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Distribution and Abundance of Brant (*Branta bernicla*) on the Central Arctic Coastal Plain of Alaska

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ABSTRACT. The distribution and abundance of brant (*Branta bernicla*) were surveyed on the central Arctic Coastal Plain of Alaska between 1989 and 1992. Numbers of nests ranged between 319 and 517 in 43 to 67 locations. More than 70% of the nesting locations consisted of ≤ 5 nests; only one or two locations had ≥ 100 nests in any year. Brant attempted to nest every year at primary sites, but less frequently at secondary and solitary nest sites. Estimated numbers of nesting brant averaged 800 birds (range = 630–1064); failed and nonbreeding brant ranged between 293 and 740 birds. During brood-rearing, approximately 900 to 3200 brant (26% to 48% goslings) used coastal habitats within the study area. Some coastal habitats were used annually; others were used only intermittently. Inland lakes were used by only a few brant each year. The earliest comparable data from the mid-1970s suggest that the population of brant in the study area has remained fairly stable. Factors affecting distribution of brant within the study area included environmental conditions, such as snowmelt and persistent ice, and predators. Indirect effects of oil development on brant distribution may include temporarily altered hydrologic regimes and elevated predator populations.

Key words: brant, *Branta bernicla*, distribution, abundance, nesting, brood-rearing, waterfowl, Alaska, Arctic

RÉSUMÉ. Entre 1989 et 1992, on a établi un relevé de la distribution et de l'abondance de la bernache cravant (*Branta bernicla*) dans la partie centrale de la plaine côtière de l'Arctique en Alaska. Le nombre de nids allait de 319 à 517 dans 43 à 67 sites. Plus de 70 p. cent des sites de nidification comportaient ≤ 5 nids; seuls un ou deux sites abritaient ≥ 100 nids au cours d'une année. La bernache essayait chaque année d'établir son nid sur un site primaire, mais moins fréquemment sur un site secondaire ou solitaire. Le nombre estimé de bernaches qui nichaient était d'en moyenne 800 oiseaux (gamme: de 630 à 1064); le nombre de bernaches dont les oeufs n'éclosaient pas et de celles qui ne se reproduisaient pas allait de 293 à 740. Au cours de l'élevage de la couvée, environ 900 à 3200 bernaches (de 26 à 48 p. cent d'oisons) utilisaient les habitats côtiers situés dans la zone d'étude. Certains habitats côtiers étaient utilisés sur une base annuelle; d'autres de façon intermittente. Chaque année, les lacs intérieurs étaient utilisés par seulement quelques bernaches. Les données comparables les plus anciennes datant du milieu des années 1970 suggèrent que la population de bernaches constituant le sujet de l'étude est restée relativement stable. Parmi les facteurs qui influençaient la distribution de la bernache dans le périmètre de l'étude, on comptait les conditions environnementales comme la fonte nivale et la glace pérenne, ainsi que les prédateurs. Les répercussions indirectes de l'exploitation pétrolière sur la distribution de la bernache peuvent inclure des changements temporaires dans le régime des eaux et une augmentation de la population de prédateurs.

Mots clés: bernache, *Branta bernicla*, distribution, abondance, nidification, élevage de la couvée, sauvagine, Alaska, Arctique

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INTRODUCTION

A small segment of the Pacific Flyway population of black brant (*Branta bernicla nigricans*) nests colonially on the Arctic Coastal Plain, the region between the Colville and Canning Rivers on the North Slope of Alaska (Fig. 1). Limited data regarding brant distribution and abundance in this region have been collected since the 1930s, when Bailey et al. (1933) noted that brant were the most common nesting waterfowl near Barrow. In 1957, Hansen (in King, 1970) first recorded large numbers of nonbreeding or failed-breeding, molting brant near Teshekpuk Lake. In 1966, King (1970) conducted surveys along the Arctic Coastal Plain and distinguished between the large flocks of molting brant identified previously and smaller, brood-rearing flocks that indicated the presence of a nesting population. Although published information on nesting (e.g., Bergman et al., 1977; Kiera, 1979) and brood-rearing locations of brant within the area of oil development is limited, numerous surveys documented in unpublished reports have identified many areas that brant use.

The central Arctic Coastal Plain has been the focus of oil exploration and development since the late 1960s. Currently, oil development extends from Prudhoe Bay and the Sagavanirktok River delta west to Kalubik Creek in the Kuparuk Oilfield. Recent exploration activities also have occurred in the Colville River delta and west of the Staines River. Concerns have been raised that development might negatively affect local populations of brant by damaging

