FINAL REPORT

TUNDRA SWAN AND BRANT SURVEYS ON THE ARCTIC COASTAL PLAIN, COLVILLE RIVER TO SAGAVANIRKTOK RIVER, ALASKA, 1993

ALICE A. STICKNEY
ROBERT J. RITCHIE
BETTY A. ANDERSON
DEBORA A. FLINT

PREPARED FOR:
ARCO ALASKA, INC.
and
KUPARUK RIVER UNIT
P. O. Box 100360
ANCHORAGE, ALASKA, 99510

PREPARED BY:
ALASKA BIOLOGICAL RESEARCH, INC.
P. O. BOX 81934
FAIRBANKS, ALASKA 99708

January 1994

EXECUTIVE SUMMARY

Tundra Swan surveys were undertaken for the sixth year in the Kuparuk Oil Field and Oil and Gas Lease Sale 54 (OGL 54) areas. In June 1993, 559 Tundra Swans and 121 nests were observed. Densities of swans and nests were estimated at 0.14 swans/km^2 and 0.03 nests/km^2. The number of swans and nests counted in 1993 were lower than in either 1992 or 1991, but numbers of swans in the 1990s were higher than numbers observed in 1988 and 1989. In August 1993, 755 adults and 244 cygnets in 95 broods were recorded in the study area. Nesting success was estimated at 79%, slightly less than in previous years, and the mean brood size was 2.5 cygnets, similar to that recorded in previous years. Densities in August were 0.19 adults/km^2 and 0.02 broods/km^2, similar to densities recorded in the 1990s, and slightly higher than those in 1988 and 1989.

In 1993, the distance of swan nests and broods from oil-related facilities and roads were assessed within three Central Processing Facility (CPF) and Milne Point units within the Kuparuk Oil Field section. Nests were located an average of 1.3 - 2.6 km away from facilities within these units. Broods were observed an average of 1.2 - 1.5 km away from oil-related facilities. Analysis of the spatial distribution of swans within these units showed that swan nests were randomly distributed with the average distance between nests between 2.7 - 3.9 km. Broods also were randomly distributed within units, but the average distance between broods was less than that for nests, ranging between 1.1 - 1.7 km.

As in previous years, densities in the study area in 1993 were lower than those reported for delta areas in northern Alaska, such as the Colville River delta and deltas in the Arctic National Wildlife Refuge. Declines in numbers in the study area may have been due to climatic conditions encountered the previous fall and winter. The declines were not substantial, however, and comparison with data from U. S. Fish and Wildlife Service and other earlier studies suggest that the number of swans in the region has increased in the past few decades.

BRANT

In 1993, aerial surveys were conducted for the fifth year to locate Brant nesting colonies and brood-rearing areas between the Colville and Sagavanirktok rivers. Surveys were not conducted east of Heald Point as they had been in previous years. Ground surveys were used to determine the numbers of Brant nests and their fates at selected locations in the oil fields. A cooperative effort was continued for the third year to capture and mark Brant within the oil fields with colored leg bands.

During aerial and ground surveys, 261 Brant nests were counted in 43 locations. The number of nests in 1993 decreased from the number counted in 1992, but was similar to the numbers recorded in 1990 and 1991. Nesting success, determined by the ground surveys, was 26%. Predation during nesting was probably the major factor contributing to the poor nesting success and was responsible for the total failure of the large colony at the mouth of the Kuparuk River.

Aerial surveys and photo censuses in late July and early August 1993 indicated that more than 1800 (40% goslings) Brant used the coastal habitats between the Colville and Sagavanirktok rivers. Numbers of both adults and goslings were substantially higher than in 1992, but lower than the peak numbers counted in 1990. The increase in numbers of adults in late July-early August from numbers counted in June was due to immigration of brood-rearing birds from the large, nearby Colville River delta colony, which had moderate-to-high nesting success.

