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RECENT CHANGES IN THE NORTH AMERICAN DISTRIBUTION AND ABUNDANCE OF WINTERING ATLANTIC BRANT

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Light-bellied Brant of the western Atlantic area, generally referred to as the Atlantic Brant (*Branta bernicla hrota*), nest in the arctic on Southampton Island and the vicinity of Foxe Basin, and from Queen Maud Gulf to Bylot Island, Northwest Territories, Canada (Palmer 1976; A. Reed, Canadian Wildlife Service, Quebec, pers. comm.). These birds winter along the U.S. Atlantic coast, largely from Massachusetts to North Carolina, with stragglers occurring as far north as Maine and south as Florida. Their habitat at this time is largely the estuarine littoral zone, including tidal flats, salt marshes, and recently, uplands adjacent to the salt marshes. Hunting seasons for this species have been closed in recent years (1932–1950, 1972–1974, 1976–1980) in response to low populations and poor recruitment of young. Sport hunting in the U.S. was reinitiated in 1981 following an increase of the population to more than 100,000 birds. In addition to the historical factors limiting its population, habitat degradation and loss, especially in the major concentration areas of New Jersey and New York, have become topics of critical concern lending urgency to the need for data to assist management of the species.

In this paper we briefly review mid-winter survey procedures, discuss the historical distribution and abundance records for Atlantic Brant, summarize and correct more recent data (1948–1980), analyze changes in this latter data set, and relate these changes to present knowledge of the food habits and habitat selection by the species. We conclude with some suggestions regarding population monitoring and the potential management impact of continued redistribution of the population within its historical winter range.

METHODS

Mid-winter inventories are conducted by the U.S. Fish and Wildlife Service with assistance from various states, the Canadian Wildlife Service in Canada, and the Direccion General de Fauna Silvestre in Mexico. These inventories are not complete, because all wintering areas are not covered and variables including weather and seasonal phenology vary from year to year and within inventory areas each year. The data are therefore point estimates with no confidence limits. Nevertheless, results of these surveys are useful for certain problems (see Larned et al. 1980: 1); and for certain species such as the Atlantic Brant, whose remote breeding grounds are not inventoried, mid-winter inventories provide the only estimate of total population size.

Atlantic Brant are perhaps one of the easiest species for an experienced observer to count from aircraft. They tend to flush from open

water and feeding areas well in advance of the airplane, but with proper maneuvering by the pilot, can be kept from breaking into smaller groups and encouraged to land as the aircraft passes. Duplicate counts can thus be prevented, and the confinement of the species to largely maritime habitat makes the location of the birds easy to predict. Brant use the same specific wintering areas each year, which facilitates aerial surveys even when the birds are distributed along many kilometers of coastline. For all of the above reasons, data collected on winter inventories are probably closer to a complete enumeration for Atlantic Brant than they are for many other species of waterfowl.

Winter inventories were initiated in 1933 by the U.S. Fish and Wildlife Service. After the late 1940's, most winter inventory data were included in the annual waterfowl status reports (see bibliography in Anderson and Henny 1972:95). We located the original flight data sheets for the winter inventories conducted in 14 states of the Atlantic Flyway during the years 1948–1980 (earlier data were judged too variable in both quality and extent of coverage to be useful in analysis) and used these original notes as our data source. Each flight sheet was hand-checked to verify row and column totals and to properly allocate counts between states where geographic overlap occurred in the reports. In some cases, correspondence with the personnel who conducted the inventories, or personnel familiar with the conduct of surveys in certain years, was necessary to interpret the voluminous hand-written reports. In this process, we corrected a number of arithmatic and transcription errors not noted in original annual summaries. Thus, the winter inventory data reported herein are more correct than previous summaries of Atlantic Brant winter population numbers, and should be used for future analyses. The corrected winter inventory data were combined within groups of adjacent states in peripheral wintering areas, but such combination did not combine data across obvious biogeographic boundaries.