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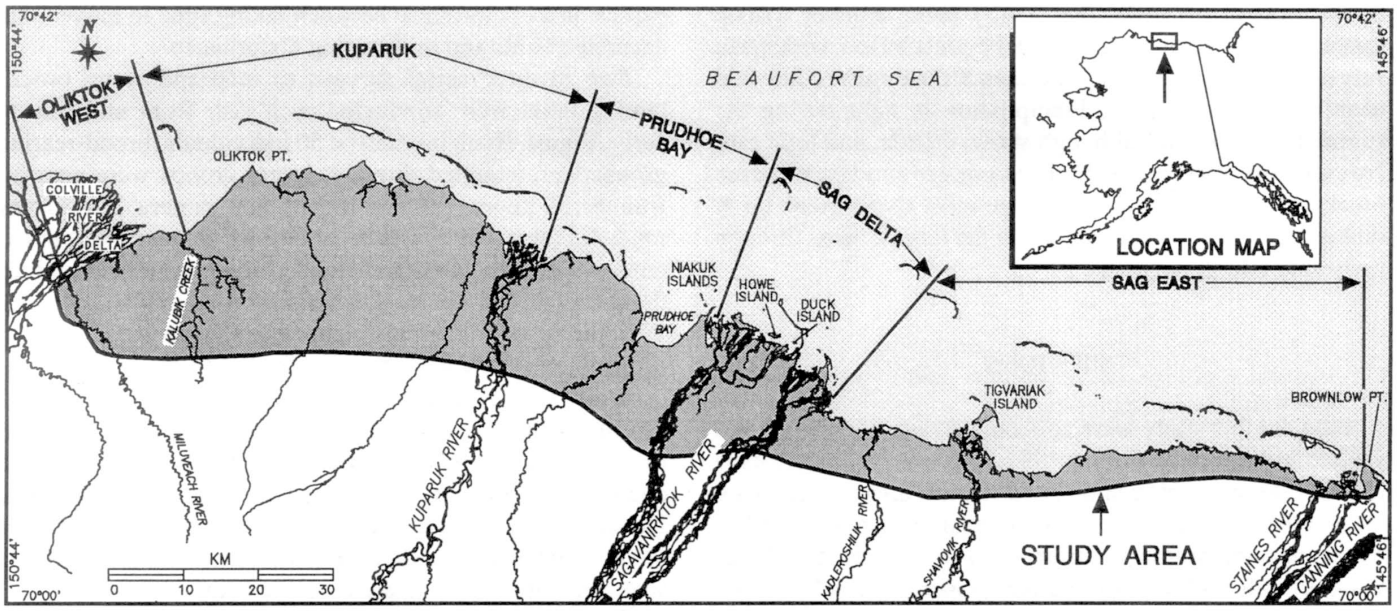

FIG. 1. Map of the central Arctic Coastal Plain of Alaska, showing the study area and coastal strata used for summarizing data.

habitat, by causing disturbance, or by increasing mortality (Mellor, 1985; Derksen et al., 1979). Thus, expanding oil development in the region, coupled with an interest in avoiding development impacts on areas traditionally used by nesting and brood-rearing brant were the main justifications for initiating our research program. Furthermore, declines in the Pacific Flyway population of brant (Raveling, 1984; Sedinger et al., 1993) provided additional justification for collecting information on abundance and distribution of this particular subpopulation. This paper summarizes our survey results, as well as additional information from unpublished sources on the distribution and relative abundance of brant during nesting and brood-rearing in the central Arctic Coastal Plain.

STUDY AREA

This study was conducted in a 2166 km^2 region along the Arctic Coastal Plain that extends from the eastern channel of the Colville River (near the mouth of the Miluveach River) to Brownlow Point, just east of the mouth of the Staines River (Fig. 1). This region contains one large river delta system (the Sagavanirktok River delta) and several smaller ones (e.g., the Kuparuk River delta). Several barrier islands and spits, mostly composed of gravel, are associated with these deltas.

The landscape of the study area is mostly flat, wet, and dominated by thaw lakes that are generally oriented perpendicularly to the prevailing northeast winds (Carson and Hussey, 1962) and drained thaw-lake basins (hereafter called basin-complexes). The three major landscape units are flat thaw-lake plains, gently rolling thaw-lake plains, and river floodplains. Flat thaw-lake plains, found primarily between the Sagavanirktok and Kuparuk Rivers, are old alluvial surfaces dominated by frost scars and ice-wedge polygons in the interlake areas. Surface relief in these plains is generally less than 2 m. Gently rolling thaw-lake plains are found east of the Sagavanirktok River and west of the Kuparuk River; these plains have a slightly higher aspect than the flat thaw-lake plains, because mounds up to 15 m in height occupy a large percentage of the interlake area. River floodplains are associated with the numerous rivers and streams that flow out to the Beaufort Sea (Walker and Acevedo, 1987).

The wetland classes in the study area range from small basins of temporarily flooded tundra to large, deep lakes with few emergents and depths to 1 m (hereafter called deep-open) to the partially drained basin-complexes. These drained basins can include different wetland classes (second generation) within the complex. Coastal aquatic wetlands vary from lagoons to ponds periodically exposed to salt water by extreme high tides (Bergman et al., 1977).

Habitat types in the study area range from unvegetated tundra in low-lying areas along the coast and shorelines of lakes to upland tundra with dwarf shrubs in more elevated, better-drained terrain (Walker and Acevedo, 1987). The principal habitat for brant along the coast is the Halophytic Sedge-Grass Meadow Tundra (habitat classification from Viereck et al., 1992) which consists largely of the small graminoids *Carex subspathacea* and *Puccinellia phryganodes*, but occasionally contains *Carex aquatilis* (Bergman et al., 1977; Markon and Derksen, 1994). The dominant vegetated habitats in the thaw-lake plains include Flooded Tundra, Wet Sedge Meadow Tundra, and Moist Sedge Meadow Tundra. All three types are dominated by *Carex aquatilis* and *Eriophorum* spp., but differ in their degree of water saturation and retention through the summer (Markon and Derksen, 1994). Moss/Peat habitats are found along the shores of second-generation lakes (Markon and Derksen, 1994) and also on some low-lying coastal islands.