During late July and early August 1993, ABR, USFWS, and LGL Alaska Research Associates captured and banded 1004 Brant, with uniquely

numbered aqua-colored tarsal bands, at 12 locations between the Kadleroshilik River and Oliktok Point. In addition to the unbanded birds that were captured, 89 Brant were recaptured that had been banded in the oil fields in either 1991 (38 birds) or 1992 (51 birds), and 112 Brant were recaptured that had been banded at other areas outside the oil fields. During the three years of the banding program, 2016 Brant have been banded with aqua-colored tarsal bands in the oil fields. Resightings and recaptures of aqua-banded Brant have begun to reveal annual patterns of use of nesting colonies and brood-rearing locations in the oil fields, as well as use of fall-staging areas in western Alaska and wintering areas in Baja Mexico.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGMENTS

These studies were funded by ARCO Alaska, Inc. Special thanks and appreciation go to Mike Joyce, Alan Schuyler and Larry Krizan for their support and patience. Paul Banyas, Jim King, Bob Burgess, Stephen Murphy, Rick Johnson, Todd Mabee, and Brett Nelson helped in the field. Philip Martin, Karen Bollinger, Dave Ward and Brett Nelson from the U. S. Fish and Wildlife Service, Mark Lindberg from the University of Alaska Fairbanks, and Steve Johnson from LGL Alaska Research Associates, Inc., contributed banding and band resighting data. Several people reviewed draft versions of this report, but Steve Murphy was particularly helpful. We appreciate the efforts of Allison Zusi-Cobb for preparing and revising the maps. Terrence Davis was instrumental in typing and formatting this report. Finally, Sandy Hamilton, Tamarack Air, Ltd., piloted our survey aircraft and continued to make us laugh.

INTRODUCTION

Tundra Swans (*Cygnus columbianus*) are a conspicuous and important component of the waterbird community in northern Alaska. These arctic-nesting swans are part of the eastern population of Tundra Swans, which winter primarily on the mid-Atlantic coast of the United States (Sladen 1973). Tundra Swans 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 usually occurs 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 (e.g., King 1970; Bartels and Doyle 1984; Conant and Cain 1987; Ritchie et al. 1989, 1990, 1991).

Brant (*Branta bernicla*) are important colonially nesting geese on the Arctic Coastal Plain. They were recorded as the most common nesting waterfowl near Barrow by 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. Colonies identified prior to the start of our surveys in 1989 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 oil industry and regulatory agencies. Swans have been considered an indicator species for the productivity and well-being of all waterfowl in the habitats in which they occur (King 1973, King and Hodges 1980). A steady increase in the eastern population of wintering swans (Serie and Bartonek 1991), and renewed interests in increasing sport harvest, could influence management considerations on their arctic breeding grounds. Brant, conversely, have shown recent substantial declines in the Pacific 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. Thus, it is important to monitor the distribution, productivity, and abundance of this species as development expands.

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). Although these surveys primarily were to collect information on Tundra Swans, incidental information on the distribution of Brant also was collected. In 1989, due to increasing interest in the status of Brant in the vicinity of the oil fields, surveys were conducted to specifically collect information on their distribution, as well as continuing the aerial surveys for swans. From 1989 to 1992, these surveys were funded by both ARCO Alaska, Inc., and BP Exploration (Alaska) Inc. In those years, aerial surveys were extended to Brownlow Point near the Staines River, and ground surveys were conducted in the Sagavanirktok River delta (1989-1992), and in the Prudhoe Bay and Kuparuk oil fields (1990-1992). In 1993, ARCO Alaska, Inc., provided the major funding for both the swan and Brant surveys, with emphasis placed on the distribution of both species in the Kuparuk Oil Field. In 1993, surveys for Tundra Swans and Brant included the following components:

1) during nesting and brood-rearing, aerial surveys to determine numbers of nests,

