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POPULATION SIZE AND STATUS OF THE NORTHERN GANNET *SULA BASSANUS* IN NORTH AMERICA, 1984

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Abstract.—The population of the Northern Gannet in North America has increased by about 22% (1.8%/yr) between 1972–1973 and 1984. The overall increases in the Gulf of St. Lawrence and in Newfoundland were similar, though all three colonies in the Gulf increased, whereas, in Newfoundland, only Funk Island showed a significant increase. The increase in the Gulf population is believed to be due to a recovery from contamination by toxic chemicals resulting in a marked rise in annual productivity and recruitment. The large increase of the Funk Island population may be related to an enhanced food supply, a recent change that seems local (based on the absence of significant increases in bird numbers at the other Newfoundland colonies).

TAMAÑO DE LAS POBLACIONES Y STATUS DE *SULA BASSANUS* EN NORTE AMERICA

Resumen.—Las poblaciones de *Sula bassanus* en Norte America, han aumentado en un 22% (1.8% por año), entre 1972–1973 y 1984. Aumentos similares han sido notados en tres colonias de aves del Golfo de St. Lawrence (Cánada) y una colonia en la Isla Funk (Newfoundland). El aumento en el número de aves de las colonias del Golfo probablemente este relacionado con la reducción marcada en contaminantes químicos tales como DDT y dieldrín. El aumenta en la colonia de Funk podria estar relacionado con aumento en la disponibilidad de alimento para las aves.

The Northern Gannet (*Sula bassanus*) population in North America is restricted to six breeding sites, three in the Gulf of St. Lawrence and three on the Atlantic coast of Newfoundland. The 1972–1973 population was about 32,700 pairs, of which 70% bred in the Gulf and 30% in Newfoundland (Nettleship 1976a). The results of that survey indicated that gannet numbers had decreased at Bonaventure Island and Anticosti Island since 1969, whereas numbers in Newfoundland had remained relatively stable during the same time interval. Reasons for the declines were uncertain, though reduced fertility owing to contamination by toxic chemicals seemed a likely prime cause (Nettleship 1975, 1976a, 1977).

This paper reports the results of aerial censuses made at all six gannet colonies during the 1984 breeding season, allowing an assessment to be made of the distribution of the population in North America and changes in size and status since 1972–1973. Results of other analyses of populations from photography made at North American gannetries in 1966,

1969, and between 1973 and 1984 are also given to provide a more complete picture of recent population trends.

METHODS

The census method used to estimate population size in 1984 was virtually identical to that used in the 1972–1973 survey: analysis from aerial photography taken from fixed-wing aircraft using methods described by Nettleship (1975, 1976a, 1976b). Procedures employed varied little between surveys except for minor differences in photographic and counting equipment and type of aircraft used (see below). Analysis of differences revealed no measurable sources of error. The counting unit of the breeding population was "nest-site holders" rather than the number of "true breeders" (i.e., pairs that built a nest and laid one egg) as only attended nests were counted and the status of each nest was unknown. The accuracy of counts of gannets taken from aerial photographs is known to be within 2–3% of nest sites recorded on the ground (Barrett and Harris 1965; Nettleship 1975, 1976b; Wodzicki et al. 1984).