The climatic conditions in the study area consist of long, cold winters, and short, cool summers, with an annual mean

temperature of -13˚C (Walker, 1985). In the summer, a steep temperature gradient occurs from the coast inland, with mean July temperatures generally less than 5˚C along the coast, and near 8˚C 50 km inland. Precipitation is light during the summer (≤ 100 mm), although snow, drizzle, and light rain are common (Walker, 1985). The timing of snowmelt and ice breakup is variable, but on average most rivers break up in mid to late May. Ice can persist on the largest lakes through early July (Bergman et al., 1977).

METHODS

Data for this study were collected during both aerial and ground surveys from 1989 to 1992. Aerial surveys were used to locate brant nesting and brood-rearing areas, to estimate the number of adults and nests at nesting locations, and to count and photograph groups of brood-rearing brant. A fixed-wing aircraft with a pilot and one (Piper Supercub) or two (Cessna 180) observers was used for all surveys. Surveys were flown at approximately 50–150 m above ground level (agl), at approximately 80–100 km/h. The area surveyed extended inland to approximately 70˚10′N west of the Sagavanirktok River, and 70˚15′N east of that river. Small gravel islands (e.g., Niakuk Islands) and spits within 1–2 km of the coast were included in the surveys. Barrier islands on the fringe of Simpson Lagoon and Gwydyr Bay (e.g., Jones Island) were not surveyed. Limited observations of nesting in previous years (e.g., Gavin, 1977; Divoky, 1978; Johnson and Richardson, 1981), the persistence of sea ice surrounding these islands, and the absence of any brant seen on a flight on 6 July 1989 led us to exclude these islands from subsequent surveys.

Aircraft surveys to locate nesting brant were conducted in mid to late June. In 1989, an intensive search of the study area was conducted; essentially all lakes and other suitable nesting habitats in the study area (e.g., deltaic islands) were surveyed for brant. Thereafter, surveys were conducted by flying a lake-to-lake route of selected wetlands (i.e., wetlands with a history of brant use, lakes with islands) within ~3.2 km wide parallel corridors across the study area. Small ponds and flooded tundra were not searched unless they occurred along the route. Coverage was intensified over river deltas; the aircraft followed parallel transect lines 0.8 km apart. Over preferred brant nesting habitats, such as lakes or wetlands with numerous islets, or river deltas (Einarsen, 1965; Bellrose, 1976; Bergman et al., 1977; Derksen et al., 1979), more than one pass at ~ 50 m agl was made. Overflights were not made above large colonies for which ground monitoring was planned.

All observations of brant were recorded on 1:63 360 U.S. Geological Survey maps and included estimated numbers of adults and nests at each location. A nest was recorded if either a down-filled bowl or an adult in incubation posture was observed. Aerial counts of nests were unavoidably incomplete, especially in areas where nests were dispersed. Some nests and incubating adults escaped detection because of their cryptic coloration; over colonies we limited the number of passes, in a compromise between taking time to make more accurate counts and minimizing disturbance.

Two to three aerial surveys to map and count brood-rearing brant were conducted each year from mid-July to early August. Brant in small (< 50 individuals) brood-rearing groups were counted directly; larger groups were counted from aerial photos taken with a 35 mm camera. The survey route followed the coastline as closely as possible, but extended inland in deltas and flooded river mouths to include the shorelines of islands. On one brood-rearing survey each year, the nesting locations mapped in June were revisited to determine the extent of their use for brood-rearing.

In all years, ground surveys were conducted in the largest colonies within the region and at most colonies accessible by the road system in the oilfields. Censuses of nests were conducted in early to mid-July after all brant had hatched. Deltaic islands where brant nested were searched in their entirety, whereas the shoreline and lacustrine islands were searched within nesting areas on the lakes.

To assess the importance of different locations within the region for nesting and brood-rearing and to analyze interannual variation in distribution and abundance of brant, the survey area was divided into five coastal strata (Fig. 1). The developed part of the region consisted of three strata (Sag Delta, Prudhoe Bay, and Kuparuk) and the undeveloped areas to the east and west of the oilfields were each considered separate strata: Sag East and Oliktok West. Location data from the aerial survey maps and ground censuses were digitized with Geographic Information System software (Atlas GIS, release 2.00, Strategic Marketing, Inc., Santa Clara, CA). Descriptions of bodies of water and vegetation in the study area followed the classifications of Bergman et al. (1977) and Viereck et al. (1992), respectively.

During compilation of the nesting data, brant associated with colonies and other nesting locations were assumed to be breeding birds, whereas those observed in flocks at other locations were assumed to be either failed or non-breeding birds. The number of nesting brant was calculated from two sources: the number actually counted at the nesting locations covered by the aerial survey, and the expected number of adults associated with the number of nests we located in the study area (i.e., number of adults = number of nests × 2). Both estimates were conservative: the former because some colonies were not surveyed and other colonies and nests had failed before the aerial surveys occurred, and the latter because not all locations were searched on the ground and some nests were undoubtedly missed from the air.

