# Population dynamics of North American Light-bellied Brent Geese as determined by productivity and harvest surveys

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## Introduction

Brent Geese *Branta bernicla* are subject to greater variation in annual breeding success than any other goose populations so far studied (Ogilvie & St. Joseph 1976). The Light-belled Brent Goose – Atlantic Brant of North America – *B. b. hrota* breeds in Arctic Canada and winters along the mid-Atlantic coast of the United States (Kirby & Obrecht 1982). In recent years, a series of breeding failures and severe winters reduced the population to less than 31,000 birds in 1977 (Nelson 1978; Kirby & Ferrigno 1980). Subsequently, the North American wintering birds have enjoyed milder winters and a series of successful breeding seasons which enabled the population to reach more than 100,000 birds by 1981. At that time, sport hunting for Atlantic Brant was reopened after continuous closure (except for 1975) from 1972 to 1980 (Kirby *et al.* 1983).

Understandably, these population fluctuations have made management actions problematic in terms of setting season lengths, bag limits, and allowable harvests. Particularly disheartening have been the years closed to hunting when subsequent severe winter weather froze coastal estuaries and marshes and caused massive die-offs from starvation. Recent action by the Atlantic Flyway Council (a co-operative State, Provincial, and Federal Governments organization), the Canadian Wildlife Service (C.W.S.), and the U.S. Fish and Wildlife Service (F.W.S.) has resulted in increased population monitoring on wintering grounds, expanded ringing operations in Canada, and initiation of several large-scale research efforts on the species.

Historical analysis begun in the mid-1970's has refined the data base. Kirby and Obrecht (1982) described recent changes in their North American distribution and winter abundance. Kirby *et al.* (in press) applied modern methods to determine survival rates of adult birds, using the entire available ringing record (1956–1975). Because recoveries and ringings were lacking in many of the years between 1956–1975, this latter study determined periodic survival rates for 6 blocks of years; mean annual survival was estimated as the geometric mean of these periodic rates. Although a rigorous analysis, this assessment did not provide a complete picture of the year-to-year dynamics of population growth and decline in response to breeding success/failure and often severe winter kill. In this paper we present a population "budget" that makes use of winter counts, productivity surveys, and harvest data to obtain independent estimates of annual survival rates. This assessment augments the analysis of Kirby *et al.* (in press) and permits several conclusions to be made regarding appropriate species management.

## Methods

Population data (midwinter inventories) for Light-bellied Brent were obtained from Kirby and Obrecht (1982) for 1968 through 1982 and from the files of F.W.S. for 1983 and 1984. Population age ratios (productivity surveys) and harvest (hunter kill) data were obtained from F.W.S. Administrative Reports which, as a check, were compared with the original field reports prepared by several State agencies in the U.S. Only years with data for total numbers, productivity, and harvest estimates were used in analysis, i.e. 1968–1984.

The presentation of results follows the pioneering methods of Lynch and Singleton (1964) and the general format illustrated by Ogilvie (1978). It is the first assessment of a goose population with such methods that permits age/cohort differentiation and thus estimation of survival rates for adults and subadults without the bias resulting from lumping first-year birds in the calculations.

## Results and discussion

Harvest data (Table 1) were used to construct the population budget (Table 2). Harvest data have only been obtained since 1962 and population age ratios (productivity) since 1969, thus preventing complete comparison with the estimates obtained by Kirby *et al.* (in press). Nonetheless, our estimated survival rate (arithmetic mean) for 1968–1984 of 0.77 differs little from Kirby *et al.*'s (in press) estimated mean annual survival rate of 0.78 for the period 1956–1975.

