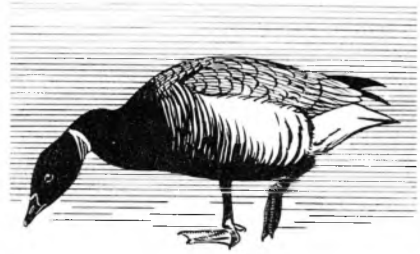
Current status and recent dynamics of the Black Brant *Branta bernicla* breeding population



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We summarize current knowledge about the distribution of Pacific Black Brant and recent dynamics of colonies, particularly on the Yukon-Kuskokwim (Y-K) Delta, Alaska. About 20,000 nests are required to produce the number of young in the autumn flight using estimates of clutch size, hatching success and gosling survival based on colonies on the Y-K Delta. More than 80% of the nests in the population can be accounted for currently on the Y-K Delta. Most moulting individuals that did not breed, or were unsuccessful, are unaccounted for in late summer. Numbers of Black Brant nesting in major colonies on the Y-K Delta declined >60% in the early 1980s, most likely as a result of local subsistence harvest combined with predation by arctic foxes. Effective management of this population requires a better understanding of the distribution of breeding and moulting birds, the importance of breeding habitat to colony dynamics and the role of both sport and subsistence harvest in population dynamics.

The mid-winter Black Brant *Branta bernicla nigricans* population declined steadily from the early 1960s through the mid 1970s. Declines were particularly significant in the continental United States (Technical Committee Pacific Flyway Council 1981). Dramatic declines in the sizes of Black Brant colonies were reported on the Yukon-Kuskokwim (Y-K) Delta in the 1980s (see below).

Black Brant are among the smallest geese (Owen 1980) and their marine habits outside the breeding season are shared only by other brant and Emperor Geese *Anser canagicus*. Brant are unique in their almost complete reliance on seagrasses *Zostera marina*, *Ruppia maritima* and marine algae e.g. *Ulva* spp. outside the breeding season (Cottam *et al.* 1944, Einarson 1965, Ward 1983, Smith *et al.* 1985). Reliance on relatively low quality food (Ward & Stehn 1989), restriction of feeding to certain portions of the tide cycle (Kramer *et al.* 1979, Ward & Stehn 1989) and a long overwater migration may limit the ability of female Black Brant to store nutrient reserves before breeding (see Ankney 1984 for data on Atlantic Brant *B. b. hrota*). Female Black Brant lay the smallest clutches of any goose (Owen 1980), yet they are relatively inattentive to the nest during incubation (Thompson & Raveling 1987, Welsh 1988), suggesting that female Black Brant begin the breeding season with relatively small nutrient reserves. Productivity of Black Brant is further reduced by their inability to defend their nests against mammalian predators (Stickney 1991). Also, a segment of the Black Brant population nests in the arctic, where nesting is precluded in some years by late snow melt (Barry 1962, Barry 1967).

The low average and variable productivity of Black Brant may increase their susceptibility to overharvesting by Man (Owen 1980). The colonial breeding pattern of Black Brant combined with their gregarious nature and use of well-defined staging and wintering areas should enable biologists to gain sufficient understanding of the dynamics of the Black Brant population to manage effectively this population. Our goal in this paper is to present recent data on the breeding distribution of Black Brant, summarize previously unpublished data on colony dynamics on the Y-K Delta, review existing data on harvest and predation, point out gaps in our understanding of Black Brant, and suggest goals for future research and management.

Distribution of breeding Black Brant

Known concentrations of Black Brant throughout their summer range were described most recently in 1981 (Technical Committee Pacific Flyway Council 1981). We

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Table 1. Approximate current sizes and locations of known Black Brant colonies[a].