RESULTS

Nesting Distribution and Abundance

Brant nested throughout the study area, with the largest concentrations of both colonies and nests located in the Sag Delta, Prudhoe Bay, and Kuparuk strata (Fig. 2, Table 1). Between 1989 and 1992, the estimated number of nests in the

entire study area ranged between 315 and 532, at 44–66 locations (Table 1). All nest and colony locations occurred within 20 km of the coast ($\bar{x}$ = 4.2 km). Between 65% and 75% of all nesting locations were within 5 km and less than 15% occurred ≥ 10 km from the coast in each year. Nests in small mainland colonies were located predominantly in Moist Sedge Meadow Tundra habitats, primarily on islands and secondarily along shorelines in basin-complex and in deep-open lake wetlands. The largest colonies occurred on deltaic or remnant islands at the mouths of the Sagavanirktok and Kuparuk Rivers. Few nests (≤1%) occurred on gravel spits or islands (e.g., Niakuk Islands, Fig. 1), and those were confined to vegetated areas, usually Moss/Peat or Halophytic Sedge-Grass Meadow Tundra.

The total number of birds observed at colonies and other nest sites covered by the aerial surveys ranged between 187 (1991) and 398 (1989) (See Table 1). The estimated number of birds associated with nests in the study area (= number of nests × 2) ranged from 630 in 1991 to 1064 in 1990 and averaged ~ 800 adults. Failed and nonbreeding brant usually were observed along the coast in Halophytic Sedge-Grass Meadow Tundra habitats later used by brood-rearing groups. Failed and nonbreeding brant ranged from a low of 293 birds in 21 flocks in 1992 to 740 birds in 51 flocks in 1991 and averaged ~ 480 birds.

Colony Size and Traditional Use

Most nesting locations in the study area consisted of only a few nests. More than 70% of the locations in any year had ≤ 5 nests, and only one or two locations in any year had > 100 nests. The remaining colonies generally had between 6 and 40 nests. Between 10 and 30 solitary nests were recorded each year, although these counts undoubtedly were conservative.

The use of specific nesting locations varied among years. Some locations had nesting brant every year (primary sites), whereas others (secondary sites) were used only once or intermittently during the four-year study. The primary sites ranged from 6 to ~ 225 nests and occurred on deltaic or remnant islands, or in lakes with large or numerous islets within basin-complexes, whereas secondary sites tended to have ≤ 5 nests and usually occurred in lake habitats with few islands. The habitat characteristics of solitary sites generally were not noted, but they were occasionally found on the ground in Moist Sedge Meadows near shallow *Carex* ponds as well as in the wetlands noted above.

The Howe/Duck islands complex was a primary site with one of the longest records of observations in the study area. This complex was located on two remnant islands in the Sag Delta stratum and was the largest brant colony in the study area, with the number of nests on Howe Island growing from

