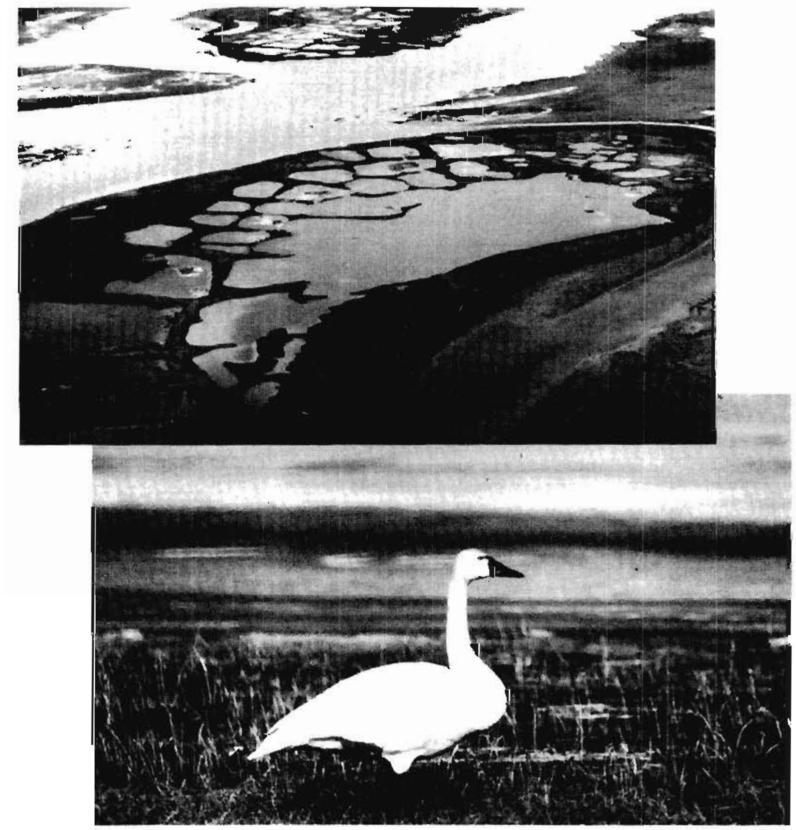
FINAL REPORT

TUNDRA SWAN AND BRANT SURVEYS ON THE ARCTIC COASTAL PLAIN, COLVILLE RIVER TO STAINES RIVER, 1992



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EXECUTIVE SUMMARY

TUNDRA SWANS

Tundra Swan surveys, using standard aerial survey protocols, were undertaken for the fifth year in the Kuparuk Oil Field and Oil and Gas Lease Sale 54 (OGL 54) areas. Surveys were also initiated in the Sagavanirktok and Foggy Island Bay region.

In the Kuparuk/OGL 54 study area, 581 Tundra Swans and 119 nests were observed in June 1992. Densities of Tundra Swans and nests were estimated at 0.13 swans/km^2 and 0.03 nests/km^2. Although numbers of swans declined in 1992 compared with 1991, counts of swans and nests were the second and third highest recorded in five years of surveys. In August 1992, 781 adult Tundra Swans and 257 cygnets in 101 broods were recorded in the Kuparuk/OGL 54 study area. Nesting success was 85% and mean brood size was 2.6 cygnets, similar to that observed in 1991. Densities during August were 0.18 adults/km^2 and 0.02 broods/km^2, slightly less than estimates from 1991.

In June 1992, 192 swans were observed in the Sagavanirktok - Foggy Island region. Within this area, numbers and densities of swans and nests were greatest on the delta (0.35 swans/km and 0.09 nests/km) compared with both the Foggy Island Bay, Sag Inland, Kuparuk Oil Field and OGL 54 sections. In August 1992, 219 adult swans and 64 cygnets in 23 broods were recorded in the Sagavanirktok River delta study area. Mean brood size was 2.8 cygnets, similar to the mean brood size in the Kuparuk/OGL 54 study area. As in June, the densities in August in the Sagavanirktok Delta section for adult swans, broods, and young were higher than those in the other sections and in the Kuparuk/OGL 54 study area.

As in previous years, densities in both study areas in 1992 were lower than those that have been reported for other areas in northern Alaska, such as the Colville River delta and the Arctic National Wildlife Refuge (ANWR). Declines in numbers in the Kuparuk and OGL 54 in 1992 may have been due to the late spring in the western Canadian Arctic. Declines were not substantial, however, and some data suggests that swans in the region may be both expanding and increasing.

BRANT

Aerial surveys were used to locate Brant nesting colonies and brood-rearing areas in the region between the Colville and Staines rivers. Ground surveys were used to determine the numbers of Brant nests and their fates at selected locations in the oil fields. In 1992, a cooperative effort was continued to capture and mark Brant within the oil fields with colored leg bands.

At least 380 Brant nests in 43 nesting locations were counted during aerial and ground surveys. During June aerial surveys, 188 Brant nests were located in the region; only 10 sites had greater than five nests, and no new large colonies were found during these surveys. Ground crews located 300 nests at 18 sites, with 192 of the nests not having been recorded previously by aerial surveys. These sites included colonies that were not covered by the aerial surveys (such as Duck Island and Surfcote). Numbers of Brant in the study area in late June 1992 (665 adults, 44% nonbreeders) were lower than previously recorded. The number of Brant nests found by ground crews in 1992 was similar to 1991. In the Sagavanirktok River delta, a decrease was due primarily to the abandonment of the Howe Island colony because of the presence of a pair of arctic foxes.

Aerial surveys and photo censuses in late July and early August 1992 indicated that approximately 930 Brant (26% goslings) used coastal habitats between the Colville and Staines rivers. Numbers of both adults and goslings were substantially lower in 1992 than in previous years and lower than expected from estimated productivity, suggesting increased post-hatch mortality. Most brood-rearing brant were distributed at coastal sites between Milne Point and the Putuligayuk River mouth.

In 1992, 687 unbanded Brant were captured between Prudhoe Bay and Oliktok Point. In addition, 68 brant were recaptured that had been previously banded, including birds originally banded in the oil fields (47%), elsewhere in Alaska (53%), and one bird from Canada. Numerous resightings of these birds have been made on staging, wintering, and breeding areas. Over 1000 Brant have been banded in the oil fields since banding was initiated in 1991.

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ACKNOWLEDGMENTS

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INTRODUCTION

Tundra Swans (*Cygnus columbianus*) are a conspicuous and important component of waterbird communities in northern Alaska. These arctic-nesting swans are part of the eastern population of Tundra Swans, which winters primarily on the mid-Atlantic coast of the United States (Sladen 1973). They are among the first migrants to arrive on the Arctic Coastal Plain in mid-May (Bergman et al. 1977). Early arrival on the breeding grounds is critical, because swans have a protracted breeding season. After an incubation and brood-rearing period of approximately 120 days, they depart the Arctic Coastal Plain during freeze-up, which occurs usually by early October (Salter et al. 1980). Several previous surveys on the coastal plain have provided basic information on the distribution, productivity, and abundance of swans on the Arctic Slope (e.g., King 1970; Bartels and Doyle 1984; Conant and Cain 1987; Ritchie et al. 1990, 1991).

Brant (*Branta bernicla*) are important colonially nesting geese on the Coastal Plain. In the past, they have been recorded as the most common nesting waterfowl near Barrow (Bailey et al. 1933) and the most common goose near Pitt Point (D. H. Fiscus, 1952-1953, unpubl. notes). Hansen (1957) reported that large numbers of Brant molted on the coastal plain, and King (1970) identified goslings as a large component of this population. Although Brant broods have been located up to 40 km inland, most colonies have been found along the coast and on major river deltas. Previously identified colony locations include the Colville River delta (Shepherd 1961), the Sagavanirktok River delta (Gavin 1980, Johnson et al. 1985), the Okpilak River delta (Spindler 1978), and Teshekpuk Lake (Derksen et al. 1979). Brant also nest on barrier islands in the Beaufort Sea (Gavin 1977, Divoky 1978, Johnson and Richardson 1980).

Tundra Swans and Brant have received considerable attention from both the regulatory agencies and the oil industry. Swans have been considered an indicator species of the productivity and well-being of all waterfowl in a given habitat (King 1973, King and Hodges 1980). A steady increase in the eastern population of wintering swans, and renewed interests in increasing sport harvest, may influence management considerations on their arctic breeding grounds. Brant, on the other hand, have shown recent declines in the western flyway population (O'Neill 1979, Raveling 1984). Both species are traditional in their selection of nesting and brood-rearing areas and, hence, are potentially vulnerable to changing conditions in these areas. It is important to assess the distribution, productivity, and abundance of this species as development expands into previously undisturbed areas.

In 1988, under contract to ARCO Alaska, Inc., Alaska Biological Research, Inc. (ABR), initiated intensive aerial surveys in the Kuparuk Oil Field and in Oil and Gas Lease Sale 54 (OGL 54) (Figure 1). Although these surveys primarily were used for collecting information on Tundra Swans, incidental information on the distribution of Brant also was collected. In 1989, BP Exploration (Alaska) Inc. became a partner in the survey program, due to an increasing interest in the status of Brant in the vicinity of the oil fields. That year and subsequently, aerial surveys for Brant were extended to Brownlow Point, and ground surveys were conducted in colonies in the Sagavanirktok River delta (1989-1992). From 1990-1992, ground surveys also were conducted in the Prudhoe Bay area and the Kuparuk Oil Field. In 1992, BP supported additional surveys for Tundra Swans on the Sagavanirktok River delta. In 1992, surveys for Tundra Swans and Brant included the following components:

1) during nesting and brood-rearing, aerial surveys to determine numbers of nests, broods, and adult Tundra Swans in the Kuparuk Oil Field, OGL 54, and the Sagavanirktok River delta - Foggy Island Bay study areas;
2) during nesting, aerial surveys of the coastal region between the Miluveach River and Brownlow Point, to count Brant and their nests and to locate Brant colonies;
3) during nesting, ground censuses of Howe and Duck islands and Surfcote, to determine numbers of nests, distribution, and productivity of Brant and other waterbird species;

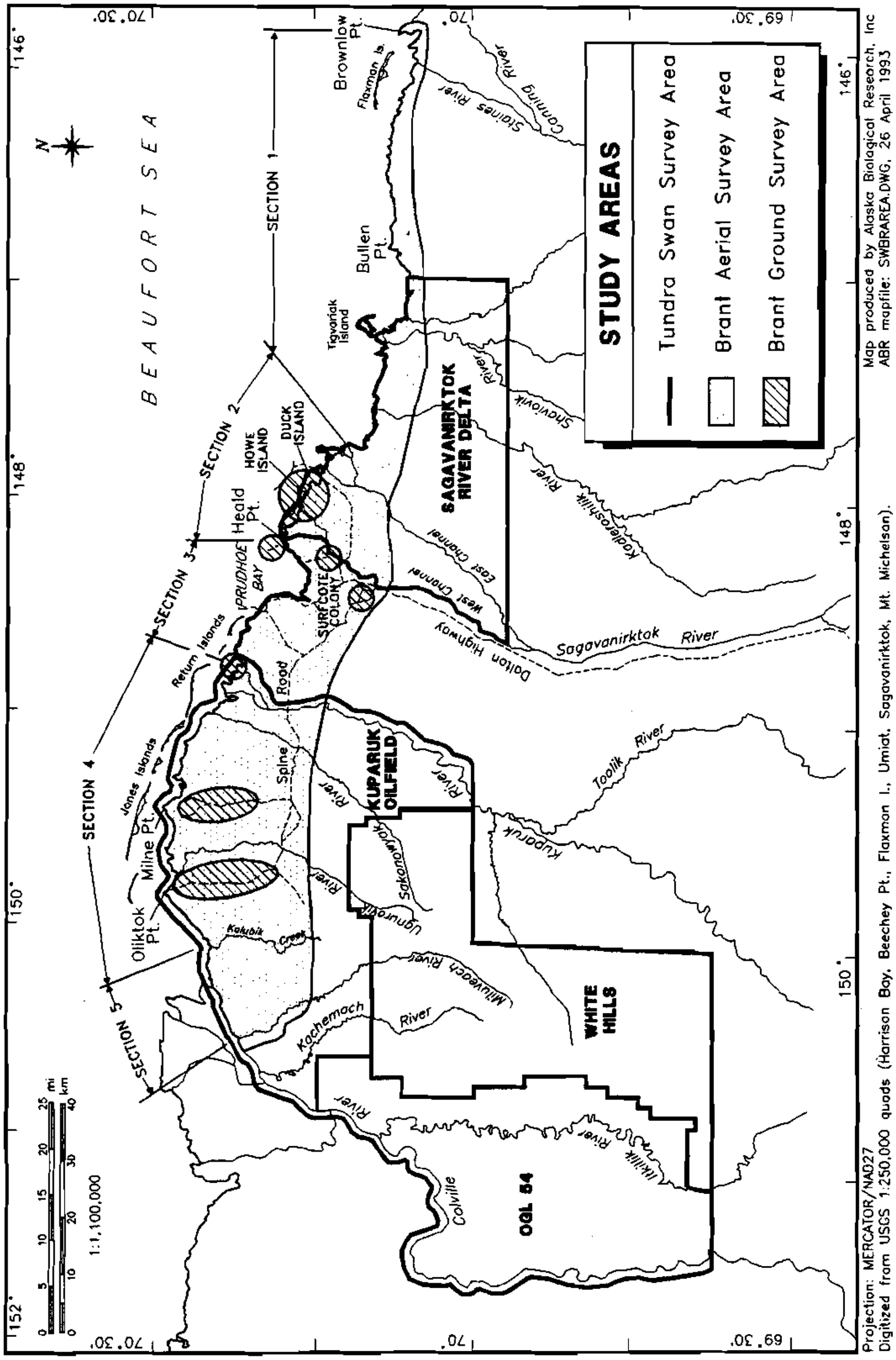


Figure 1. Study areas for Tundra Swan and Brant investigations in 1992.

4) during nesting, ground surveys at selected sites in the Kuparuk River and Milne Point units, to determine numbers of nests and productivity of Brant;
5) during brood-rearing, aerial surveys of the coastal region between the Miluveach River and Brownlow Point, to count Brant and to locate their brood-rearing areas; and
6) during brood-rearing, capture and color-banding of Brant in the area between the Kuparuk River and Prudhoe Bay;

STUDY AREA

During 1992, as in previous years of the study, surveys for Tundra Swans and Brant were conducted on the Arctic Coastal Plain between the Staines River and the eastern channel of the Colville River (Figure 1). Most of this region is characterized by large, oriented thaw lakes and polygonized tundra (Carson and Hussey 1962). A number of braided rivers cross the study area and produce deltas ranging in size from a few small islands to the complex, multi-channeled Sagavanirktok River delta. Salt-marsh vegetation occurs in patches along the coastline, but is most common in protected embayments and on deltas. Tundra Swan surveys extended into the White Hills, an upland area south of the Arctic Coastal Plain between the Itkillik and Kuparuk rivers (Wahrhaftig 1965), where the areal extent of lakes is greatly reduced. Landforms and vegetation of the Arctic Coastal Plain have been described in detail by Walker et al. (1980).

Aerial surveys for Tundra Swans covered the entire Kuparuk Oil Field (~2,200 km^2) and OGL 54 (~1,700 km^2). In 1992, the White Hills section (~2,200 km^2) south of the Kuparuk Oil Field was reincorporated into our surveys after exclusion in 1991. Also in 1992, the Sagavanirktok River delta - Foggy Island Bay region (~1,700 km^2) was included in our surveys (Figure 1). This region includes the area between the western channel of the Sagavanirktok River and the Kavik River, and extends approximately 25 km inland. The Sagavanirktok River delta includes a wide variety of land forms and vegetation types ranging from wetlands characteristic of the Arctic Coastal Plain to dry, alpine-like habitats along river bluffs and islands (Gallaway and Britch 1983). The Prudhoe Bay Oil Field, surveyed in 1990 and 1991, was not surveyed in 1992.

Aerial surveys for Brant were conducted on the Arctic Coastal Plain between Brownlow Point (near the mouth of the Staines River) and the Miluveach River near its junction with the Colville River (Figure 1). (This region is referred to as the 'Colville to Staines' region in the text.) The areas surveyed were similar to those described by Ritchie et al. (1991) and included offshore islands, inland areas in the Kuparuk and Prudhoe Bay oil fields, and the area between the Sagavanirktok and Staines rivers, within 5 km of the coast. The study area included a variety of landforms and vegetation types ranging from thaw lakes and polygonal wet tundra, to dry alpine-like habitats in some areas of deltas (Gallaway and Britch 1983). The study area was typical of the Arctic Coastal Plain, which has been described in detail by Walker et al. (1980).

PART 1: TUNDRA SWAN SURVEYS

METHODS

Aerial survey methods in 1992 followed the U. S. Fish and Wildlife Service (USFWS) Tundra Swan Survey Protocol (USFWS 1987) and were similar to those used in previous years for this study (Ritchie et al. 1990, 1991; Stickney et al. 1992). A Cessna 185 aircraft was flown along fixed-width, east-west, 1.6 km-wide transects. The flightlines were directly over township and section lines, and all observations were recorded on 1:63,360 USGS maps. However, in the White Hills section, the survey followed a lake-to-lake route, because waterbodies are limited in number in this area. For all areas, the aircraft was flown 150 m above ground level (agl) and at an airspeed of 145 km/h. Survey dates were selected to be consistent with the timing of previous surveys. Nesting surveys were conducted between 20 and 28 June 1992, and brood-rearing surveys were conducted between 16 and 21 August 1992 (Appendix 1).

During sampling, each of two observers scanned a transect approximately 800-m wide on each side of the aircraft, while the pilot navigated and scanned ahead of the aircraft. A standardized set of codes for pairs of swans, single swans, flocks, nests, and broods was employed (USFWS 1987). When possible, observations of other wildlife (primarily species of geese, loons, and nests of Glaucous Gulls [*Larus hyperboreus*]) were recorded.

All Tundra Swan location data were entered onto digital maps (developed from 1:63,360 USGS maps by AeroMap U.S., Inc.) corresponding to the appropriate field map. Estimates of areas (km^2) used for density calculations and spatial analysis were measured from these base maps using AutoCAD software (Autodesk, Inc., Sausalito, CA). Because in previous years the areas of survey coverage were obtained by less accurate means (i.e., hand-held planimeters), slight differences between this year's densities and previous years' densities are due primarily to this refinement. In addition, slight differences in absolute numbers and densities are due to the separation of survey data for the White Hills section, previously included in the Kuparuk and OGL 54 sections. Estimates of survey-coverage for each USGS quadrangle in the study area are summarized in Appendix 2. Summary statistics for nesting and brood-rearing surveys followed the format established in 1988 and modified in 1990 (Ritchie et al. 1989, 1991).

For the USGS Beechey Point B-5 quad, we assessed whether there were increasing trends in swan numbers (e.g., adults, broods) using linear regression to measure the degree of association between year of survey and seven years of swan population data.

For the Sagavanirktok River delta - Foggy Island Bay study area, we evaluated two hypotheses to assess differences in densities and productivity of Tundra Swans among sections:

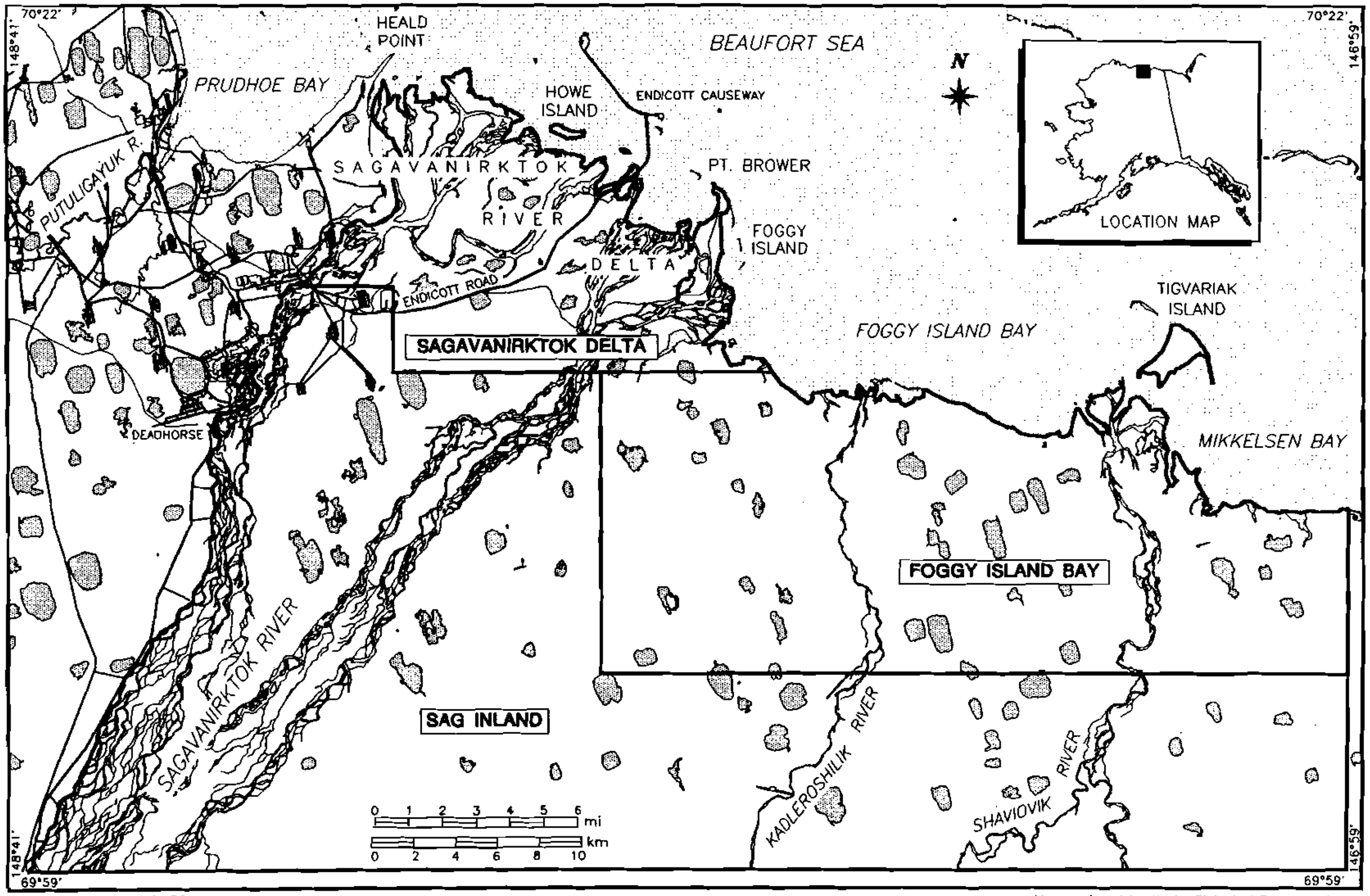
Ho_1: The density of Tundra Swans during the summer did not differ between the Sagavanirktok River delta and adjacent sections

Ho_2: The mean brood size of Tundra Swan pairs did not differ among the Sagavanirktok River delta and adjacent sections.

The Sagavanirktok River delta study area was divided into three sections: the Sagavanirktok Delta, Foggy Island Bay, and Sag Inland sections (Figure 2). Comparisons among sections were made of the average minimum distance (nearest neighbor) between nests and broods. Nearest neighbor distances (Clark and Evans 1954) were used to measure spatial relationships in the populations of the three sections. The ratio "R" was computed by dividing the sum of all nearest neighbor distances (Σr) in a sample by the mean of nearest neighbor distances that would be expected in a random distribution:

$$R = \frac{\Sigma r}{(2\sqrt{\rho})^{-1}} .$$

This ratio can be used as a measure of the degree that the observed distribution approaches or departs from a random distribution, with R = 1 indicating a random distribution, R = 0 a clumped distribution, and R = 2 a uniform distribution (Clark and Evans 1954).



Projection: Mercator/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quads;
coastline, facilities and major rivers updated from aerial photography (1973–1990).

Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92TSBPSA.MAP, 26 April 1993
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Figure 2. Sagavanirktok River - Foggy Island Bay study area and three sections (Sagavanirktok Delta, Foggy Island Bay, Sag Inland) used for analysis of Tundra Swan densities, 1992.

RESULTS AND DISCUSSION

KUPARUK OIL FIELD AND OGL 54 AREA

Tundra Swan Distribution in June

During nesting surveys in June 1992, 581 Tundra Swans were seen at 349 locations (Table 1, Appendix 3). Most were not associated with nests and probably were non- or failed breeders; only 33% were associated with nests. As in previous years, most (60%) swans were observed in the Kuparuk Oil Field, with 37% in OGL 54 and 2% in the White Hills section. One hundred-nineteen nests were observed in the entire study area. Seventy-five nests were located in the Kuparuk Oil Field and 44 nests were located in OGL 54. No nests were recorded in the White Hills section.

As observed in previous years of surveys, swans were distributed wherever large lakes and drained basins occurred (Figure 3; Ritchie et al. 1990, 1991; Stickney et al. 1992). Although we have not quantified habitat use during our surveys, it appeared that Tundra Swans were selecting sites in drier, more upland areas in 1992 than in previous years. The use of drier areas may have been related to the delayed departure of ice on many lakes in the region that was evident in 1992.

In the Kuparuk Oil Field and OGL 54, the densities of nests (0.03 nests/km^2 in both sections) were similar (Appendix 4). However, numbers of adults were higher in the Kuparuk Oil Field than in OGL 54: adults with nests (0.06 vs 0.04 adults/km^2), adults without nests (0.11 vs 0.9 adults/km^2). Densities of swans were low (0.01 adults/km^2) in the White Hills section.

The number of Tundra Swans counted in June 1992 in the combined Kuparuk Oil Field and OGL 54 sections declined 10% from 1991, although swans in both years were more numerous than in previous years (Figure 4, Table 1). The largest decrease (-11%) was in the number of adult swans not associated with nests. The number of adults with nests was similar between 1992 and 1991, but nesting adults in 1992 were 5% less than in 1990. The number of nests in 1992 declined slightly between 1991 (-6%) and 1990 (-2%); however, nest numbers in 1992 were more than 50% higher than either 1989 or 1988.

Within the study area, numbers of swans decreased proportionately more in OGL 54 than in the Kuparuk Oil Field (Figure 4, Table 1). Overall in 1992, 18% fewer adult swans were seen in OGL 54 compared to 4% fewer in the Kuparuk Oil Field than were counted in 1991. Both areas had decreased numbers of adults that were not associated with nests in 1992. In OGL 54, the number of adults with nests in 1992 decreased 10% and 11% from 1991 and 1990, respectively. In the Kuparuk Oil Field, however, the number of adults with nests was similar to or increased slightly (8%) over 1990 and 1991 numbers. There were 8% fewer nests in OGL 54 in 1992 compared with 1991 and 1990. The Kuparuk Oil Field had three fewer nests in 1992 compared with 1991, but two more nests than in 1990.

Productivity and Distribution in August

During surveys in August, 1065 Tundra Swans (797 adults and 268 juveniles) were observed at 369 locations in the Kuparuk/OGL 54 study area (Table 2, Figure 5, Appendix 5). Adults with broods constituted 25% of all adult swans seen. In the Kuparuk Oil Field, brood-rearing adults represented 29% of all adults seen (Figure 6), whereas they only represented 18% of all adults seen in the OGL 54.

Between June and August 1992, the number of adult Tundra Swans increased 37% in the study area, although the increase in OGL 54 was greater (44%) than in the Kuparuk Oil Field (34%) (Tables 1 and 2). Most of the increase in swans was due to increases in numbers of adults without broods (Figure 5): a 46% increase from June to August in the Kuparuk Oil Field and a 77% increase in the OGL 54. Although most of the swans not associated with broods were observed in pairs, the number of flocks (>2 swans) tripled in the study area between June and August. In OGL 54, the average flock size increased from 3.0 birds/flock in June to 4.9 birds/flock (range = 3 - 18 birds) in August. No flocks were recorded in the White Hills section.

As in previous years, some redistribution of Tundra Swan adults with broods probably occurred between the Kuparuk Oil Field and OGL 54 sections (Tables 1 and 2). The Kuparuk Oil Field had a 12% increase between June and August in the number of breeding adults, while OGL 54 had a 21% decrease. This difference may be partly due to immigration of adults and

Table 1. Numbers of Tundra Swans and nests recorded during June on aerial surveys in the Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54), and White Hills study areas, Alaska, 1988-1992.

Area	Year	No. of Adults With Nests	No. of Nests	No. of Adults Without Nests	Total Swans
Kuparuk Oil Field	1988	50	26	148	198
	1989	70	44	183	253
	1990	120	73	169	289
	1991	112	78	252	364
	1992	**121**	**75**	**228**	**349**
OGL 54	1988	45	28	185	230
	1989	53	34	158	211
	1990	81	48	154	235
	1991	80	48	182	262
	1992	**72**	**44**	**144**	**216**
Subtotal (Kuparuk/OGL 54)	1988	95	54	333	428
	1989	123	78	341	464
	1990	201	121	323	524
	1991	192	126	434	626
	1992	**193**	**119**	**372**	**565**
White Hills[a]	1989	0	0	15	15
	1990	3	2	12	15
	1992	**0**	**0**	**16**	**16**

[a] The White Hills section of the study area was not surveyed in each year; this information has been presented in earlier reports on OGL 54 totals.

broods from nesting areas to more favorable coastal brood-rearing habitats, as reported in other studies (McLaren and McLaren 1984, Stewart and Bernier 1989).

During 1992, 101 Tundra Swan broods comprising 268 young were counted, with most broods (67%) observed in the Kuparuk Oil Field (Table 2). Four broods were seen in the White Hills section. Because no nest sites were found in the White Hills section during June surveys, these observations suggest that nests had been overlooked or broods immigrated into the area. Average brood sizes were 2.7, 2.5, and 2.8 young for the Kuparuk Oil Field, OGL 54, and White Hills, respectively. The densities of adults without broods were similar for the Kuparuk Oil Field and OGL 54 (Appendix 4). However, other density variables were higher in the Kuparuk Oil Field than in OGL 54. Substantially higher densities of both breeding adults (0.06 adults/km^2) and young (0.09 young/km^2) were present in the Kuparuk Oil Field than in OGL 54 (0.03 adults/km^2 and 0.04 young/km^2). Furthermore, the proportion of young in the total population was greater in the Kuparuk Oil Field (28.3%) than in the OGL 54 section (18.8%).