We analyzed the data in several ways. Our primary interest was the distribution of the birds each year rather than the actual number of birds observed; i.e., percent distribution was of interest. An arc sine transformation (Snedecor and Cochran 1980:290) was used to stabilize the variance in the percentage data. We investigated the trend of the percent of Brant in a given area over time with a multiple linear regression analysis that fitted separate lines (intercepts and slopes) for each area in a single analysis that pooled the area error terms to obtain more degrees of freedom. Another analysis compared the slopes in different areas. Results were expressed as trends (%); estimates of the trends were obtained from the untransformed data to remove the distortion due to transformation. Significance levels, however, were obtained from analyses of transformed data. Finally, we compared the slope estimates for all areas with Scheffe's method (Kleinbaum and Kupper 1978:271) which is appropriate for multiple comparisons. All possible combinations of the 7 areas defined for analysis were compared and the significant ($P < .05$) relationships were schematically illustrated.

RESULTS AND DISCUSSION

Historical numbers of Atlantic Brant.—Numbers of Atlantic Brant fluctuate dramatically in response to environmental conditions. Severe spring weather can result in partial or complete reproductive failure in any year (Barry 1962). In recent years, losses from severe weather on the wintering grounds north of North Carolina have included a catastrophic decline following the winter of 1976–1977 to perhaps the lowest population level ever recorded (Nelson 1978, Kirby and Ferrigno 1980). Early records of both the distribution and abundance of Atlantic Brant are of limited value. Phillips (1932) estimated that the wintering population probably never exceeded one-third of a million birds, which appears reasonable in view of more recent population numbers. Cottam et al. (1944) misquoted Phillips' estimate as two-thirds of a million birds and concluded that the wintering population in 1933–1934 was 10% of that in 1930–1931, indicating a massive decline. The population reduction claimed by Cottam et al. was actually 20% of the estimates of 1930–1931, or about 66,000 birds, a population low that has also been reached in recent times.

Much has been made of an apparent precipitous decline of Atlantic Brant in the early 1930's following the die-off of eelgrass (*Zostera* spp., reviewed by Rasmussen 1977), a favorite food. There is little doubt that there were fewer Brant following the eelgrass die-off. That this reduction in numbers was due to starvation when favored foods disappeared, as claimed by Lincoln (1950), Cottam and Munro (1954), and others, however, is questionable (Palmer 1976:269). Certainly, recent reviews of the food habits of the species on its wintering grounds (Ogilvie 1978: 80, Palmer 1976:270–273) and our observations along the New Jersey coast, do not support the extreme food specificity of this species claimed by some earlier authors. We conclude, therefore, that early claims of both a very large population size for the species (ca. some large fraction of a million birds) and a rapid decline of the species to numbers from which it has subsequently never recovered, cannot be substantiated for the 20th century. Data available for the 1800's and earlier are not suitable for quantitative analysis. Recent data do emphasize, however, that various combinations of poor breeding success and severe winters are capable of substantially reducing the North American wintering Atlantic Brant population. Conversely, given a series of favorable seasons on both the summer and winter grounds, the response of the Brant population can be spectacular, with apparent increases of over 100% in as little as 2 years. Corrected recent population data for Brant wintering in the United States are presented in Table 1.

Recent winter distribution trends.—Analysis of the recent winter distribution of Atlantic Brant reveals a number of significant trends (Table 2). The overall regression analysis comparing the slopes of the estimated trends indicated significant differences among the areas ($P < .0001$). Scheffe's multiple comparison method yielded nested relationships among the slopes calculated from the 1948–1980 data. The areas with

TABLE 1. Corrected mid-winter inventory counts of Brant along the Atlantic coast of the United States, 1948–1980.[a]