Colony	Location	Number of breeding pairs
Kokechik Bay	Y-K Delta	6134 ± 295[b]
Tutakoke River	Y-K Delta	4601 ± 202
Kigigak Island	Y-K Delta	3383 ± 162
Baird Inlet	Y-K Delta	5416 ± 358
Dispersed nests and small aggregations	Y-K Delta	4163[c]
Nugnugaluktuk River	Seward Peninsula	200[d]
Prudhoe Bay	Alaska North Slope	380[e]
Colville River Delta	Alaska North Slope	400[f]
Anderson River Delta	Northwest Territories	400[g]

[a]Black Brant nest in small groups and isolated pairs in the Canadian Arctic. An unknown number of small colonies occur in Russia. Only areas that have been visited or surveyed since 1980 are included here.
[b]SE for colonies for which estimates were based on video transects in 1992.
[c]W. Butler and R. Stehn, U.S. Fish and Wildlife Service unpubl. data from 1991.
[d]R. King pers. comm. This colony contained no nests in 1992, which may have resulted from the late spring (E. Peltola pers. comm.).
[e]Ritchie *et al.* 1990.
[f]T. Rothe pers. comm.
[g]M. Lindberg pers. comm.

rely here on this earlier report, as well as on the results of intensive work on the Y-K Delta during the 1980s and 1990s, and accounts of visits to arctic colonies during this period.

The largest known concentrations of nesting Black Brant outside of the Y-K Delta occur at the mouths of the Colville and Anderson Rivers, and in small colonies at the mouth of the Nugnugaluktuk River (Seward Peninsula) and in the Prudhoe Bay area (Table 1, Fig. 1). Black Brant nest solitarily and in small colonies throughout the central Canadian arctic and on Banks and Victoria Islands (Technical Committee Pacific Flyway Council 1981). Nine

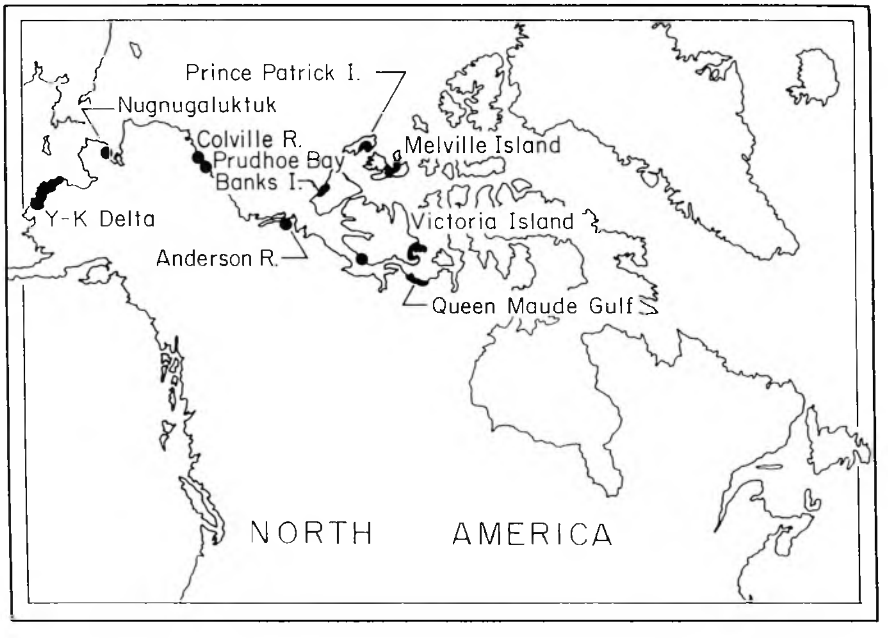

Figure 1. Locations of important breeding colonies of Black Brant in North America.