Although 119 nests were located in June in the study area, only 101 broods were observed

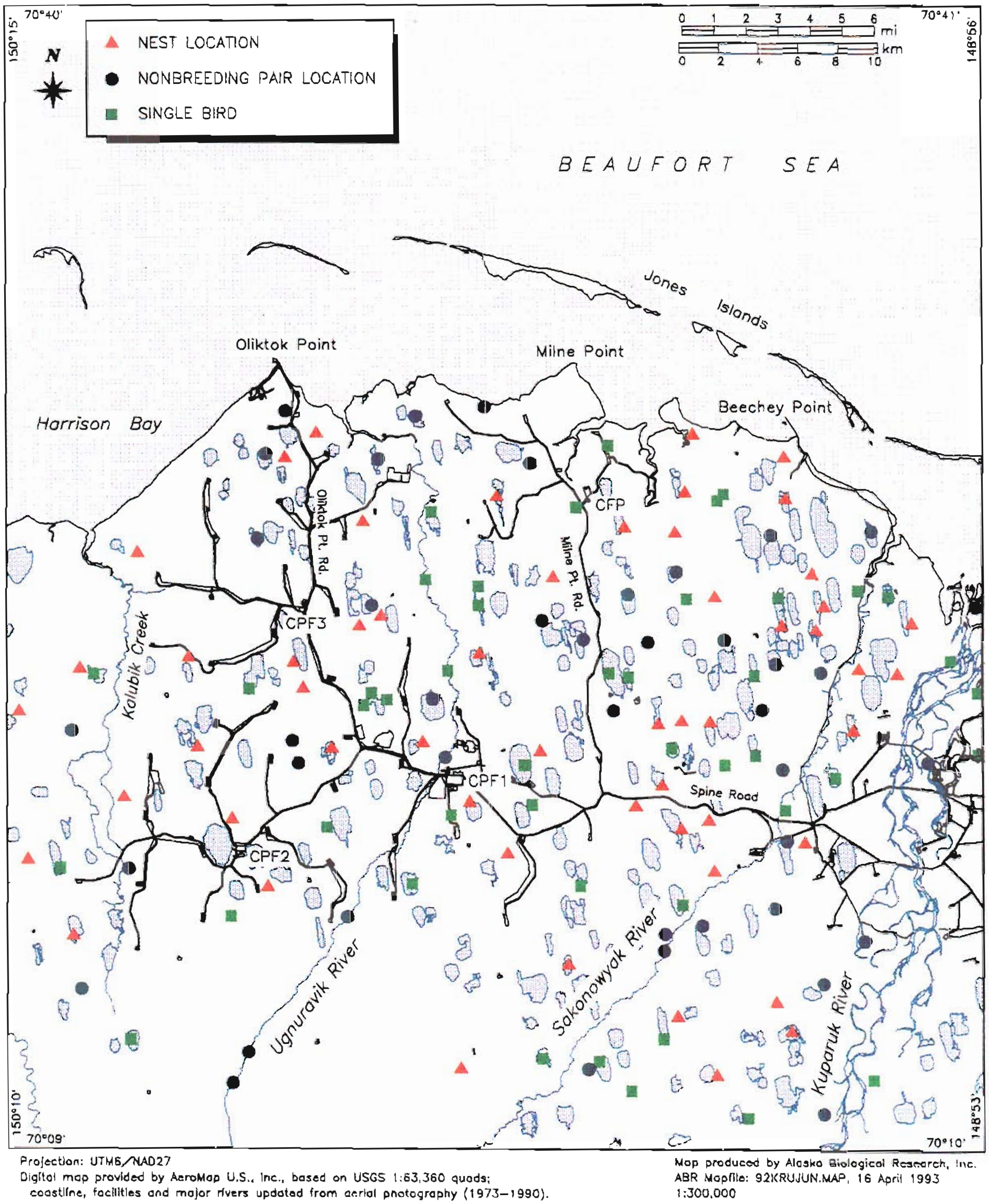


Figure 3. Locations of Tundra Swan nests and nonbreeding pairs observed during aerial surveys in the central Kuparuk Oil Field, Alaska, 20-26 June 1992.

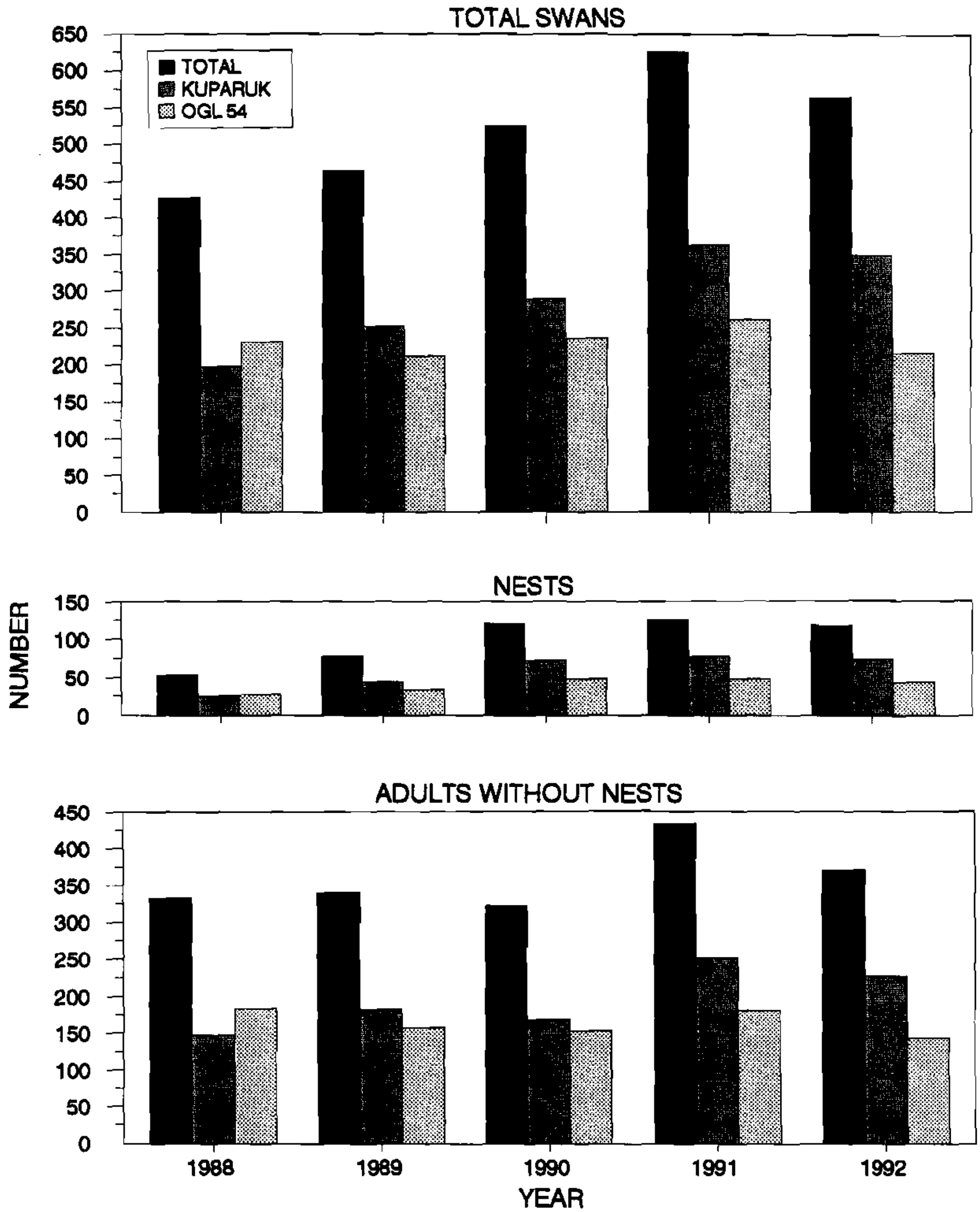


Figure 4. Numbers of Tundra Swans, adults without nests, and nests recorded during aerial surveys in June in the Kuparuk Oil Field and Oil and Gas Lease 54 (OGL 54) study areas, Alaska, 1988-1992.

Table 2. Numbers of Tundra Swans and broods recorded during August on aerial surveys in the Kuparuk Oil Field, and Oil and Gas Lease 54 (OGL 54), and White Hills study areas, Alaska, 1988-1992.

Section or Area	Year	No. of Adults With Broods	Total Broods	Total Young	Mean Brood Size	No. of Adults Without Broods	Total Adults	Total Swans	Percentage Young
Kuparuk Oil Field	1988	86	44	93	2.1	225	311	404	23.0
	1989	84	45	103	2.3	304	388	491	21.0
	1990	141	72	199	2.8	285	426	625	31.8
	1991	134	69	175	2.5	359	493	668	26.2
	1992	**135**	**68**	**185**	**2.7**	**334**	**469**	**654**	**28.3**
OGL 54	1988	32	16	38	2.4	281	313	351	10.8
	1989	38	19	39	2.1	235	273	312	12.5
	1990	64	32	97	3.0	210	274	371	26.1
	1991	73	37	108	2.9	255	328	436	24.8
	1992	**57**	**29**	**72**	**2.5**	**255**	**312**	**384**	**18.8**
Subtotal (Kuparuk/OGL 54)	1988	118	60	131	2.2	506	624	755	17.4
	1989	122	64	142	2.2	539	661	803	17.7
	1990	205	104	296	2.8	495	700	996	29.7
	1991	207	106	283	2.7	614	821	1104	25.6
	1992	**192**	**97**	**257**	**2.6**	**589**	**781**	**1038**	**24.8**
White Hills[a]	1989	0	0	0	-	10	10	10	0
	1990	0	0	0	-	16	16	16	0
	1992	**8**	**4**	**11**	**2.8**	**8**	**16**	**27**	**40.7**

[a] The White Hills section of the study area was not surveyed in each year; this information has been presented in earlier reports in OLG 54 totals.

in August. The number of broods indicated a nesting success of 85%, which is similar to previous years (Table 2). However, because a few nest sites are missed during nesting surveys (Stickney et al. 1992), and we suspect that brood counts are more accurate than nest counts, this estimate of nest success probably is high.

The number of broods and mean brood size in 1992 were similar to both 1990 and 1991, and higher than the same categories in 1988 and 1989 (Table 2). The percentage of young observed during the surveys in 1992 (24.8%) was slightly lower than in 1991 (25.6%). Both years were lower than 1990 (29.7% young), but were higher than 1988 and 1989 (<18% young).

Numbers of adult swans in the study area decreased approximately 5% between 1991 and 1992 (Table 2). The decrease was greater for adults with broods (7%) than for adults without broods (4%). The number of adults with broods also was slightly lower in 1992 than in 1990. However, the number of adults without broods in 1992 was 19% higher than in 1990. Most of the decrease in 1992 compared with 1991

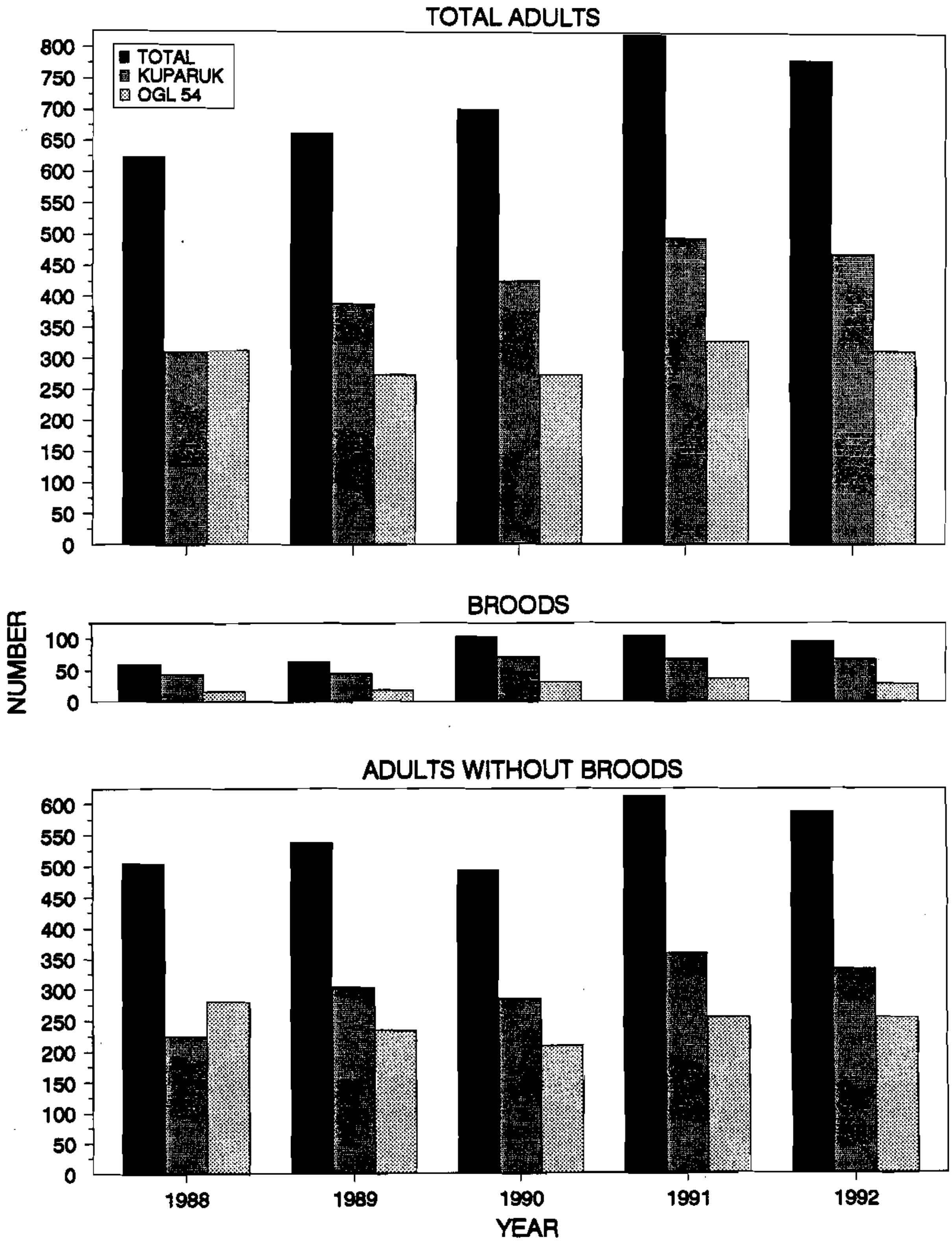


Figure 5. Numbers of Tundra Swans, broods, and adults without broods recorded during August on aerial surveys in the Kuparuk Oil Field and Oil and Gas Lease 54 (OGL 54) study areas, Alaska, 1988-1992.

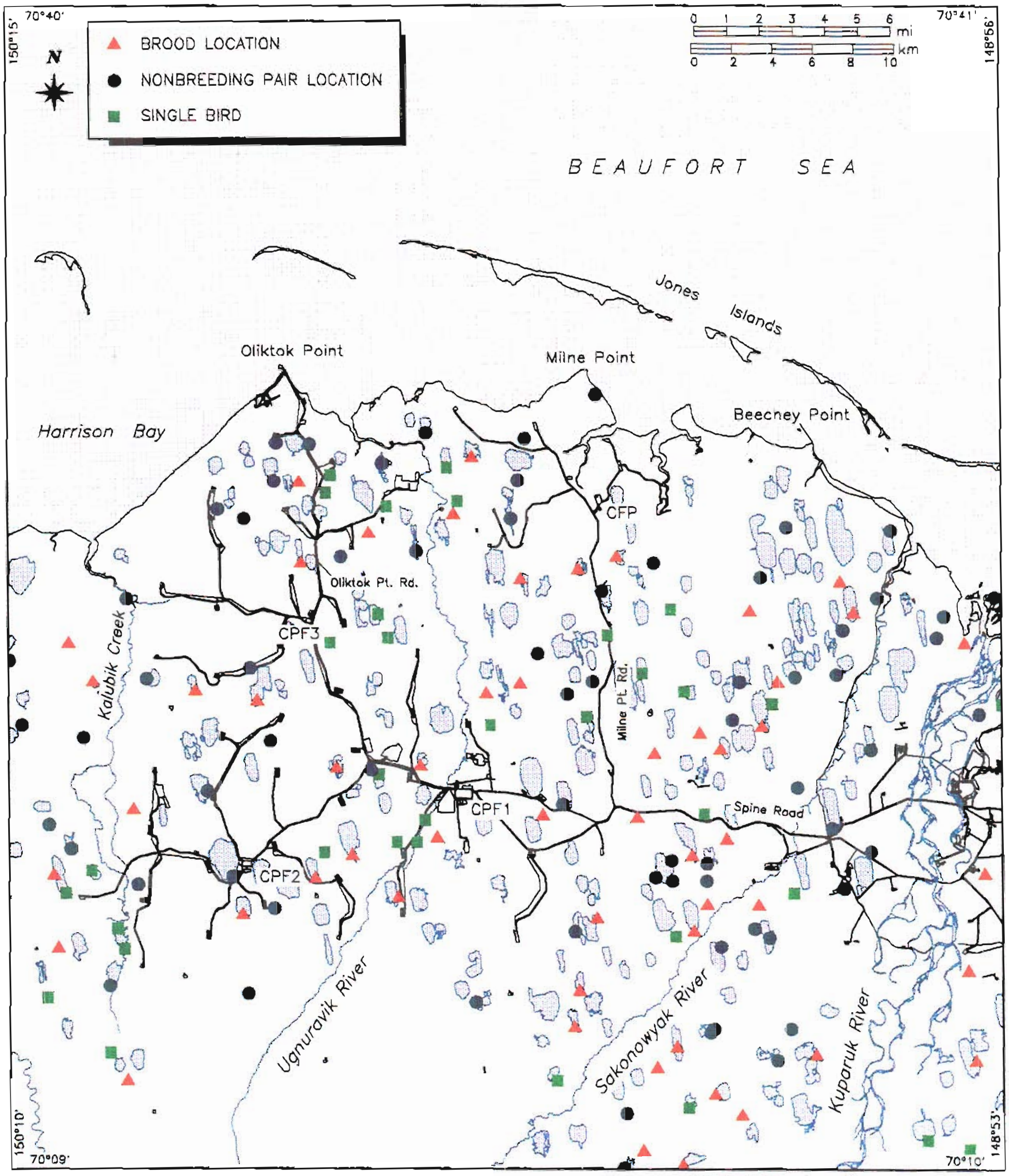


Figure 6. Locations of Tundra Swan broods and nonbreeding pairs observed during aerial surveys in the central Kuparuk Oil Field, Alaska, 17-21 August 1992.

occurred in OGL 54 for the number of adults with broods (-22%), the number of broods (-22%), and total young (-33%). In the Kuparuk Oil Field, only the number of broods showed a slight decrease (-1%) from 1991 to 1992. The number of adults without broods in both sections of the study area decreased only slightly (-5%) from 1991 to 1992.

SAGAVANIRKTOK RIVER - FOGGY ISLAND BAY AREA

Distribution in June

During the nesting survey in 1992, 192 Tundra Swans were observed in the Sagavanirktok River - Foggy Island Bay study area (Table 3, Figure 7), Appendix 6). Most (69%) of the swans observed were adults without nests. Each of the three sections of the study area (Sagavanirktok Delta, Foggy Island Bay, and Sag Inland sections) had similar numbers of swans, although the Sagavanirktok Delta section had a higher percentage of breeding adults associated with nests (38%) than did the other two sections (<31% each). Foggy Island Bay had the largest percentage of adult swans (76%) that were not associated with nests.

Despite the similarities in numbers of Tundra Swans among the three sections, the densities were different (Figure 8, Appendix 7). The Sagavanirktok Delta section had the highest densities in all categories of swans. Both the Foggy Island Bay and Sag Inland sections had nest densities ≤0.03 nests/km^2, and breeding adult densities ≤0.04 swans/km^2. Foggy Island Bay had the second highest density of total swans (0.17 swans/km^2), because of the occurrence of large numbers of swans not associated with nests (0.13 swans/km^2). The Sag Inland section had the lowest values of the three sections in all density categories.

The Sagavanirktok Delta section had much higher densities of adult Tundra Swans and nests (0.35 adults/km^2 and 0.09 nests/km^2) in comparison with the Kuparuk/OGL 54 study area (0.13 adults/km^2 and 0.03 nests/km^2; Appendices 4 and 7). The Foggy Island Bay section had densities similar to the Kuparuk/OGL 54 study area, but the Sag Inland section had lower densities.

The average minimum distance (nearest neighbor) between Tundra Swan nests was lower in the Sagavanirktok Delta section (2.1 km/nest) than in the other two sections (>3.5 km/nest) but not significantly so (F = 2.918, P = 0.0662). Nests in the Sagavanirktok Delta had a nearly uniform distribution (R = 1.33, n = 16 nests), as did nests in the Foggy Island Bay section (R = 1.41, n = 12 nests), whereas nests in the Sag Inland section appeared to be randomly distributed (R = 0.89, n = 13 nests).

Distribution in August

During brood-rearing surveys in August 1992, 284 Tundra Swans were counted in the Sagavanirktok River delta - Foggy Island Bay study area (Table 4, Figure 9). Adults with broods constituted 21% of total adults, although the percentage was greatest in the Sagavanirktok Delta section (33% of total adults) and least in the Foggy Island Bay section (14% of total adults).

Twenty-three broods comprising 64 young were observed in the study area (Table 4; Figure 9; Appendix 8). Half of the broods were located within the Sagavanirktok Delta section and six broods were found in both the Foggy Island Bay and Sag Inland sections. The average brood size in the study area was 2.8 young; the largest average brood size was observed in the Sagavanirktok Delta (3.2 young) and the smallest average brood size was observed in the Sag Inland section (2.3 young), but these differences were not significant (P = 0.211). The overall nesting success for the study area (based on number of broods/number of nests) was approximately 56%.

The number of adult Tundra Swans increased 14% (from 192 to 219 adults) in the study area between June and August (Table 4). Most of the increase was in the number of adults not associated with nests or with broods, from 69% of total adults in June to 79% in August. Of the three sections, the percentage of adults that were without broods was greatest in the Foggy Island Bay section (86%), and least in the Sagavanirktok Delta section (70%).

The Sagavanirktok Delta section had the highest densities of Tundra Swans and broods in August (Appendix 7) of any other section or study area. Densities of total swans and broods reached 0.63 birds/km^2 and 0.07 broods/km^2, in contrast to the other two sections (≤0.23

Table 3. Numbers of Tundra Swans and nests recorded during aerial surveys in the Sagavanirktok River delta study area, Alaska, 27-28 June 1992.

Location	Adults with Nests	Total Nests	Adults without Nests	Total Swans
Sagavanirktok Delta	23	16	37	60
Foggy Island Bay	18	12	56	74
Sag Inland	18	13	40	58
Total	59	41	133	192

swans/km² and ≤0.01 broods/km², respectively). In addition, the Sagavanirktok Delta section had higher densities in all categories compared with the Kuparuk/OGL 54 study area (Appendices 4 and 7).

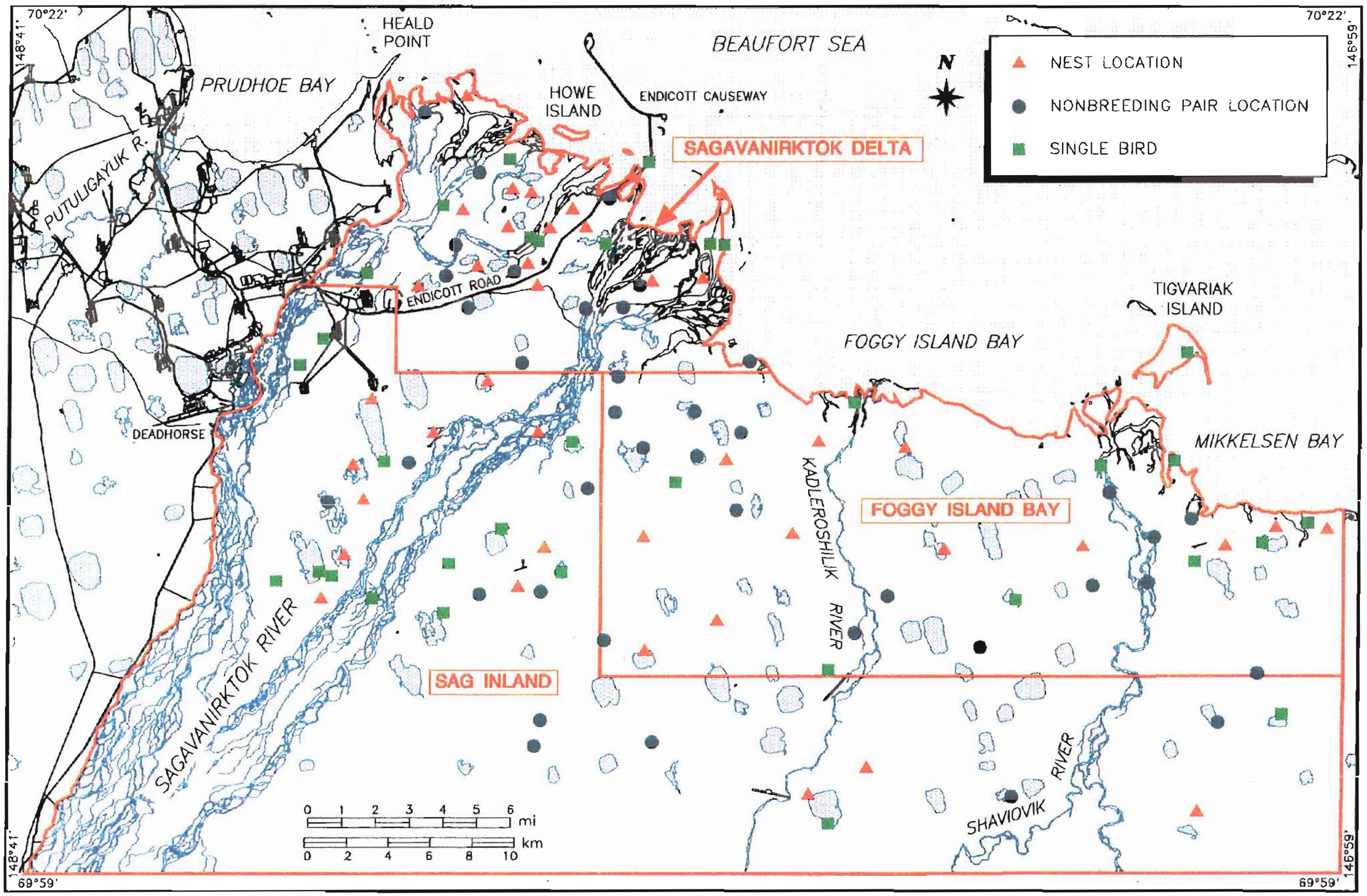
Broods within the Sagavanirktok Delta section were spaced more closely together than in the other two sections. The average minimum distance between broods was 1.9 km, while in both the Foggy Island Bay and Sag Inland sections, the average minimum distance was ≥5.0 km between broods. The spacing of broods differed significantly among sections ($F_{2,20}$ = 6.4654, P = 0.0068). The distribution of broods could not be assessed in either the Foggy Island Bay or inland sections due to small samples of broods (n = 6 each).

REGIONAL CONDITIONS DURING 1992

It is difficult to attribute local spring conditions to declines in Tundra Swans and nests in the region in 1992. Spring and summer temperatures were close to normal (average monthly temperatures for the nesting period were within 1°C of the long-term monthly means [NOAA 1992]) and snow melt was not noticeably delayed. Furthermore, two characteristics of the Tundra Swan population suggest that Tundra Swan numbers should have increased and not declined in 1992. First, the count of Tundra Swans in January 1992 on the Atlantic coast was the highest ever recorded (J. Bartonek, USFWS., pers. commun.). Unless late-winter mortality was unusually high, greater numbers of Tundra Swans should have initiated spring migration in 1992 than during the previous years of our study. Second, with high production of cygnets in 1990 in the Kuparuk/OGL 54 study area, one might have expected a greater number of potential breeders in the region, as juveniles from 1990 entered the breeding population for the first time. (The age when Tundra Swans first breed is variable, with two years being a minimum [Palmer 1976].)

Conditions at spring staging areas may have been a more important factor than local conditions in affecting the number of swans returning to our study areas in 1992. Poor weather along the west coast of the continent delayed the migration of Brant and other waterfowl to Alaska breeding grounds in 1992 (see Brant section, this report). Similarly, spring conditions were much later than normal along the arctic coast in western Canada (J. Hines, Canadian Wildlife Service, pers. commun.), along which Tundra Swans migrate (Bellrose 1976, Johnson and Herter 1988). Like Brant arriving from the west, Tundra Swans destined for northern Alaska may have been delayed or prevented from reaching this distant breeding area by adverse conditions. Palmer (1976) noted cases where Tundra Swans encountered severe weather fronts during spring migration, were forced to land, and lingered at locations distant from breeding areas throughout the summer.

No unusual weather events, which might have reduced productivity, occurred from June - August. However, freeze-up was unusually early in 1992 (J. Helmericks, Golden Plover Air, pers. commun.). No open water or swans were observed on an aerial survey of the Colville River delta - Kalubik Creek area on 17 September



Projection: Mercator/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quads;
coastline, facilities and major rivers updated from aerial photography (1973–1990).

Map produced by Alaska Biological Research, Inc.
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Figure 7. Locations of Tundra Swan nests and non-breeding pairs observed during aerial surveys in the Sagavanirktok River-Foggy Island Bay study area, Alaska, June 1992.

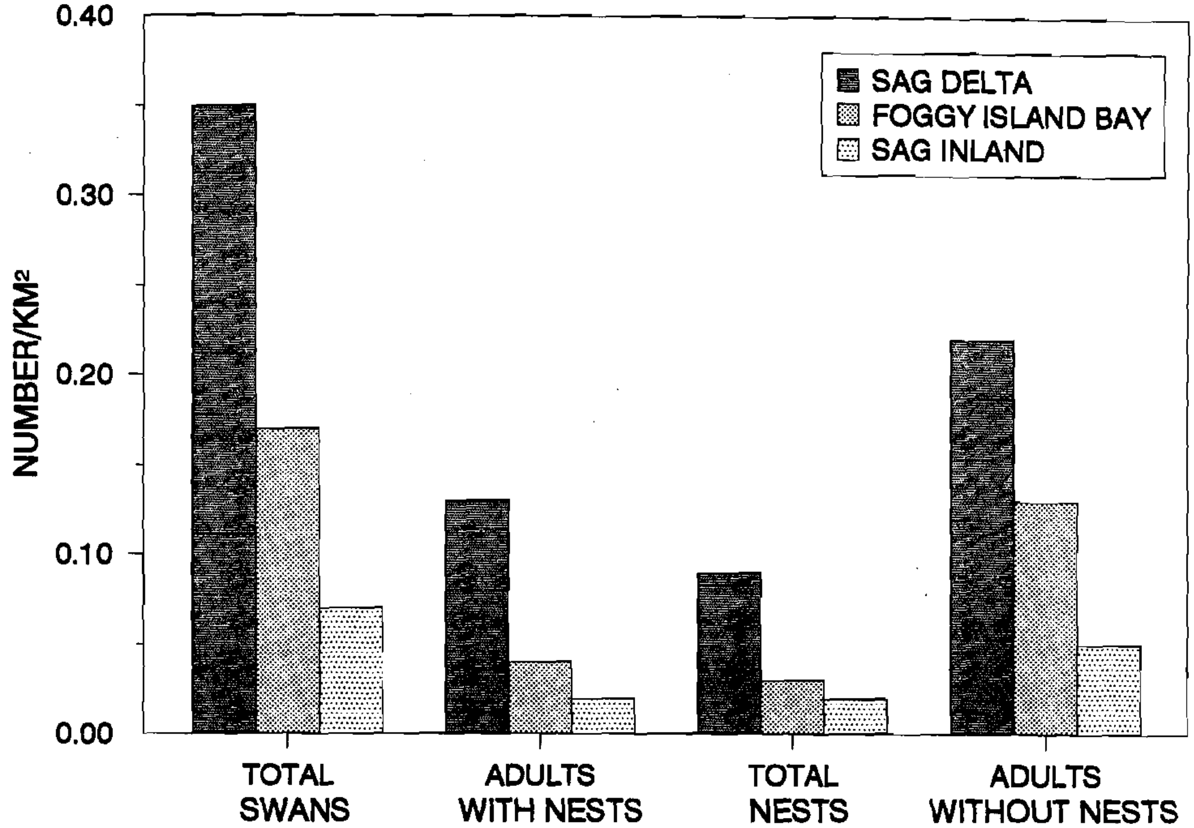


Figure 8. Densities of Tundra Swans and nests in the Sagavanirktok River delta study area, Alaska, June 1992.