Year	Number of Brant observed							
	MA	NY	NJ	DE	MD	VA	NC	Total
'48	60	0	43,500	0	13,750	0	500	57,810
'49	0	0	57,300	0	9200	7400	1500	75,435
'50	0	400	63,400	0	8350	2000	0	74,150
'51	0	0	82,700	310	3050	24,100	2400	112,568
'52	0	ND	90,000	0	4850	8500	154	103,506
'53	282	2615	141,800	0	2100	8300	165	155,262
'54	735	17,198	162,600	1600	32,170	30,000	850	245,153
'55	500	19,050	151,000	0	75	12,700	500	183,825
'56	0	25,350	108,100	450	11,300	18,750	435	164,385
'57	14	9620	143,550	342	3700	4400	410	162,036
'58	50	14,550	184,500	946	7350	3486	175	211,057
'59	0	34,300	175,400	4266	840	1660	960	217,426
'60	75	33,400	183,200	3840	972	16,350	500	238,338
'61	100	39,375	200,830	12,853	2900	9100	500	265,688
'62	505	28,680	88,750	804	800	4700	200	124,490
'63	0	52,839	109,000	5555	400	5500	200	173,494
'64	960	23,840	143,550	9200	1900	2900	350	182,700
'65	12	10,900	165,100	1200	1400	7350	20	185,982
'66	300	17,500	151,600	1100	0	1350	0	171,850
'67	50	23,274	189,050	2350	100	4200	0	219,024
'68	75	15,375	182,000	1500	600	13,500	300	213,450
'69	430	19,950	78,200	3050	1500	27,400	300	130,831
'70	6	6705	96,100	800	300	1900	700	106,511
'71	65	12,805	129,400	1395	400	6900	0	150,965
'72	2925	14,852	48,600	665	3200	2800	200	73,242
'73	325	10,581	22,600	275	400	6454	200	40,835
'74	332	21,436	46,350	1435	1200	16,700	200	87,653
'75	523	24,045	55,200	500	0	7700	400	88,408
'76	1128	17,040	99,000	1135	1600	6900	200	127,003
'77	2348	13,622	26,900	6335	2200	21,700	500	73,605
'78	3845	8936	14,600	2278	1600	10,810	400	42,740
'79	760	8211	31,890	885	100	1700	0	43,554
'80	3282	18,912	31,570	3269	2300	8406	1500	69,242

[a] Five states with small numbers of wintering Brant on rare occasions are not included in the body of the table. They were as follows (years not listed were those when no Brant were recorded): ME: '51—4; NH: '52—1; VT: '52—no data; CT: '49—35, '69—1, '75—40, '78—135, '80—3; RI: '51—4, '52—1, '78—136, '79—8; PA: '60—1, '61—30, '62—51; SC: '68—100, '78—25. Data collected in these states are, however, included in the totals presented for each year.

the largest rates of increase (N.Y.) and decrease (N.J.) were clearly unrelated as shown by their positions at the ends of the schematic illustration (Table 2). The slopes of the regression lines for the 4 areas with smaller Brant populations and more moderate rates of change were identified as not significantly different from one another as were the 3 areas with declining percentages of the wintering population.

Increases in percent distribution in New England, New York, Dela-

TABLE 2. Trends in percent distribution of Atlantic Brant along the U.S. Atlantic coast from 1948 to 1980 as shown by midwinter inventory counts.

Area	Trend (T) %	$P > \|T\|$	Scheffe's comparison[a]		
New York[b]	+5.14	0.0001			+
Virginia	+2.06	0.0132		+	+
Delaware	+0.85	0.0094		+	+
New England[c]	+0.91	0.0089		+	+
Southeast[d]	−0.04	0.8850	+	+	
Maryland	−2.31	0.0016	+		
New Jersey	−6.61	0.0001	+		

[a] Areas noted by the symbol in any column are those with nonsignificantly different slopes in the regression analysis.
[b] Includes Pennsylvania.
[c] Maine, New Hampshire, Vermont, Connecticut, Rhode Island, Massachusetts.
[d] North and South Carolina.

ware, and Virginia have occurred at the expense of Maryland and New Jersey, with no significant ($P > .05$) trends occurring south of Virginia. Although the increase in Brant wintering in New York since the 1930's has been generally evident, the downward trend in the other large concentration area, New Jersey, has not. Bull (1964:114) described the Brant along the Long Island, New York shore as very abundant in winter since 1951, with a noticeably increasing trend since the 1940's. Annual fluctuations in the total number of Brant have apparently masked the trends in New Jersey, historically the area of greatest winter concentration. Penkala et al. (1975) suggested that the large percentage of Atlantic Brant wintering in New Jersey reduced the problem of Brant management to one of appropriate harvest management. Our analysis suggests that although New Jersey is of major importance, careful assessment of the species throughout its range is needed.