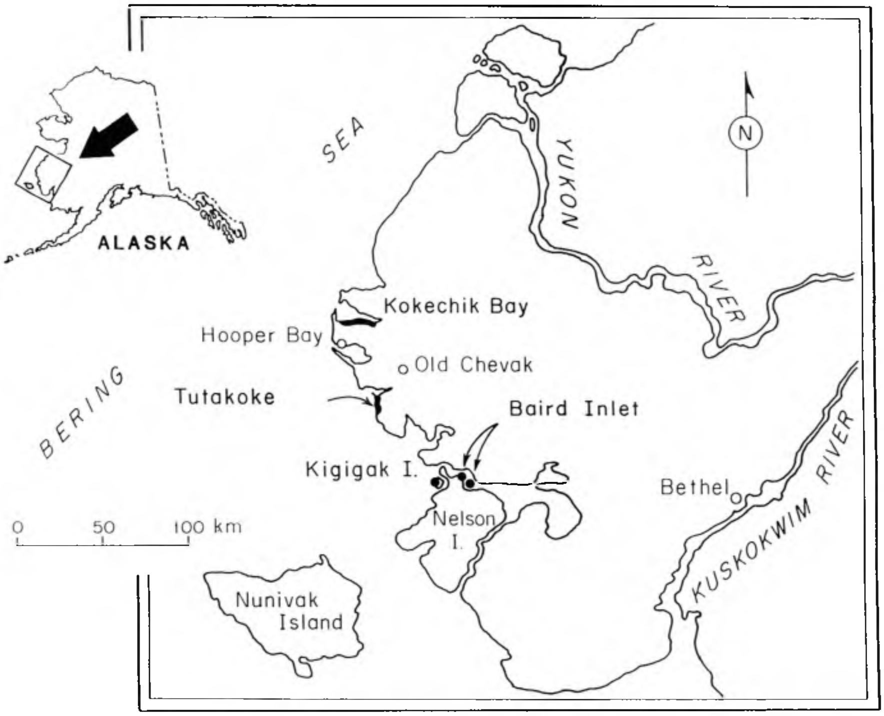

Figure 2. Locations and approximate sizes of Black Brant on the Yukon-Kuskokwim Delta colonies.

thousand Black Brant were reported on Banks Island in late summer (T.W. Barry in Technical Committee Pacific Flyway Council) but the number of breeding pairs there is uncertain. Brant nesting on Melville, Prince Patrick, and adjacent islands are distinct genetically from other Pacific Brant (Shields 1990) and have a discrete winter distribution (Reed *et al.* 1989a). Nevertheless, we include these Brant in this report because they are not separated from Black Brant in fall surveys at Izembek Lagoon, Alaska. Black Brant also nest in Russia on the Chukotsk Peninsula but precise data on numbers and locations are lacking. Recent visits to Wrangel Island indicate that past reports of one or two thousand breeding brant (Uspenski 1964) no longer accurately describe the situation; fewer than 100 pairs are thought to nest here currently (Ward *et al.* 1993).

Brant nest in four major colonies on the Y-K Delta (Fig. 2). Numbers of nests in each of the four major colonies were estimated in 1992 using a Canon-A1 camcorder mounted in a fixed-wing aircraft. Sixty transects were flown and videographed at 150 m altitude over the Kokechik Bay, Tutakoke River and Kigigak Island colonies, while 38 transects were flown at Baird Inlet. Aerial transects were ground-truthed by locating all Black Brant nests on 11 transects at Tutakoke River and six transects at Kigigak Island. Counts from video images were adjusted for missed nests (*c.* 32%) and objects misidentified as nests based on the ground-truthed transects. The colony at Kokechik Bay is the largest currently with 6134 pairs (Table 1). The colonies at the mouth of the Tutakoke River and at Baird Inlet have about 4600 and 5160 pairs, respectively, while the colony on Kigigak Island has 3400 pairs. Aerial surveys on the Y-K Delta designed to estimate numbers of nests of other species of geese (W. Butler unpubl.) allow estimates of the number of brant nesting singly and in small aggregations (defined as <100 pairs). In 1991, an estimated 4200 such brant nests occurred on the Y-K Delta (W. Butler & R. Stehn unpubl.).

Table 2. Calculation of the number of Black Brant nests in the population during the late 1980s.