1992 (L. Byrne, ABR, pers. commun.). Although Tundra Swan cygnets are probably capable of flight in 60-70 days (Bellrose 1976), this early freeze-up may have been a source of mortality. Monda (1991) found carcasses of 14 nearly fledged Tundra Swans in the Arctic National Wildlife Refuge (ANWR) between 1988 and 1990 and suggested that early winter weather in the previous years may have been the cause of their demise. An abbreviated fall in 1992 increased mortality of nearly fledged Trumpeter Swans (*Cygnus buccinator*) in Minto Flats, interior Alaska (R. King, USFWS, pers. commun.).

COMPARISONS WITH OTHER EASTERN POPULATION TUNDRA SWANS

Interannual comparisons among regions are complicated by habitat differences, local weather conditions, and variability related to differences in survey procedures. Still, comparisons of population parameters in our study areas with other regions help to establish the relative importance of each area.

In comparison with densities reported for other areas of northern Alaska, such as the Colville River delta (Hawkins 1983, ~~ADF&G 1990,~~ Campbell and Rothe 1990, Smith et al. 1992) and ANWR (Platte and Brackney 1987, Brackney 1989, Monda 1991) mean densities of swans in 1992 in the Kuparuk Oil Field, OGL 54, Foggy Island Bay, and Sag Inland sections were low (Table 5). Values in our study areas were closer to densities recorded as "medium" (0.04-0.40 swans/km^2) in northern coastal regions of the National Petroleum Reserve - Alaska (NPR-A) (King 1979) and for similar geographic areas surveyed in 1970-1977 (Welling and Sladen, unpubl. manusc.). In 1992, densities of Tundra Swans were greatest for the Sagavanirktok River delta section, but still less than the Colville River delta (Smith et al. 1992)

Mean brood sizes in the Kuparuk/OGL 54 and Sagavanirktok River delta study areas were similar to those recorded in other northern Alaska areas (Table 5) (King 1970, Hawkins 1983,

Table 4. Numbers of Tundra Swans and broods recorded during aerial surveys in the Sagavanirktok River delta study areas, Alaska, 17-19 August 1992.

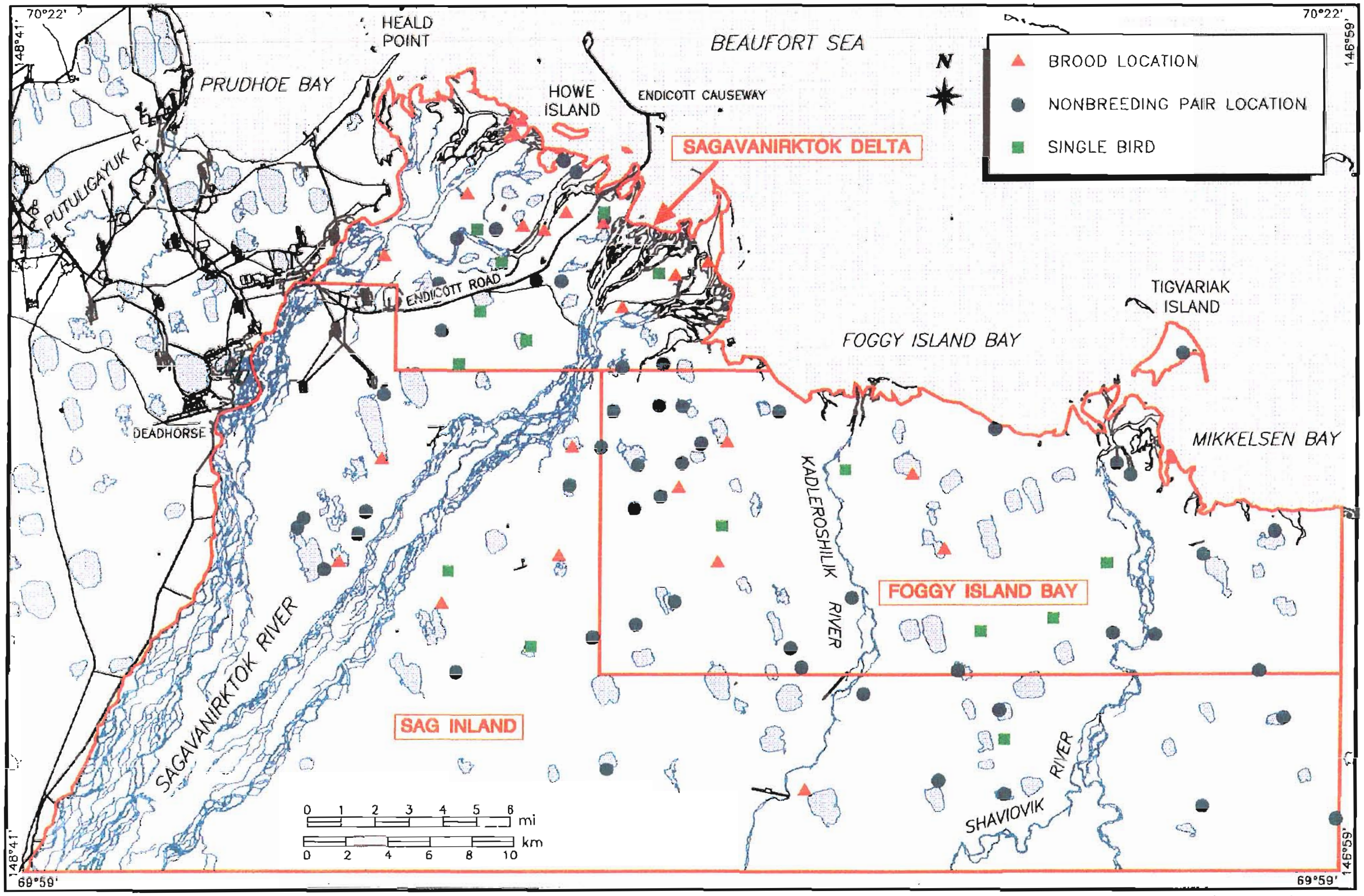
Location	Adults With Broods	Total Broods	Total Young	Mean Brood Size	Adults Without Broods	Total Adults	Total Swans	Percent Young
Sagavanirktok Delta	22	11	35	3.2	52	74	109	31.8
Foggy Island Bay	12	6	15	2.5	76	88	103	14.6
Sag Inland	12	6	14	2.3	45	57	71	19.7
Total	46	23	64	2.8	173	219	283	22.5

Bartels and Doyle 1984, Conant and Cain 1987, Platte and Brackney 1987, Campbell and Rothe 1990, Smith et al. 1992). Mean brood sizes in these study areas also were similar to or higher than those reported for Tundra Swans in the northern part of their range in Canada (McLaren and McLaren 1984, Stewart and Bernier 1989). Percentages of young in the Kuparuk/OGL 54 study area also were within ranges reported for other populations in Alaska and Canada (McLaren and McLaren 1984, Platte and Brackney 1987, Wilk 1988, Stewart and Bernier 1989, Campbell and Rothe 1990). The Sagavanirktok Delta section, however, had an exceptionally higher percentage of young.

REGIONAL POPULATION STATUS

Although numbers of nests, broods, and Tundra Swans declined slightly in the region in 1992 compared with 1991 and 1990, a number of characteristics of this population suggest a long-term increasing trend in numbers of Tundra Swans. First, using data gathered during brood-rearing surveys (August), counts of Tundra Swans and broods have increased substantially from our first surveys, especially in the Kuparuk Oil Field section of our study area. Second, for the area between Oliktok Point and Milne Point Road (Beechey Point B-5 USGS quad, Figure 6, Appendix 9), for which we have a greater data set (7 years), stronger indications of an increase in Tundra Swans in the region are indicated by increasing numbers of young (r^2 = 0.83), broods (r^2 = 0.81), and adults during brood-rearing (r^2 = 0.96) for the area since 1986 (Figure 10; Appendix 9). Finally, although we only have three recent years of data from the Sagavanirktok River delta for comparison, Tundra Swans appear to have increased since 1986 (Table 6). Numbers of swans in inland areas of OGL 54 have varied more among years (see Table 2). There is no information available prior to 1992 for inland areas near the Sagavanirktok River and Foggy Island Bay.

It is difficult to measure the temporal or geographic extent of this increase because few comparable surveys have occurred in the region. However, a number of observations support the hypothesis that swans generally have increased in the area. First, early references to swan numbers in northern Alaska most often noted their "irregular and scattered" distribution (Gabrielson and Lincoln 1959). Dixon (1943), for example, rarely observed Tundra Swans along a 200-mile section of coastal plain in northeastern Alaska in 1913 and 1914, whereas Tundra Swans were found to be common in the 1970s and 1980s (Andersson 1973, Brackney 1989). Bailey et al. (1933) described swan numbers near Barrow as a few stragglers each season, with a few nesting near Cape Halkett. Fiscus (unpubl. notes 1952-1953) recorded a single swan in his extensive bird list from field studies near Pitt Point and the Colville River in



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Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quads;
coastline, facilities and major rivers updated from aerial photography (1973–1990).

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Figure 9. Locations of Tundra Swan broods and nonbreeding pairs observed during aerial surveys in the Sagavanirktok River-Foggy Island Bay study area, Alaska, August 1992.

Table 5. Density and productivity information for Tundra Swan populations, northern Alaska (adult density during brood-rearing [July-August]).

Location	Adult Density (km^2)	Young Density (km^2)	Nest Density (km^2)	Average Brood Size	Percent Young	Years
Colville Delta[a]	0.33	0.12	-	2.5	-	1970-1977
Colville Delta[b]	0.57	0.13	0.06	2.4	21	1982-1989
Colville Delta[c]	0.90	0.14	0.04	2.4	16	1992
ANWR[d]	-	-	-	2.6	26	1982-1988
Sag Delta[e]	0.35	0.21	0.09	3.0	42	1992
Sag Delta[a]	0.17	0.09	-	2.8	-	1970-1977
OGL 54[f]	0.18	0.04	0.02	2.6	19	1988-1992
Umiat[a]	0.16	0.02	-	2.3	-	1970-1977
Kuparuk[f]	0.19	0.07	0.04	2.5	26	1988-1992
Beechey[a]	0.08	0.02	-	2.3	-	1970-1977
NPR-A[g]	-	-	-	2.2-2.3	-	1977-1978

[a] Welling and Sladen, unpubl. manuscript.
[b] Campbell and Rothe 1990.
[c] Smith et al. 1993.
[d] Brackney 1989.
[e] ABR studies (this report, Sagavanirktok River section only).
[f] ABR studies.
[g] King 1979.

1952, although he traveled in an area later considered to be the center of swan abundance in northern Alaska (Bartonek 1969).

As late as 1969, with the exception of the Colville River delta and Teshekpuk Lake areas, most Tundra Swans on the Arctic Coastal Plain were considered nonbreeders or extremely unsuccessful at nesting (Bartonek 1969). Aerial survey data from which this interpretation was deduced described a much less abundant swan population than is depicted by recent survey data. An aerial survey of nearly 1400 km of transects on the Arctic Coastal Plain in early July 1956 recorded fewer than 20 swans (Hansen 1957). An estimate of approximately 800 Tundra Swans in 1966, based on an aerial survey of the arctic slope, also indicated swans were much less common than today (King 1970). Because only a few, small (2.2 yg/broods) broods were identified during the latter surveys, King suggested that swans might be at some ecological limit to breeding. Finally, in the early 1970s, Gavin (1972) reported 34-42 pairs of Tundra Swans during aerial surveys of wildlife

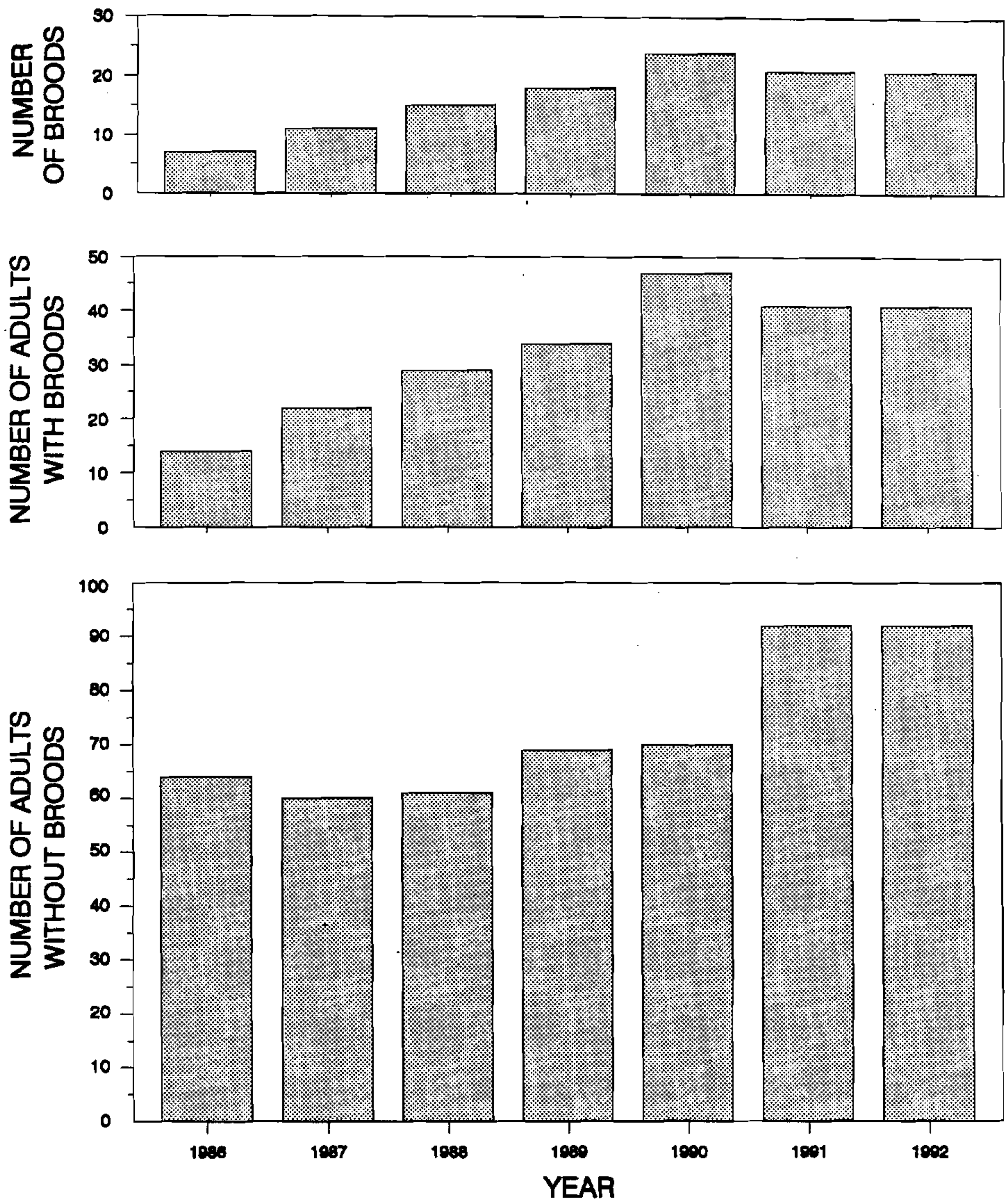


Figure 10. Numbers of Tundra Swans observed during aerial surveys in the Beechey Point B-5 quadrangle (central Kuparuk Oil Field), Alaska, August 1986-1992.

Table 6. Numbers of Tundra Swans and broods recorded during aerial surveys in the Sagavanirktok River delta study area, Alaska, USGS Quad Beechey Point-B2, in August 1986, 1988, and 1992.

Year	Adults with Broods	Total Broods	Total Young	Mean Brood Size	Adults without Broods	Total Adults	Total Swans	Percent Young
1986[a]	4	2	5	2.5	32	36	41	12.2
1988[a]	7	4	9	2.3	13	20	29	31.0
1992	18	9	28	3.1	28	46	74	37.8

[a] Information from USFWS annual Tundra Swan reports, Juneau, AK.

between the Colville and Canning rivers. Although he gathered information on a number of wildlife species, his estimates of Tundra Swans also suggest that the regional population at that time was smaller than the current regional population.

More recent studies, including surveys in years preceding our surveys, suggest that numbers and reproductive success have fluctuated widely, although certain areas have greater densities and productivity than others (Table 5). Intensive aerial surveys between 1970 and 1977 at a number of North Slope locations between the Colville and Sagavanirktok river deltas documented greater numbers of swans than previously recorded, and significant differences in the densities of adults and juveniles among areas (Welling and Sladen, unpubl. manuscript). The greatest densities (and the most productive areas) were on or adjacent to the Colville and Sagavanirktok river deltas. In contrast, densities, especially of juveniles, were lowest in the Beechey and Umiat localities of Welling's and Sladen's study area, corresponding with portions of our Kuparuk and OGL 54 sections, respectively (Table 5). More recent studies on the Colville River delta suggest a more static breeding population with some increases. The mean count of adults in spring for the period 1983-1989 was 221 birds, an increase of 92% over the average of 115 birds identified during the period 1970-1977 (Bart et al. 1991). (Two hundred and eighty-seven adult swans were recorded on the Colville in spring of 1992 [T. Rothe, ADF&G, unpubl. notes].) Surveys on the coastal plain of ANWR (1982-1989) also have shown wide fluctuations, rather than significant increases, in all categories of adult swans (i.e., pairs with broods, total adults, flocked adults; Brackney 1989). Estimates of adults on the Arctic Coastal Plain in Alaska (1986-1990) reveal a slight trend upward (Brackney and King 1992).

Long-term increases in numbers of Tundra Swans in the area may not be too surprising given a historical perspective of swan management. Overharvest, suspected as being a major factor in declines of both Tundra and Trumpeter swans before passage of the Migratory Bird Treaty of 1916, may have affected swan numbers in northern Alaska (Banko and McKay 1964, Palmer 1976). Indices of the number of Tundra Swans in North America have risen significantly and nearly doubled during the period from 1955 to 1989 (Serie and Bartonek 1991). Annual rates of change are +2.3% for the eastern population of Tundra Swans, a rate consistent with the long-term trend. Bellrose (1976) surmised that most of this increase in the 1960s was dependent primarily on increases of Tundra Swans in eastern Canada and not northern Alaska, but this assumption was made with minimal data gathered in Alaska before 1970. Interestingly, increased estimates of Tundra Swan numbers in northern Alaska by the early 1970s correspond roughly with the reoccupation of southern breeding areas where swans had been previously extirpated (e.g., Manitoba, Quebec) (Lumsden 1975). Numbers of swans also increased on King William Island in Canada's arctic from 300 in 1960 to 1000-

2000 in 1982 (Stewart and Bernier 1989), while mid-winter indices of swan numbers on their winter range increased approximately 78% during the same period (Serie and Bartonek 1991).

In conclusion, recent data suggests that swans have increased in our study areas since at least 1986, coinciding with significant increases of swans on their wintering areas. Lower densities of swans occur in the Kuparuk Oil Field, OGL 54, and Foggy Island Bay compared with the Sagavanirktok and Colville river deltas. This difference may suggest that nesting or brood-rearing habitats are less preferred or more limited in most of our study areas. It also may suggest that these areas are not saturated with breeding swans as the deltas may be, and therefore, provide a greater potential for expansion of the Tundra Swan population. Additional years of survey will allow us to monitor the long-term trends in the Tundra Swan population and further our understanding of factors affecting the geographic variation in population parameters.

PART 2: REGIONAL BRANT SURVEYS

METHODS

AERIAL SURVEYS

Aerial surveys were used to locate Brant nesting and brood-rearing areas and to count adults and goslings in five designated coastal sections between the Colville and Staines rivers (Figure 11) in 1992. A "Supercub" P-18 aircraft with a pilot and one observer was used for all surveys. Surveys were flown at approximately 100-150 m above ground level (agl) and at approximately 80-100 km/h airspeed. Methods were similar to those used from 1989-1991 (Ritchie et al. 1990, 1991; Stickney et al. 1992).

The aerial survey to locate nesting Brant was conducted on 30 June and 1 July 1992. Generally, this survey was flown from lake to lake within a broad predetermined path. The area surveyed extended inland to approximately 70°10'N and 70°15'N in all areas west and east, respectively, of the Sagavanirktok River. The survey included more intensive coverage (i.e., transects ~0.8 km apart) of the Kuparuk, Sagavanirktok, Kadleroshilik, and Shaviovik river deltas. In addition, all nesting areas identified during 1988-1991 were revisited.

All observations were recorded on 1:63,360 USGS maps. Data recorded for each nesting location included estimated numbers of adults and nests. A nest was recorded if either a down-filled bowl or an adult in incubation posture was observed. Aerial counts of Brant and their nests were conservative, because of the difficulty of observing incubating Brant and because the number of aerial passes made over a colony was limited to minimize disturbance. Comparisons of counts among years (1989-1992) used data from previous years' reports (Ritchie et al. 1990, 1991; Stickney et al. 1992) and data from 1992.

Three aerial surveys to locate and enumerate brood-rearing Brant were conducted on 9 July, 25-28 July, and 30 July 1992. The survey route followed the coastline as closely as possible extending inland along the shorelines of deltaic islands and bays. Nesting locations were revisited during 25-28 July, to determine whether they also were used for brood-rearing. Additional surveys were conducted during brood-rearing in portions of the study area: on 15 July, West Dock to Tigvariak Island was flown (in conjunction with a survey to locate Snow Geese [*Chen caerulescens*]) and on 1 August, Oliktok Point to Heald Point (in conjunction with a survey to identify possible locations to band Brant; Figure 11).

Brant in small brood-rearing groups (<50 individuals) were counted directly. Individuals in larger groups (≥50 individuals) were counted from aerial photos taken on each survey with a 35-mm camera, a 135-mm lens, and Ektachrome (200 ASA) film. Numbers of Brant per kilometer of coastline were determined for the five sections delineated in Figure 11. Linear densities were computed from measurements of coastline taken from 1:63,360 USGS maps. The proportion of goslings was calculated for each section and for the region as a whole.

Comparisons were made among years (1989-1992) for the number of adults (both with and without broods), broods, and brood sizes. Data from previous years were from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

For other statistical analyses, data from the brood-rearing surveys (i.e., numbers of adults, goslings and groups) were summarized by survey number (up to three surveys), coastal section, and group location. For groups that were photographed, the count of adults and goslings from the photographs was substituted for the aerial count.

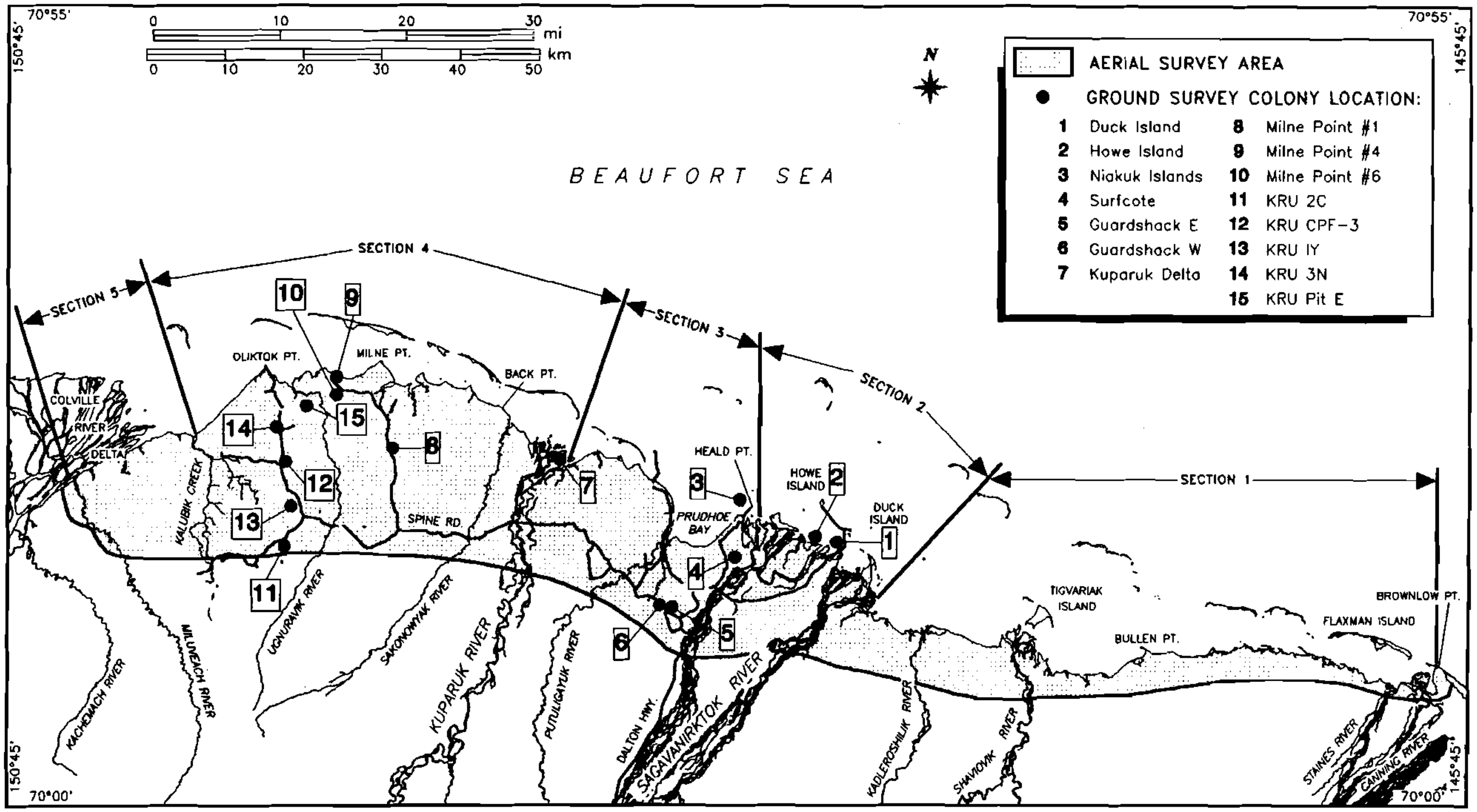
The data from the aerial surveys, 1989-1992 (Ritchie et al. 1990, 1991; Stickney et al. 1992, this report), were used to test three hypotheses about Brant in the study area:

Ho_1: Numbers of Brant did not differ among coastal sections during brood-rearing;

Ho_2: The proportion of young Brant did not differ among coastal sections during brood-rearing; and

Ho_3: Numbers of Brant in the region have not changed over time.

The first two hypotheses were tested using analysis of covariance (ANCOVA), described below, and the third hypothesis was tested using linear regression.



Projection: MERCATOR/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quads; coastline, facilities and major rivers updated from aerial photography (1973–1990).

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Figure 11. Study area for aerial and ground surveys for Brant on the Arctic Coastal Plain, Alaska, 1992. Not all ground surveys are indicated on the map. The five sections of coastline are described in Ritchie et al. (1991).

The ANCOVA models for both Ho_1 and Ho_2 used the same independent variables, but different dependent variables. The independent variables were coastline length, year, and section. The dependent variables were total Brant (Ho_1) and proportion of goslings (Ho_2). Type 1 (sequential) sum of squares was used in both models, which accounts for the effect of variables in the order that they are entered (Abacus Concepts, Inc., 1989). Coastline length was entered first as the covariate, followed by year, and by sections. Data for two surveys per year were used in the analysis, representing repeated sampling of the same birds. Therefore, surveys, as a factor, were considered to be nested within sections and the nested variable (survey within section) was used as the error term for testing the significance of the section variable (Abacus Concepts, Inc., 1989).

Residual plots from the ANCOVA model were examined and dependent variables were transformed if necessary to stabilize variance. Proportions were transformed using the arcsine of the square root (Steel and Torrie 1980). An F-test was used to test for lack of fit of linear regression models. Results of all tests were considered significant at $P \leq 0.05$. The ANCOVAs were conducted with SuperAnova software (Abacus Concepts, 1989) and regressions were run using SuperAnova and JMP (SAS Institute Inc., 1989) statistical software.

GROUND SURVEYS

Ground surveys in 1992 were conducted in selected colonies to gather information on nesting phenology, nesting success and productivity, as well as more precise estimates of the number of nests in colonies that were identified from aircraft (Figure 11). Ground surveys included reconnaissance visits in June, monitoring during the hatch, and post-hatch visits in July. Phenological information was collected at Howe and Duck islands in the Sagavanirktok River delta, and at Surfcote in the Prudhoe Bay area. Other nesting aggregations in the Prudhoe Bay area, the Niakuk Islands, the Kuparuk River delta, and at various locations along the road systems in the Kuparuk and Milne Point oil fields also were visited to gather information on nest numbers and nesting success.

Prior to 1990, information on phenology, productivity, and distribution of Brant was obtained in conjunction with ongoing Snow Goose research on Howe Island (Burgess et al. 1992). Beginning in 1990, studies focused on the phenology, distribution, and productivity of Brant were conducted on the Sagavanirktok River delta (Ritchie et al. 1991). Little information on phenology was collected in 1991 because the Howe Island colony was abandoned by Brant early during nesting.

In 1992, estimates of dates of nest initiation were based on observations of Brant at Duck Island and at Surfcote. Observations of hatching were made at Surfcote. For each new brood observed, the date of hatching was assumed to be one day before the date of dispersal (following Barry 1956). The date of initiation of each nest was calculated by subtracting the combined incubation (24 days; Barry 1956) and laying periods from the estimated hatching date. The laying period was conservatively estimated by multiplying the brood size at dispersal by the rate of laying (1.3 days/egg; Barry 1956).

Nesting locations were visited after hatching (mid-July) at the following locations (Figure 11):

1) Section 2: Sagavanirktok River delta (Duck and Howe islands);
2) Section 3: Prudhoe Bay (Surfcote, the Niakuk Islands, and two unnamed lakes near Lake Coleen);
3) Section 4: Kuparuk River delta (two islands near the mouth) and the Kuparuk Oil Field (locations along the road system where nesting Brant had been observed during a preliminary survey in June).

Methods used during the nest censuses were described by Ritchie et al. (1991). Nesting success was calculated for each nesting area visited as the percentage of nests that hatched at least one egg. Gosling production and survival were not estimated in 1992 because of inadequate samples of broods at hatching/dispersal.

Data on total number of Brant nests, and percent nesting success collected on ground surveys in 1992 were summarized by nesting location. The following hypotheses were examined:

Ho_4: The number of Brant nests in the Sagavanirktok River delta and the Prudhoe Bay area are constant over time

Ho_5: The number of nests in the study area did not differ between 1992 and previous years.