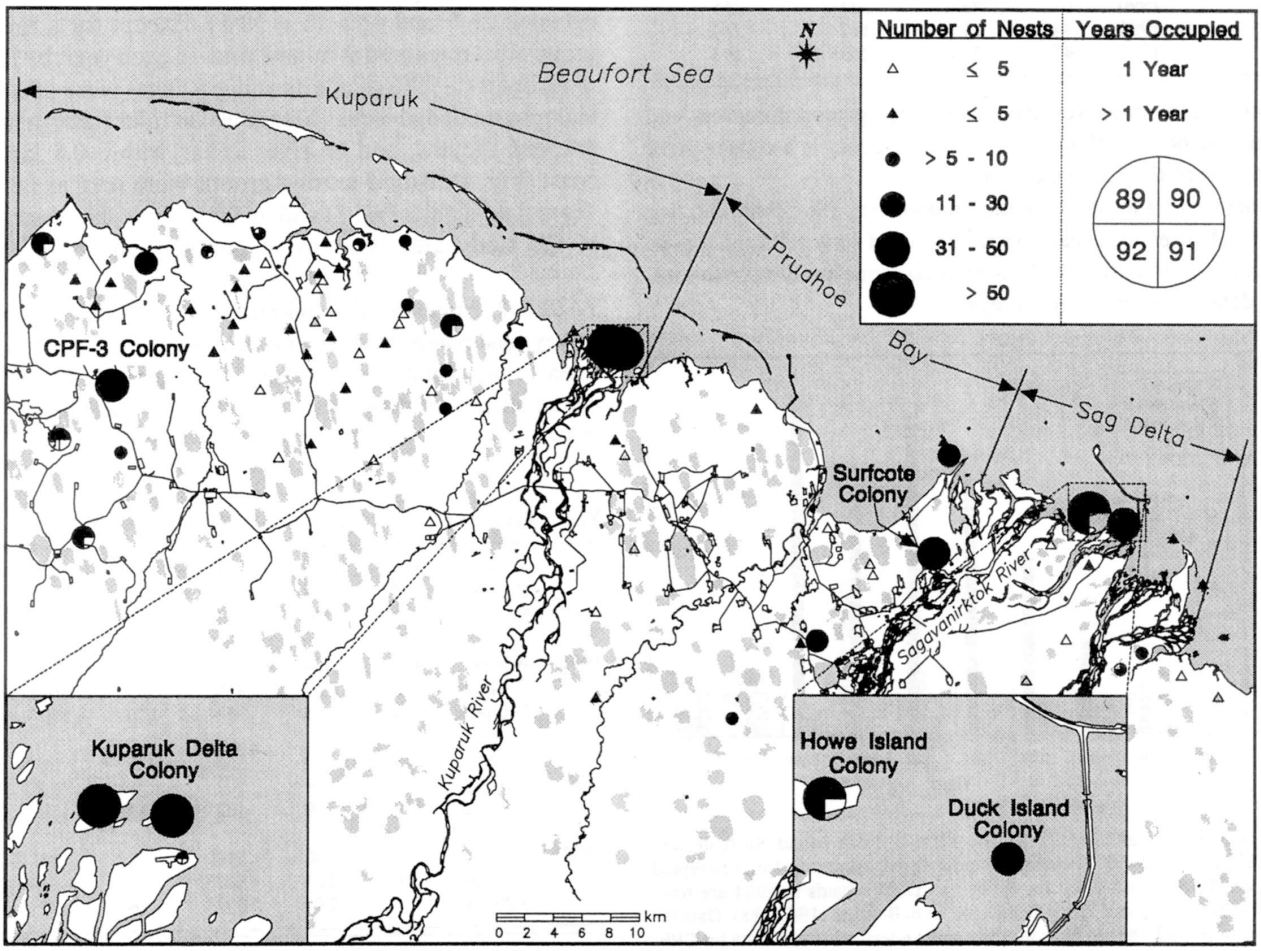

FIG. 2. Location and size of nesting areas for brant in the region of highest concentration on the central Arctic Coastal Plain, 1989–92. Insets detail the Kuparuk delta colony and the Howe/Duck islands complex, but the circle sizes are not to scale.

TABLE 1. The numbers of locations and nests of brant, the estimated number of adults associated with nests, and the counts of adults at nesting locations, and nonbreeders and failed breeders during June on the central Arctic Coastal Plain, Alaska, 1989–92.

Coastal Stratum	Year	Number of nesting locations	Number of nests[1]	Aerial count of adults at nesting locations[2]	Aerial count of nonbreeders and failed breeders
Oliktok West	1989	5	13	36	85
	1990	4	8	22	100
	1991	3	7	12	94
	1992	2	3	4	22
Kuparuk	1989	39	150	265	113
	1990	39	224	276	176
	1991	23	169	69	179
	1992	25	235	282	131
Prudhoe Bay	1989	10	37	45	69
	1990	9	41	42	57[3]
	1991	11	82	65	230
	1992	10	86	57	53
Sag Delta	1989	7	170	5	101
	1990	4	241	3	98
	1991	3	43	8	143
	1992	6	47	16	19
Sag East	1989	5	11	47	85
	1990	5	18	41	46
	1991	4	14	33	94
	1992	2	5	10	68
TOTAL	1989	66	381	398	453
	1990	61	532	384	455
	1991	44	315	187	740
	1992	45	376	369	293

[1] Some sites were surveyed by air, some by ground observers, and some by both methods; the combined count is a conservative estimate of the number of nests.

[2] Some nesting locations in the Prudhoe Bay (Surfcote) and Sag Delta (Howe/Duck islands) strata were not surveyed from the air.

[3] Includes a ground count of nonbreeders at one location; otherwise, all data are from aerial surveys.

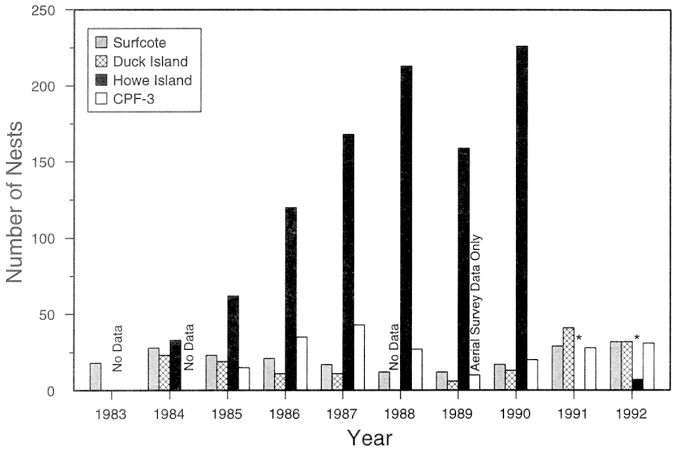

FIG. 3. Number of brant nests at the Howe Island, Duck Island, Surfcote, and CPF-3 colonies, 1983–92. The asterisks indicate the years arctic foxes disrupted nesting on Howe Island. Data for Howe and Duck islands in 1984 are from Johnson et al. (1985), and 1985–88 data are from Burgess (1985–88). Data for Surfcote from 1983–88 are from Murphy and Anderson (1992). Data for CPF-3 from 1985–88 are from Hampton (1989). All other data are from this study.

33 nests in 1984 (Johnson et al., 1985) to 226 nests in 1990 (Fig. 3). The number of nests on Duck Island was much lower, fluctuating between 6 and 41. The increasing trend in this colony-complex was interrupted in 1991 and 1992 as a result of egg predation by arctic foxes (*Alopex lagopus*) during nest initiation on Howe Island.

Other primary sites included the Surfcote colony in the Prudhoe Bay stratum, and the CPF-3 and the Kuparuk delta colonies in the Kuparuk stratum. Both the Surfcote colony and the CPF-3 colony fluctuated between 10 and 32 nests during the four-year survey (Fig. 3). The colony on the delta of the Kuparuk River occupied two to three islands annually and consisted of 80–130 nests (Fig. 2).