The range in mean annual survival rate was from 0.41 to 0.97 (Table 2). The low rate of 0.41 in 1971–72 resulted from extremely patchy distribution of food on the wintering grounds which made the birds substantially more vulnerable to hunters. In 1976–77 and to a lesser extent in 1977–78, massive starvation and winter kill occurred on the wintering grounds (Kirby & Ferrigno 1980), yielding survival rates similar to 1971–72. Review of historical records (Kirby & Obrecht 1982) shows that large portions of the population often cannot be accounted for from year to year. Although this is undoubtedly in part the result of sampling problems and bias in estimates of total population size as obtained in aerial waterfowl midwinter inventories, others are not, and are truly declines in total numbers (cf. Lynch & Voelzer 1974). For example,

**Table 1. Harvest data for Atlantic Brant 1962–63 through 1983–84[a].**

| Year | Total harvest | Ratio young:other |
|---|---|---|
| 62–63 | 26,906 | 0.51 |
| 63–64 | 34,049 | 0.80 |
| 64–65 | 30,008 | 0.44 |
| 65–66 | 13,781 | 0.31 |
| 66–67 | 32,559 | 1.38 |
| 67–68 | 22,743 | 0.48 |
| 68–69 | 24,350 | 0.09 |
| 69–70 | 18,387 | 1.18 |
| 70–71 | 25,636 | 1.02 |
| 71–72 | 66,754 | 0.15 |
| 72–73 | 0 | N/A |
| 73–74 | 195 | 1.00 |
| 74–75 | 235 | 0.00 |
| 75–76 | 30,397 | 1.05 |
| 76–77 | 0 | N/A |
| 77–78 | 572 | 2.87 |
| 78–79 | 553 | 0.38 |
| 79–80 | 454 | 1.03 |
| 80–81 | 100 | divisor = 0.0 |
| 81–82 | 31,527 | 0.26 |
| 82–83 | 23,583 | 0.53 |
| 83–84 | 37,560 | 0.56 |

[a]Harvest data obtained from administrative reports of the U.S. Fish and Wildlife Service Migratory Bird Management Office, Laurel, Maryland. Brant can only be identified as first-year or after-hatching-year birds in harvest surveys. The category "other" thus includes two year and older birds in adult-like (Basic) plumage. Procedures for and limitations of this survey are discussed in Martin and Carney (1977).

**Table 2. Population budget for Atlantic Brant wintering in North America during recent years in which productivity data were obtained (1969–70 through 1983–84).**

| Year | Proportion[a] young (p) | Winter inventory[b] ($N_W$) | Harvest[c] Young ($H_Y$) | Harvest[c] Other ($H_A$) | Population Preseason[d] Total ($N_{pre}$) | Population Preseason[d] Young ($Y_{pre}$) | Population Preseason[d] Other ($A_{pre}$) | Population Postseason[e] Young ($Y_{post}$) | Population Postseason[e] Other ($A_{post}$) | Apparent[f] survival (S) |
|---|---|---|---|---|---|---|---|---|---|---|
| 68–69 | | 130,831 | | | | | | | | |
| 69–70 | 0.304 | 106,511 | 9,953 | 8,434 | 124,898 | 38,094 | 86,804 | 28,141 | 78,370 | 0.60 |
| 70–71 | 0.390 | 150,965 | 12,944 | 12,691 | 176,600 | 68,874 | 107,726 | 55,930 | 95,035 | 0.89 |
| 71–72 | 0.057 | 73,242 | 8,707 | 58,047 | 139,996 | 7,980 | 132,016 | –729 | 73,969 | 0.49 |
| 72–73 | 0.0008 | 40,835 | 0 | 0 | 40,835 | 33 | 40,802 | 33 | 40,802 | 0.56 |
| 73–74 | 0.594 | 87,653 | 98 | 98 | 87,849 | 52,182 | 35,667 | 52,084 | 35,569 | 0.87 |
| 74–75 | 0.121 | 88,408 | 0 | 235 | 88,643 | 10,726 | 77,917 | 10,726 | 77,682 | 0.89 |
| 75–76 | 0.442 | 127,003 | 15,569 | 14,838 | 157,400 | 69,571 | 87,829 | 54,002 | 73,001 | 0.83 |
| 76–77 | 0.101 | 73,605 | 0 | 0 | 73,605 | 7,434 | 66,171 | 7,434 | 66,171 | 0.52 |
| 77–78 | 0.295 | 42,740 | 424 | 148 | 43,312 | 12,777 | 30,535 | 12,353 | 30,387 | 0.41 |
| 78–79 | 0.053 | 43,554 | 152 | 401 | 44,107 | 2,338 | 41,769 | 2,186 | 41,368 | 0.97 |
| 79–80 | 0.399 | 69,242 | 230 | 224 | 69,696 | 27,809 | 41,887 | 27,579 | 41,663 | 0.96 |
| 80–81 | 0.337 | 97,074 | 100 | 0 | 97,174 | 32,748 | 64,426 | 32,648 | 64,426 | 0.93 |
| 81–82 | 0.179 | 104,500 | 6,506 | 25,021 | 136,027 | 24,349 | 111,678 | 17,843 | 86,657 | 0.89 |
| 82–83 | 0.235 | 123,600 | 12,499 | 11,084 | 147,183 | 34,588 | 112,595 | 22,089 | 101,511 | 0.97 |
| 83–84 | 0.323 | 127,300 | 21,034 | 16,526 | 164,860 | 53,250 | 111,610 | 32,216 | 95,084 | 0.77 |

