.24, z = -0.40, P = 0.70) (Fig. A3), but there was a small but significant interaction between age and sex, in that second-year males were more likely to return wearing geolocators than other age-sex groups (estimate 3.19 ±1.59, z = 2.01, P = 0.04).

Table A1. Relative return rates of geolocator birds from East Bay Island by year and by sex.

Year deployed–retrieved	# Geolocators deployed	# Geolocators returned
2010-2011[a]	30	6 (20%)
2011-2012	28	7 (25%)
2012-2013	25	8 (32%)
TOTAL	83	21 (25%)
Overall females	40	9 (22.5%)
Overall males	42	12 (29%)

[a] Does not include 20 geolocators deployed on fledged hatch-year birds, of which none returned (see text above for details).

(a) (b)

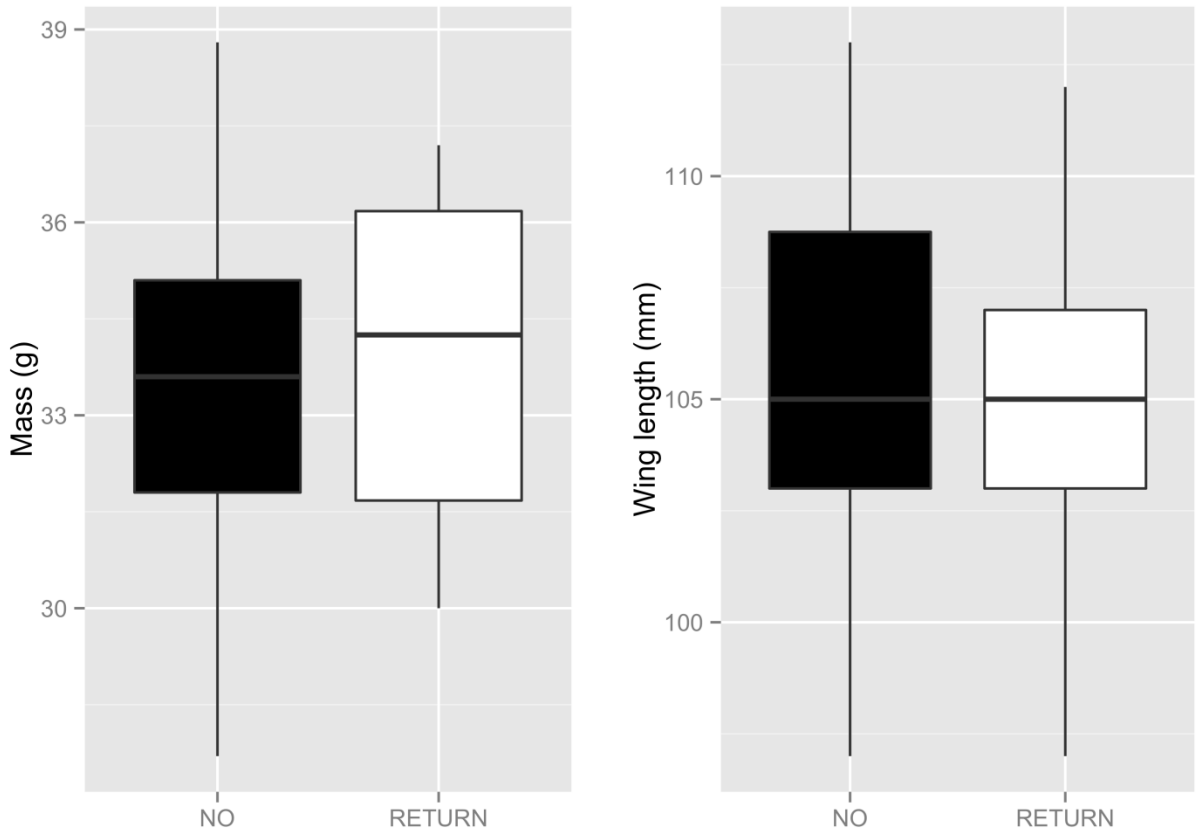

Figure A2. (a) Mass and (b) wing length for birds which received geolocators and did not return ('NO') compared to those that did return with geolocators ('RETURN') were not significantly different. Boxplots show median with boxes extending to first and third quartile and whiskers extending to maximum and minimum.