The remaining primary sites in the Prudhoe Bay and Kuparuk strata generally had fewer nests than Surfcote, CPF-3, and the Kuparuk delta colonies. Most nesting locations in these strata were secondary sites. The other strata, Sag East and Oliktok West, had the fewest brant nests (< 20 each in any year), and nesting locations in these sections were mainly secondary sites.

Brood-rearing Distribution

From 900 to ~ 3200 brant (adults and goslings) were observed in brood-rearing areas between 1989 and 1992 (Table 2). The gosling component of these groups ranged between 26% and 48% ($\bar{x}$ = 38%). Except for a few small groups that remained at inland lakes in each year, by late July most brant (> 99% of adults and goslings) were observed in Halophytic Sedge-Grass Meadows on tidal flats, in lagoons, at creek mouths, and on river deltas within 0.8 km of the coast (Fig. 4). Brood-rearing groups were seen as far east as Tigvariak Island (Fig. 1) and as far west as the western edge of the study area. Groups of nonbreeding, molting brant

TABLE 2. Numbers of brood-rearing brant counted from aerial surveys and photos made in late July and early August in coastal strata in the central Arctic Coastal Plain, Alaska, 1989–92. The numbers represent an average of the counts recorded on two surveys.

		Coastal Strata					
Year	Age Group	Oliktok West	Kuparuk	Prudhoe Bay	Sag Delta	Sag East	TOTAL
1989	Adults	109	406	234	50	113	912
	Goslings	87	294	121	73	33	608
	Subtotal	196	700	355	123	146	1520
1990	Adults	176	684	439	87	286	1672
	Goslings	203	701	315	83	265	1567
	Subtotal	379	1385	754	170	551	3239
1991	Adults	234	430	360	6	86	1116
	Goslings	276	279	102	8	33	698
	Subtotal	510	709	462	14	119	1814
1992	Adults	0	160	510[1]	2	23	694
	Goslings	0	124	112[1]	4	4	242
	Subtotal	0	284	622[1]	6	27	936

[1] Includes inland group seen by ground observers.

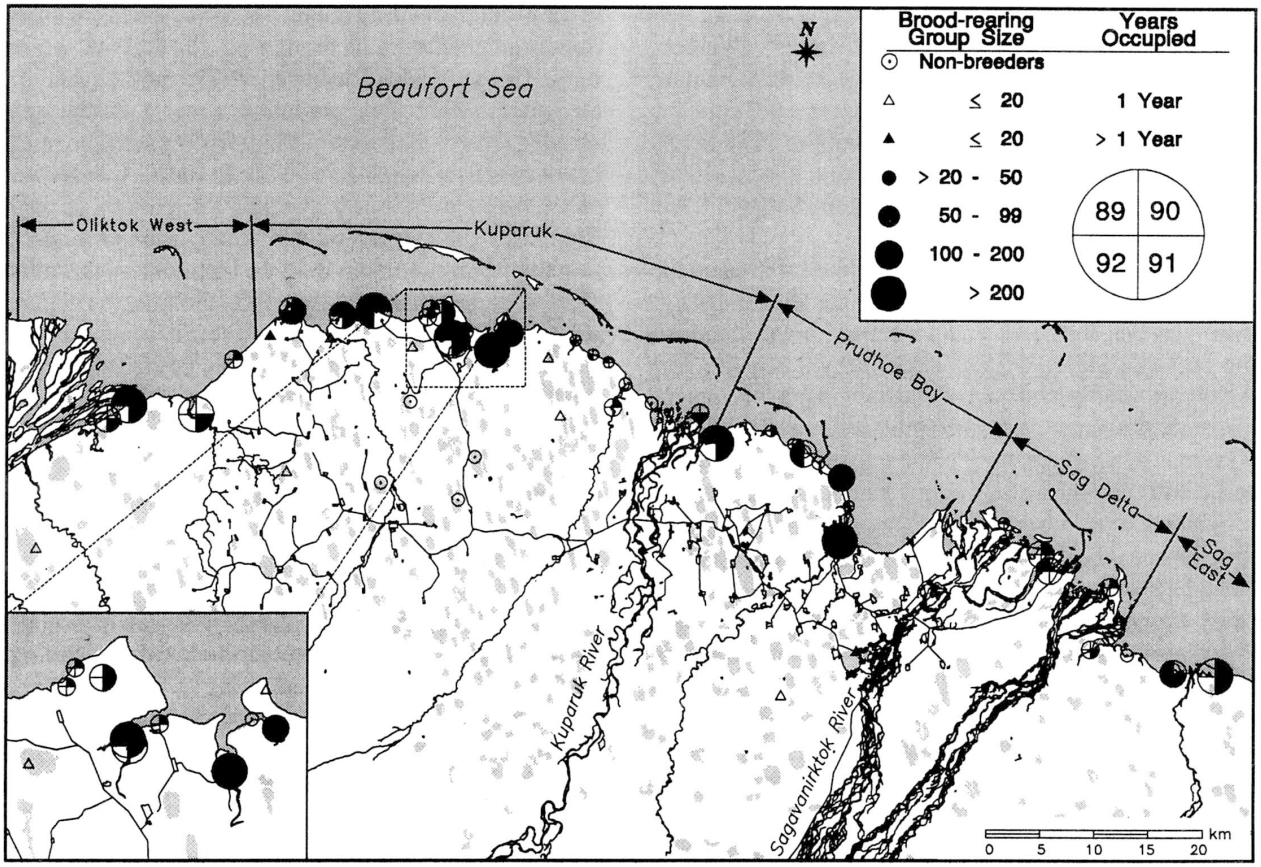

FIG. 4. Locations of brood-rearing areas and size of brood-rearing groups of brant in the region of highest concentration on the central Arctic Coastal Plain, 1989–92.