Brant nesting data has been collected over the past 8-10 years for Howe and Duck islands in the Sagavanirktok River delta and the Surfcote colony in the Prudhoe Bay area. Fewer years (2-4 years) of data are available for other nesting locations in the region.

To assess Ho_4, each colony was examined separately by regression analysis with year as the independent variable and number of nests as the dependent variable. The trend for number of Brant nests on Howe Island was tested with all years (1984-1992), and with 1991-1992 (when the island was abandoned due to fox predation) excluded.

For Ho_5, the number of nests for 1992 was compared to the mean number of nests for each nesting location surveyed on the ground with at least two previous years of data using a Wilcoxon signed-ranks test (Conover 1980). Howe Island was excluded from this analysis because it was abandoned in both 1991 and 1992.

BANDING

ABR banded Brant between Prudhoe Bay and Back Point (west of the Kuparuk River delta) from 1 to 3 August 1992. A Bell 206 Helicopter was used to deploy a 6-person ground crew and to assist in herding Brant into traps at both locations. Traps were constructed from two sections of 25-mm mesh nylon nets, 15 m long x 1.5 m high, and dyed gray-green to make them less conspicuous. These nets were strung between fiberglass fence posts and arranged in an oval ("corral") shape with an opening ~3 m wide. Twenty-five meter lengths of black plastic bird netting formed wings that extended at 45° angles from the opening, creating a funnel-shaped approach to the corral.

The helicopter herded Brant onto land and then deployed four people, two on each sides of the group, to restrain the geese. The helicopter then positioned another two people to construct the trap approximately 100 m from the crew restraining the Brant. Upon erection of the trap, the ground crew herded the geese toward and into the trap. Once Brant were in the trap, separate holding and release pens within the trap were created using extra nylon net. Brant were moved into the holding pen in small groups (<15 birds) to limit the potential for injuries.

Following methods outlined in a procedures manual (ABR 1992), each Brant was aged by plumage characteristics, sexed by cloacal examination, and marked with two tarsal bands. A stainless steel, size 7(A) band was placed on the left tarsus, and an aqua-colored, plastic band, with engraved black, alpha-numeric codes was placed on the right tarsus. All Brant were weighed and a sample of Brant, including all recaptured birds, was measured. Five measurements were taken (in mm, to the nearest 0.1 mm): exposed culmen, tarsal length (total and tarsus bone), primary (9th) length, and flattened-wing chord (Dzubin and Cooch 1992).

Generally goslings were banded first, followed by adults. After all birds had been banded and placed in the release pen, the sides of the corral were lowered slowly and the Brant were allowed to move as a group towards open water. The birds were observed for 10 minutes following their release, and any injuries were noted.

Bird banding schedules were completed and sent to the USFWS Bird Banding Laboratory in Laurel, Maryland. Information also was sent to USFWS researchers studying Brant migration in Alaska.

Little is known about the population dynamics of Brant nesting within the oil fields, but the colonial nesting habits of this species may create distinct subpopulations in the region. The following hypothesis using banding data was examined:

Ho_6: There is no interchange or movement of Brant among banding areas within the oil fields or those outside of the oil fields.

Brant have now been banded in three separate areas of the oil fields and in areas on the Yukon-Kuskokwim Delta and Colville River delta in Alaska, as well as in Canada and on Wrangel Island, Russia. Recaptures and/or resightings of birds from banding areas other than the area in which ABR banded Brant will indicate that interchange is occurring.

For birds originally banded in the oil fields in 1991 and recaptured in 1992, the distance (in km) between the original banding location and the recapture location was measured from a 1:250,000 USGS map (Beechey Point quadrangle). Mean distances between original capture and recapture locations were calculated. Because of the limited sample size and lack of banding east of the Sagavanirktok River, no statistical comparisons were undertaken.

Sex and age were determined for all captured Brant, but because of difficulty in accurately ageing second-year birds using only plumage characteristics, no breakdown of age beyond gosling and adult categories was attempted for previously unbanded Brant in 1992. Recaptured Brant were assigned to age classes based on the age previously recorded. For example, Brant banded as goslings were of known age, whereas all birds banded as second-year birds or adults (i.e., in 1991 or earlier) were classified as adult birds. The sex composition of recaptured Brant was examined for equal numbers of males and females with a Chi-square test (α = 0.05).

RESULTS AND DISCUSSION

NESTING

Abundance and Distribution

No new Brant colonies were found in the study area in 1992. On ground and aerial surveys between the Colville and Staines rivers, 380 Brant nests at 43 locations were recorded (Figure 12, Table 7). Of these, 188 nests were identified during aerial surveys at 40 locations (11 solitary nests and 29 sites with ≥2 nests); only 10 of these locations had ≥5 nests. Ground crews found 300 nests at 18 sites; 192 of these nests had not been recorded previously by aerial surveys. These locations included colonies that intentionally were not surveyed from the air (e.g., Surfcote in the Prudhoe Bay area [32 nests], Duck Island in the central Sagavanirktok River delta [32 nests]) and colonies that had failed by the time the aerial surveys were conducted (Howe Island [7 nests]). Because of difficulty in detecting colonies and nests that had failed prior to our surveys and because all colonies are not ground-truthed, our estimate of the total number of nests is conservative.

Most Brant nests (177 nests; 94%) were located in wet tundra vegetation, including islets in ponds and lakes, and flooded tundra in drained basin-complexes; 11 nests were found on offshore islands and gravel spits. Twenty-four of 40 nest locations (60%) found during the aerial surveys were within 5 km of the coast, and the overall mean distance was 5.4 km (range = <0.8 - 23 km) from the coast.

The number of Brant nests in the study area in 1992 (380 nests) increased over 1991 (319 nests), but was still lower than numbers recorded in 1990 (517 nests; Table 7; Ritchie et al. 1991, Stickney et al. 1992). This increase suggested that conditions for nesting may have been slightly better in 1992 than 1991. The decrease in nest numbers in 1992 compared to 1990 was largely the result of the abandonment of the Howe Island colony for the second year, which was caused by the presence of arctic foxes (*Alopex lagopus*) during nest initiation. During both 1992 and 1991, small colonies near Howe Island (i.e., Duck Island and Surfcote) supported more nests than had been recorded there prior to 1991, suggesting that these colonies provided alternative locations for Howe Island birds. In areas east of the Sagavanirktok River (Section 1) and west of Kalubik Creek (Section 5), the number of Brant nesting and the number of locations occupied were low in 1992 compared to previous years. However, the number of Brant nesting in these sections in all years was small compared to Sections 2-4. In both Sections 3 and 4 (Prudhoe Bay and Kuparuk/Milne oil fields), the number of nests was greater in 1992 than in any previous year (Table 7). Most Brant (86%) in the study area nested in these two sections, with the largest colony at the mouth of the Kuparuk River delta (134 nests).

Counts made during aerial surveys indicated that at least 665 adult Brant were present in the

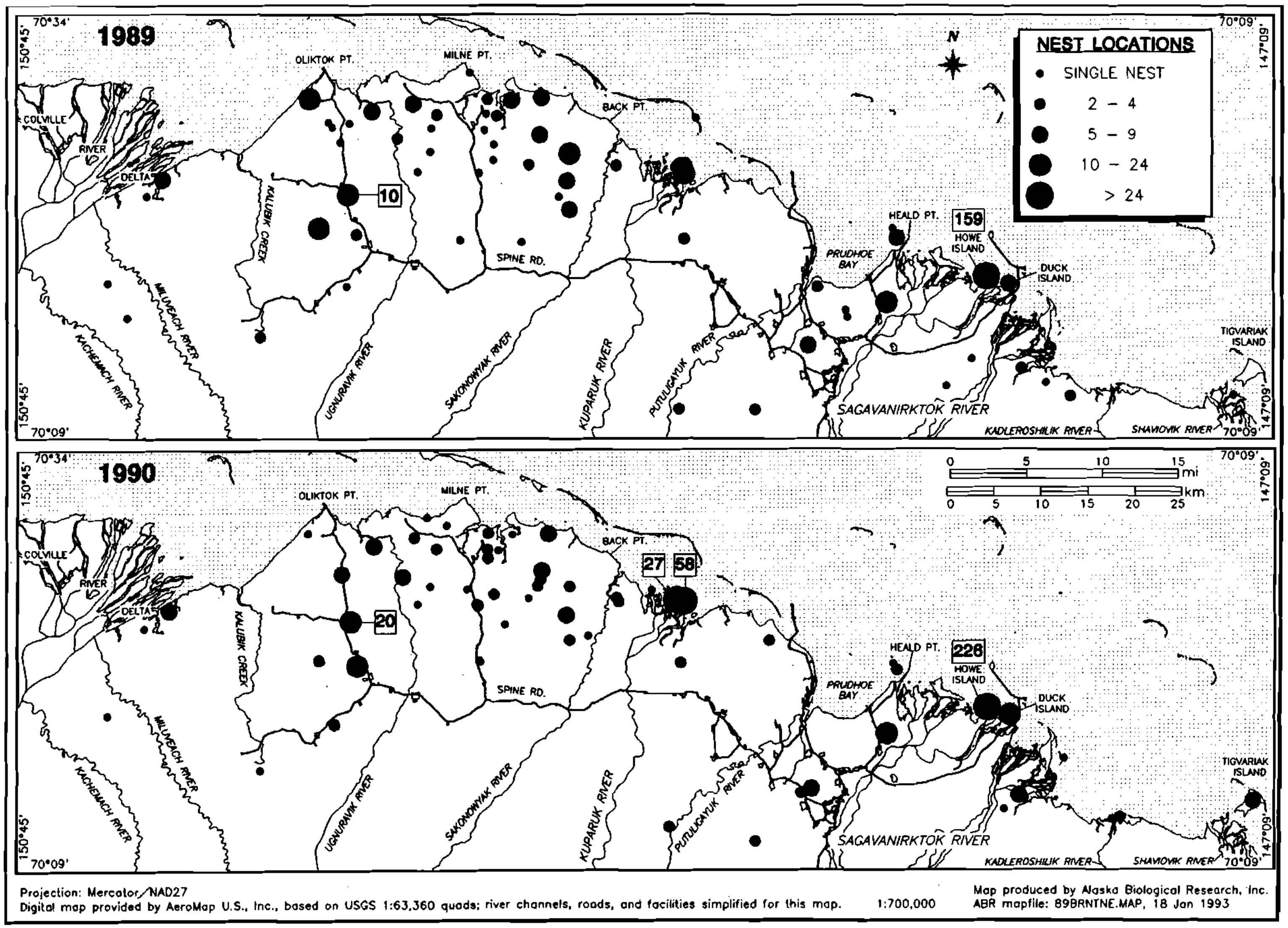


Figure 12. Locations and sizes of Brant colonies and solitary nests during June on the Arctic Coastal Plain between the Colville and Staines rivers, Alaska, 1989-1992. The numbers indicate the largest colonies.

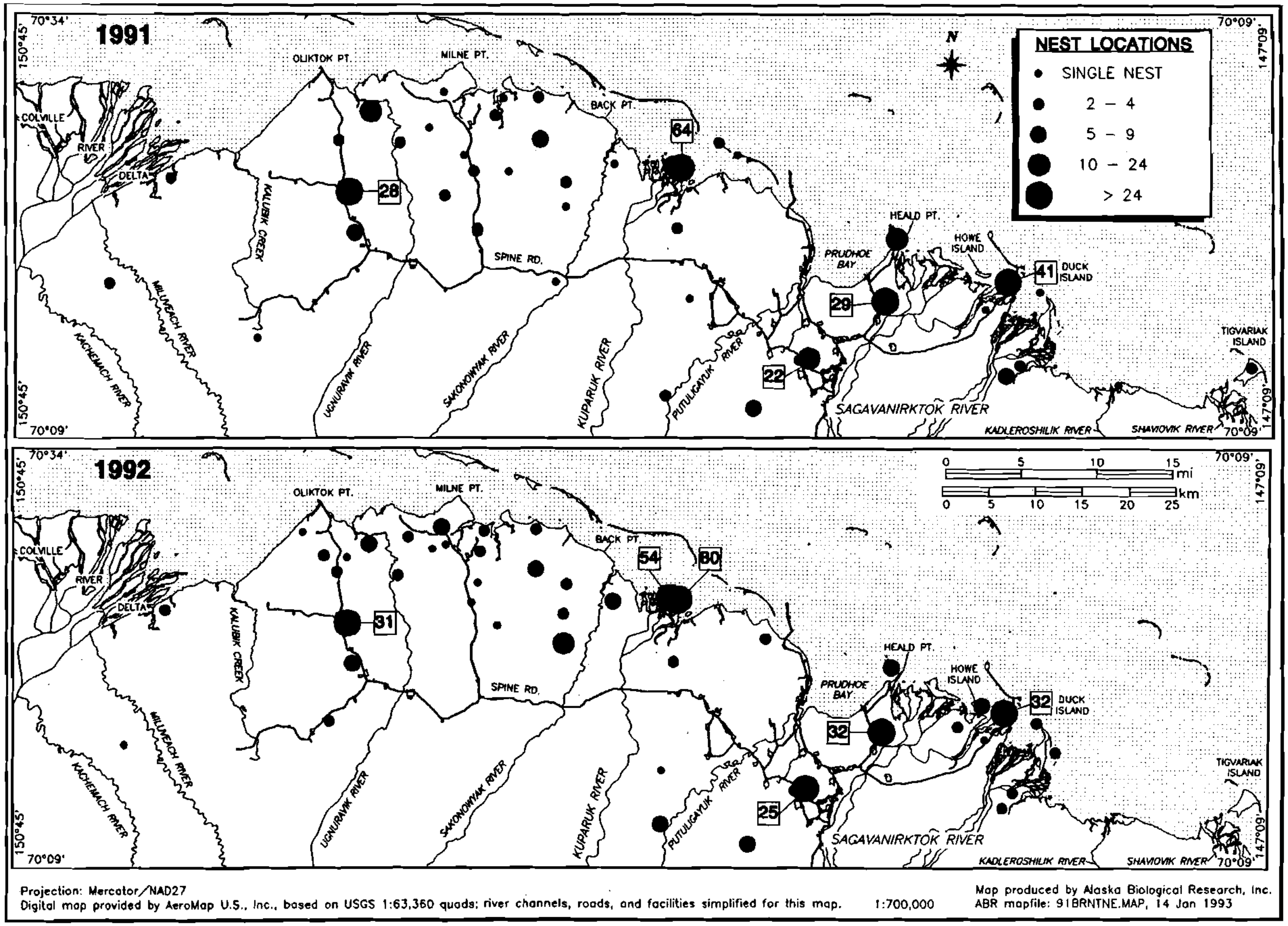


Figure 12. Page 2.

Table 7. Distribution of Brant nests (and locations) in June in sections of the Arctic Coastal Plain between the Colville and Staines rivers, Alaska, 1989-1992. Sections are delineated in Figure 8 and nesting locations in Figure 9. Data for 1989-1991 are from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

Coastal Section		Year	Number of Brant Nests (locations)[a] Aerial Survey Count		Ground Survey Count		Combined[b] Count	
1.	Brownlow Pt. to Sagavanirktok R.	1989	11	(5)	-	(-)	11	(5)
		1990	19	(6)	-	(-)	19	(6)
		1991	14	(4)	-	(-)	14	(4)
		1992	5	(2)	-	(-)	5	(2)
2.	Sagavanirktok R. Delta	1989	4	(4)	166	(3)	170	(7)
		1990	1	(1)	240	(3)	241	(4)
		1991	1	(1)	42	(2)	43	(3)
		1992	7	(3)	40	(3)	47	(6)
3.	Heald Pt. to Kuparuk R.	1989	21	(6)	16	(5)	37	(11)
		1990	24	(8)	17	(1)	41	(9)
		1991	32	(9)	67	(4)	83	(11)
		1992	30	(9)	69	(5)	86	(10)
4.	Kuparuk R. to Kalubik Cr.	1989	151	(39)	-	(-)	151	(39)
		1990	130	(38)	143	(13)	208	(38)
		1991	58	(18)	143[c]	(10)	172	(26)
		1992	143	(24)	191	(10)	240	(24)
5.	Kalubik Cr. to Miluveach R.	1989	13	(5)	-	(-)	13	(5)
		1990	8	(4)	-	(-)	8	(4)
		1991	7	(3)	-	(-)	7	(3)
		1992	3	(2)	-	(-)	3	(2)
Total		1989	200	(59)	182	(8)	382	(67)
		1990	182	(57)	400	(17)	517	(61)
		1991	112	(35)	252	(16)	319	(47)
		1992	188	(40)	300	(18)	380[d]	(43)

[a] ( ) = number of locations or colonies.

[b] Some sites were surveyed by both air and ground observers; combined count is the minimal number of different nests.

[c] Includes abandoned nests on the Kuparuk River delta.

[d] Total is conservative because more nests were found during ground surveys, but not all locations checked from the air were resurveyed on the ground.

study area in late June. Of this total, 293 adults were observed in areas without nests and were assumed to be failed breeders or nonbreeders (Table 8). Approximately 65% (190) of these nonbreeders occurred in six large flocks that ranged in size from 20 to 50 birds. As in

Table 8. Distribution of nonbreeding adult Brant in June on sections of the Arctic Coastal Plain between the Colville and Staines rivers, Alaska, 1989 - 1992. Sections are as delineated in Figure 8. Data for 1989 - 1991 are from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

		Nonbreeding Adults			
Coastal Section	Year	No. of Adults	Mean Flock Size	Range	n[a]
1. Brownlow Point to Sagavanirktok River	1989	101	14.4	2-40	7
	1990	46	9.2	1-30	5
	1991	94	10.4	4-25	9
	1992	68	17.0	4-50	4
2. Sagavanirktok River delta[b]	1989	85	28.3	1-80	3
	1990	98	12.3	3-28	8
	1991	143	13.0	3-32	11
	1992	19	4.8	2-8	4
3. Heald Point to Kuparuk River	1989	73	12.2	2-30	6
	1990	57 [c]	28.5	22-35	2
	1991	230	28.8	1-110	8
	1992	53	13.3	5-25	4
4. Kuparuk River to Kalubik Creek	1989	124	9.5	1-30	13
	1990	176	11.7	1-60	15
	1991	189	11.8	1-80	16
	1992	131	21.8	1-40	6
5. Kalubik Creek to Miluveach River	1989	85	42.5	27-58	2
	1990	100	50.0	40-60	2
	1991	94	13.4	2-40	7
	1992	22	7.3	2-10	3
TOTAL	1989	468	15.1	1-80	31
	1990	477	14.9	1-60	32
	1991	750	14.7	1-110	51
	1992	293	14.0	1-50	21

[a] n = number of flocks.
[b] Does not include nonbreeding birds at large colonies (Howe Island, Duck Island, Surfcote Colony).
[c] Includes ground count of nonbreeders at mouth of Putuligayak River.

previous years, most of the nonbreeders (88%) were observed on the coast in areas that were later used by molting and brood-rearing Brant (Ritchie et al. 1990, 1991; Stickney et al. 1992). The number of nonbreeding Brant was the lowest recorded in the four years of surveys. The reason for the decrease was unknown, but may have been due in part to conditions encountered during spring migration (see Nesting Phenology), or may have been an artifact of the timing of the nesting survey, which was 4-8 days later than in previous years.

Section 1: Staines River (Brownlow Point) to Sagavanirktok River

In 1992, five nests (3% of nests recorded on aerial surveys) were found at two locations in Section 1, and both locations were within 2 km of the coast and west of the Kadleroshilik River (Figure 12, Table 7). Nests were found only during aerial surveys; ground observations were not made in Section 1. The two locations used in 1992 have the longest history (3-4 years) of nesting of all sites in Section 1. No nests were recorded at previously used locations east of the Kadleroshilik River (e.g., Tigvariak Island). The number of nests in this section were the lowest recorded since surveys began in 1989 (Table 7). Tigvariak Island may not have been used this year because persistent ice around the island facilitated access by terrestrial predators, such as arctic foxes.

Sixty-eight nonbreeding adults were recorded in Section 1, primarily between the Sagavanirktok and Kadleroshilik river deltas (Table 8). In 1992, locations of nonbreeding adults were similar to those recorded in previous years (Table 8).

Section 2: Sagavanirktok River Delta

In 1992, 47 nests were recorded at six locations in Section 2 (Figure 12, Table 7); only seven of these nests were located during aerial surveys. Ground surveys found 32 nests on Duck Island in 1992, seven nests on Howe Island, and one nest was observed within 200 m of the Endicott Road (Figure 13, Table 9). The number of Brant nests found in Section 2 in 1992 was slightly higher than in 1991 (43 nests), but much lower than in 1989 (170 nests) and 1990 (241 nests; Table 7). As was mentioned previously, in both 1991 and 1992 the decrease was due primarily to the abandonment of the Howe Island colony. The number of Brant nests on Duck Island increased in both years, however, probably in response to the abandonment of Howe Island.

Nineteen nonbreeding Brant were recorded in 1992 at four locations on the Sagavanirktok River delta (Table 8). The number of nonbreeders was substantially lower than in previous years and the average group size was smaller.

Section 3: Heald Point to Kuparuk River (Prudhoe Bay)

Eighty-six Brant nests were recorded at 10 locations in 1992 in Section 3 (Figure 12, Table 7). Thirty of these nests were recorded at nine locations during aerial surveys (16% of total nests) and ground surveys identified an additional 56 nests, including 32 nests in the Surfcote colony, in the Prudhoe Bay area. Other nesting locations included the Niakuk Islands (eight nests) and lakes associated with the upper Putuligayuk River and Prudhoe Bay. Two lakes northwest of Lake Coleen, Guardshack East and Guardshack West, had 25 and four Brant nests, respectively (Table 9).

The number of Brant nests in 1992 was the highest recorded in Section 3 since our surveys began (Table 7). Surfcote had the greatest number of nests since it was first monitored in 1983 (Figure 13; Murphy et al. 1990, this study). The increase in Section 3 over 1989 and 1990 could be attributed to the greater intensity of ground surveys conducted in this region since 1991 and displacement of birds from Howe Island. However, the slight increase since 1991 indicated that nesting conditions were more favorable in 1992.

Although numbers of nests in Section 3 increased, the number of nonbreeding Brant was the lowest ever recorded, albeit only slightly lower than numbers observed in 1989 and 1990 (Table 8). Fifty-three nonbreeding Brant were recorded at four locations on the west shore of Prudhoe Bay and near the mouth of the Putuligayuk River. Nonbreeding groups used areas similar to those used in previous years.

Section 4: Kuparuk River to Kalubik Creek (Kuparuk/Milne Point oil fields)

During ground and aerial surveys in 1992, 240 Brant nests at 24 locations were identified in Section 4. Most of the nesting locations (24 of 40; 60%) and nests (143 of 188; 76%) identified on aerial surveys were located in this section (Figure 12, Table 7). Ground crews counted 191 nests within the Kuparuk Oil Field

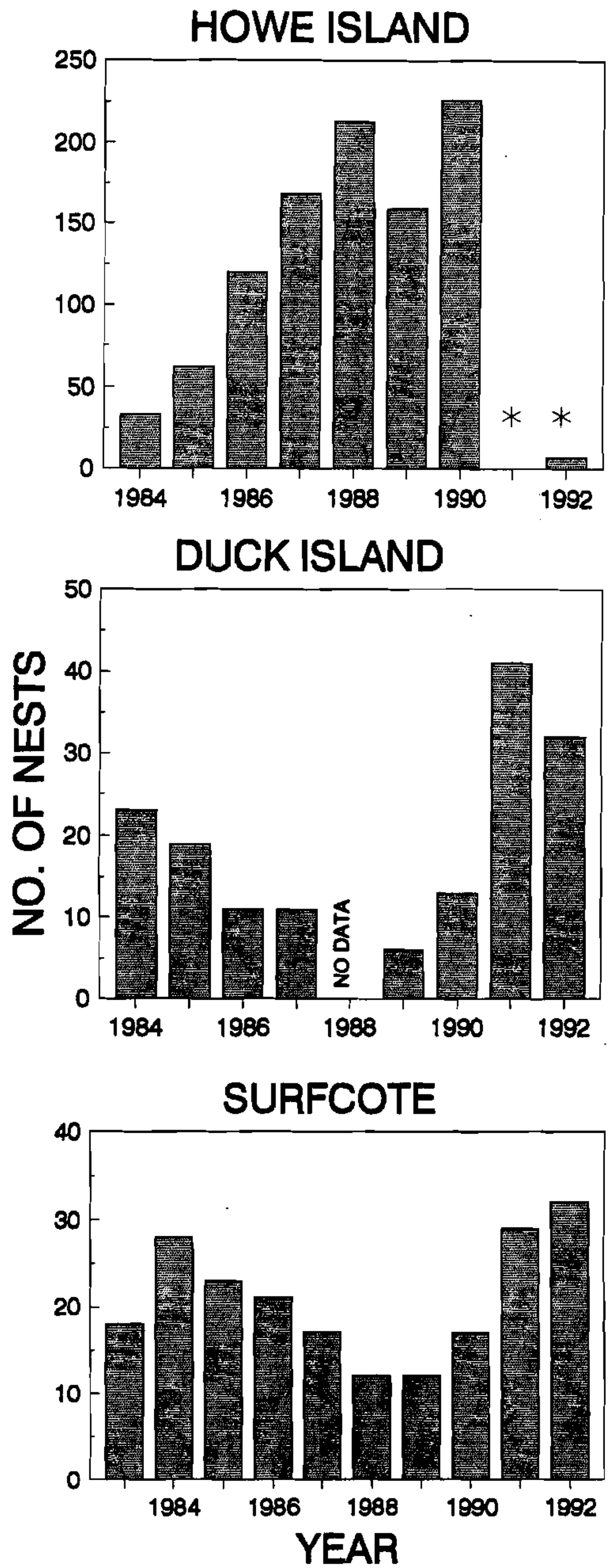


Figure 13. Number of Brant nests in the Howe Island, Duck Island,, and Surfcote colonies, Alaska, 1983-1992. The asterisks (*) indicate the years the Howe Island colony was virtually abandoned. Data for Howe and Duck islands prior to 1989 from Burgess and Ritchie (1991), data for the Surfcote colony for 1983 and 1984 from Woodward-Clyde Consultants (1983, 1985), for 1985-1989 from Murphy and Anderson (1992), data for all other years from Ritchie et al. (1990, 1991), Stickney et al (1992).

Table 9. Numbers of Brant nests located during ground surveys and percent success in three sections in July 1992. Most nesting locations shown in Figure 12.

Nesting Location	Total Nests	No. Successful	No. Failed	No. Unknown	Percent Success
2. Sagavanirktok R. delta					
Howe Island	7	0	7	0	0
Duck Island	32[a]/19[b]	4[b]	0[b]	15[b]	21[b]
Endicott Road	1	0	1	0	0
Subtotal	**40[c]/27**	**4**	**8**	**15**	**15**
3. Heald Pt. to Kuparuk R.					
Surfcote	32	20	11	1	63
Guardshack East	25	12	13	0	48
Guardshack West	4	2	2	0	50
Niakuk #1	7	1	0	6	14
Niakuk #2	1	0	0	1	0
Subtotal	**69**	**35**	**26**	**8**	**51**
4. Kuparuk R. to Kalubik Cr.					
Milne Pt. #1	1	1	0	0	100
Milne Pt. #4	5	1	4	0	20
Milne Pt. #6	1	0	1	0	0
Kuparuk Delta #1	80	62	15	3	78
Kuparuk Delta #2	54	43	2	9	80
KRU CPF-3	31	17	8	6	55
KRU 3N	3	3	0	0	100
KRU Pit E	6	4	2	0	80
KRU 1Y	8	2	6	0	25
KRU 2C	2	1	1	0	50
Subtotal	**191**	**134**	**39**	**18**	**70**
TOTAL	**300[c]/287**	**173**	**73**	**41**	**60**

[a] Nest count from observations.
[b] Nest count from ground census.
[c] Includes nest count from observations of Duck Island.

(Table 9). Of these nests, 134 were recorded on two islands in the Kuparuk River delta, 50 were recorded at five locations in the Kuparuk River Unit and seven nests occurred at three locations along the Milne Point road system.

The general distribution and locations of nests were similar to those reported in 1989-1991 (Figure 12). At least four sites (KRU CPF-3, KRU 2C, Kuparuk Delta #1, Kuparuk Delta #2) had more nests in 1992 than in 1991. The Kuparuk Delta contained about 20% more nests in 1992 than in either 1990 or 1991.

One hundred thirty-one nonbreeding Brant were recorded at coastal locations, primarily between Oliktok and Milne points (Table 8). Although the largest number of nonbreeders in 1992 was counted in Section 4, this section contained a lower number of nonbreeders than in the previous two years. Most Brant in 1992 were recorded in areas that were used in previous years.

Section 5: Kalubik Creek to Miluveach River

Only three Brant nests were recorded during 1992 at two locations in Section 5 of the study area (Figure 12, Table 7); ground surveys were not made in this section. Brant had been recorded at these locations in previous years (Ritchie et al. 1990, 1991). Numbers of nests in this section typically have been small compared to other sections, with few breeding birds compared to the number of Brant in nonbreeding flocks.

Twenty-two nonbreeding Brant in three small flocks were recorded (Table 8). The number of nonbreeders observed in Section 5 was the lowest recorded since 1989.

Nesting Phenology

Weather on the Arctic Coastal Plain during 1992 probably had only a small effect on the productivity of Brant in the oil fields. The average monthly temperatures for the nesting period were within 1° C of the long-term monthly means (NOAA 1992). On 25 May, snow coverage of the Sagavanirktok River delta was estimated to range from 50-85%, but was light and melted quickly in ensuing days. Islands, such as Howe and Duck islands, were mostly snow-free by 25 May, so nesting habitat was available when Brant arrived in late May. Extensive coverage of ice on ponds and inlets remained through early to mid-June, however, and may have delayed nesting at some inland locations. The Kuparuk River broke up on 29 May, one day later than previous records (A. Schuyler, ARCO Alaska, Inc., pers. commun.), and water levels in the Sagavanirktok River crested on 3 June. The break-up of sea ice was 1-2 weeks late (B. Reynolds, SAIC, pers. commun.) and in many areas the bottom-fast ice thawed in place. The bottom-fast ice between Howe Island and the mainland remained in place through at least 8 June, with about 75% of the water surface frozen. This ice coverage provided arctic foxes with access to the Howe Island colony during nest initiation of both Brant and Snow Geese.

Conditions elsewhere during spring migration may have influenced the timing and synchrony of arrival, and possibly the number of Brant that arrived in the oil fields. Extensive, persistent snow and ice in the Yukon-Kuskokwim Delta delayed nest initiation there (J. Sedinger, Univ. of AK Fairbanks, pers. commun.; M. Lindberg, Univ. of AK Fairbanks, pers. commun.), and similar conditions in Norton Sound and the Beaufort Sea may have hampered migration of birds destined for the study area. The first Brant on Howe Island were sighted on 28 May, two days later than the first sighting of Brant on the Colville River delta (P. Martin, USFWS, unpubl. data). The arrival of Brant on Howe Island was within the range of dates (typically from late May through the first week of June) observed during 1989-1992 (Ritchie et al. 1990, 1991; Stickney et al. 1992), and during observations of the Snow Goose colony on Howe Island from 1986-1988 (Burgess and Ritchie 1991). However, numbers in the area increased slowly after first arrival compared to arrival of Brant in previous years.