Current winter range of the species.—The southeast (North and South Carolina) now seems to be beyond the normal winter range of Atlantic Brant. Although the birds were common off the Outer Banks of North Carolina into the early portion of the 20th century (Pearson et al. 1919: 89–91), they have never been common in South Carolina (Sprunt and Chamberlain 1970:108–109, 585). Although only recent data are available (1976 to present), greatest numbers of Brant have been seen in North Carolina during years of extreme weather and hard freezes that make normal estuarine and salt marsh foods unavailable farther north (J. G. Goldsberry, Office of Migratory Bird Management, pers. comm.). Similar circumstances perhaps also apply in Virginia and Delaware. Declines in Brant use of Maryland may be related to the more isolated nature of the habitat available to Brant in adjacent Delaware and Virginia. Coastal development has been more pronounced along the Maryland coast than in areas of Delaware and Virginia where Brant are most often found. At the northern end of the winter range, increases in New

England are confined to Massachusetts, where in some years, small flocks congregate along Cape Cod. Historical records indicate sporadic and low level use of most of the New England coast by Brant, a condition that continues to this day.

The distance between the southern New Jersey marshes and the west end of Long Island is ca. 240 km as the Brant would fly along the coast. Banding records indicate some Brant movement between New Jersey and New York (H. W. Knoch, New York Dep. Environ. Conserv., pers. comm.), but Brant from both locations seem to arrive in James Bay at about the same time each year during spring migration (Palmer 1976: 257). The major difference is that the birds from Long Island do not all fly to James Bay and then farther north in the direction of Southampton Island as evidently do most of the New Jersey birds. Instead, some birds proceed directly north through Ungava Bay (Lewis 1937). No data suggest major advantages to be gained by choosing either route to the species' nesting areas, although that through Ungava Bay is slightly more direct to Baffin Island and the former is more direct to the Foxe Basin. The physiological advantages gained by choosing a slightly shorter migration route, if indeed one of these routes is shorter, appear minor. It may be that the ability to determine the most appropriate time to move to the breeding grounds from spring staging areas is differentially enhanced, depending upon the ultimate destination of the birds, by appropriate choice of staging areas and routes for access to the north.

Our hypothesis reached from the above, despite the decidedly speculative nature of all of the migration route data, is that advantages gained by individual Brant from wintering in either New Jersey or New York probably relate more to availability of food and freedom from disturbance on the wintering grounds than from any advantage to be obtained by beginning spring migration only 240 km or so farther north. Unfortunately, the impact upon Brant distribution of recent closure of hunting seasons and the return of eelgrass to its former range have not been and perhaps cannot be quantified. Likewise, the more recent dependence of Brant in New Jersey on sea lettuce (*Ulva lactuca*), an irregularly abundant algae, despite the return of eelgrass, has added an additional complicating factor. This food resource is in almost all years depleted or destroyed by wind and wave action by mid- or late winter. Thus, although data are confined largely to casual observations in both areas and intensive plant sampling only in New Jersey (R. E. Kirby, H. H. Obrecht, III, R. B. Owen, Jr., and J. K. Ringelman, unpubl. data) it seems that preferred Brant foods might be more consistently available of late along the Long Island coast than they are in New Jersey, especially since Brant have recently taken to feeding on fields, lawns, and in agricultural areas in greater numbers throughout their range, but especially in New York. Descriptions of the specific areas currently used by wintering Atlantic Brant are provided in the Appendix.

We emphasize that there are 2 non-exclusive explanations for the changes in Brant distribution that we have found: (a) changes in the

wintering areas of individual birds, and (b) differential survival and fecundity of Brant using various winter locations. It is most likely that a combination of factors is involved, separation of which can only be accomplished by analysis of annual survival rates, annual reproductive success, and the winter distribution of birds using each of the breeding colonies in Canada or each of the major wintering locations (e.g., the approach used by Raveling 1978).

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APPENDIX

Review of historical data on Atlantic Brant distribution and abundance and communication with persons knowledgeable of Brant movements and behavior provided the following assessment of current Brant wintering distribution along the United States Atlantic coast. Unpublished notes and review of State records were provided by A. Hutchinson (ME), H. C. Lacalliade (NH), W. Crenshaw (VT), C. C. Allin (RI), S. R. Hill (CT), H. W. Knoch (NY), F. Ferrigno (NJ), T. W. Whittendale (DE), and V. D. Stotts (MD). W. W. Blandin, Atlantic Flyway Representative, U.S. Fish and Wildlife Service, Office of Migratory Bird Management, provided internal documents and assisted the compilation of these notes.