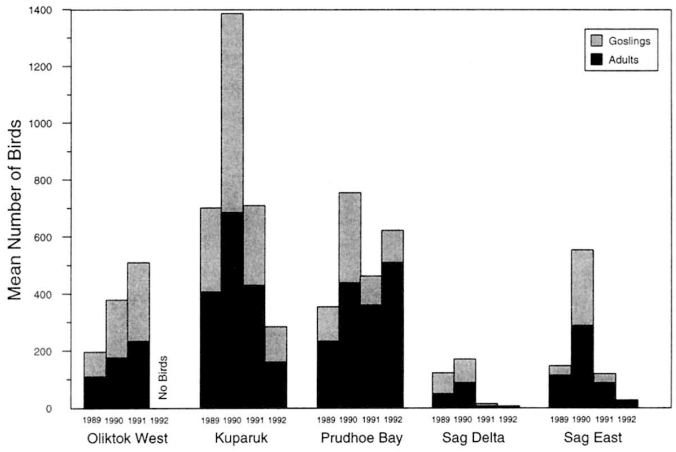

FIG. 5. Numbers of adult and gosling brant during brood-rearing by coastal stratum, 1989–92.

often occurred in the same halophytic meadows as did brood-rearing brant, but the two groups usually were segregated spatially.

The distribution of brant during the brood-rearing period varied among both coastal strata and years (Fig. 5) and appeared to be related to both nesting success and suitable habitat availability. Two strata, Kuparuk and Prudhoe Bay, consistently supported large numbers of brood-rearing brant in all years. Numbers of brant using these two strata ranged from a low of 906 birds (in 1992) to a high of 2139 birds (in 1990) and represented 65% (in 1991) to 97% (in 1992) of all brant in the study area at that time. The number of brant during brood-rearing was greater than could be accounted for by the number nesting in these strata and indicated that birds nesting in adjoining strata immigrated to these brood-rearing areas. Fewer groups and birds used the other three strata during brood-rearing.

Use of specific brood-rearing locations varied among years. Some coastal habitats were used annually, regardless of the size of the brood-rearing population, whereas others were used only intermittently (e.g., when the brood-rearing population was high in 1990; see Fig. 4). Sheltered areas of Halophytic Sedge-Grass Meadows at the mouths of creeks and rivers or within bays and estuaries were used more consistently than were areas along exposed coastline.

DISCUSSION

Nesting

Colonies ranging from a few to > 100 nests attracted nesting brant each year of our study on the central Arctic Coastal Plain; many of these colonies are known to have been used since the 1970s. For example, Gavin (1977) found 17–28 brant nests on Howe and Duck islands combined in early

1970s, and a colony of approximately 110 nests was reported on the Kuparuk River delta in 1974 (D.V. Derksen, U.S. Fish and Wildlife Service, Anchorage, pers. comm. 1989). Brant at small colonies in the Kuparuk Oilfield have been reported since development of that field in 1981 (M.R. Joyce, ARCO Alaska, Inc., Anchorage, pers. comm. 1990) with 15–43 nests recorded at the CPF-3 colony between 1985 and 1988 (Hampton, 1989).

No long-term data were gathered prior to the 1970s on the number of brant in the study area during nesting. Evidence from our surveys suggests that currently brant numbers fluctuate between 900 and 1500 birds. Previous aerial surveys in the mid-1970s indicated that the number of brant in approximately the same area ranged between 715 and 1007 birds (Gavin, 1978), suggesting similar numbers of brant.

Specific colonies showed different trends. The number of nests at Howe Island, situated 1 km from the coast, increased dramatically from Gavin's (1977) observations of a few nests in the early 1970s to > 200 nests in 1990. The colony complex in the east channel of the Colville River, which has some limited isolation from the mainland, also has shown an increase in nest numbers from the late 1980s through the early 1990s (from 415 nests in 1988 to > 900 nests in 1993; Bayha et al., 1992; P.D. Martin, USFWS, Fairbanks, pers. comm. 1993). Conversely, the Surfcote and CPF-3 colonies, on the mainland, showed no similar increasing trend.

The two most important factors influencing nesting distribution and the number of nests on the breeding grounds were environmental conditions and the number and types of predators present. The persistence of snow and ice in arctic nesting areas has been shown to affect both the timing and potential of nest initiation and consequent nest success (Barry, 1962; Prop et al., 1984; de Boer and Drent, 1989), preventing nesting in some areas (McLaren and Alliston, 1985) and limiting nesting habitats in other areas (Boyd and Maltby, 1979). During our study, we recorded reduced nesting effort in 1991, a year which had persistent snow and ice and cool temperatures, compared to 1990, the year with the most favorable weather conditions. In addition to natural environmental conditions, oil development has indirectly influenced nesting distribution through altered hydrologic regimes due to frozen road culverts. The resultant delay in lake drainage and subsequent flooding of nest islands was observed to limit habitat availability at the time of nest initiation in some colonies in some years (Murphy et al., 1989).