The first observation of nest initiation on Duck Island was 3 June with nest initiation peaking between 6-8 June (Figure 14), similar to the nest initiation of Brant observed on the Colville River delta (P. Martin, USFWS, unpubl. data). No nests were initiated on Duck Island after 8 June. Although nest initiation was observed at Surfcote on 3 June, these few (2-3) nests apparently did not persist. The first initiation of nests that persisted ≥3 days was on 6 June, with most nests being initiated between 8-10 June. Nest initiation (and first observation of nests) at Surfcote was asynchronous, because ice and high water levels made nesting habitat available gradually. New nests were last initiated on 15 June. The estimated dates of nest initiation of seven broods with known brood sizes ranged between 8-10 June.

Ice coverage (10-95%) and water levels (moderate to high) varied on 9-10 June at nesting locations of Brant in the Kuparuk Oil Field. At this time, Brant were still initiating nests, although colonies such as CPF-3 were well established. During an overflight of the Kuparuk River delta on 7 June, the islands used for nesting by Brant were entirely snow-free and large numbers (≥75) of Brant were present. Some Brant were already incubating nests, but many flew, indicating that they were still in the process of nest initiation.

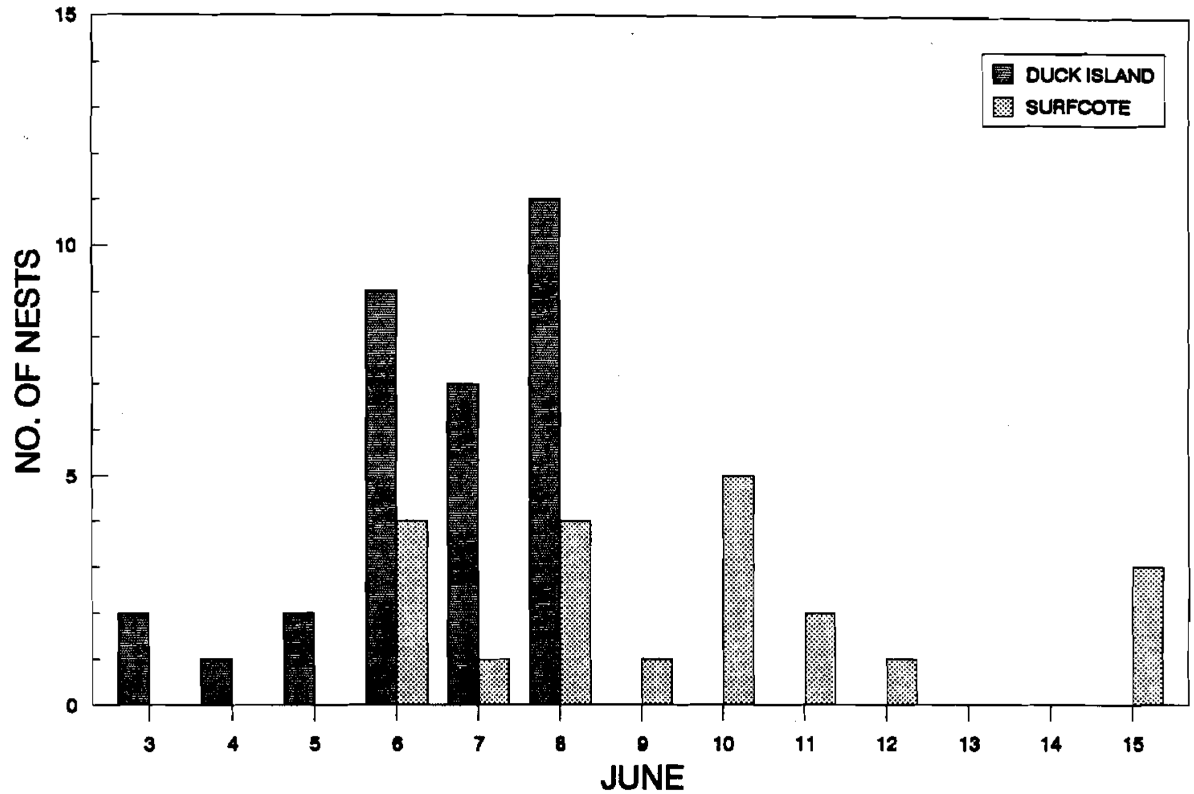


Figure 14. Dates of nest initiation at Duck Island and Surfcote colonies, Alaska, 1992.

Productivity

The average nesting success of Brant determined by ground surveys at selected colonies in Sections 2-4 (Sagavanirktok River delta to the Kuparuk Oil Field) was 60%, but ranged from 0-100% (Table 9). Conditions for nesting apparently were more favorable for Brant in 1992 than in 1991, when nesting success for the same area was only 23% (Stickney et al. 1992).

Section 2: Sagavanirktok River delta

As in 1991, the nesting success of Brant on the Sagavanirktok River delta was low (<20%; Table 9). Although some Brant attempted to nest on Howe Island after the foxes had left, none of these nests were successful. The single nest observed near the Endicott Road failed early. Duck Island supported slightly fewer nests in 1992 (32 nests) than in 1991 (41 nests), but nesting success as determined by the ground surveys was similar (21% vs. 20%, respectively). Despite successful hatching of some nests, only one gosling was ever seen on the nearby mainland. As in other years, predation by Glaucous Gulls from the Duck Island colony (29 gull nests) was probably a factor both in low nesting success and in low gosling survival.

Section 3: Heald Point to Kuparuk River (Prudhoe Bay)

Nesting success of Brant in Prudhoe Bay ranged from <15% (Niakuk Islands) to 63% (Surfcote) (Table 9). Both lakes northwest of Lake Coleen (Guardshack East and West) had higher nesting success in 1992 than in 1991. One successful nest was found on the largest Niakuk island (Niakuk #1). Although nesting success from the Niakuk Islands was difficult to determine (nest bowls do not persist in the gravel substrate), predation by the large numbers of gulls nesting on these islands probably reduced both nesting success and gosling survival.

Section 4: Kuparuk River to Kalubik Creek (Kuparuk / Milne Point oil fields)

Nesting success of Brant at locations within the Kuparuk Oil Field was much higher in 1992 (59%; Table 9) than in 1991 (17%). Nesting locations along the road system in the Kuparuk River Unit generally had higher nesting success in 1992 than in 1991. However, only three of six known locations along the Milne Point road system supported nesting by Brant and only two nests out of seven hatched successfully. The two islands at the mouth of the Kuparuk River supported the most nests, and also had high nesting success (79%). Snowy Owls (*Nyctea scandiaca*) were observed on these islands in June and may have been responsible for the failure of some nests and the death of at least one adult.

Breeding Population Trends

Examination of multi-year nesting data suggested no clear pattern common to all colonies. In the ground survey study area, the number of nests in 1992 was significantly greater than the mean of the previous 2-3 years (Ho_5; n = 12 locations, Wilcoxon signed-ranks T = 2.296, P = 0.01).

No consistent long-term trend (Ho_4) was apparent for numbers of Brant nests at colonies on Howe and Duck islands and at Surfcote, however. The number of nests on Howe Island significantly increased over time (range = 33-226 nests, n = 7 years, adjusted r^2 = 0.81, P = 0.0036), but only if 1991 and 1992, the years foxes disrupted nesting, were excluded (Figure 15, Appendix 10). At Duck Island (range = 6-41 nests) and Surfcote (range = 12-32 nests), there was no monotonic (unidirectional) relationship for the number of nests with year (Figure 15). A quadratic regression fit the Duck Island data better (n = 8 years, adjusted r^2 = 0.55, P = 0.0576; Figure 15, Appendix 10) than the Surfcote data (n = 10 years, adjusted r^2 = 0.32, P = 0.1091, Figure 12, Appendix 10). In both cases, the data suggest a decline in the number of nests from the early 1980s through 1989, with an increase thereafter. The increase in the number of Brant nests at both Duck Island and Surfcote in both 1991 and 1992 was probably influenced more by the abandonment of Howe Island, than by intrinsic growth in the colonies themselves. The almost total abandonment of the Howe Island colony, usually the largest aggregation of Brant in the oil fields, influenced any statistical analysis of trends.

Comparisons of goose nesting data from the Lisburne Development Area between 1983 and 1989 indicate no annual pattern common to all species in the oil fields. The number of nests of Canada Geese (*Branta canadensis*) was lowest in 1986, and of Greater White-fronted Geese (*Anser albifrons*) in 1987 (Murphy and Anderson 1992), whereas 1989 was generally a low year for Brant nests at Surfcote, Duck Island, and Howe Island.

Nest numbers and nesting success of arctic-nesting geese are thought to be influenced in part by a complex interaction between body condition of the geese and weather factors (de Boer and Drent 1989). Although the role of temperature has been considered inconclusive (Boyd 1982, 1987; Summers 1986), snow melt has been found to have a strong influence on both the timing of nest initiation and body condition, both of which influence nesting success (Barry 1962, Prop et al. 1984, de Boer and Drent 1989). Within the oil fields, the relationship of nesting with weather and/or snow melt has varied by location and species. At the Surfcote colony, Murphy and Anderson (1992) found no consistent relationship between snow melt and nesting success of Brant. At Howe Island numbers of nests of both Snow Geese and Brant decreased in 1989, a year with delayed snow melt, but reached maximal numbers in 1990, a year with early snow melt (Ritchie et al. 1990, 1991, Burgess et al. 1992). However, while Snow Geese had moderate nesting success (64%) in 1989, and high nesting success (90%) in 1990 (Burgess et al. 1992), Brant had good nesting success (≥80%) in both years (Ritchie et al. 1990, 1991). Because studies have generally required 5-33 years of research (de Boer and Drent 1989) to assess the long-term relationship of weather factors and snow melt with productivity, it is too early to assess the effects of these factors on nesting population of Brant in the oil fields.

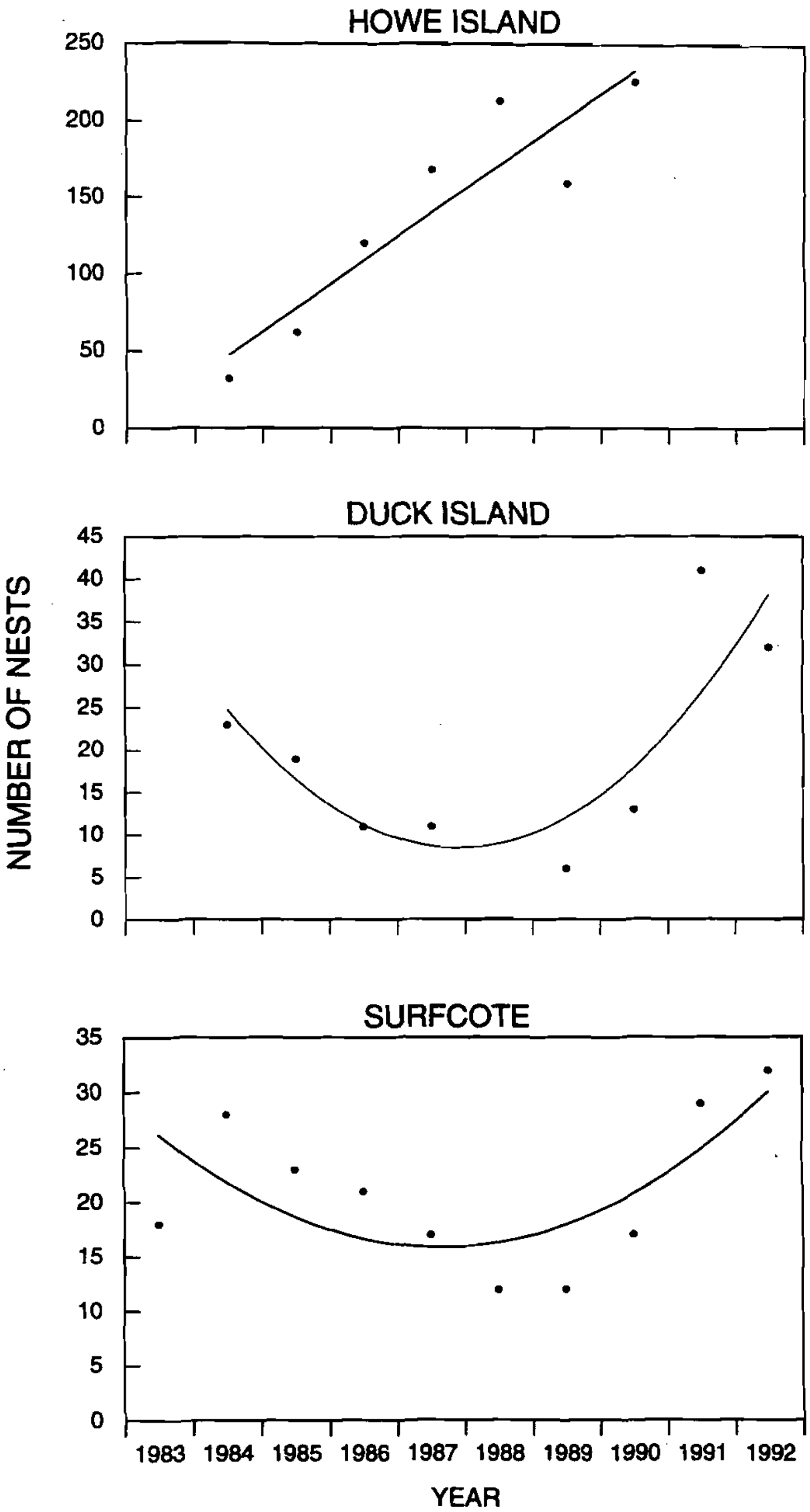


Figure 15. Linear regressions of the relationship between year and the number of nests in the Howe Island, Duck Island, and Surfcote colonies, Alaska, 1983-1992. The Howe Island data does not include 1991-1992. Data for Howe and Duck islands prior to 1989 from Burgess and Ritchie (1991), data for the Surfcote colony for 1983 and 1984 from Woodward-Clyde Consultants (1983, 1985), for 1985-1989 from Murphy and Anderson (1992), data for all other years from Ritchie et al. (1990, 1991), Stickney et al (1992).

BROOD-REARING/MOLTING BRANT
Abundance and Distribution

Counts from aerial surveys and photo censuses indicated that approximately 930 Brant used coastal habitats between the Colville and Staines rivers in late July 1992 (Figure 16, Table 10). Approximately 26% (238) of these Brant were goslings, compared with 38% (698) in 1991, 48% (1567) in 1990 and 40% (608) in 1989. Numbers of both adults and goslings in 1992 were substantially lower than in any previous year (Table 11). Correspondingly, densities of adult and gosling Brant were also much lower in 1992. Although the density of adults in 1992 (2.3 adults/km of coastline) was only slightly less than in 1991 (3.7 adults/km of coastline), it was substantially less than in 1990 (5.5 adults/km of coast). The density of goslings (0.8 goslings/km of coastline) was dramatically lower than for any other year (>2.0 goslings/km of coastline). Despite the increase in nesting success in the study area from 1991 to 1992 (from 23% to 60%), many fewer goslings occurred in the area at the time of the brood-rearing surveys. Although not all the factors contributing to the decline in gosling numbers have been identified, predators, such as arctic foxes and Glaucous Gulls, were probably a major influence.

Except for one small group (4 adults, ≥4 goslings) located inland, most Brant (>99% of adults and goslings) were observed in or near arctic salt marsh vegetation on tidal flats, lagoons, creek mouths, and river deltas within 0.8 km of the coast (Figure 16). No Brant were recorded east of the Kadleroshilik River during the aerial surveys for this study, but other observers saw a group of approximately 50 Brant (number of goslings unknown, but suspected to be low) east of the Shaviovik River on 24 July (B. Lawhead, ABR, pers. commun.).

Brood-rearing groups of Brant in 1992 (Figure 16) used similar areas to those used in previous years, but the largest groups were restricted to the area between Heald Point and the Kuparuk River (Section 3). Few Brant were recorded at sites adjacent to and east of the Saganvanirktok River delta. Numbers of Brant recorded between the Kuparuk and Miluveach rivers also declined dramatically. This decline was due largely to poor nesting success at the main Colville River colony (P. Martin, USFWS, unpubl. data), which may be a regular source of brood-rearing birds in these sections.

Section 1: Staines River (Brownlow Point) to Sagavanirktok River

A mean of 27 Brant (four goslings; 15% of section total) were counted in the east channel of the Sagavanirktok River and at the mouth of the Kadleroshilik River (Figure 16, Table 10). No Brant were recorded east of the Kadleroshilik River during aerial surveys in 1992. The scarcity of birds in this area contributed to low numbers of brood-rearing Brant in the whole study area compared to other years (Table 11). The previous low count for this section was 119 Brant in 1991. The proportion of goslings was the lowest ever recorded for Section 1, as well as being the lowest recorded for any coastal section in 1992. The density of both adults and goslings was <1.0/km of coastline, a reflection of the low numbers in Section 1 (Figure 17).

Section 2: Sagavanirktok River delta

In late July, a single brood (two adults, four goslings) was recorded on the Sagavanirktok River near the Endicott Road (Figure 16, Table 10). Although similarly low numbers also were observed in 1991, substantially greater use was recorded in 1989 and 1990 (Table 11). Large groups of brood-rearing Brant were not expected, however, because productivity was extremely low in Section 2 for the second consecutive year.

Section 3: Heald Point to Kuparuk River (Prudhoe Bay)

A mean of 614 Brant (108 goslings, 18% of section total) were recorded in this section during aerial surveys (Figure 16, Table 10). An additional eight Brant were seen inland by ground observers. As in previous years, most birds (>280 adults, >20 goslings) were observed at the mouth of the Putuligayuk River. Another large brood-rearing group (104 adults, 71 goslings) was observed near Point McIntyre, and smaller groups were observed along the northwestern coast of Prudhoe Bay. A small group of Brant (4 adults, ≥4 goslings) was observed inland at a pond along the Spine Road near Pump Station 1. The use of this site during

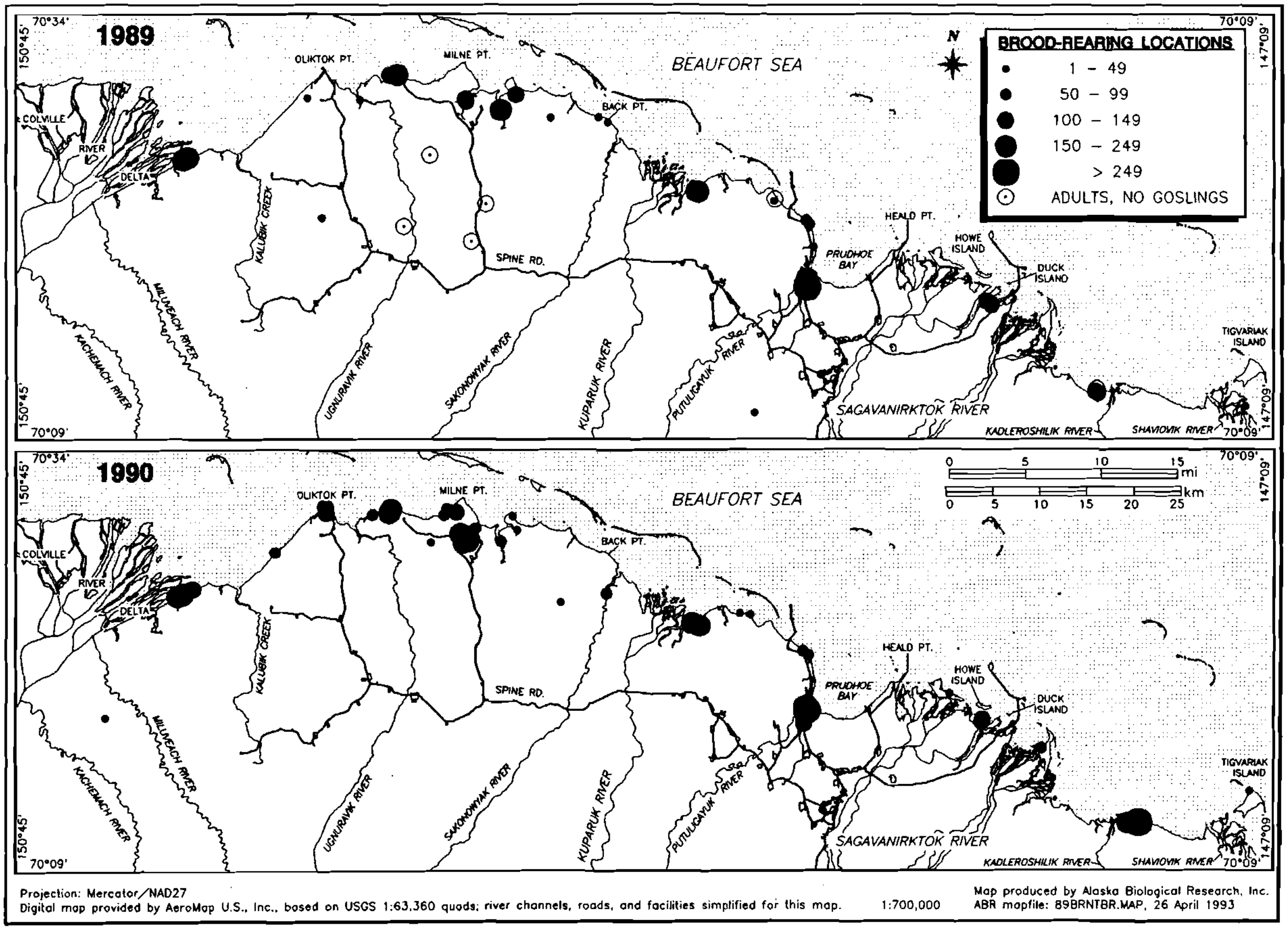


Figure 16. Location and sizes of Brant brood-rearing groups on the Arctic Coastal Plain between the Colville and Staines rivers, Alaska, 1989-1992.

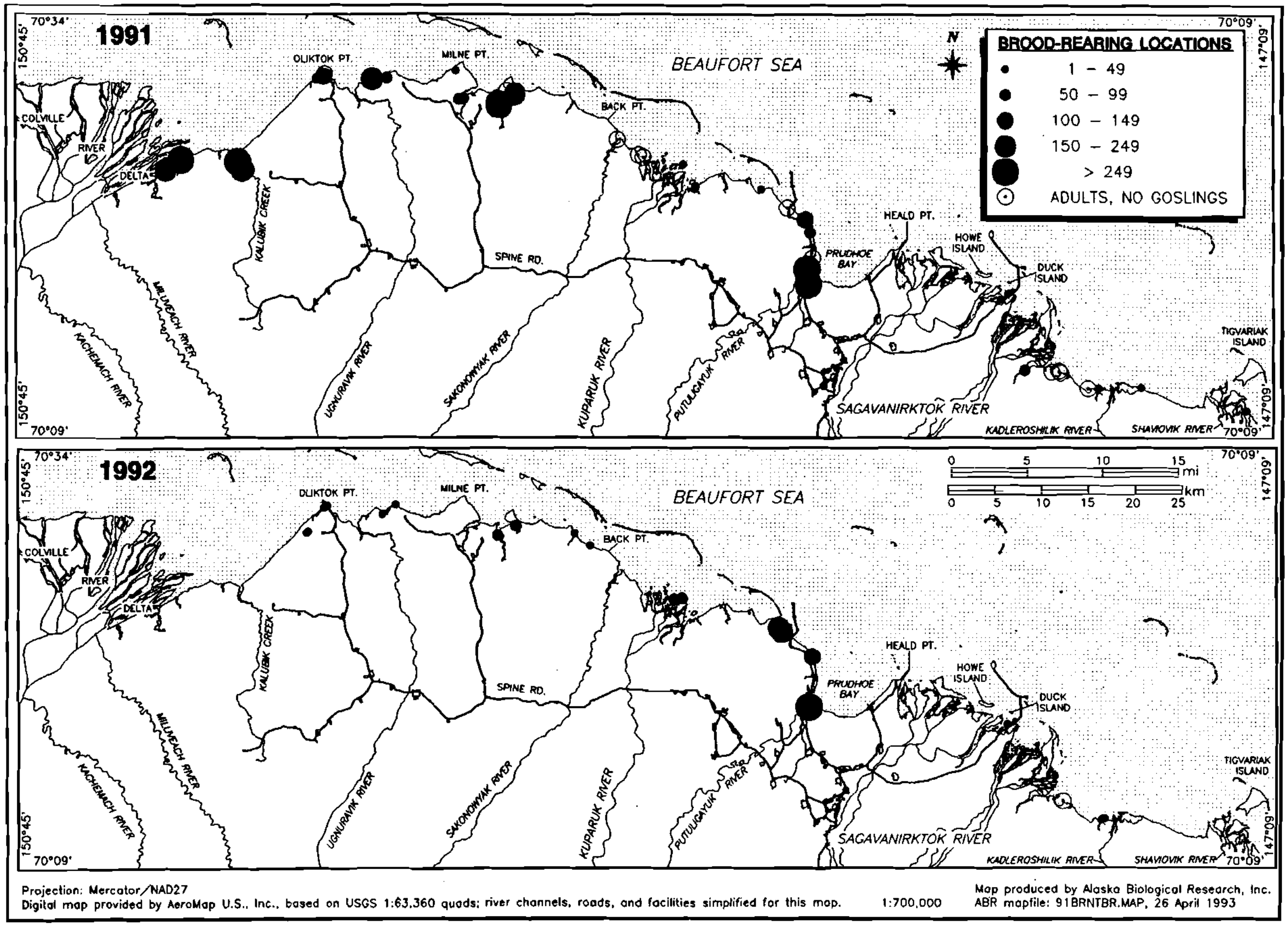


Figure 16. Page 2.

Table 10. The distribution, size, and composition of brood-rearing groups of Brant, as determined by two aerial surveys on the Arctic Coastal Plain between the Colville and Staines rivers, Alaska, 27-28 and 30 July 1992. Numbers are from photos and aerial counts. Locations of brood-rearing groups are shown on Figure 13.

Coastal Section	27-28 July Survey				30 July Survey		
	Length (km) of Coastline	Adults	Goslings	Total	Adults	Goslings	Total
1. Brownlow Pt. to Sagavanirktok R.	97	24	4	28	22	4	26
2. Sagavanirktok R. delta	32	2	4	6	0	0	0
3. Heald Pt. to Kuparuk R.	45	515	112	627	496	104	600
4. Kuparuk R. to Kalubik Cr.	80	149	117	266	171	130	301
5. Kalubik Cr. to Miluveach R.	48	0	0	0	0	0	0
TOTAL	302	690	237	927	689	238	927

brood-rearing had not been recorded during previous years of this study.

In contrast to decreased numbers of Brant in other sections in 1992, the number (and consequently the density) of adults recorded in this section was the highest in four years of surveys (Figure 17, Table 11). The number of goslings also increased slightly (10%) over 1991 levels, but was lower than 1990 (315 goslings), a reflection of low productivity on the Sagavanirktok River delta (i.e., Howe and Duck islands), as well as the influence of predators on post-hatching survival. In previous years, the delta was a major contributor to brood-rearing groups in the Prudhoe Bay region (Ritchie et al. 1991). The large brood-rearing group near Point McIntyre in 1992 may be attributed to the large number of nests and high nesting success of Brant on the Kuparuk River delta.

Section 4: Kuparuk River delta to Kalubik Creek (Kuparuk/Milne Point oilfields)

Mean counts of 284 Brant (124 goslings, 44% of section total) were observed in Section 4 (Figure 17, Table 10). Primary areas of use included bays and salt marshes near Milne Point. Limited numbers were counted north and east of the Ugnuravik River mouth, and near Oliktok Point. Brood-rearing groups were found on islands in the Kuparuk River delta for the first time since 1989.

Numbers of Brant, and consequently densities (2.0 adults/km, 1.6 goslings/km; Figure 17) were substantially lower than in other years (Table 11). The previous low count for this area was 700 Brant in 1989 (5.1 adults/km, 3.7 goslings/km). The decrease in 1992 was probably due to the poor success of the main Colville River delta colony (P. Martin, USFWS, unpubl. data), which in the past contributed to brood-rearing groups in this section (Stickney et al. 1992).

Table 11. Mean numbers of brood-rearing Brant counted from aerial surveys and photos made in late July and early August in the coastal sections between the Colville and Staines rivers, Alaska, 1989-1992. Data for 1989-1991 are from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

Coastal Section	Mean Number of Adults (n=2 surveys)				Mean Number of Goslings (n=2 surveys)			
	1989	1990	1991	1992	1989	1990	1991	1992
1. Brownlow Pt. to Sagavanirktok R.	113	286	86	23	33	265	33	4
2. Sagavanirktok R. delta	50	87	6	2[a]	73	83	8	4[a]
3. Heald Pt. to Kuparuk R.	234	439	360	510[b]	121	315	102	112[b]
4. Kuparuk R. to Kalubik Cr.	406	684	430	160	294	701	279	124
5. Kalubik Cr. to Miluveach R.	109	176	234	0	87	203	276	0
TOTAL	912	1672	1116	694	608	1567	698	242

[a] Counts based on single survey 27-28 July 1992.
[b] Includes inland group seen by ground observers.

Section 5: Kalubik Creek to Miluveach River

No Brant were observed on either of the late July aerial surveys, although 19 Brant (including two goslings) were counted in Section 5 during a survey on 9 July. In past years, 196-510 birds have used this area (Table 11). A probable contributing factor to the absence of birds was the poor success of the main Colville River delta colony (P. Martin, USFWS, unpubl. data), which is a major source of Brant brood-rearing in Section 5 (Stickney et al. 1992).

Brood-rearing Trends

Assessment of the hypothesis (Ho_1) that the number of brood-rearing Brant did not vary among coastal sections and among years indicated that there was a significant interaction between the two factors ($F_{11,13}$ = 47.32, P = 0.0001; Figure 18; Appendix 11). In all years, Section 2 (Sagavanirktok River delta) had the lowest number of brood-rearing birds, while Section 3 (Heald Point to the Kuparuk River) had consistently high numbers. However, other sections showed variation among years (Figure 18). For example, in three out of four years (1989-1991), Section 4 had more birds than did Section 3, in 1990 substantially more (1385 birds in Section 4 compared to 754 birds in Section 3). In 1992, however, Section 4 had far fewer brood-rearing Brant (284 birds) than did Section 3 (624 birds).