Calculation of the number of young in the fall population

	Fall population (X 10^3)[a]	Proportion young[a]	Young (X 10^3) n
1989	148.9	0.239	35.6
1990	123.2	0.192	23.7
1991	125.8	0.278	35.0
			x=31.4

Parameters required to estimate the number of nests

Nest success[b] = 0.796
Clutch size at hatch[c] = 3.79
Gosling survival from hatching to fledging[d] = 0.642
Survival from fledging to Izembek = for calculation set at either 0.75 or 1.00

Number of nests in the population

1. Assuming survival from fledging to Izembek = 1.0
   $N = (31.4 \times 10^3)(0.796)^{-1}(3.79)^{-1}(0.642)^{-1}(1.0)^{-1}$
   = 16,212 (range 12,237-18,381)[e]
2. Assuming survival from fledging to Izembek = 0.75
   $N = (31.4 \times 10^3)(0.796)^{-1}(3.79)^{-1}(0.642)^{-1}(0.75)^{-1}$
   = 21,616 (range 16,315-24,508)[e]

[a]From Conant *et al.* 1990, 1991, 1992.
[b]For the Tutakoke River and Kokechik Bay colonies, from Anthony *et al.* 1991.
[c]Flint 1993.
[d]Flint 1993.
[e]Range calculated from extreme values of number of young in fall (23,700 and 35,600).

Total numbers of nests in the population

We calculated the number of nests in the current population using estimates of number of young in the population during fall staging combined with estimates of clutch size and survivorship from eggs to fall staging. The number of young in the population during fall staging must equal the product of the number of nests in the population, nesting success (proportion of nests hatching at least one egg), the number of eggs that hatch per successful clutch, gosling survival rate from hatch to fledging and the survival rate from fledging to arrival on the fall staging area. Because the required parameters vary both temporally and geographically it is impossible to calculate precisely the number of young contributed by each breeding area, so the calculations that follow are intended to provide only an approximate estimate of the number of nesting pairs in the population. Between 1989 and 1991, an average of 31,400 young of the year were observed at Izembek Lagoon (Conant *et al.* 1989, 1990, 1991) in the fall (Table 2) where it is believed that the entire population stages (Gabrielson & Lincoln 1959, Bellrose 1980, Reed *et al.* 1989b). Hatching success of nests that were initiated at the Tutakoke River and Kokechik Bay colonies on the Y-K Delta during this period averaged 80% (Anthony *et al.* 1991). The average number of eggs that hatched in clutches hatching at least one egg was 3.79 (Flint 1993) and survival probability of goslings from hatching to fledging was 0.642 at the Tutakoke River colony (Flint 1993). If 100% of goslings survived from fledging to fall staging, then 16,200 nests were required to produce the observed number of young. If we assume that 75% of goslings that fledged survived to reach Izembek Lagoon, then about 21,600 nests were required to produce the observed number of young in the fall (Table 2). Approximately 23,700 nests can be accounted for on the Y-K Delta (Table 1). These estimates combined with those from Table 2 suggest that virtually all of the production in the Black Brant population can be accounted for by nests on the Y-K Delta. No large concentrations other than those in Table 1 have been reported from arctic Canada (R. Alisauskas, R. Bromley pers. comm.) (except possibly Banks Island) nor do significant numbers of nests exist on Wrangel Island (see above). Under nearly all scenarios in Table 2 the number of nests on the Y-K Delta exceeds that necessary to produce all of the young in the entire population, suggesting that our estimates of nest success, clutch size, pre- or postfledging survival are not representative of the entire population. The estimates of nest success (0.796) in Table 2 likely overestimates the nest success of dispersed nesting Black Brant and those in small aggregations (Raveling 1989). Nevertheless, Black Brant nesting on the four major colonies of the Y-K Delta (18,926) for which we believe our estimates of nest success, clutch size and survival are representative, alone could account for 77-100% of the young produced under the scenarios in Table 2.