Predators also influence the number of brant nests and, likely, their distribution in the study area. Several avian and mammalian predators were present in the study area, but arctic foxes and brown bears (*Ursus arctos*) had the greatest potential impact for disrupting nesting or destroying colonies. Nest predation by arctic foxes dramatically reduced nesting success on Howe Island in the late 1970s (Gavin, 1978), and in 1991 and 1992 (this study). Brown bears had the same effect on Howe Island in 1985 (Burgess, 1985–88) and in 1992 in the Colville colony (P.D. Martin, USFWS, Fairbanks, pers. comm. 1992). Predation by brown bears appears to be more common in our study area than elsewhere in the brant's breeding range, but arctic foxes are known to be important predators of brant eggs throughout the breeding range (Barry, 1966; Raveling, 1989; Anthony et al., 1991; Stickney, 1991). Fox predation can retard the growth of established colonies, and potentially prevent the initiation of new ones (Syroechovsky, 1972). In the case of Howe Island, arctic foxes temporarily checked the growth of the colony. Raveling (1989) reported that small colonies suffer proportionally more predation than do large colonies. In our study area, with many small, dispersed colonies, the effects of fox predation over the four-year study were severe, but irregular and localized. Oil development may be indirectly increasing the number of predators, especially arctic foxes, in the segments of the study area where they have access to artificial food sources (Eberhardt et al., 1983; Burgess et al., 1993), potentially increasing predation.

Brood-rearing

Previous information on the distribution of brood-rearing groups in the study area was limited and conflicting; Kiera (1979) observed groups remaining at or near their nesting locations, while Bergman et al. (1977) reported that brant nesting at another location migrated to coastal habitats after hatching. It was apparent from our study that both patterns of brood-rearing movements occur, but that bird use of inland lakes was minimal.

The concentration of most brood-rearing birds in two strata indicated not only that brant migrated from nesting areas out to the coast, but also that birds from adjoining areas migrated to areas with extensive areas of Halophytic Sedge-Grass Meadow Tundra. During our study, it was confirmed that a large percentage of birds from Howe Island migrated into the Prudhoe Bay stratum; our hypothesis that brant from the Colville colony migrated in large numbers to the Kuparuk stratum was confirmed by a cooperative banding study with USFWS and LGL Alaska Research Associates, Inc. (Stickney et al., 1994).

Population Status

The brant that nest and rear their broods in and around the oilfields of the central Arctic Coastal Plain, in combination with the birds from the colonies on the Colville River delta, appear to be the most numerous segment of breeding brant in northern Alaska. Compared to the brant that nest on the Yukon-Kuskokwim Delta, however, the numbers nesting in northern Alaska represent a small fraction of the total Pacific Flyway population (Sedinger et al., 1993). The pattern in our study area of nesting in small- to medium-sized colonies, instead of the large (> 1000 nests) colonies found in the Yukon-Kuskokwim Delta, renders individual colonies more vulnerable to the effects of predation (Raveling, 1989); however, this dispersion may limit the impact of predation on a regional scale. King (1970) suggested that a dispersed distribution pattern could represent a buffer to wholesale nesting failure of the larger colonies.

While no statistical comparisons of the distribution and abundance of brant in the study area prior to and after oil development are possible, some general observations can be made. Colonies adjacent to roads and facilities for which pre-development data exist remain active. The distribution of brant during brood-rearing does not indicate an avoidance of facilities; instead, a five-year study indicates that habitat preferences and traditional use, rather than disturbance, may be the most important factors in determining use of nesting and brood-rearing locations (Murphy and Anderson, 1992). We suspect that the most important influences of oil development on brant may not be the direct result of human disturbance, but rather the indirect effects of human activity, such as elevated predator populations. Eberhardt et al. (1983) suggested that oil development increased the density of breeding foxes as well as the abundance of natural dens in the vicinity of development facilities. This suggestion was confirmed during a 1992 study that compared the density and productivity of foxes in developed and neighboring undeveloped areas (Burgess et al., 1993). This latter study reported the use of artificial secondary dens (e.g., culverts, utilidors, and crawl spaces), as well as the temporary use of dumpsters by fox families. Burgess et al. (1993) suggested that the availability of artificial foods in the winter may increase the proportion of females whelping; in the summer, it may increase the survival rate of pups. The availability of artificial foods appears to buffer the fox population against natural fluctuations and probably increases the predation of natural, and possibly preferred, foods, including eggs and juvenile birds.

From our surveys and review of historical information, we can conclude that the population of brant inhabiting the central Arctic Coastal Plain represents the main segment of the North Slope population in Alaska, that the main breeding colonies in the region are supporting numbers of birds that are comparable to those historical records, and that oil development has not permanently displaced birds from colony locations and brood-rearing areas traditionally used prior to development. We think that continuing monitoring of brant on the central Arctic Coastal Plain is warranted while the resource development continues to expand in the region and the Pacific Flyway brant population continues to decline.

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