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Mortality rates of Hudson Bay Snow Geese, 1967–74[1]

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Abstract
Estimated mortality rates of Lesser Snow Geese banded at three Hudson Bay colonies (McConnell River, NWT; La Pérouse Bay, Man.; Cape Henrietta Maria, Ont.) show wide yearly fluctuations in the 8 years 1966–67 to 1973–74. The rates for young geese in the first year after fledging varied from 37.9% (in 1973–74) to 76.3% (in 1967–68), with a period mean of 58.9%. The rates for adult geese (more than a year old when first marked) varied from 7.9% (in 1973–74) to 64.8% (in 1966–67), with a mean of 25.0% There was a marked downward trend in first-year mortality over the period, but no marked trend in adult losses. Rates of loss of adults and young in the same year were highly correlated.

Introduction

Examining recovery series from banded Snow Geese in 1972 I obtained some rather unexpected results, which were referred to briefly in a preliminary report on recovery analyses by Dzubin, Boyd and Stephen (1975). The most striking results were: (1) mortality rates of adult geese were higher in 1967–71 than in some earlier years, back to 1952; (2) mortality of young geese in the first year of life after banding, though higher than that of older geese, showed less year to year variability; (3) there were no evident differences in the mortality of marked birds from the eastern and western Hudson Bay stocks, although the recovery rates of eastern birds were lower. Because the estimated rates of adult mortality in the period 1967–71 were unexpectedly high and might therefore indicate a deterioration in the welfare of these Snow Goose stocks, I have re-examined the recovery data, including those reported up to August 1975. In this Note I have re-applied Ricker's method of estimating survival, as used in 1972, to the corrected and updated recoveries of recent years and have compared the annual estimates of survival with recent information on the size of the population.

Estimates of annual survival, 1966–67 to 1973–74

The estimator used (after Ricker 1958) is $\hat{s} = \dfrac{B_2\, R_{13}}{B_1\,(R_{23}+1)}$

with variance $(\hat{s}) = (\hat{s})^2 - \dfrac{(B_2)^2\, R_{13}\,(R_{13}-1)}{(B_1)^2\,(R_{23}+1)\,(R_{23}+2)}$

where $\hat{s}$ = estimated rate of survival between times t_1 and t_2; B_1 and B_2 = number of birds banded at times t_1 and t_2 respectively; R_{13} = recoveries of birds banded at t_1 and made after t_2; R_{23} = recoveries of birds banded at t_2. In this application period 3 (= after time 2) is variable, extending from time t_2 (whenever that was) to the cut-off date of February 1975. For simplicity and consistency, only recoveries due to hunting during the legal open seasons have been used in determining the R_{ij}. The B_t refer to newly-banded geese only, ignoring recaptures and rebandings. The estimated variance allows for sampling variability but not for heterogeneity within the population.

The western Hudson Bay samples result from bandings at the very large McConnell River colony (about 150 000 breeding pairs in 1973: Kerbes 1975) in 1968 to 1970 and at the much smaller La Pérouse colony each year since 1969. Nearly all the adult geese marked at the McConnell River during the period were fitted with conspicuous metal and plastic neck collars. These apparently increased the reporting rate of the associated leg bands, but not the mortality rate of the marked geese. At La Pérouse Bay, Manitoba, where about 3 000 pairs have nested in recent years (Kerbes 1975), a high proportion of the geese in the colony is now banded, so that the marked birds are fully representative of those in the colony. At Cape Henrietta Maria (CHM), Ontario, substantial annual bandings have been accomplished annually since 1969. As no banding has been done on Baffin Island since 1968, the CHM bandings have to be taken as representative of the Eastern stock thereafter, even though the Cape is far south of Baffin Island. The geographical distribution of band recoveries from the two sites make this assumption appear less unreasonable than might be supposed (Dzubin, Boyd and Stephen 1975).

Despite the relatively large number of geese banded and the high cumulative recovery rates (as compared with those for most species of birds), the variances of the survival estimates are high and the probable limits wide. I have narrowed the limits by combining data from the two sexes and the two colour phases and in some cases from the various banding sources. That involves a risky judgement that population heterogeneity is not of over-riding importance as compared with sample size. The general consistency of estimates from different samples in the same year (Table 1) encourages that belief. My interest here is not in the subtleties of intra- and inter-colony variation, but in gaining from banding some idea of gross changes in survival from year to year and, especially, over a run of years: are there discernible trends?