[a]Obtained in November of each year on the wintering grounds, largely in New Jersey, by estimating the percentage of first-year birds and the mean brood size in feeding and resting flocks (see Ogilvie 1978: 155–156 for a discussion of standard techniques).

[b]Data from Kirby and Obrecht (1982) and more recent unpublished data from USFWS Migratory Bird Management Office records.

[c]Calculated from data in Table 1.

[d]$N_{pre} = N_W + H_Y + H_A$; $Y_{pre} = p \cdot N_{pre}$; $A_{pre} = N_{pre} - Y_{pre}$

[e]$Y_{post} = Y_{pre} - H_Y$; $A_{post} = A_{pre} - H_A$

[f]$S = A_{post} / N_W$ of the previous year.

survival rates during 1972–73 were low (Table 2), despite closure of hunting during this period. The population did not rebound after the high harvest rates of 1971–72. Instead, there was a complete breeding failure and also the loss of many adults and subadults. The population was reduced to an extremely low level.

The data presented in Table 2 need qualification. The lack of accuracy in some years can be illustrated by 1971–72 data which show more first-year birds to have been harvested than were estimated to be in the population. Nevertheless, these data do illustrate the relatively high survival rates of these geese in most years.

Several management implications are apparent. First, Atlantic Brant have high "adult" survival rates much as do other long-lived birds with delayed sexual maturity. However, as in many other species of Arctic-nesting birds, reproduction is hindered by severe weather on the breeding grounds in some years. A second management implication is that the population must be managed on the basis of not only total population size, but also the relative distribution of the various age groups in the population. In other words, high population numbers do not necessarily indicate resilience in the population. For example, if large fractions of a Brant population are sub-adults incapable of immediately adding young to the population, large harvests might substantially delay the return of the population to higher numbers for not just one but a number of years. Third, since predicting the success of either wintering or breeding birds is difficult until immediately before or after mortality or breeding failure occur, management of the species should aim to maintain sufficient population numbers to rebound from not just one but a series of bad years. Finally, we take the opportunity to reiterate Boyd's (1978) plea that Brant biologists should make every effort to identify age classes in the field. Because of the significant population oscillations in numbers, survival, and age class representation common in Atlantic Brant, we suggest that cohort management is the best scheme possible for these geese.

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**Summary**

Midwinter inventories of total numbers, population–age ratios in the autumn, and estimates of the total numbers of and age ratios in hunter-killed birds were used to develop a population budget for Atlantic Brant – Light-bellied Brent Geese – *Branta bernicla hrota* for the period 1968–84. Substantial fluctuations in productivity and survival occurred even in the absence of hunting seasons for 9 of the 17 years. Annual survival estimates ranged from 0.41 to 0.97 for birds > 1 year of age; mean annual survival for the 17-year period was 0.77, little different from an estimate of 0.78 recently obtained from ringing records.

This summary confirms high adult survival for Atlantic Brant as in other long-lived birds with delayed sexual maturity and irregular breeding failure. The combination of these factors results in unequal age-cohort representation from year to year. Population size alone, therefore, is not an indicator of population resilience. Proper management should aim to maintain Atlantic Brant at a level sufficient to rebound from sequential breeding and wintering failure. We propose management by age-cohort as the best scheme for these geese.

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