Number of nonbreeders in the population

Winter indices during 1989-91 averaged 133,851. If all of these individuals survived until the breeding season, then after subtracting successful nesting pairs (number of nests (from Table 2) X nest success X 2), between 99,438 and 108,041 failed breeders and nonbreeders would have been present in the population in late summer. Approximately 84% of adult females survive from the wintering area to reach the Y-K Delta (D.H. Ward unpubl.), producing an estimate of approximately 112,435 Black Brant at the start of the breeding season. Only 13,700 Black Brant were counted at Teshekpuk Lake, a major moulting area, in 1989 (R.J. King in Derksen *et al.* 1992) and fewer than 5000 moulting Black Brant were present on Wrangel Island in 1990 (Ward *et al.* 1993). Therefore, between 59,322 and 67,925 moulting Black Brant were unaccounted for following hatch. A significant fraction of these birds were likely present on the Y-K Delta where, historically, large numbers of Black Brant moulted (Lensink unpubl.). Surveys of potential moulting areas are important to identify habitat used by moulting Black Brant and because of the potential for subsistence harvest in local areas on the Y-K Delta.

Colony dynamics on the Y-K Delta

Concern about declining populations of geese nesting on the Y-K Delta prompted the staff of the Yukon Delta National Wildlife Refuge to estimate the number of nesting pairs in three (Kokechik Bay, Kigigak Island, Tutakoke River) of the four major colonies on the Y-K Delta during 1981 and 1982 (Table 3). These estimates were based on 30 m wide strips randomly placed from the high tide line inland until no more nesting Black Brant were encountered. Numbers of 30 m wide strips searched in each colony as follows: Tutakoke River, 15 and 21 strips in 1981 and 1982, Kokechik Bay, 31 and 33 strips in the 2 years and Kigigak Island, 12 and 22 strips in 1981 and 1982. Estimates of the number of Black Brant nests in each of these colonies were also made in 1985 and 1986. During the second set of estimates 50 m radius circular plots were placed randomly in each colony (e.g. Anthony *et al.* 1991). Sampling was stratified during the second sampling period based on earlier studies on each colony.

Estimated number of nests in the three colonies totalled 20,750 in 1981 and 12,000 in 1982 (Table 3). By 1985-86 numbers of nests on these three colonies had declined to 8550, a 59% decrease from the 1981 estimate. While the winter population index is highly variable, the 3-year average of this index declined from 155,260 to 132,390 (22,900 individuals) between 1981-82 and 1985-86 (Bartonek 1990), which is similar to the expected decline of 24,400 based only on the disappearance of breeding pairs from Y-K Delta colonies. Although not conclusive, this comparison suggests that the decline observed on the Y-K Delta did not occur throughout the remainder of the population.

Dynamics of the Tutakoke River colony

The Tutakoke River colony is a remnant of a larger colony that existed in the lower Kashunuk River-Tutakoke River area in the 1960s (Shepherd 1964) and there are accounts of this colony dating back to the 1880s (Nelson 1883). C. Lensink established twelve 10-acre plots in this colony in 1966. Each plot consisted of five 2-acre circular subplots. Plots could be divided into three groups

Table 3. Dynamics of Black Brant colonies on the Y-K Delta in the early 1980s.

Colony	Estimated pairs *n* 1981[a]	1982[a]	1986	% change 1981-86
Tutakoke	7400	2800	1100	-85.1
Kigigak	8350 (6400)[b]	1500	1050	-87.4 (83.6)
Kokechik	6950	7700	6400	-7.9
Total	22700 (20750)[b]	12000	8550	-62.3 (58.8)

[a]From Byrd *et al.* 1982.
[b]Area of the colony was likely overestimated in 1981. Estimated number in parentheses is based on a colony area comparable to that in 1982.