In 1984, the gannetries in the Gulf of St. Lawrence were photographed from a twin-engined Islander aircraft on 25 Jul. by P. Brousseau using a Hasselblad camera (120 mm lens) and by D. N. Nettleship using a Pentax 6 × 7 camera (200 mm lens), both with PXP 220 black-and-white film. The three Newfoundland colonies were photographed by D. N. Nettleship using a Pentax 6 × 7 camera with PXP 220 black-and-white film: Baccalieu Island and Funk Island on 4 Jul. 1984 from a twin-engined Aztec aircraft, and Cape St. Mary's on 27 Aug. 1984 from a twin-engined Queen Air Beech B-80 aircraft. In other years (1975–1980) aerial photographs of colonies were taken during June or July from single- or twin-engined fixed-winged aircraft by G. Chapdelaine and P. Dupuis in the Gulf of St. Lawrence (*Bird Rocks*—13 Jul. 1976 [Cessna 337, Hasselblad], 14 Jul. 1979 [Cessna 337, Hasselblad]; *Bonaventure Island*—22 Jul. 1976 [DC-3, Wild RC-18], 14 Jul. 1979 [Cessna 337, Hasselblad]) and by D. N. Nettleship in Newfoundland (*Funk Island*—5 Jul. 1975 [Beaver, Pentax 6 × 7], 14 Jul. 1980 [Cessna 337, Pentax 6 × 7]). All photographs were taken through an open window or belly hatch of each aircraft. Details of the photo surveys conducted in 1966 and 1969, before the 1972–1973 baseline was established, are given in Nettleship (1975, 1976a) and Poulin (1968). Procedures used in the 1966 census differed from those employed from 1969 onwards and so the 1966 data are restricted to the text to elucidate trends.

RESULTS

Present breeding population.—The census results of 1984 indicate the size of the North American gannet population to be about 40,100 pairs, with 27,800 (69.4%) in the Gulf of St. Lawrence and 12,300 (30.6%) on the Atlantic coast of Newfoundland (Table 1). The population has increased by about 22% since 1972–1973, an increase that appears similar in both the Gulf of St. Lawrence and Newfoundland populations. All

TABLE 1. Present number of pairs of gannets in North America and changes between 1972–1973 and 1984.

Colony	1972–1973 Number pairs[a]	1972–1973 %	1984 Number pairs[a]	1984 %	% Change
Gulf St. Lawrence:					
Bonaventure I.	17,281	52.8	21,090	53.0	+22
Anticosti I.	135	0.4	155	0.4	+15
Bird Rocks					
Great Bird	4527	13.8	5812	14.6	+28
North Bird	804	2.5	778	2.0	−3
Totals	22,747	69.5	27,835	69.4	+22.4
Newfoundland:					
Cape St. Mary's					
Bird Rock	5260	16.1	5085	12.8	−3
Mainland cliffs	0	0	430	0.2	+[b]
Baccalieu I.	673	2.0	677	1.7	+1
Funk I.	4051	12.4	6075	15.3	+50
Totals	9984	30.5	12,267	30.6	+22.9
Totals	32,731	100.0	40,102	100.0	+22.5

[a] Represents the number of "nest-site holders."
[b] New sub-colony (see text for details).

gannetries in the Gulf increased in size whereas only Funk Island did so in Newfoundland. Bonaventure Island accounted for almost 75% of the increase in the Gulf (Table 1).

Recent colony changes.—Table 2 and Figure 1 summarize the estimates of population sizes at the six colonies between 1969 and 1984. These count figures, derived from standardized aerial census procedures, allow precise comparisons to be made, the results of which are adequate to identify status changes and population trends (see Methods). The results of a single census made in 1966 at Bonaventure Island using combined aerial photography and boat and ground counts are used to provide important background information for that colony.

Bonaventure Island, Quebec (48°30'N, 64°09'W)

The number of gannets decreased gradually from 1969 to 1976 (−20%) after which they increased at least from 1979 to 1984 (+15.6%), and probably as early as 1977 (Table 2 and Fig. 1). The overall increase from 1973 to 1984 was 22% (Table 1) The difference in population size between 1969 and 1984 was only 1%, a difference that is within the limits of accuracy of the census technique. That suggests that the population has returned to the 1969 level. The 1984 estimate also approximates the estimate of 21,215 pairs in 1966 by Poulin (1968), the highest level the population is known to have attained. However, even though the 1984 count was similar to those for 1966 and 1969, there was a change in

TABLE 2. Census results from aerial photography at gannet colonies in North America between 1969 and 1984.