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Table 1

Estimates of annual survival of Hudson Bay Lesser Snow Geese banded at McConnell River (NWT), La Pérouse Bay (Man.) and Cape Henrietta Maria (Ont.), for the years 1966–67 to 1973–74. Data for blue and white colour phases and for males and females are pooled

Banding year	McConnell River					La Pérouse Bay					Cape Henrietta Maria				
	B_1^*	R_{13}	R_{23}	$\hat{s}$	s.d. ($\hat{s}$)	B_1	R_{13}	R_{23}	$\hat{s}$	s.d. ($\hat{s}$)	B_1	R_{13}	R_{23}	$\hat{s}$	s.d. ($\hat{s}$)
Adults (more than 1 year old when banded)															
1966	827	53	228	0.3521	0.0536	–					–				
1967	1258	138	250	0.7085	0.0749	–					–				
1968	1621	199	162	0.7848	0.0826	–					–				
1969	1042	100	211	0.6899	0.0835	71	7	141	0.7235	0.2793	2025	157	157	0.9858	0.1107
1970	1524	123	253	0.6835	0.0749	1042	91	74	0.6532	0.1012	2009	102	64	0.5491	0.0865
1971	2151	–				561	54	124	0.8601	0.1395	703	38	46	1.1479	0.2478
1972	–					1117	52	97	0.5087	0.0870	998	28	53	0.7056	0.1628
1973	–					1060	39	32	0.7945	0.1866	1358	29	60	0.8132	0.1820
First year birds															
1966	3969	186		0.2574	0.0254	–					–				
1967	2519	85		0.2179	0.0273	–					–				
1968	1450	126		0.5555	0.0657	–					–				
1969	1565	78		0.3583	0.0474	578	38		0.4824	0.0877	40	1		0.3179	0.0253
1970	1041	64		0.5206	0.0727	2774	129		0.3478	0.0500	3078	116		0.4076	0.0627
1971	654	–				858	44		0.4583	0.0799	97	4		0.8756	0.4513
1972	–					2491	80		0.3510	0.0530	1000	28		0.7042	0.1625
1973	–					2690	59		0.4736	0.1024	896	9		0.3825	0.1355

*For adults, $B_2(t) = B_1(t+1)$. For first year birds, B_2 and R_{23} are identical with the entries in the Adult section.

Whatever the answer there is an important corollary question: is it practicable by any affordable banding program to estimate survival in order to detect trends?

Mortality rates and reported hunting kill

Although the initial estimate is of the survival rate, $\hat{s}_t$, it is in some ways more useful to work with its complement, the mortality rate $\hat{m}_t$ (= $1 - \hat{s}_t$), the pooled annual values of which are shown in Table 2. The principal features of those values are their wide variation, coupled with an apparent downward trend in the mortality of young geese. Although the first and last values of the adult rate are respectively very high and very low, there is no clear trend over the intervening years, and the limits of the estimates are wide.

Ricker's method makes no use of direct recoveries (i.e. in the hunting season immediately following marking) in estimating survival over the first year. Thus $\hat{m}$ is independent of r_d (the direct recovery rate). Comparing the two it is possible to see whether the reported kill corresponds in a consistent way with the estimated mortality. The annual ratios of direct recoveries to expected total deaths in the first year ($\hat{m}$ B_1)

Table 2

Percentage annual mortality rates, 1966–67 to 1973–74, of Hudson Bay Snow Geese, estimated from hunting season recoveries of geese banded at three colonies. Samples of both colour phases and both sexes are pooled; $\hat{m}_t = 1 - \hat{s}_t$; limits calculated as ±1.96 s.d. ($\hat{s}$); period mean obtained from annual values weighted by R_{13}