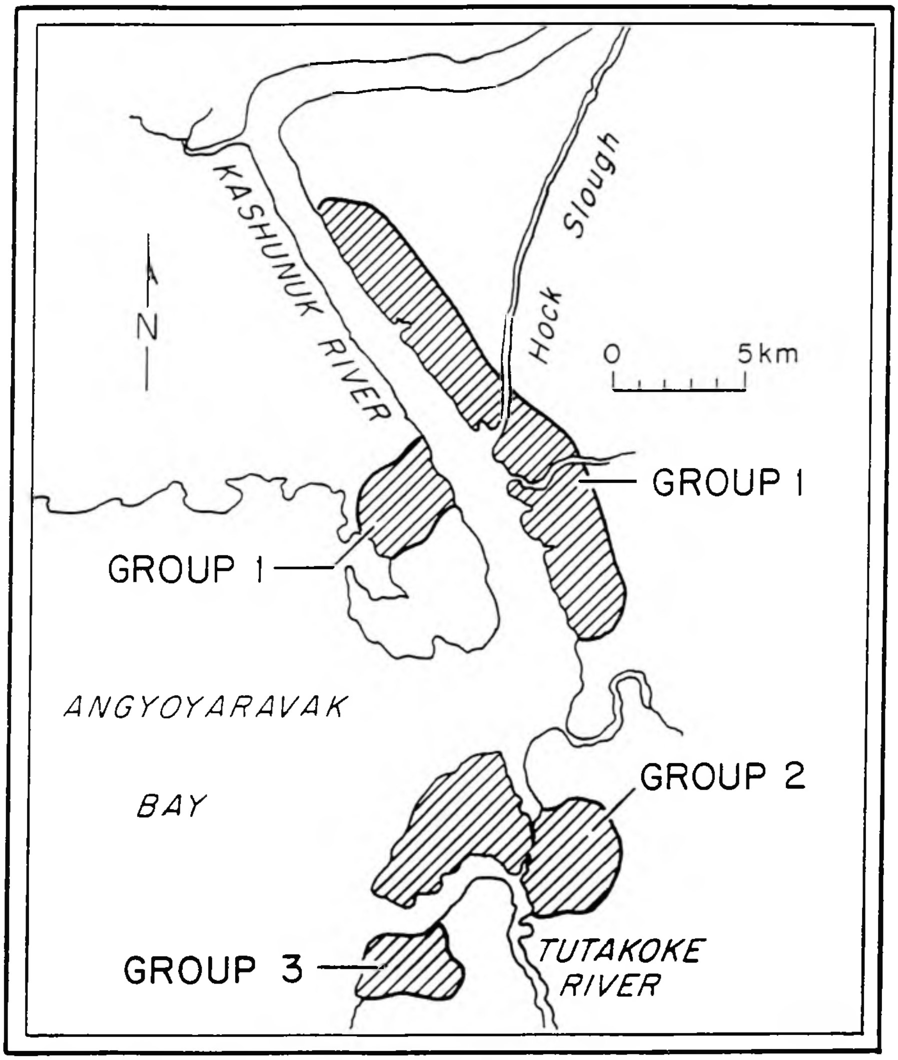

Figure 3. Geographic locations of groups of Black Brant nesting plots in the lower Kashunuk River-Tutakoke River area, 1965-80.

based on location (Fig. 3). Group 1 consisted of six plots in the lower Kashunuk River region, group 2 was composed of four plots between the Tutakoke and Kashunuk Rivers, and group 3 consisted of two plots south of the Tutakoke River.

Numbers of nests on Lensink's plots declined between 1966 and 1980 and virtually no Black Brant were nesting on these plots by 1984 (Sedinger pers. obs.). The decline observed south of the Tutakoke River in the early 1980s (see above) had actually started during the 1970s in the northern portion of the colony. In fact, numbers of nests declined 63% along the Kashunuk River (group 1 plots) by 1980, compared with declines of 29% and 49% between the Tutakoke and Kashunuk Rivers, and south of the Tutakoke River, respectively, from 1966 to 1980. This pattern indicates that the colony declined first in the most northern area, along the Kashunuk River, and later in the more southern portion, south of the Kashunuk River. The magnitude of the decline before 1980, if any, in the colony south of the Tutakoke River is unknown. Nevertheless, the declines along the Kashunuk River before 1980, combined with declines south of the Tutakoke River between 1981-82 and 1985-86, indicate that the overall decline in nesting Black Brant in the lower Kashunuk River area since the mid 1970s has been much greater than indicated in Table 3.