Colony	Number of pairs[a]							
	1969	1972	1973	1975	1976	1979	1980	1984
Gulf St. Lawrence:								
Bonaventure	20,511	—	17,281	—	16,400	18,245	—	21,090
Anticosti	167	135	—	—	—	—	—	155
Bird Rocks								
Great Bird	4397	—	4527	—	3953	4455	—	5812
North Bird	807	—	804	—	500	387	—	778
Newfoundland:								
Cape St. Mary's	—	5260	—	—	—	—	—	5515
Baccalieu	—	—	673	—	—	—	—	677
Funk I.	—	4051	—	4300	—	—	4925	6075

[a] Represents the number of "nest-site holders."

pattern of distribution of the birds. In 1984, the population comprised 12,633 (60%) cliff-top pairs (nests on flattish ground on top of the cliff) and 8457 (40%) cliff-ledge pairs (pairs on ledges on the cliff face), whereas in 1969 the values were 42.2% and 57.8%, respectively (Nettleship 1975), a difference that is highly significant ($\chi^2 = 13.18$, df = 1, $P < 0.001$). The habitat differences between counts from 1973 onwards also are significant when compared with the distribution patterns for 1966 and 1969. Cliff-top birds accounted for 61% of the increase between 1976 and 1984. In general, this means that the rate of increase has been higher on cliff-top habitat than on the cliff-face, and that most of the increase following the 1976 low has occurred among birds breeding on the cliff-top habitat (Chapdelaine et al. 1987, Nettleship 1975).

Gullcliff Bay, Anticosti Island, Quebec (49°09'N, 61°42'W)

The number of pairs at this colony seems to have increased slightly since 1972, from 135 to 155 pairs, or roughly 15%. The difference seems likely to be real, as the colony is small and easy to census. It is, however, still below the 1969 level of 167 pairs (Table 2).

Bird Rocks, Magdalen Islands, Quebec (47°50'N, 61°09'W)

The population at the Bird Rocks is divided into two parts, Great Bird and North Bird (see Nettleship 1976a: Fig. 4). Overall, the total number of pairs increased from 5331 to 6590 (24%) between 1973 and 1984, with all of the increase occurring on Great Bird (Table 1) through an expansion of the nesting area on flattish ground at the top of the cliffs. At Great Bird, numbers remained fairly stable from 1969 to 1979 except for 1976 when numbers were about 11% lower than the mean (4460 pairs) of the 1969, 1973, and 1979 counts. Numbers increased by 30% between 1979 and 1984 (Table 2 and Fig. 1). On North Bird, the population seemed to have decreased between 1973 and 1979 (−52%) and then increased