A significant interaction between year and section also existed in the analysis of the proportion of goslings among sections and among years (Ho_2; $F_{11,12}$ = 9.28, P = 0.0003; Figure 18; Appendix 11). Section 2 (Sagavanirktok River delta) had the highest proportion of goslings, while Section 1 (Staines River to Sagavanirktok River) had the smallest proportion (except in 1990), indicating that this

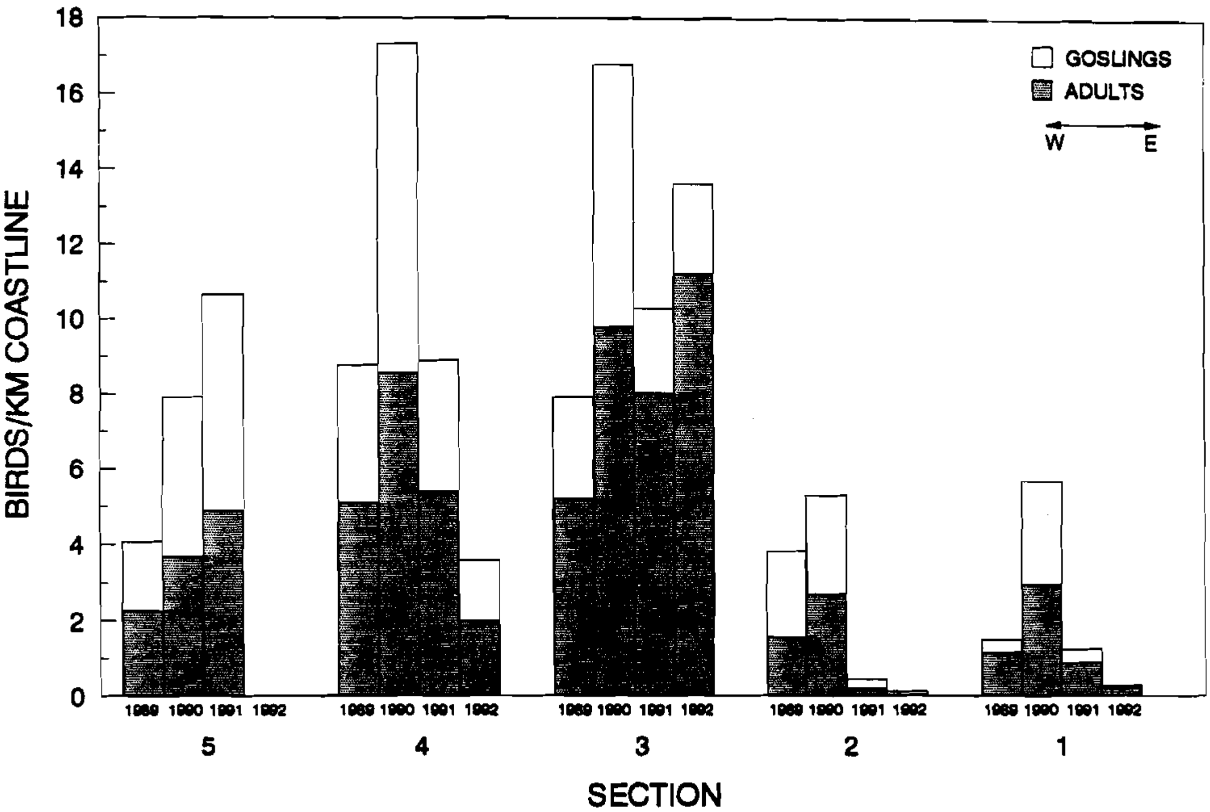


Figure 17. Linear densities of adult Brant and goslings during late July-early August in each of five coastal sections of the study area between the Colville and Staines rivers, Alaska, 1989-1992. Data for years 1989-1991 from Ritchie et al. 1990, 1991, and Stickney et al. 1992.

section was largely used by non- or failed breeders. The highest proportion of goslings in all sections was observed in 1990, which was a good year for productivity (Ritchie et al. 1991), while the smallest proportions were generally observed in 1991 and 1992, poor years for productivity and survival (Stickney et al. 1992).

In examining whether there is a trend between 1989-1992 in numbers of brood-rearing Brant in the study area (Ho_3), an *F*-test for lack of fit (Neter et al. 1985:123) determined that linear regression did not fit the data. More years of data and a multivariate approach will be necessary before any type of trend can be detected by standard statistical techniques.

Fluctuations in numbers of brood-rearing Brant among years are not unusual. Extreme annual variation in productivity has been reported in other Brant populations (Barry 1962, Pacific Flyway Council 1981). Numbers of Brant on fall-staging areas in southwestern Alaska also have varied widely among years (Conant 1989), reflecting annual variation in productivity in the western Arctic. However, depressed numbers of goslings following increased nesting success, suggests post-hatching predation was influential in 1992. The levels of brown bear (*Ursus arctos*) activity were high in the oil fields, but mainly centered around the North Slope Borough Landfill (D. Schideler, ADF&G, unpubl. data). Also, the number of Golden Eagles (*Aquila chrysaetos*) appeared to be high in 1992, not only in the oil fields (D. Schideler, ADF&G, pers. commun.), but also on the Colville River delta (P. Martin, USFWS, unpubl. data). Arctic foxes are abundant predators that prey on geese (Eberhardt et al. 1982, Murphy and Anderson 1992) and several studies have suggested that varying predation rates by arctic foxes influenced the productivity of Brant on the Taimyr Peninsula in

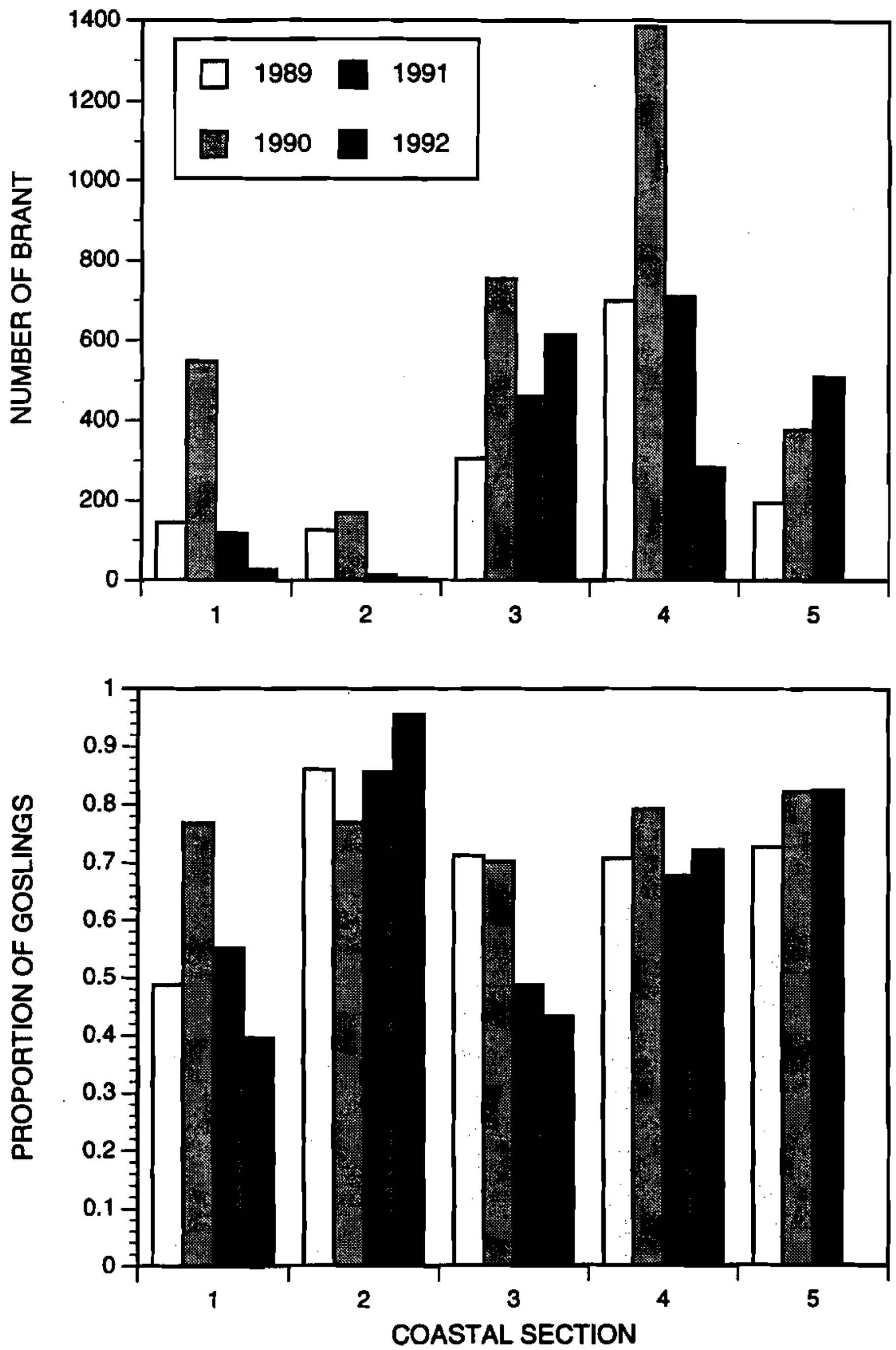


Figure 18. The number of Brant and proportion of goslings during late July-early August by section and year in the study area between the Colville and Staines rivers, Alaska, 1989-1992. Data for years 1989-1991 from Ritchie et al. 1990, 1991, and Stickney et al. 1992.

Russia (Summers 1986, Summers and Underhill 1987).

BRANT BANDING

In August 1992, ABR captured and banded 587 Brant at six locations in the Prudhoe Bay Oil Field between the Sagavanirktok River and Back Point (Area 2) and the USFWS (P. Martin, USFWS, unpubl. data) captured and banded 100 Brant at Oliktok Point and Milne Point (Area 3) in the Kuparuk Oil Field (Figure 19; Table 12). During the aerial survey on 30 July 1992, 689 adults and 238 goslings were counted between the Sagavanirktok River and the eastern channel of the Colville River (Table 10), thus, the banding effort accounted for approximately 78% of all adults and 92% of all goslings in the region. No Brant were banded east of the Sagavanirktok River (Area 1) by LGL Alaska Research Associates, Inc., because few (22 adults and 4 goslings) Brant were counted in that area during the aerial survey. Including Brant banded in 1991 (n = 325), the number of unbanded Brant marked with aqua tarsal bands in the oil fields now totals 1012 birds. In addition to the unbanded birds captured in 1992, 68 Brant (62 in Area 2, 6 in Area 3) were recaptured that had been banded previously, both in the oil fields in 1991 and elsewhere. Six of these recaptured Brant did not have colored tarsal bands and were banded with aqua bands by the banding crews. Thus, the population of aqua-banded Brant now totals 1018. Weights were taken on 579 unbanded birds and standard body measurements were taken on a subsample of 131 birds (see Appendix 12).

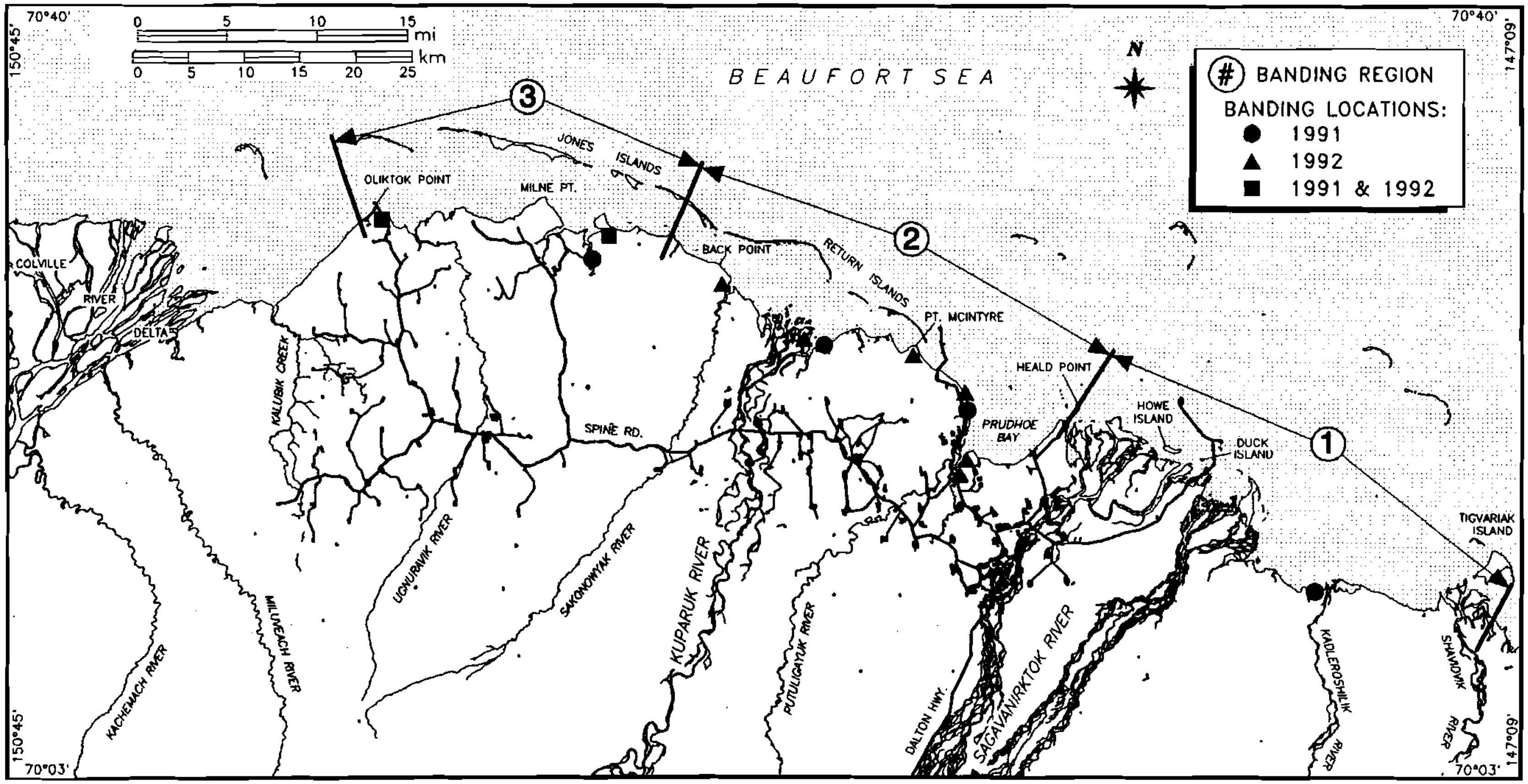
Of the 687 Brant banded in 1992, 218 (31.7%) were goslings that ranged in size from large, completely downy birds to birds with almost fully formed flight feathers. Goslings comprised a large proportion of all flocks captured except for the flock of 201 molting adults at the mouth of the Putuligayuk River (north site) and the flock at Oliktok Point, which contained only two goslings (Table 12).

Brant recaptured during banding drives in 1992 included birds that had been previously banded on the North Slope, in western Alaska, and in Canada (Table 13). Of 32 recaptured birds originally banded in the oil fields in 1991, 24 (75%) were banded on the west coast of Prudhoe Bay (Area 2) and 8 (25%) were banded in the vicinity of Foggy Island Bay (Area 1). Of those recaptured birds originally banded outside the oil fields, most came from the Teshekpuk Lake area (13 birds; 19.1% of all recaptures) and the Yukon-Kuskokwim Delta in western Alaska (13 birds; 19.1%). The remaining recaptured Brant were from two additional locations on the North Slope, the Colville River Delta (seven birds; 10.3%) and Kalubik Creek (two birds; 2.9%), and from Campbell Island near the Anderson River delta in western Canada (one bird; 1.5%).

The sex and age composition of all recaptured birds revealed a slight, although nonsignificant (Chi-square test, $P > 0.25$), trend for more males being recaptured than females (37 males and 31 females) (Table 13). Only six second-year (known age) birds (8.8% of all recaptures) were recaptured in 1992, and most (five birds) of those birds were females. Although 138 goslings were banded in the oil fields in 1991, only one gosling was subsequently recaptured in 1992 as a second-year bird (a female originally banded at Foggy Island Bay, recaptured on the Kuparuk River Delta).

For Brant banded in the oil fields, the mean distance between the original banding location in 1991 and the recapture location in 1992 was 12.7 km (n = 32, SD = 13.0, range = 0.5-47.8 km). Females were recaptured slightly farther from their original banding location than males ($\bar{x}$ = 14.0 km [n = 17] and $\bar{x}$ = 11.9 km [n = 15], respectively). A comparison of the mean distance between banding and recapture locations, based on the original banding locations, indicates that these distances are biased because no Brant were banded in Area 1 in 1992. The mean distance between original banding location and recapture location for birds banded at the West Prudhoe Bay coast site was 5.8 km (n = 24, SD = 4.4, range = 0.5-12.8), whereas the mean distance for birds banded in the Foggy Island Bay region was 33.3 km (n = 18, SD = 6.3 km, range = 29.2-47.8). Of particular interest, however, was the lack of interchange between birds banded west of the Kuparuk River delta and those banded to the east.

Resightings of banded Brant in 1992 were



Projection: Mercator/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quads;
coastline, facilities and major rivers updated from aerial photography (1973–1990).

Map produced by Alaska Biological Research, Inc.
ABR mapfile: BRANBAND.MAP, 26 April 1993
1:600,000

Figure 19. Banding regions and banding locations for Brant in the North Slope oil fields, 1991-1992. The U.S. Fish and Wildlife Service banded Brant in region 3, Alaska Biological Research, Inc. banded Brant in region 2, and LGL Alaska Research Associates, Inc. banded Brant in region 1 (1991 only).

Table 12. Sex- and age-composition of previously unbanded Brant captured and banded in the Prudhoe Bay and Kuparuk oil fields, August 1992. Locations of banding sites are depicted in Figure 16. Banding data from Milne Point and Oliktok Point were provided by USFWS (P. Martin, unpubl. data).

Banding Location[a]	Age[b]	Male	Female	Unknown	Total
South Putuligayuk River	Goslings	13	12	0	25
	Adults	18	19	0	37
	Total	31	31	0	62
North Putuligayuk River	Goslings	0	0	0	0
	Adults	84	117	0	201
	Total	84	117	0	201
West Prudhoe Bay coast	Goslings	5	4	0	9
	Adults	8	7	0	15
	Total	13	11	0	24
Point McIntyre	Goslings	27	38	1	66
	Adults	43	47	0	90
	Total	70	85	1	156
Kuparuk River delta	Goslings	22	30	0	52
	Adults	30	22	0	52
	Total	52	52	0	104
Back Point	Goslings	11	11	0	22
	Adults	9	9	0	18
	Total	20	20	0	40
Milne Point[c]	Goslings	24	18	0	42
	Adults	15	20	0	35
	Total	39	38	0	77
Oliktok Point[c]	Goslings	1	1	0	2
	Adults	8	12	1	21
	Total	9	13	1	23
TOTAL	Goslings	103	114	1	218
	Adults	215	263	1	469
	Total	318	367	2	687

[a] Location of banding sites are depicted in Figure 19.
[b] Sub-adult (second-year birds) are included in the adult age class.
[c] Banding data from Milne Point and Oliktok Point were provided by USFWS (P. D. Martin, pers. commun.).

Table 13. Sex- and age-composition of banded Brant recaptured in the Prudhoe Bay and Kuparuk oil fields, August 1992. Recapture data from Milne Point and Oliktok Point were provided by USFWS (P. Martin, unpubl. data).

Recapture Location	Subadults[a]			Adults		
Original Banding Location	Male	Female	Unknown	Male	Female	Unknown
South Putuligayuk River						
West Prudhoe Bay coast	0	0	0	1	2	0
Teshekpuk Lake	0	0	0	3	1	0
Yukon-Kuskokwim Delta	0	0	0	1	1	0
North Putuligayuk River						
Foggy Island Bay	0	0	0	3	4	0
West Prudhoe Bay coast	0	0	0	5	4	0
Teshekpuk Lake	0	0	0	4	1	0
Yukon-Kuskokwim Delta	0	1	0	1[b]	2	0
Campbell Is., Canada	0	0	0	1	0	0
West Prudhoe Bay coast						
West Prudhoe Bay coast	0	0	0	4	3	0
Point McIntyre						
West Prudhoe Bay coast	0	0	0	2	3	0
Kalubik Creek	0	1	0	0	0	0
Colville River Delta	1	0	0	1	2	0
Teshekpuk Lake	0	0	0	1	1	0
Yukon-Kuskokwim Delta	0	0	0	1	1	0
Kuparuk River Delta						
Foggy Island Bay	0	1	0	0	0	0
Colville River Delta	0	0	0	1[c]	0	0
Teshekpuk Lake	0	0	0	1	0	0
Yukon-Kuskokwim Delta	0	2	0	1	0	0
Milne Point[c]						
Kalubik Creek	0	0	0	1	0	0
Colville River Delta	0	0	0	1	1[d]	0
Yukon-Kuskokwim Delta	0	0	0	2	0	0
Oliktok Point[c]						
Colville River Delta	0	0	0	1	0	0
TOTAL	1	5	0	36	26	0

[a] 1-yr-old birds (i.e., banded as goslings in 1991).
[b] 4-yr-old bird (banded as gosling in 1988).
[c] Recapture data from Milne Point and Oliktok Point were provided by USFWS (P. D. Martin, pers. commun.).
[d] 2-yr-old bird (banded as gosling in 1990).

collected opportunistically in the oil fields by ABR and USFWS biologists from early June to late July, and in the oil fields and on the Colville River delta by Mark Lindberg (graduate student, University of Alaska Fairbanks) during early July. Most of the resighting effort was on the Sagavanirktok River delta (near the Endicott Road) in June and at Oliktok Point in July. Colored tarsal bands were read on 66 individuals during June and July 1992. Brant banded on the North Slope accounted for approximately 85% (56 of 66 individuals) of all resighted birds, with those banded in the Colville River delta (14 birds), Teshekpuk Lake (17 birds), and Kalubik Creek (three birds) predominating. Although the numbers of Brant banded in each banding area were not equal in 1991, an almost equal number of Brant from each banding area were resighted in 1992: Area 1, Foggy Island Bay vicinity (seven birds); Area 2, Prudhoe Bay Oil Field (seven birds), and Area 3, Oliktok and Milne points, (nine birds). Of the remaining resightings in the oil fields, seven were Brant banded on the Yukon-Kuskokwim Delta and three were Brant banded at locations outside Alaska. Two of the three Brant banded outside Alaska were from Canada: one bird from the Smoke Moose River delta (near the Anderson River delta, Northwest Territories) and one bird, wearing a white tarsal band with obscured black lettering, banded in 1987 either on the Prince Patrick Islands, on Melville Island, or on the Anderson River delta (D. Derksen, USFWS, pers. commun.). The third Brant banded outside Alaska was banded as an adult on Wrangel Island, Russia, in July 1991.

Only 8 of 66 (12.1%) individuals resighted during June and July in the oil fields were subsequently recaptured during banding drives in August. This low percentage suggests that much movement of individuals through the oil fields occurs during the summer months, particularly during June (only one of eight individuals recaptured in August was seen in June). In late June or early July, some nonbreeding or failed-breeding Brant move from the oil fields to molt in the vicinity of Teshekpuk Lake. Twenty-two individuals (33.3% of 66 birds) were resighted on more than one day, indicating that residence time in the oil fields can exceed several days for transient birds. However, only two Brant that were seen on more than one day earlier in the summer were recaptured in August. As noted above for recaptured individuals, birds banded in the oil fields west of the Kuparuk River delta were not resighted to the east and vice versa.

The sex and age composition of the 58 individuals resighted but not recaptured (recaptured birds are included in Table 13), revealed an approximately equal sex ratio (28 males:29 females, 1 unknown) and a predominance of adult birds (n = 53; 91.4%) (Table 14). All of the second-year (known age) birds resighted in 1992 were originally banded at North Slope locations (Table 14).

Resightings of Brant with aqua-colored tarsal bands already have provided much information on the staging and wintering grounds of Brant banded in the Prudhoe Bay and Kuparuk oil fields. Brant banded in the oil fields in 1991 were resighted in fall 1991 at Izembek Lagoon on the Alaska Peninsula, in winter 1991-1992 at three locations in Baja Mexico, during spring 1992 at Humboldt Bay, California, and during summer 1992 on the Yukon-Kuskokwim Delta in western Alaska, at Teshekpuk Lake on the North Slope of Alaska, and on Banks Island, Northwest Territories, Canada (USFWS and Can. Wildl. Serv., unpubl. data) (Figure 20). Aqua banded Brant again were resighted at Izembek Lagoon in fall 1992 and on the wintering grounds in Mexico during winter 1992-1993 (Figure 20). One Brant banded as a gosling by ABR in 1992 was killed by a hunter near Samish Bay, Washington, in December 1992.

Of the three wintering sites monitored by USFWS personnel in Baja California, Brant banded in the oil fields were seen most commonly at Bahia San Quintin (41 of 50 resightings in 1991-1992; 146 of 183 resightings in 1992-1993). Preliminary analysis of the resighting data from Mexico indicates that populations of Brant from western and northern Alaska use different wintering areas, although some overlap does occur (Ward et al. 1992).

Data on resightings and recaptures of Brant banded in the oil fields in 1991 have led us to reject our null hypothesis (Ho_8) of no interchange of Brant between banding areas within the oil fields and no interchange with banding locations outside of the oil fields. Information gathered to date suggests that interchange is occurring

Table 14. Sex- and age-composition of Brant resighted in the Prudhoe Bay and Kuparuk oil fields and on the Colville River Delta, 1992. Only birds that were not subsequently recaptured are included.

Original Banding Location / Resighting Location	Subadults*			Adults		
	Male	Female	Unknown	Male	Female	Unknown
ALASKA						
Foggy Island Bay						
Sagavanirktok River Delta	0	0	0	2	4	0
West Prudhoe Bay coast						
Putuligayuk River	0	0	0	1	1	0
West Dock Road	0	0	0	1	1	0
Milne Point						
Oliktok Point	1	2	0	0	0	0
Colville River Delta	0	0	0	1	0	0
Oliktok Point						
Oliktok Point	0	0	0	3	2	0
Kalubik Creek						
Putuligayuk River	1	0	0	0	0	0
West Dock Road	0	0	0	1	1	0
Oliktok Point	0	0	0	1	1	0
Colville River Delta						
Oliktok Point	1	0	0	6	7	0
Colville River Delta	0	0	0	1	2	0
Teshekpuk Lake						
Sagavanirktok River Delta	0	0	0	1	0	0
Milne Point	0	0	0	0	1	0
Oliktok Point	0	0	0	3	3	0
Yukon-Kuskokwim Delta						
Sagavanirktok River Delta	0	0	0	1	0	0
Putuligayuk River	0	0	0	1	1	0
Oliktok Point	0	0	0	2	1	0
CANADA						
Prince Patrick/Melville Island						
Sagavanirktok River Delta	0	0	0	0	0	1
Smoke Moose River delta						
Sagavanirktok River Delta	0	0	0	0	1	0
RUSSIA						
Wrangel Island						
Sagavanirktok River Delta	0	0	0	0	1	0
TOTAL	3	2	0	25	27	1

* 1-yr-old birds (i.e., banded as goslings in 1991).

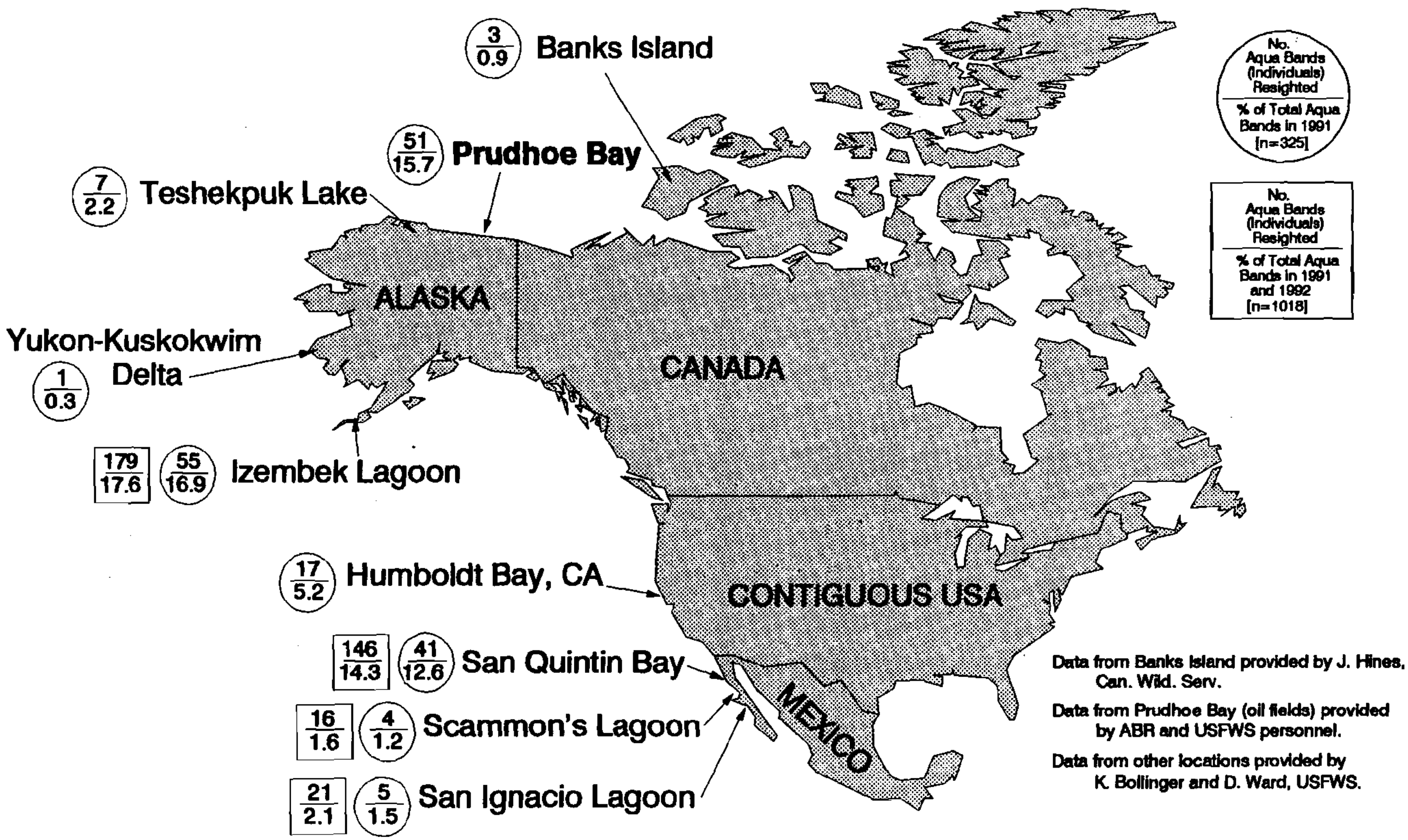


Figure 20. Locations where Brant banded in the oil fields in August 1991 and 1992 were resighted. Resightings on Banks Island, Yukon-Kuskokwim Delta, and at Teshepuk Lake were from summer 1992; other resightings were from fall 1991 and fall 1992 (Izembek Lagoon), winters 1991-1992 and 1992-1993 (Mexico), and spring 1992 (Humboldt Bay).

between nearby banding locations on the North Slope (Colville River delta, Teshekpuk Lake, and Kalubik Creek) and in the oil fields, and that some Brant banded in western Alaska, in western Canada, and in Russia do use the oil fields, at least during a portion of the summer season. For Brant banded in the oil fields, data gathered in 1992 have provided some interesting insights: 1) few goslings banded in 1991 were subsequently resighted or recaptured in 1992; 2) some fidelity to brood-rearing (molting) areas within the oil field was apparent; 3) interchange occurred between brood-rearing (molting) areas in the oil fields, and 4) no interchange appeared to be taking place between Brant banded west of the Kuparuk River delta and those banded to the east, although birds banded in the Colville River delta occurred in both areas.