Causes of the local decline on the Y-K Delta, particularly in the Kashunuk River area, are unknown. These causes, however, are likely to be local to the Y-K Delta, or affect primarily Black Brant nesting there, because the declines in the mid-winter index during the early 1980s can be accounted for largely by declines in colonies on the Y-K Delta (see above).

Harvest

Estimated harvest by sport and subsistence hunters in the early 1960s was approximately 20,000 birds annually (Klein 1966, Technical Committee Pacific Flyway Council 1981), the harvest being about evenly divided between the two groups of hunters. This harvest exceeded 10% of the winter population at the time, based on mid-winter inventories (Bartonek 1990). These harvest estimates must be considered crude for several reasons. The hunter questionnaire survey and bag checks, from which the sport harvest was estimated, are likely to be imprecise when hunting is highly localized (as it is for Black Brant), or when relatively few surveyed hunters participated in a particular harvest. The hunter questionnaire survey also contains numerous biases (e.g. Wright 1978), which are difficult to assess for Black Brant. Earlier estimates of subsistence harvest (Klein 1966) must be considered suspect because the samples of hunters were not randomly selected and potential reporting biases exist in these data just as they do in the hunter questionnaire survey. For example, in Klein's (1966) study, Black Brant were reported to be important species in the harvest of Yukon River villages, yet these villages were inland from the coast, where residents were unlikely to encounter migrating Black Brant. In contrast, Black Brant were not reported in the harvest of several villages on the Bering Sea coast, where Black Brant have been important in the harvest in recent years (Copp 1985, Copp & McCaffery 1987, Wentworth 1990) and were likely important during the period of Klein's (1966) study.

Historically, Black Brant harvests represented smaller proportions of the population than harvest levels for other North American geese which, assuming a band reporting rate of 0.36 (Martinson & McCann 1966), ranged from 9 to 27% of the population (Grieb 1970, Hanson & Eberhardt 1971, Boyd *et al.* 1982, Brownie *et al.* 1985, Kirby *et al.* 1986, Gavin & Reed 1987). Interestingly, estimated annual harvest rates for Atlantic Brant averaged 9% between 1956 and 1975 (based on the above estimates of band reporting rate and recovery rates (Kirby *et al.* 1986)), while the population declined *c.* 80% between the 1950s and 1977 (Rogers 1977 in Owen 1980). A substantial portion of this decline occurred during the severe winter of 1976-77 when freezing conditions decreased food availability and may have increased susceptibility to harvest (H. Boyd pers. comm.). These data suggest, however, that ecological conditions encountered by brant and/or their life-history traits may increase the importance of harvest to the population dynamics of brant, relative to other geese.

Total reported sport and subsistence harvest levels for Black Brant in the late 1980s were about 8000 individuals per year (Kramer 1988, Wentworth 1990), approximately half of the estimated annual harvest in the 1960s and about 6% of the mid-winter inventory. Harvest, by itself, therefore would not seem to be a controlling factor for the Black Brant population. Several factors, however, bear on this conclusion. First, brant adults represent a larger proportion of the sport harvest than is the case for most other goose populations. Ratios of immatures to adults in the Black Brant harvest have been 0.57-0.64:1 in the recent past (D.H. Ward unpubl., W. Eldridge pers. comm.), whereas juveniles frequently equal, or outnumber, adults in the harvest of other goose populations (Chapman *et al.* 1969, Grieb 1970, Raveling & Lumsden 1977, Boyd *et al.* 1982). Second, earlier migration of breeding versus nonbreeding Black Brant (Henry 1980, Sedinger unpubl.) likely concentrates the spring subsistence harvest on breeding Black Brant on the Y-K Delta, which may be the least vulnerable component of the population in the sport harvest of goose populations nesting elsewhere. Five times as large a proportion of Brant ≤2 years old (potential breeding individuals) as yearlings was observed from first arrival through the first day of nesting (Sedinger unpubl.), a period when much of the spring subsistence harvest occurs. Third, the subsistence harvest on the Y-K Delta likely includes disproportionately Black Brant from the Y-K Delta breeding populations (because of earlier migration by these individuals) and therefore must be evaluated relative to the number of nests on the Y-K Delta, rather than the population as a whole. For example the reported subsistence harvest on the Y-K Delta in 1989, by itself, represented 7% of the estimated size of the nesting population, and total harvest (including sport harvest) of this segment of the population may have exceeded 10%. Therefore, despite the low overall harvest levels on Black Brant, harvest of some segments of the population may be sufficiently substantial to be a factor in population regulation.