(a) (b)

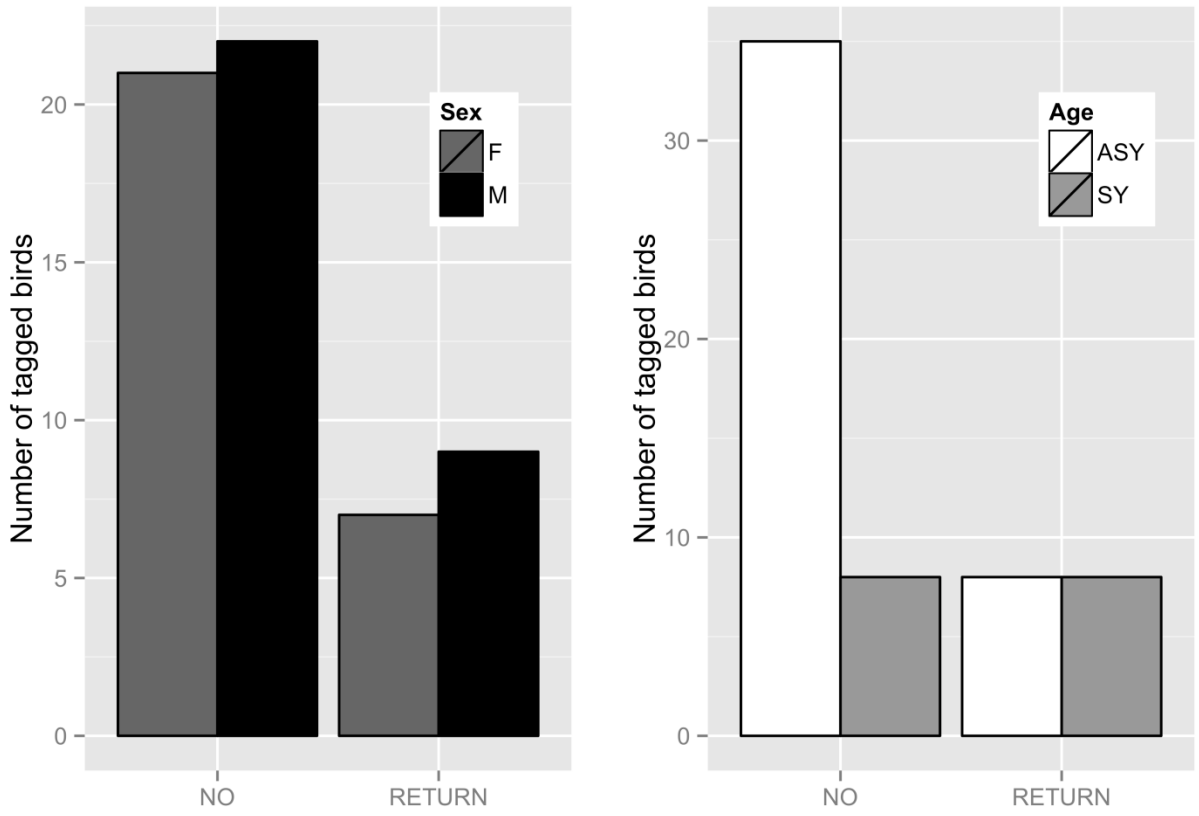

Figure A3. Number of geolocator-tagged birds by (a) sex and (b) age that did not return ('NO') compared to the number that did return ('RETURN'). There were significantly more SY males that returned relative to the other age-sex groups.