With the increased population of Brant banded in the oil fields, additional information can be collected in 1993 and subsequent years to address questions about movements between breeding colonies and brood-rearing areas in the oil fields, fidelity of breeding adults to particular colonies, fidelity (and fate) of goslings banded in the oil fields, and breeding in the oil fields by Brant that were banded as goslings elsewhere. Particular effort should be expended to identify movements between breeding colonies and major brood-rearing/molting areas, such as the mouth of the Putuligayuk River and Oliktok Point.

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Appendix 1. Summary of Tundra Swan and Brant aerial surveys conducted in the Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54), and the Sagavanirktok-Foggy Island study areas, Alaska, June-August, 1992.

Survey Type	Location[1]	Date	Aircraft	Flight Time (hrs)	Transect Length (km)
Swan					
Nesting	Kuparuk Oil Field and OGL 54	20-27 June	C-185	25	2375
	Sagavanirktok R. delta and Foggy Is. Bay	27-28 June	C-185	8	
Brood-Rearing	Kuparuk Oil Field and OGL 54	16-21 August	C-185	25	2375
	Sagavanirktok R. delta and Foggy Is. Bay	16 August	C-185	8	908
Brant					
Nesting	Miluveach R. to Staines R. inland to 20 km	30 June-1 July	PA-18		
Brood-rearing	Kuparuk Delta and coastline (Tigvariak Island to Milne Point)	9-10 July	PA-18		
	Coastline, Miluveach R. to Staines R.	25-28 July	PA-18		
		30 July	PA-18		

[1] Locations are mapped on Figure 1

Appendix 2. Areas of survey coverage of six Tundra Swan study area sections, northern Alaska, 1992[1].

USGS Quadrangle		Transect[1] Lengths (km)	Aerial Coverage (km²) Kuparuk Oil Field	OGL 54	White Hills	Sag Delta	Foggy Island Bay	SAG Inland
Beechey Point	A-4	172	252.1	-	-	-	-	-
	A-5	138	224.3	-	407.4	-	-	-
	B-4	283	424.6	-	-	-	-	-
	B-5	390	605.4	-	-	-	-	-
	C-4[2]	+	+	-	-	-	-	-
	C-5	8	6.2	-	-	-	-	-
Harrison Bay	A-1	124	201.9	-	429.7	-	-	-
	A-2	191	-	337.2	96.4	-	-	-
	A-3	63	-	108.1	-	-	-	-
	B-1	260	409.6	-	-	-	-	-
	B-2	41	57.9	-	-	-	-	-
Umiat	C-1	53	-	-	330.4	-	-	-
	C-2	91	-	175.4	155.5	-	-	-
	C-3	94	-	162.1	-	-	-	-
	D-1	72	-	-	637.6	-	-	-
	D-2	291	-	526.0	110.7	-	-	-
	D-3	228	-	379.6	-	-	-	-
Beechey Point	A-1	285	-	-	-	-	252.7	210.8
	A-2	386	-	-	-	64.4	180.4	353.5
	A-3	192	-	-	-	-	-	296.8
	B-2	80	-	-	-	96.7	-	-
	B-3	8	-	-	-	10.7	-	-
Total		**3332**	**2182.0**	**1688.4**	**2167.7**	**171.8**	**433.1**	**861.1**

[1] = Calculated from digitized maps of each USGS Quadrangle.
[2] = < 1.6 km²

Appendix 3. Numbers of Tundra Swans and nests recorded (by quadrangle) during aerial surveys in the Kuparuk Oil Field and the Oil and Gas Lease 54 (OGL 54) study areas, Alaska, 17-21 June 1992.

Location (USGS Quadrangle)		Adults with Nests: Pair	Adults with Nests: Single Adult	Adults with Nests: Total	Total Nests	Adults without Nests: Pair	Adults without Nests: Single Adult	Adults without Nests: Flocks	Adults without Nests: Flocked Swans	Adults without Nests: Total	Total Swans
Beechey Point	A-4	6	3	15	9	2	8	3	16	28	43
	A-5	3	0	6	3	4	3	0	0	11	17
	B-4	12	11	38	24	21	21	2	7	70	108
	B-5	11	8	30	19	15	19	2	7	56	86
	C-4	-	-	-	-	-	-	-	-	-	-
	C-5	-	-	-	-	-	-	-	-	-	-
Harrison Bay	A-1	4	1	9	5	6	4	0	0	16	25
	A-2	8	5	21	13	8	10	0	0	26	47
	A-3	2	0	4	2	0	2	0	0	2	6
	B-1	6	5	17	11	9	9	3	19	46	63
	B-2	2	2	6	4	4	3	0	0	11	17
Umiat	C-1	0	0	0	0	1	0	0	0	2	2
	C-2	4	1	9	5	9	2	1	3	23	32
	C-3	1	0	2	1	4	3	0	0	11	13
	D-2	11	4	26	15	18	9	1	3	48	74
	D-3	2	6	10	8	10	12	2	6	38	48
Total		72	46	193	119	111	105	14	61	388	581

Appendix 4. Densities of Tundra Swans, nests, and broods (per km^2) recorded during aerial surveys in the Kuparuk Oil Field and Oil and Gas Lease 54 (OGL 54) study areas, Alaska, June and August 1992.

		Nesting Survey (June)				Productivity Survey (August)					
Location	USGS Quadrangle	Adults with Nests	Nests	Adults without Nests	Total Adults	Adults with Broods	Broods	Young	Adults without Broods	Total Adults	Total Swans
Kuparuk Oil Field											
Beechey Point	A-4	0.05	0.03	0.10	0.16	0.07	0.04	0.11	0.08	0.16	0.27
	A-5	0.02	0.01	0.04	0.06	0.02	0.01	0.03	0.04	0.06	0.09
	B-4	0.08	0.05	0.15	0.24	0.06	0.03	0.08	0.25	0.32	0.40
	B-5	0.05	0.03	0.09	0.14	0.07	0.03	0.10	0.15	0.21	0.31
	C-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.15	0.15	0.15
Harrison Bay	A-1	0.03	0.02	0.06	0.09	0.01	<0.01	0.02	0.07	0.08	0.10
	B-1	0.06	0.03	0.11	0.15	0.07	0.03	0.08	0.16	0.23	0.30
	B-2	0.09	0.06	0.17	0.26	0.12	0.06	0.12	0.15	0.28	0.40
OGL 54											
Harrison Bay	A-2	0.06	0.04	0.08	0.14	0.06	0.03	0.06	0.18	0.24	0.30
	A-3	0.04	0.02	0.02	0.06	0.02	0.01	0.03	0.12	0.14	0.17
Umiat	C-1	0.0	0.0	0.03	0.03	0.0	0.0	0.0	0.0	0.0	0.0
	C-2	0.06	0.03	0.14	0.20	0.06	0.03	0.10	0.10	0.16	0.26
	C-3	0.01	<0.01	0.07	0.09	<0.01	<0.01	<0.01	0.17	0.18	0.19
	D-1	0.0	0.0	0.0	0.0	0.02	0.01	0.03	0.02	0.04	0.07
	D-2	0.05	0.03	0.09	0.14	0.03	0.02	0.04	0.17	0.21	0.25
	D-3	0.03	0.02	0.10	0.13	0.03	0.01	0.03	0.14	0.16	0.19
Kuparuk Oil Field Subtotal		0.05	0.03	0.10	0.16	0.06	0.03	0.08	0.15	0.21	0.29
OGL 54 Subtotal		0.04	0.02	0.08	0.12	0.03	0.02	0.04	0.14	0.17	0.21
Kuparuk/OGL 54 Total		0.04	0.03	0.09	0.13	0.04	0.02	0.06	0.13	0.18	0.23

Appendix 5. Numbers of Tundra Swans and broods recorded (by quadrangle) during aerial surveys in the Kuparuk Oil Field and the Oil and Gas Lease 54 (OGL 54) study areas, Alaska, 16-21 August 1992.

Location (USGS Quadrangle)		Adults with Broods: Pair	Adults with Broods: Single Adult	Adults with Broods: Total	Total Broods	Total Young	Mean Brood Size	Adults without Broods: Pair	Adults without Broods: Single Adult	Adults without Broods: Flocks	Adults without Broods: Flocked Swans	Adults without Broods: Total	Total Adults	Total Swans	Percent Young
Beechey Point	A-4	10	0	20	10	30	3.0	6	2	1	9	23	43	73	41.1
	A-5	3	0	6	3	8	2.7	3	2	1	4	12	18	26	30.8
	B-4	15	0	30	15	40	2.7	29	7	10	48	113	143	183	21.9
	B-5	20	1	41	21	63	3.0	24	16	8	28	92	133	196	32.1
	C-5	0	0	0	0	0	0.0	1	0	0	0	2	2	2	0.0
Harrison Bay	A-1	2	0	4	2	6	3.0	6	3	1	3	18	22	28	21.4
	A-2	10	0	20	10	22	2.2	20	3	3	18	61	81	103	21.4
	A-3	1	0	2	1	3	3.0	4	4	0	0	12	14	17	17.6
	B-1	14	0	28	14	33	2.4	14	7	7	31	66	94	127	26.0
	B-2	4	0	8	4	8	2.0	2	0	2	6	10	18	26	30.8
Umiat	C-2	5	0	10	5	17	3.4	7	2	0	0	16	26	43	39.5
	C-3	0	1	1	1	1	1.0	8	1	3	9	26	27	28	3.6
	D-1	1	0	2	1	3	3.0	1	0	0	0	2	4	7	42.9
	D-2	9	0	18	9	24	2.7	21	7	8	45	94	112	136	17.6
	D-3	5	0	10	5	10	2.0	17	4	3	12	50	60	70	14.3
Total		99	2	200	101	268	2.7	164	58	47	213	597	797	1065	25.2

Appendix 6. Numbers of Tundra Swans and nests recorded (by quadrangle) during aerial surveys in the Sagavanirktok River delta study area, Alaska, 27-28 June 1992.

		Adults with Nests				Adults without Nests					
Location	USGS Quadrangle	Pair	Single Adult	Total	Total Nests	Pair	Single Adult	Flocks	Flocked Swans	Total	Total Swans
Beechey Point	A-1	4	3	11	7	10	8	2	12	40	51
	A-2	6	7	19	13	21	9	1	4	55	74
	A-3	1	4	6	5	1	7	2	6	15	21
	B-2	7	9	23	16	7	8	0	0	22	45
	B-3	0	0	0	0	0	1	0	0	1	1
Total		18	23	59	41	39	33	5	22	133	192

Appendix 7. Densities of Tundra Swans, nests, and broods (per km^2) recorded during aerial surveys in the Sagavanirktok River delta study area, Alaska, June and August 1992.

Section	Nesting Survey (June)				Productivity Survey (August)					
	Adults with Nests	Nests	Adults without Nests	Total Adults	Adults with Broods	Broods	Young	Adults without Broods	Total Adults	Total Swans
Sagavanirktok Delta	0.13	0.09	0.22	0.35	0.13	0.06	0.20	0.30	0.43	0.64
Foggy Island Bay	0.04	0.03	0.13	0.17	0.03	0.01	0.03	0.18	0.20	0.23
Sag Inland	0.02	0.02	0.05	0.07	0.01	<0.01	0.02	0.05	0.07	0.08
Total	0.04	0.03	0.09	0.13	0.03	0.02	0.04	0.12	0.15	0.19

Appendix 8. Number of Tundra Swans and nests recorded (by Beechey Point quadrangle) during aerial surveys in the Sagavanirktok River delta study area, Alaska, 17-19 August 1992.

	Adults With Broods						Adults without Broods							
USGS Quadrangle	Pair	Single Adult	Total	Total Brood	Total Young	Mean Brood Size	Pair	Single Adult	Flocks	Flocked Swans	Total	Total Adults	Total Swans	Percent Young
BP A-1	3	0	6	3	9	3.0	16	4	5	16	52	58	67	13.4
BP A-2	8	0	16	8	19		24	7	5	26	81	97	116	16.4
BP A-3	2	0	4	2	4	2.0	6	0	0	0	12	16	20	20.0
BP B-2	9	0	18	9	28	3.1	8	5	2	7	28	46	74	37.8
BP B-3	1	0	2	1	4	4.0	0	0	0	0	0	2	6	66.7
TOTAL	23	0	46	24	64	2.7	54	16	9	46	173	219	283	22.6

Appendix 9. Summaries of Tundra Swans counts during brood-rearing in a portion of the Kuparuk Oil Field (Beechey Point, B-5 quadrangle), Alaska, August 1986-1992.

Year	Adults with Broods			Total Brood	Total Young	Mean Brood Size	Adults without Broods					Total Adults	Total Swans	Percent Young
	Pair	Single Adult	Total				Pair	Single Adult	Flocks	Flocked Swans	Total			
1986[a]	7	0	14	7	15	2.1	25	8	1	6	64	78	93	16.1
1987[a]	11	0	22	11	26	2.4	18	14	3	10	60	82	108	24.1
1988[b]	14	1	29	15	34	2.3	23	7	1	3	56	85	119	28.6
1988[c]	13	2	28	15	31	2.1	25	3	2	8	61	89	120	25.8
1989[d]	16	2	34	18	36	2.0	31	3	1	4	69	103	139	25.9
1990[e]	23	1	47	24	67	2.8	21	19	3	9	70	117	184	36.4
1991[f]	20	1	41	21	52	2.5	25	10	8	32	92	133	185	28.1
1992	20	1	41	21	63	3.0	24	16	8	28	92	133	196	32.1
Mean ($\bar{x}$)	15.9	1	32.6	16.7	41.4	2.5	24.1	11.0	3.7	13.9	72.5	105.0	146.4	28.3

[a] USFWS Survey - Conant and Cain 1987
[b] USFWS Survey - R. King, USFWS, pers. comm.
[c] Ritchie et al. 1989
[d] Ritchie et al. 1990
[e] Ritchie et al. 1991
[f] Stickney et al. 1992

Appendix 10. Summary statistics for the linear regressions testing the relationship between the number of nests on Howe and Duck islands in the Sagavanirktok River delta and at the Surfcote colony in the Lisburne Development Area, Alaska, between 1983 and 1992. The Howe Island data are presented for the years 1983-1990. Data for Howe and Duck islands prior to 1989 are from Burgess and Ritchie (1991); data for the Surfcote colony for 1983-1984 are from Woodward-Clyde Consultants (1983, 1985), for 1985-1989 are from Murphy and Anderson (1992). Data for all other years are from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

1. Howe Island

a. Model Summary

Count: 7
r: 0.918
Adjusted r^2: 0.811

Source	df	SS	MS	F	*P*
Model	1	26970.036	26970.036	26.714	0.0036
Error	5	5047.964	1009.593		

b. Model Coefficients

Variable	Coefficient	SE	t-test	*P*
Intercept	-61527.964	11931.422	-5.157	0.0036
Year	31.036	6.005	5.169	0.0036

1. Duck Island

a. Model Summary

Count: 8
r: 0.825
Adjusted r^2: 0.553

Source	df	SS	MS	F	*P*
Model	2	680.749	340.375	5.331	0.0576
Error	5	319.251	63.85		

Appendix 10. Continued

2. Duck Island (Continued)

b. Model Coefficients

Variable	Coefficient	SE	t-test	*P*
Intercept	5557237.179	1966090.00	2.83	0.0368
Year	-5592.456	1977.96	2.83	0.0368
$Year^2$	1.407	0.49747	2.83	0.0368

3. Surfcote

a. Model Summary

Count: 10

r: 0.685

Adjusted r^2: 0.317

Source	df	SS	MS	F	*P*
Model	2	206.798	103.399	3.092	0.1091
Error	7	234.102	33.443		

b. Model Coefficients

Variable	Coefficient	SE	t-test	*P*
Intercept	2378232.100	994145.00	2.39	0.048
Year	-2393.604	1000.40	-2.39	0.048
$Year^2$	0.602	0.252	2.39	0.048

Appendix 11. Analyses of covariance (ANCOVA) tables and residual plots for number of Brant by section and year and for the proportion of goslings by section and year. The sections are delineated in Figure 11 and the years are 1989-1992. The groups sizes of Brant were transformed with a natural logarithm and the proportions of goslings were transformed using the arcsin of the square root. Coastline length was used as the covariate. Data for 1989-1991 are from Ritchie et al. (1990, 1991) and Stickney et al. (1992).

1. Brant Numbers

Model Summary
Count: 37
r: 0.997
Adjusted r^2: 0.985

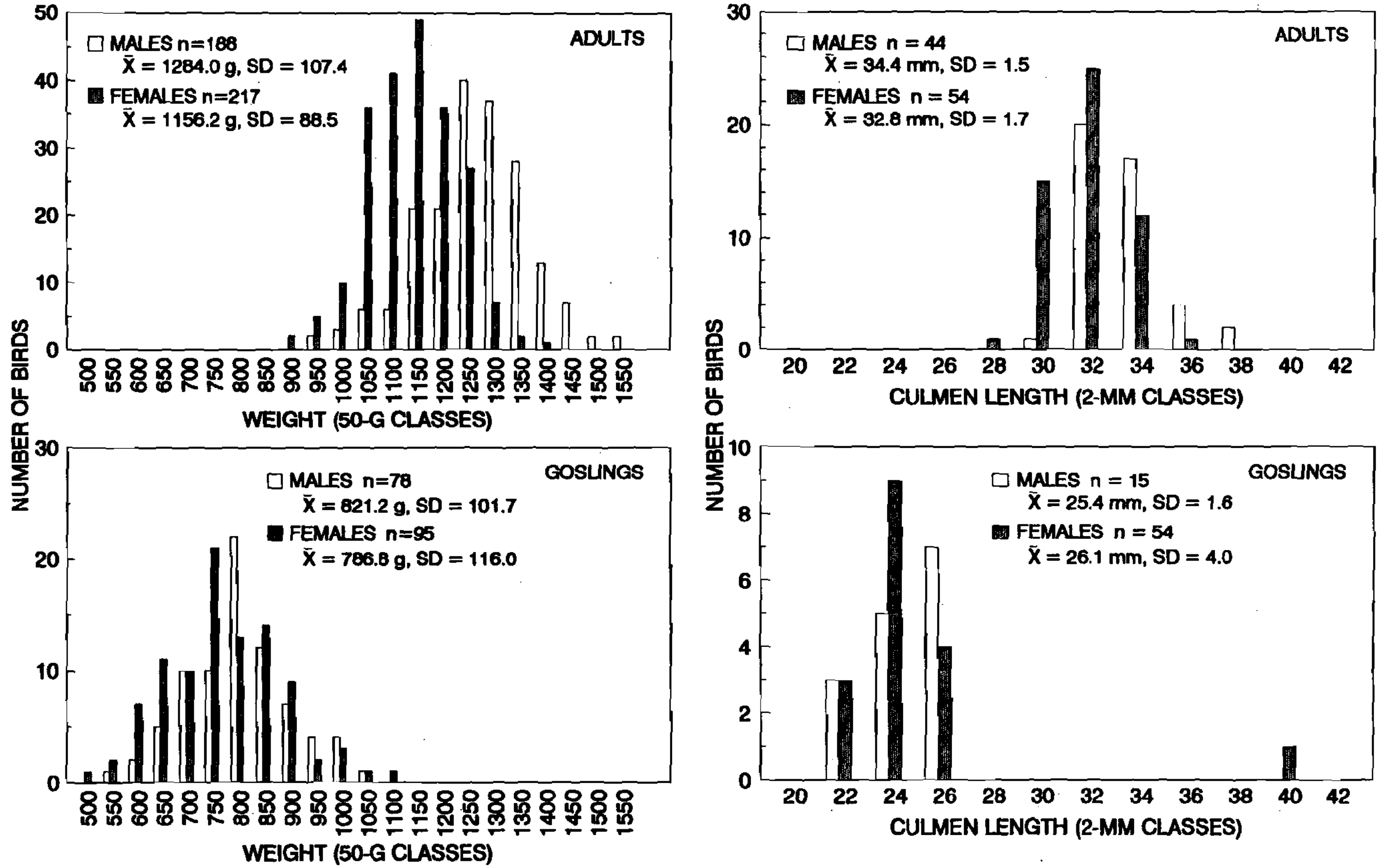
Source	df	MS	F	P	Error Term
Coastline Length	1	114166.3	63.926	0.0001	MSE
Year	3	300136.4	168.059	0.0001	MSE
Section	3	728698.5	258.631	0.0001	MS Survey (Within Section)
Survey No. (Within Section)	5	2817.5	1.578	0.2344	MSE
Year*Section	11	84506.1	47.318	0.0001	MSE
Residual	13	1785.9			

Appendix 11. (Continued)

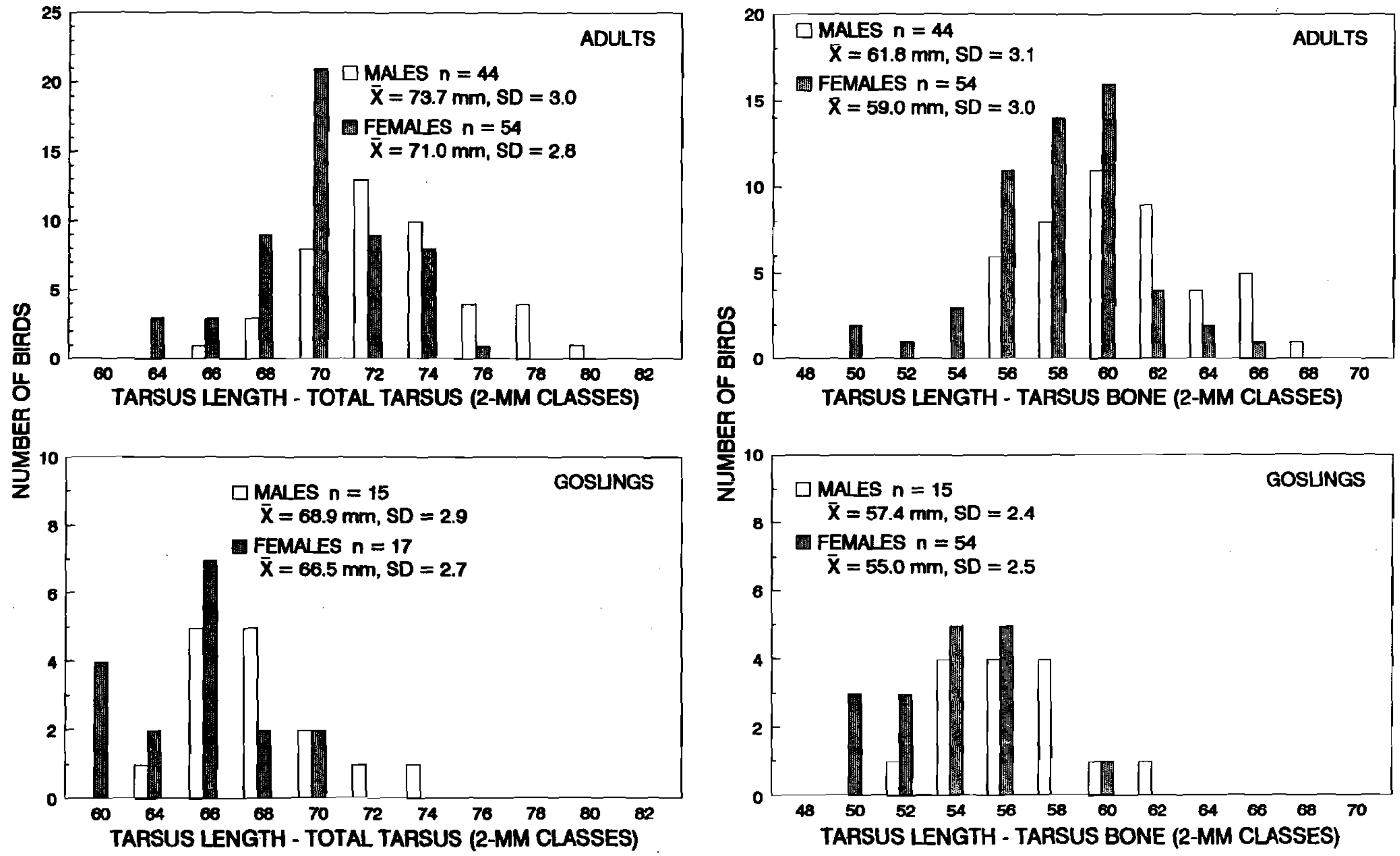
2. Proportion of Goslings

Model Summary
Count:151
r: 0.622
Adjusted r^2: 0.276

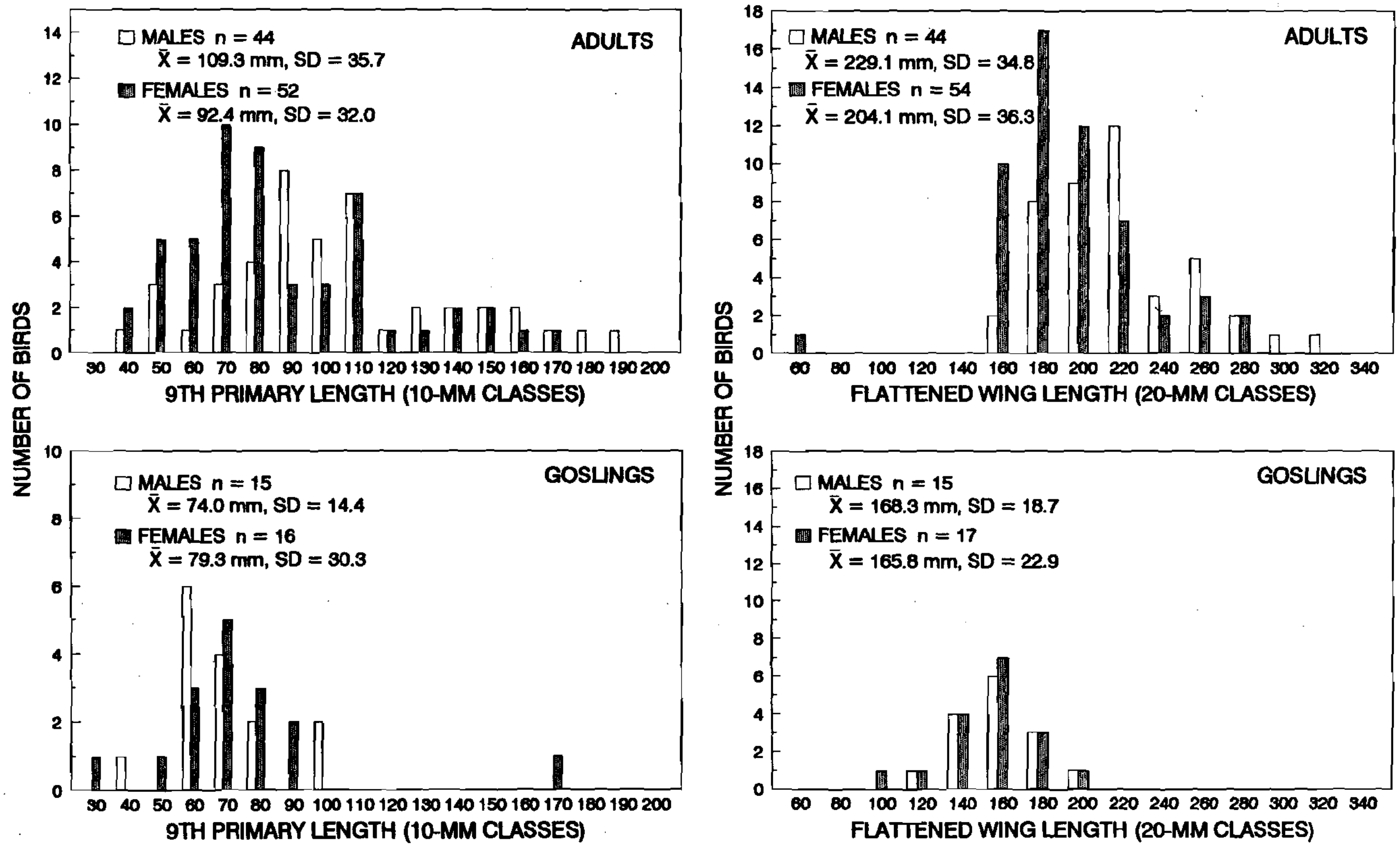
Source	df	MS	F	P	Error Term
Coastine Length	1	0.172	74.353	0.0001	MSE
Year	3	0.122	17.615	0.0001	MSE
Section	3	0.297	42.730	0.0005	MS Survey (Within Section)
Survey No. (Within Section)	5	0.009	0.754	0.5994	MSE
Year*Section	11	0.236	9.279	0.0003	MSE
Residual	12	0.028			



Appendix 12a. Weights (g), by age class and sex, of unbanded Brant captured during banding drives in August 1992. Measurements of culmen length (mm) taken on a subsample of the unbanded birds.

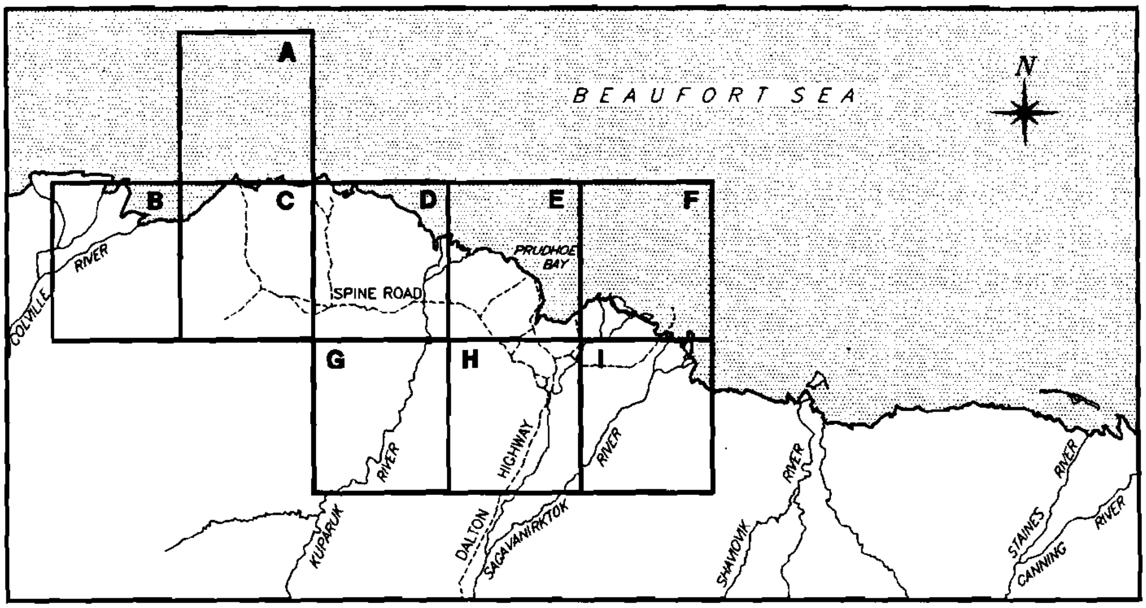


Appendix 12b. Tarsus length (total tarsus and tarsus bone, in mm), by age class and sex, of a sample of unbanded Brant captured during banding drives in August 1992.



Appendix 12c. Length of the 9th primary (mm) and the flattened wing (mm), by age class and sex, of a sample of unbanded Brant captured during banding drives in August 1992.