Subsistence harvest during the late brood-rearing period was substantial in the lower Kashunuk-Tutakoke River area in the 1970s; in one year 8% of recently banded individuals were recovered from hunting camps within two weeks of banding (Eisenhauer 1977). This harvest has declined substantially during the 1980s (Sedinger pers. obs.) but may have played a role in the earlier decline of the Tutakoke River colony.

Predation

Through the 1960s and 1970s, Black Brant in the lower Kashunuk-Tutakoke River colony experienced high nesting success (>70% of nests hatched in most years, excepting years of stormtides, which occurred about once per decade, Lensink unpubl.). High nest success was associated with low numbers of arctic foxes *Alopex lagopus* in the coastal meadows where Black Brant nest (Eisenhauer 1977). During the early 1980s, arctic foxes were abundant in the lower Kashunuk River area (Anthony *et al.* 1991) and nest success was very low (2% and 7% in 1984 and 1985, respectively). These high predation rates undoubtedly played a role in the rapid decline of the Tutakoke River colony during the early 1980s. Declines in the size of this colony before 1980 played a role indirectly in low nest success during the early 1980s, however, because lower numbers of nests reduced the potential for swamping predators (Raveling 1989).

It is unclear what caused the high incidence of fox predation in the early 1980s. One hypothesis is that low tundra vole *Microtus oeconomus* numbers in inland areas where foxes have dens prevented foxes from breeding (Anthony *et al.* 1991). This, in turn, allowed arctic foxes to range into coastal areas where they preyed heavily on Black Brant eggs (Anthony *et al.* 1991). Additionally, marine mammal carcasses on the coast may have attracted nonbreeding foxes into coastal areas used by Black Brant for nesting.

Research needs for management of Black Brant

In this review we have attempted to describe the current status and recent dynamics of the Black Brant population and point out areas of ignorance about this population. Below we identify data that need to be obtained for better management of Black Brant.

1. Delineate the nesting population, including particularl Soviet and Canadian breeding areas and dispersed nesting brant on the Y-K Delta. Delineation of these other nesting populations is important to assess our estimates of the relative importance of the Y-K Delta segment of the population. Enumeration of *all* breeding populations is necessary for their individual management, which cannot be accomplished effectively using existing surveys.
2. Improve estimates of *both* sport and subsistence harvest, including age ratios and origin of brant in the harvest.
3. Develop demographically based models that will assist in assessing the importance of annual variation in nest success caused by weather and predation and the importance of management actions, such as regulation of harvest or protection of particular habitats.

The Alaska Fish and Wildlife Research Center (especially D. V. Derksen) and Migratory Bird Management, Region 7, U.S. Fish and Wildlife Service, have supported much of this work. Yukon Delta National Wildlife Refuge has provided the principal logistical support for work on the Y-K Delta. Many Yukon Delta NWR staff have participated in collection of data reported here. C.P. Dau esti-

mated age ratios at Izembek Lagoon during the 1980s. We also thank numerous individuals (cited in the text) for sharing unpublished observations or data with us. Many of the unpublished reports we cite are available from the Library, USFWS, Region 7, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA.

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