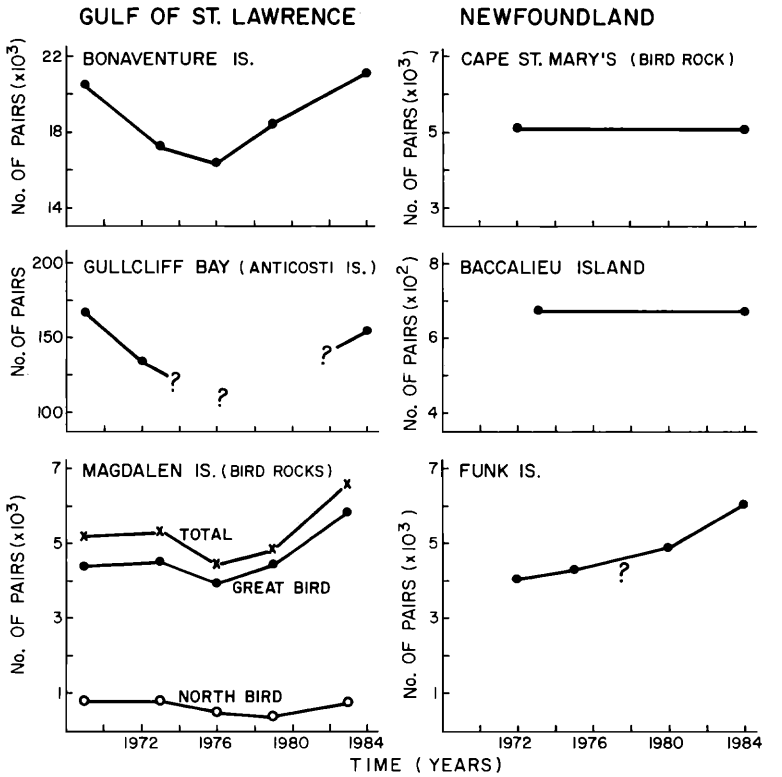

FIGURE 1. Changes in gannet numbers and possible trends at the six gannetries in North America between 1969 and 1984. (See text for details.)

from 387 to 778 pairs by 1984, a number similar to that counted in 1969 and 1973 (Tables 1 and 2). Fluctuations in numbers at North Bird are to be expected as the lower parts of the area used for nesting are vulnerable to wave action and destruction of nests.

Cape St. Mary's, Newfoundland (46°50'N, 54°12'W)

A comparison of the census figures for 1972 and 1984 indicates a relatively stable population, as the 3% difference between counts falls within the limits of the census technique (Table 1 and Fig. 1). The major change over the 12-yr period has been the establishment and growth of a small group of breeders on the mainland cliffs. The gannet colony at Cape St. Mary's originally comprised one group restricted to Bird Rock, a large 152 m high rock stack, only slightly separated from the adjacent mainland cliffs. Recently, however, a second group has developed on the mainland east of Bird Rock, increasing from two pairs in 1972 (W. Threlfall, pers. comm.) to about 430 pairs of nest-site holders in 1984 (analysis from aerial photography). Mainland nesting attempts have oc-

curred at Cape St. Mary's in the past, but the present expansion is the first known to have been successful. Details of the mainland expansion are reported by Montevecchi and Wells (1984).

Baccalieu Island, Newfoundland (48°07'N, 52°47'W)

The number of pairs at this colony seems to have remained relatively stable between 1973 and 1984 (Tables 1 and 2). There were no significant differences in the count figures between years for the three cliff areas comprising the colony. A comparison of 1984 counts made from photos taken from land and boat with those derived from aerial photographs differed by 2.3%.

Funk Island, Newfoundland (49°46'N, 53°11'W)

The population at this site remained fairly stable from 1972 to 1975 at 4000–4300 pairs, after which time it increased to 4900 pairs by 1980 and to 6000 pairs in 1984 (Table 2 and Fig. 1). Because no aerial photographs were taken between 1975 and 1980, it is uncertain when the 50% increase between 1972 and 1984 (Table 1) began. However, ground counts in 1975 and 1978 suggested an increase only after 1978. In 1978 a total of 3877 nests were counted (W. Montevecchi, pers. comm.), a figure similar to the 3933 nests recorded by D. N. Nettleship during a ground count in 1975. If the increase began only in 1979 and the population is assumed to have remained around 4300 pairs until then, numbers increased by 14.5% between 1978 and 1980, and by 23.3% between 1980 and 1984 (Table 2). Thus, the average annual rate of increase from 1978 to 1984 ($n = 6$) could be as high as 6.9%.

DISCUSSION

Gannet populations in North America are either maintaining their numbers or increasing. In 1984, the total population comprised about 40,100 pairs of nest-site holders, with 69.4% in the Gulf of St. Lawrence and 30.6% in Newfoundland. The population increased by 22.5% between 1972–1973 and 1984, with most of the change occurring at Bonaventure Island and Funk Island. There was no significant change in proportion of the total population in the two regions.