Below, we discuss the major concentration areas of wintering Brant, i.e., their location from mid-November through January. No attempt is made to enumerate or assess extralimital records or to account for each unique sighting of Brant reported in the literature or made available as unpublished notes.

MAINE: Although small numbers of Brant are sometimes observed in the fall, largest numbers appear during spring migration. Wintering Brant have not been recorded in the last 25 yr. During this time, surveys covered the majority of available Brant habitat.

NEW HAMPSHIRE: Brant are extremely uncommon at any time, sightings have been confined to individuals or small groups in fall and spring. No wintering birds have been recorded in the small coastal area available. The single bird reported in 1952 may have been injured.

VERMONT: No winter records exist. Incidental late fall occurrences and subsequent hunter harvest on Lake Champlain are documented by hunter questionnaire responses in 1967, 1970, and 1971.

MASSACHUSETTS: Small numbers are usually found during an average year. Concentrations occur between Brewster and Eastham on the North Shore of Cape Cod, with some flocks stopping in the vicinity of Plymouth in some years. Gross habitat changes seem to have prevented recent concentration of the birds in Boston Harbor, an important area for Brant for many decades.

RHODE ISLAND: Brant have recently been found in small concentrations (ca. 50 birds) at 6 locations in Washington County and 4 locations in Newport County. Early reports mention their presence in larger flocks of Canada Geese. Wintering birds have been located in only 4 of the last 33 yr.

CONNECTICUT: Brant only rarely visit the coast during the winter. Documentation of even historical use of this part of New England is limited to reports of rare stragglers and only a few wintering birds in the late 1800's.

NEW YORK: Brant are found largely in the western half of the south shore of Long Island. Average distributions are about 25% in Great South Bay, 25% in South Oyster Bay, 40% in the Hampstead Bay area, and 10% near Jamaica Bay National Wildlife Refuge (NWR). The species is currently observed farther inland than earlier and is often found feeding on golf courses, lawns, agricultural areas, and the marsh edge near open water.

NEW JERSEY: Brant winter in large numbers from Barnegat Bay south to Cape May, and in some years, also on the marshes of the Delaware Bay side in small numbers. Fewer than 10% of the birds now winter on the extensive eelgrass beds of Barnegat Bay, historically the greatest concentration area in the state. Most birds are now found to the south on extensive sea lettuce beds. When disturbed, the birds move to the ocean outside the barrier islands. Otherwise, they remain on the extensive network of bays, sounds, tidal creeks, inlets, and the Intracoastal Waterway from north of Atlantic City to the Cape, with concentrations especially in the Reeds-Absecon Bay area near Brigantine NWR, Lakes Bay, Townsends-Stites Sound, Great Sound, and Grassy-Richardson Sound. Large flocks trade back and forth along this 32 km segment of the state's coastline.

DELAWARE: Brant have used Delaware's lower bays intermittently throughout this century. Most use now occurs in the southeast corner of Rehoboth Bay and along the northeast shore of Indian River Bay. Small numbers can be found in Assawoman Bay.

MARYLAND: Meager winter records exist for most coastal areas, but the concentration of birds is largely from Ocean City Inlet south. The birds are distributed generally throughout Sinepuxent Bay, but are restricted to the east shore of Chincoteague Bay because of the distribution of aquatic plants. Only stragglers occur in Chesapeake Bay, usually only during migration.

VIRGINIA: Brant are distributed throughout the estuaries of Accomac and Northampton counties. In normal years, perhaps 40% winter in Chincoteague Bay (Chincoteague NWR in part), another 40% from Kegotank Bay through Burton's Bay, and 20% in Hog Island Bay and to the south.

NORTH CAROLINA: Although Brant historically occurred in the northern sounds and throughout Pamlico Sound, small numbers found there today during an average year are largely in the Back Bay-Currituck Sound area (Back Bay NWR in part), with small groups scattered down into Pamlico Sound on the extensive seagrass flats behind Cape Hatteras National Seashore and Pea Island NWR.