Appendix 13. Map locations of Brant nests and brood-rearing staging groups between the Colville and Staines rivers, Alaska, as determined from aerial and ground surveys in June and July, 1992.



Projection: MERCATOR/NAD27
Digitized from USGS 1:250,000 quads (Harrison Bay, Beechey Pt., Flaxman I.)
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: FQUADS.DWG, 22 April 1993

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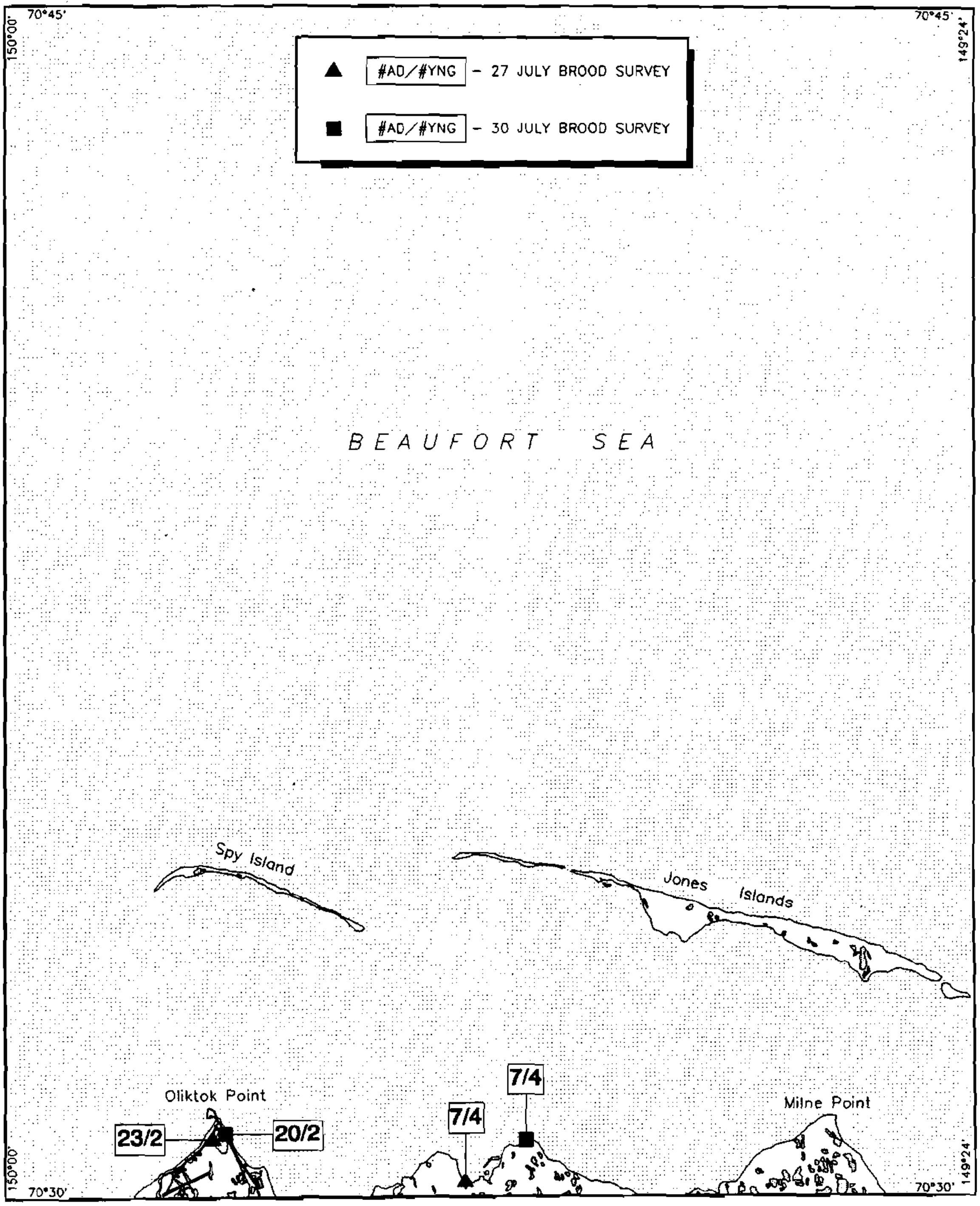
0 10 20 30 40 km

13A



Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. C-5); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPC-5.MAP, 22 April 1993

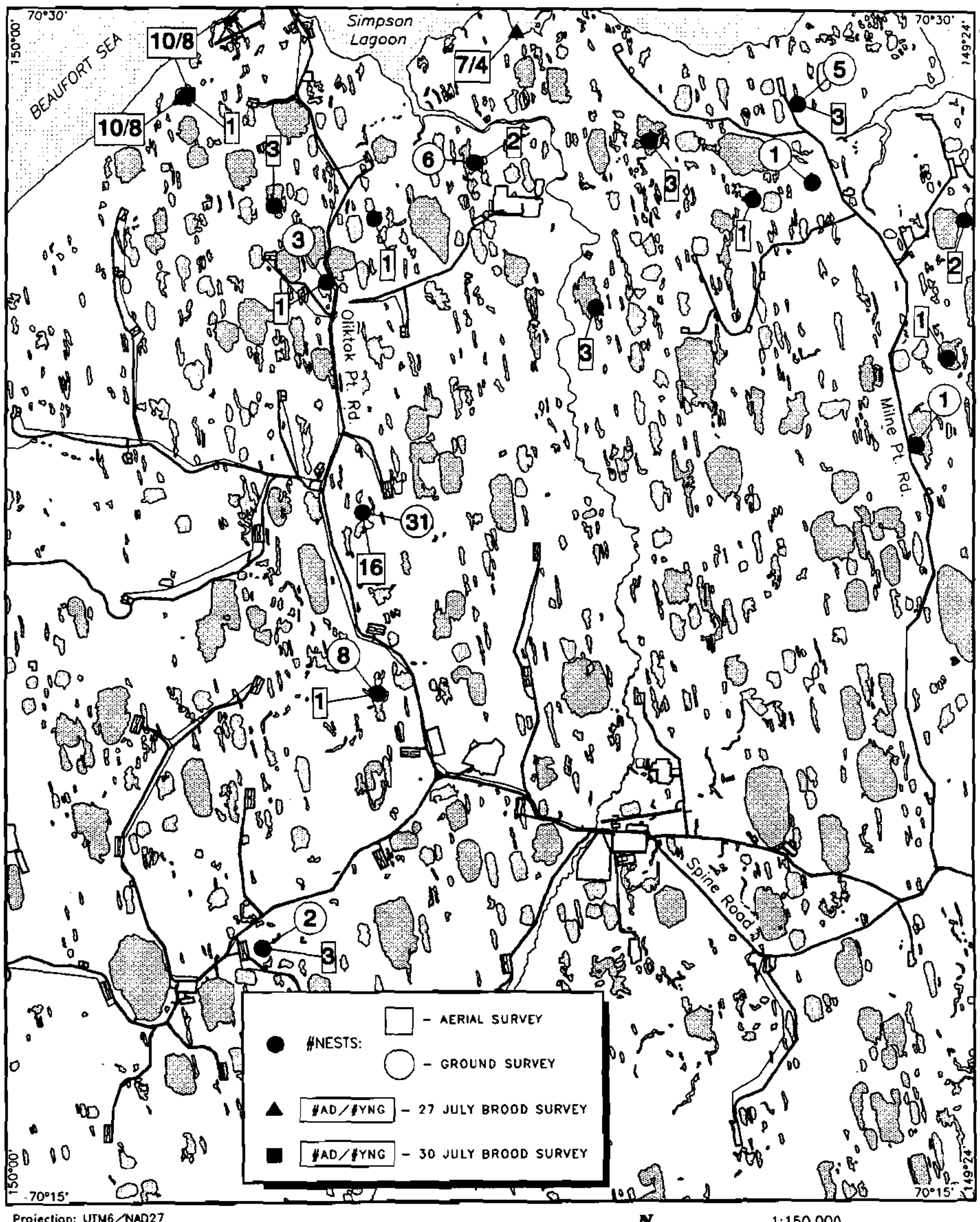
13B

Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Harrison Bay B-1).
coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92HBB-1.MAP, 22 April 1993

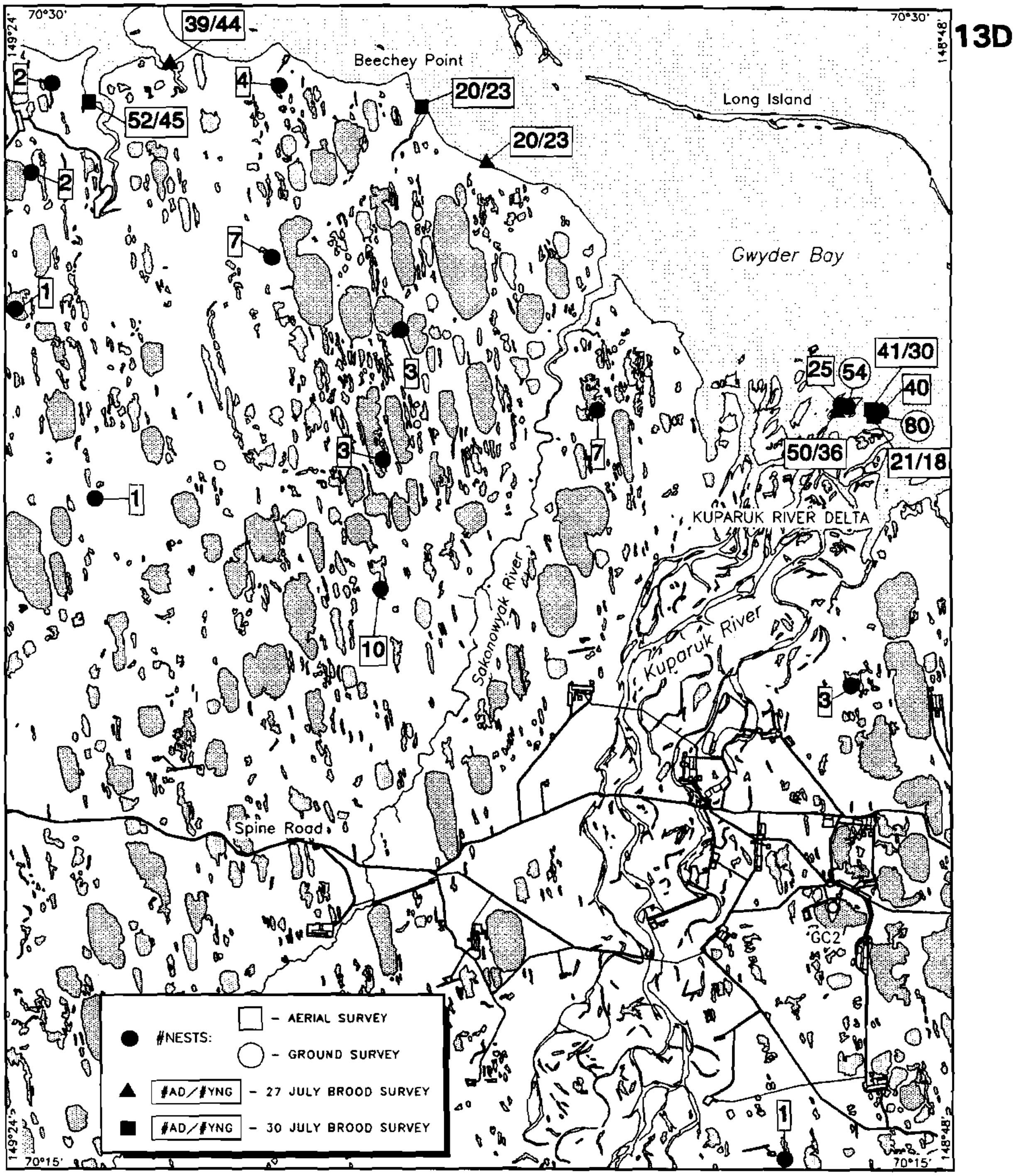
N

1:150,000
0 1 2 3 mi
0 1 2 3 4 5 km

13C

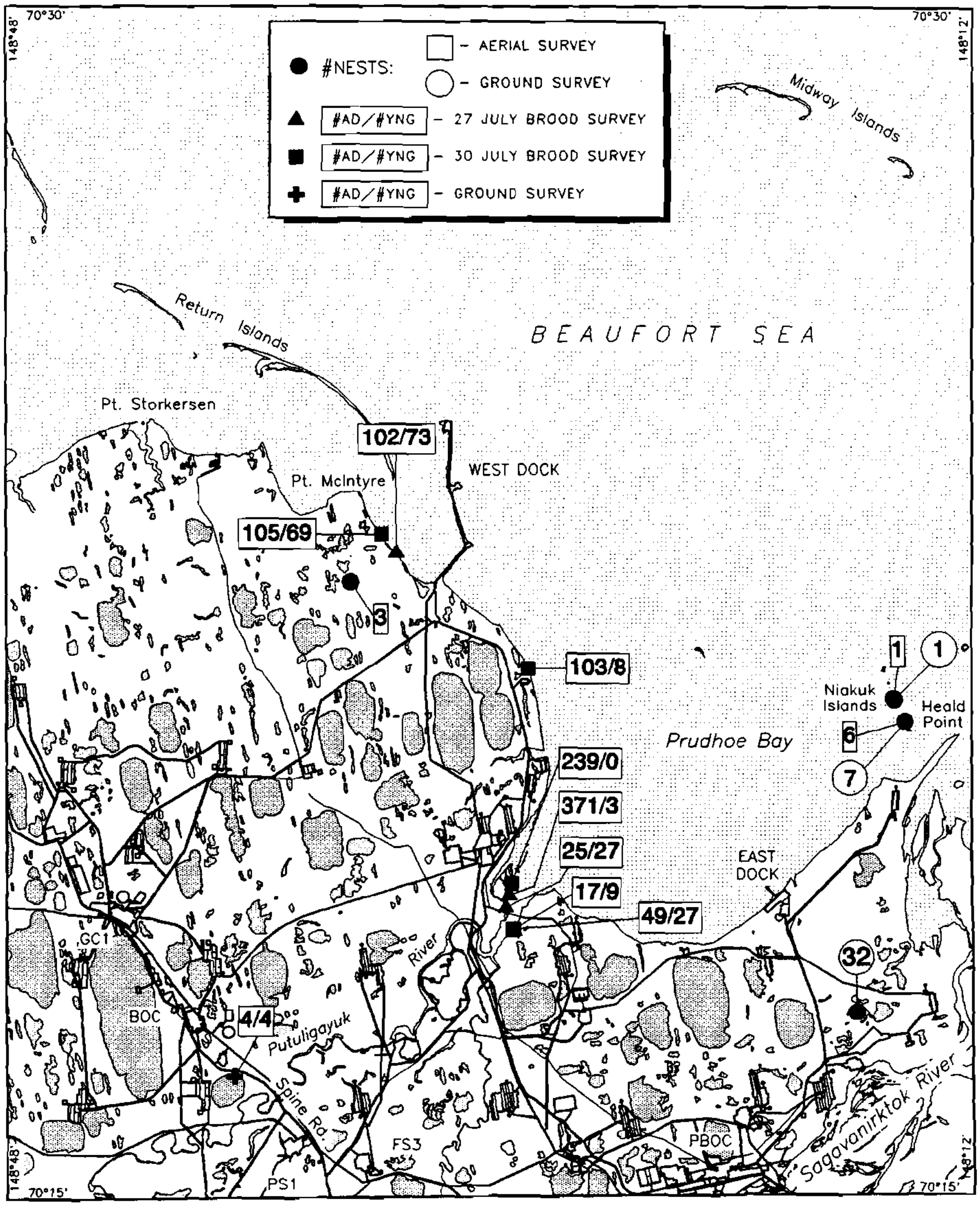


Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-5); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPB-5.MAP, 19 April 1993



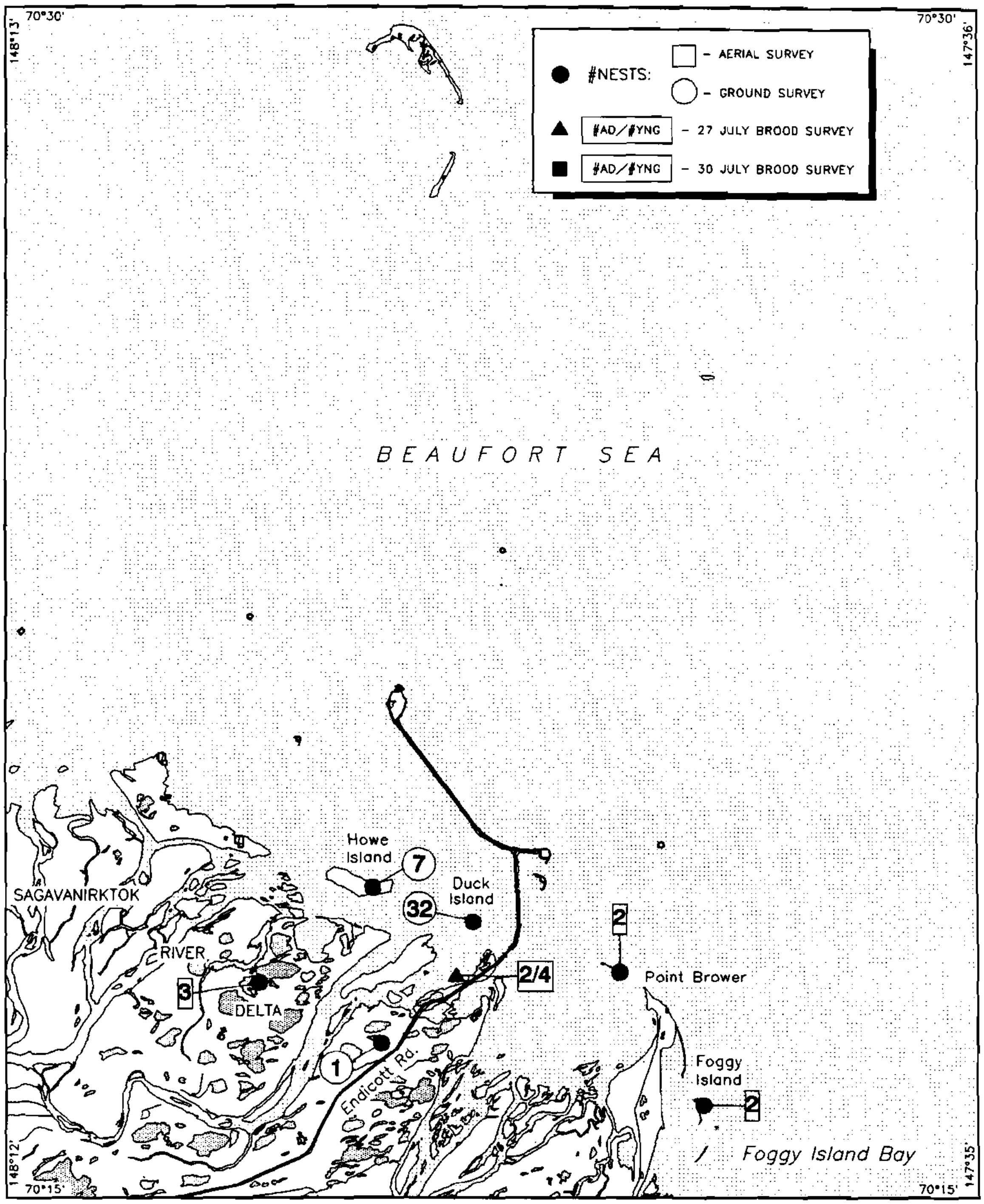
Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-4); coastline, facilities and major rivers updated from aerial photography (1973–1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPB-4.MAP, 19 April 1993

13E

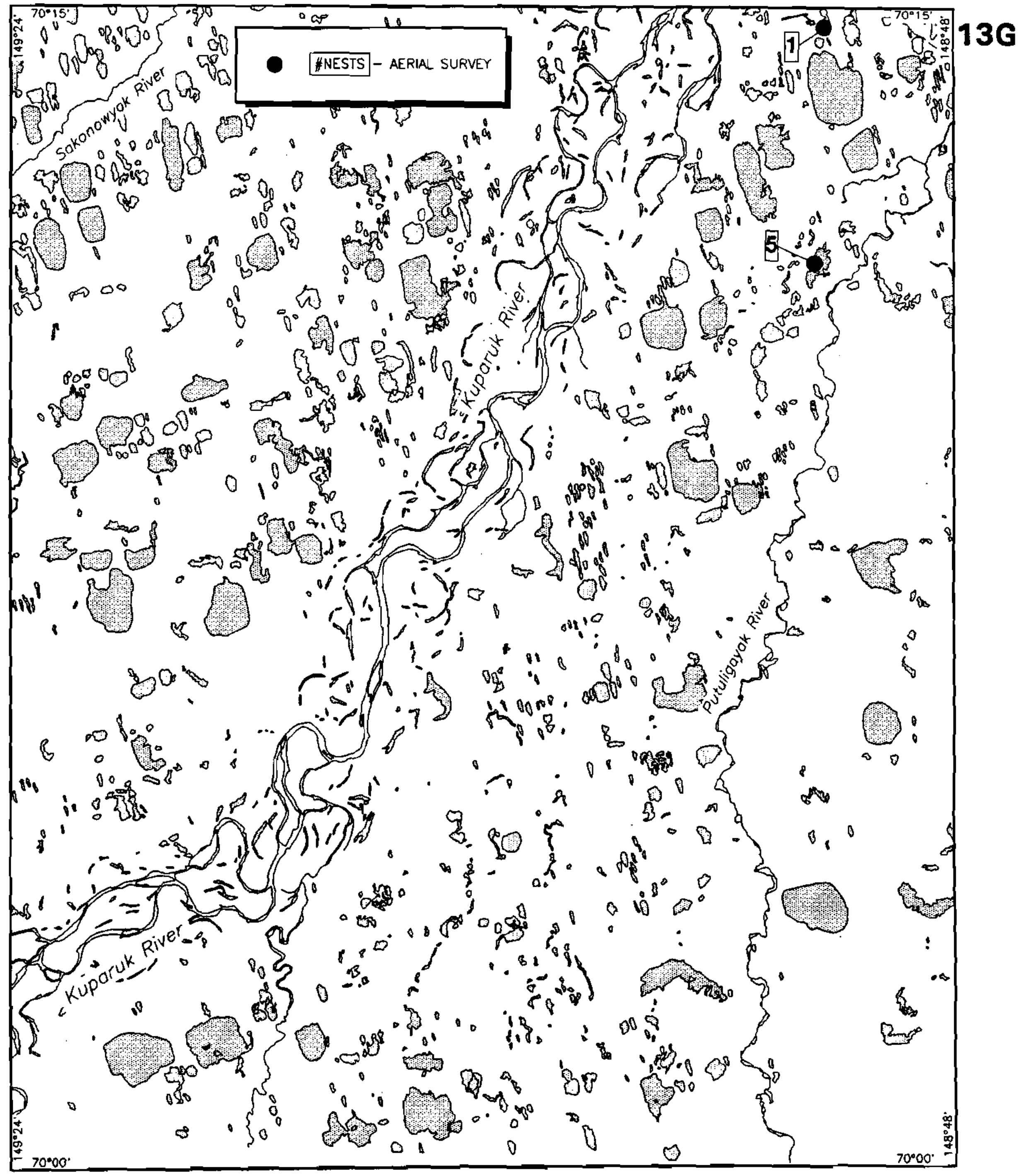


Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-3); coastline, facilities and major rivers updated from aerial photography (1973–1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPB-3.MAP, 19 April 1993

13F



Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-2); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPB-2.MAP, 20 April 1993



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Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. A-4); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
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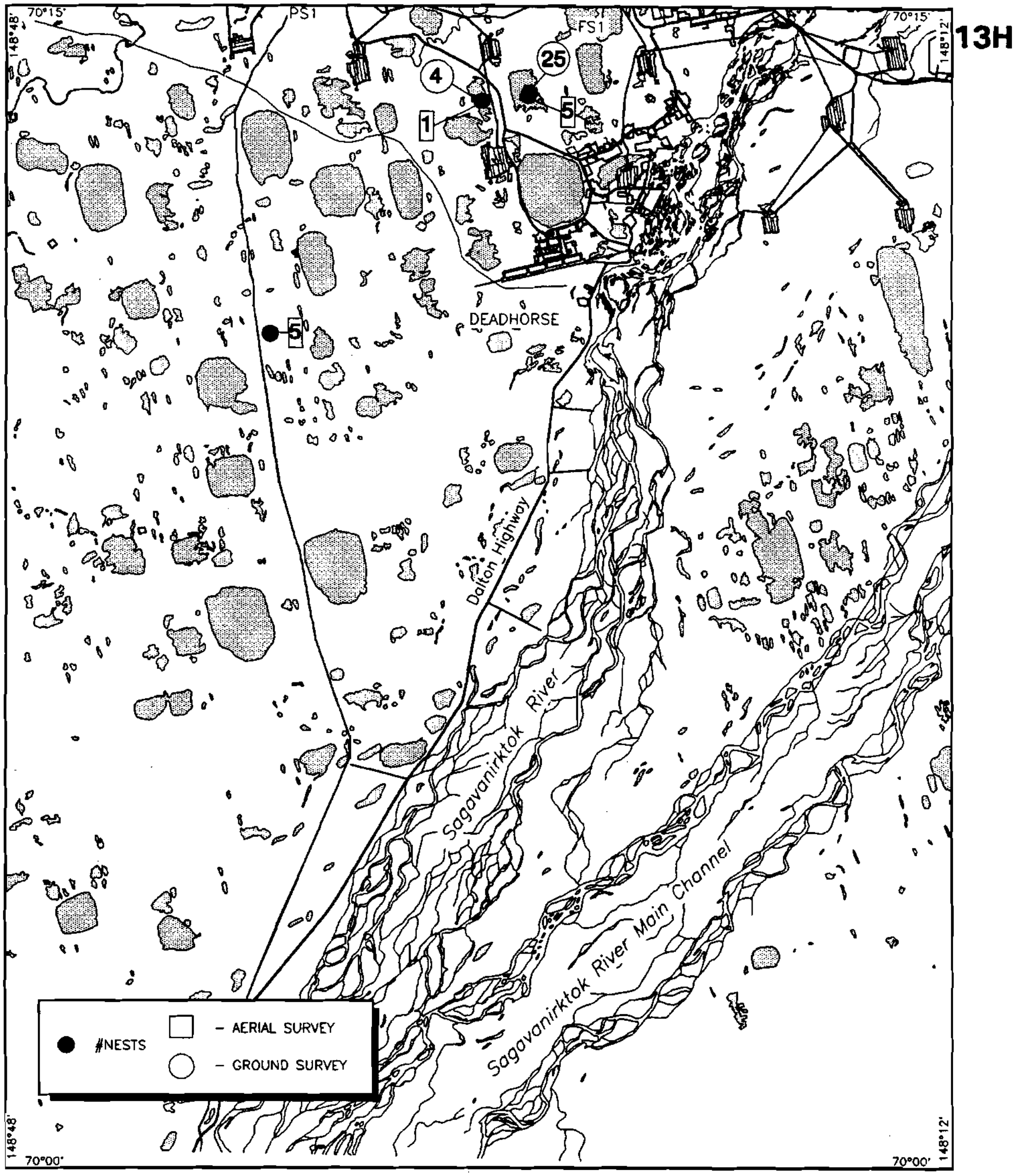
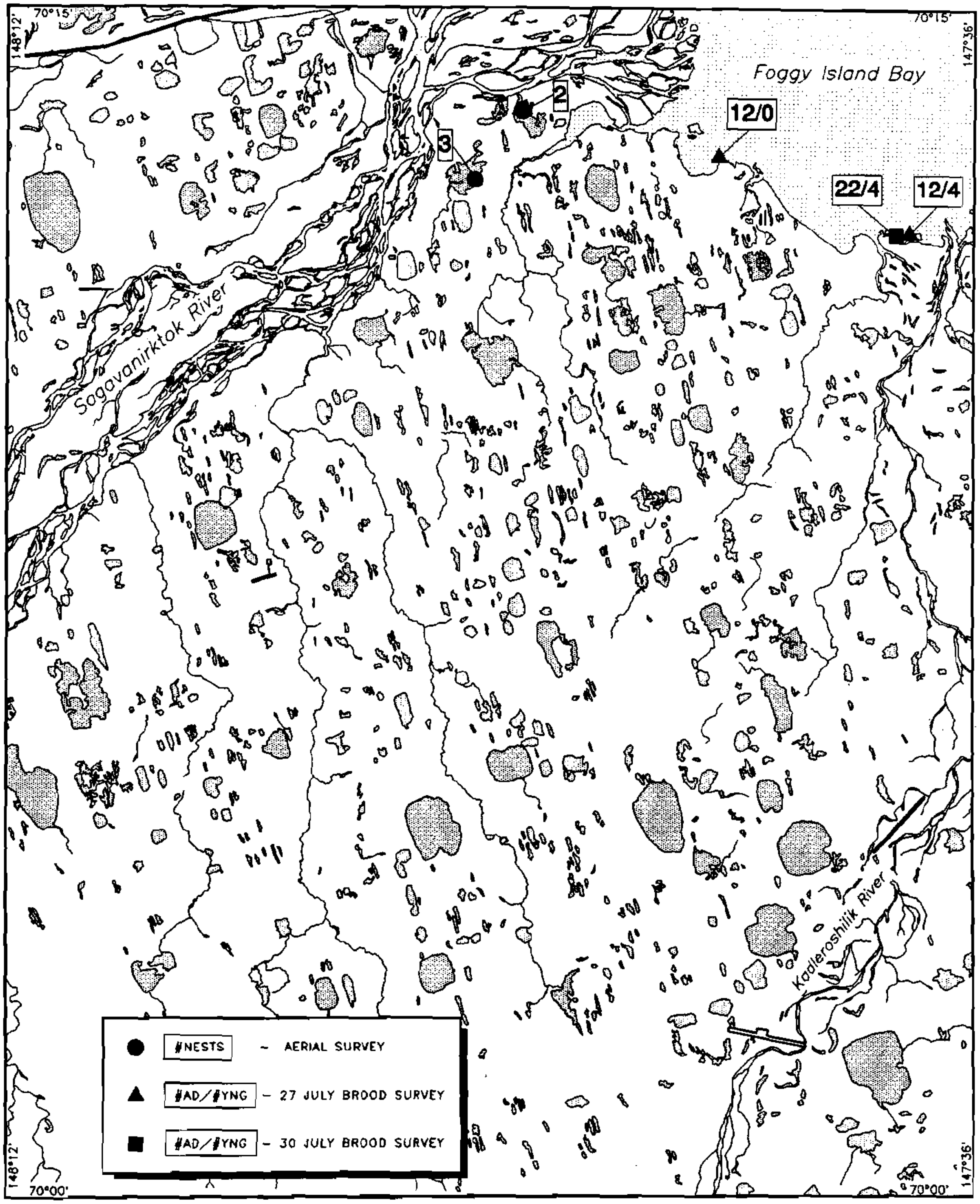


Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. A-3); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPA-3.MAP, 20 April 1993

131



Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. A-2);
coastline, facilities and major rivers updated from aerial photography (1973–1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 92BPA-2.MAP, 20 April 1993

N

1:150,000

0 1 2 3 mi

0 1 2 3 4 5 km