The decline in the Gulf of St. Lawrence population between 1966 and 1976 appeared to have stopped soon after 1976. Numbers at Bonaventure Island increased to a known high of 21,200 pairs in 1966, and then declined to 17,200 by 1973 (Nettleship 1975, 1976a) and 16,400 by 1976. That 23% reduction over a 10-yr period was then followed by a marked increase in numbers to the 21,100 pairs recorded in 1984, a rise that probably continues. Most of these fluctuations in numbers can be explained by changes in gannet productivity and levels of toxic chemical contamination in the birds. Hatching success was very low (36–40%) between 1966–1970, increasing to 58% in 1974 and 78–89% from 1976–1984. This marked increase in breeding performance coincided with a significant decrease in the concentration of DDT and dieldren residues

in gannet eggs which suggests that toxic chemical contamination was responsible for the low hatching success from 1966 to at least 1970 and the subsequent decline in population (see Chapdelaine et al. 1987 for details). While this explains the changes in bird numbers *per se,* the slower rate of increase of birds nesting on cliff-face habitat is more difficult to understand. It seems linked to interaction of three factors: changes in the age structure and productivity of the birds within the two habitats, and a less stable habitat on the cliffs than the cliff-tops (Chapdelaine et al. 1987).

Trends in the two other Gulf colonies were similar. Anticosti Island birds declined between 1969 and 1972 (and also had declined before then: Nettleship 1976a), though whether or not they continued to decrease to a low in 1976 (as at Bonaventure and Bird Rocks) is unknown. The major difference at the Bird Rocks colony was in the timing of the decline. Numbers seem to have declined only after 1973, reaching a low in 1976 and then increasing through 1979 to a recent high of 5600 pairs in 1984. Most of the changes in numbers were due to fluctuations at Great Bird; the relatively small breeding group on North Bird has increased to almost the size it was in 1969 and 1973.

Events at the colonies in Newfoundland since the 1972–1973 survey are different. Cape St. Mary's and Baccalieu Island remained roughly stable and Funk Island underwent a substantial increase in size over the 12-yr period. Counts at Cape St. Mary's and Baccalieu Island have not significantly changed between 1972 and 1984. The small difference between counts of pairs (133 pairs, or <3%) on Bird Rock, Cape St. Mary's, falls close to the limit of accuracy of the census procedure and may be an artifact of technique. On the other hand, the mainland expansion at Cape St. Mary's is real. The gradual increase of the mainland group from two pairs in 1972 to about 430 pairs of nest-site holders by 1984 suggests that a change in population status (from stable to increasing) is underway. The fact that at least 110 of the 430 pairs (26%) had young in 1984 (W. Montevecchi and J. Wells, pers. comm.) supports this view of population increase.

The rapid expansion in numbers of gannets at Funk Island is more difficult to explain. It seems likely that the population remained relatively unchanged from 1959 to 1972 (based on five ground counts that were similar although they underestimated actual size by 25–35%: see Nettleship 1976a for details), followed by an increase of about 6% (2%/yr) between 1972 and 1975, 14.5% (2.9%/yr) between 1975 and 1980, and 23.3% (5.8%/yr) from 1980 to 1984. The overall 50% increase from 4050 pairs in 1972 to 6075 pairs in 1984 represents a mean annual increase of 4.2%, not much above the 2.4% to 3.4%/yr rate estimated by Nelson (1978) for the entire Northern Gannet population over the period 1939–1969. Reasons for the increase are unclear, but there is little evidence to suggest immigration of birds from other colonies in eastern Canada or elsewhere. The changes in population size can best be explained by the productivity of the Funk Island population alone. It seems likely that

conditions for breeding in the vicinity of Funk Island have improved recently (early to mid 1970s), resulting in a relatively high annual productivity and post-fledging survival of young (W. Montevecchi, pers. comm.). An enhanced local food supply seems a likely prime cause of the increase in the Funk colony, though whether it has been brought about by natural factors (oceanographic/climatological changes), human activities (e.g., indirect effects of commercial fisheries), or some combination of these is unknown (for additional details see Nettleship et al. 1984, Evans and Nettleship 1985).

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