Breeding year	$\hat{m}$	Limits (adults)	$\hat{m}$	Limits (first year birds)
1966	64.8	54.3–75.3	74.3	69.3–79.3
1967	21.7	11.2–32.2	76.3	71.7–81.0
1968	21.5	5.3–37.7	44.4	31.5–56.9
1969	24.4	13.1–35.8	53.5	43.8–63.2
1970	38.8	29.5–48.1	61.3	55.3–67.4
1971	15.2	0 –33.3	47.8	31.5–64.1
1972	39.0	22.5–55.5	50.1	37.8–62.4
1973	7.9	0 –36.6	37.9	18.5–57.2
Mean	25.0		58.9	

are compared in Table 3. Despite the fluctuations from year to year, especially in the samples from single colonies, it is remarkable that the period mean ratios are very similar for adults and first-year birds, though differing from one banding site to another (see lower half of Table 3). If we had an appropriate measure of reporting rate (i.e. what fraction of the bands found on geese shot during the legal hunting season in Canada and the US is reported to the banding laboratory at Patuxent) we could use the difference between total expected deaths and deaths due to legal hunting as a measure of other causes of death. Using the arbitrary levels of reporting (25% and 33%) suggested as appropriate for the US by experimental studies in this field leads to a somewhat bewildering array of alternatives. In some years (e.g. 1967, 1971, 1973) legal shooting seems to account for more than the total number of expected deaths. In others (1966, 1969 and 1970) losses from other causes seem to have been important. This subject urgently needs further exploration.

Recruitment in relation to losses

The question of whether recruitment is sufficient to offset losses is important but in the present state of our ignorance largely rhetorical. What really matters is the recruitment of sufficient breeding females to replace casualties and in turn

Table 3

Comparison of number of direct hunting season recoveries (R_d) with number of expected deaths ($E = \hat{m}$ B_1)

Breeding year	Adults			First year		
	R_d	E	$\lambda' = R_d/E$	R_d	E	$\lambda' = R_d/E$
1966	46	535.8	0.0859	327	2947.2	0.1110
1967	125	565.5	0.2210	301	2734.5	0.1101
1968	53	348.9	0.1490	117	644.5	0.1815
1969	138	762.0	0.1811	267	1103.6	0.2419
1970	193	1657.9	0.1164	590	3679.2	0.1604
1971	164	492.6	0.3329	124	649.8	0.1908
1972	90	825.4	0.1090	304	1750.0	0.1737
1973	81	190.3	0.4256	291	1358.3	0.2142
Sum/mean	890	5378.4	0.1653	2321	14867.1	0.1561

	Adults		First year	
	λ' (La P.)	λ' (CHM)	λ' (La P.)	λ' (CHM)
1969	0.0509	2.6119	0.1972	0.1466
1970	0.1384	0.0607	0.1559	0.1212
1971	0.2676	–	0.1485	0.4977
1972	0.1312	0.0613	0.1540	0.1864
1973	0.2617	0.0946	0.1822	0.0596
Mean	0.1639	0.1161	0.1636	0.1176

to produce sufficient offspring to replace themselves. It is hard even in principle to decide what the necessary rate of replacement should be for any species, such as all the northern-breeding geese, in which on average a female will be a potential breeder in several seasons, but may not even attempt to breed in a year when snow cover persists. For these stocks of Lesser Snow Geese, for which the estimates of mortality and of effective fertility are very imprecise and seem unlikely to be greatly improved, it may well be fruitless to attack the question of adequate recruitment by combining the products of age-specific and time-specific survival rates derived from banding. However, as the alternatives present difficulties too, CWS is embarking on efforts to produce better models of survival and more efficient estimators.

An alternative approach is to look directly at the number of breeding geese, as was done for the first time in June 1973 (Kerbes 1975). An attempt to do so in June 1972 had been frustrated by late snow cover on Southampton Island and Baffin Island, which resulted in the abandonment of nesting by a large part of the population and the temporary disappearance of more than half a million geese (most of which must nevertheless have survived somewhere). The photographic technique used in 1973 was expensive and the results took a long time to obtain. CWS continues to study ways of speeding up the estimating process and improving its precision by better stratified sampling. It seems probable that a technically adequate sample census can be carried out every few years, although the cost of an annual census seems unacceptably high at present.

It is scarcely sufficient to wait for the accumulation of a series of breeding censuses to verify whether all is well with the Hudson Bay stock. In June 1975 Kerbes and others (Ross 1975) conducted an aerial survey of the colonies, using sample counting and photography to check colour phase ratios and subjective appraisals of colony outlines (i.e. area occupied by nesting birds) matched against the detailed results of 1973. They concluded that, despite abortive nesting in the north of the range in 1974, the breeding population in 1975 was at least as large as in 1973. As subsequent breeding in 1975 was highly successful it may be concluded that at present there is no serious imbalance between recruitment and losses from the breeding population.

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