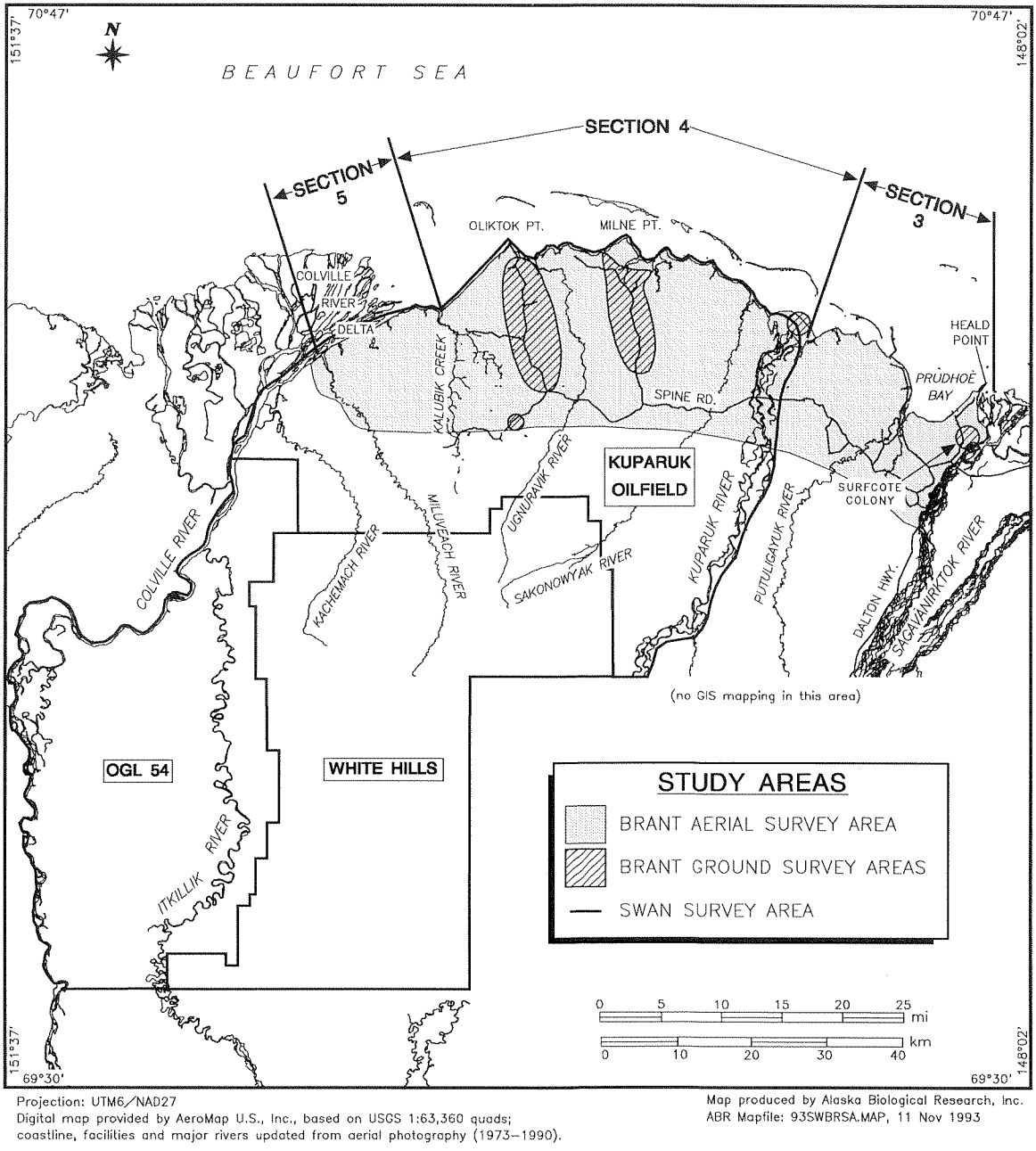
broods, and adult Tundra Swans in the Kuparuk Oil Field and OGL 54 study areas;

2) during nesting, aerial surveys of the coastal region between the Miluveach River and Heald Point, to count Brant and their nests and to revisit traditional, and to locate new, Brant colonies;
3) during nesting, ground surveys at selected sites in the Kuparuk and Milne Point oil fields to determine numbers of nests and productivity of Brant;
4) during brood-rearing, aerial surveys of the coastal region between the Miluveach River and Heald Point, to count Brant and to locate their brood-rearing areas; and
5) during brood-rearing, to capture and color-band Brant in the area between Oliktok Point and Prudhoe Bay.

STUDY AREA

During 1993, as in previous years of the study, surveys for Tundra Swans and Brant were conducted on the Arctic Coastal Plain between the Sagavanirktok 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).

The study area for aerial surveys for Tundra Swans covered the entire Kuparuk Oil Field (~2200 km^2) and OGL 54 (~1700 km^2) and the White Hills sections (~2200 km^2) (Figure 1). Aerial surveys for Brant were conducted on the Arctic Coastal Plain between Heald Point (near the western channel of the Sagavanirktok River) and the Miluveach River near its junction with the Colville River (Figure 1). (This region is referred to as the 'Colville to Sagavanirktok' region in the text.) The areas surveyed were similar to those described by Ritchie et al. (1991) and included offshore islands, and inland areas in the Kuparuk and Prudhoe Bay oil fields, within 5 km of the coast.



Projection: UTM6/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: 93SWBRSA.MAP, 11 Nov 1993

Figure 1. Study areas for Tundra Swan and Brant investigations between the Colville and Sagavanirktok rivers, Alaska, 1993.

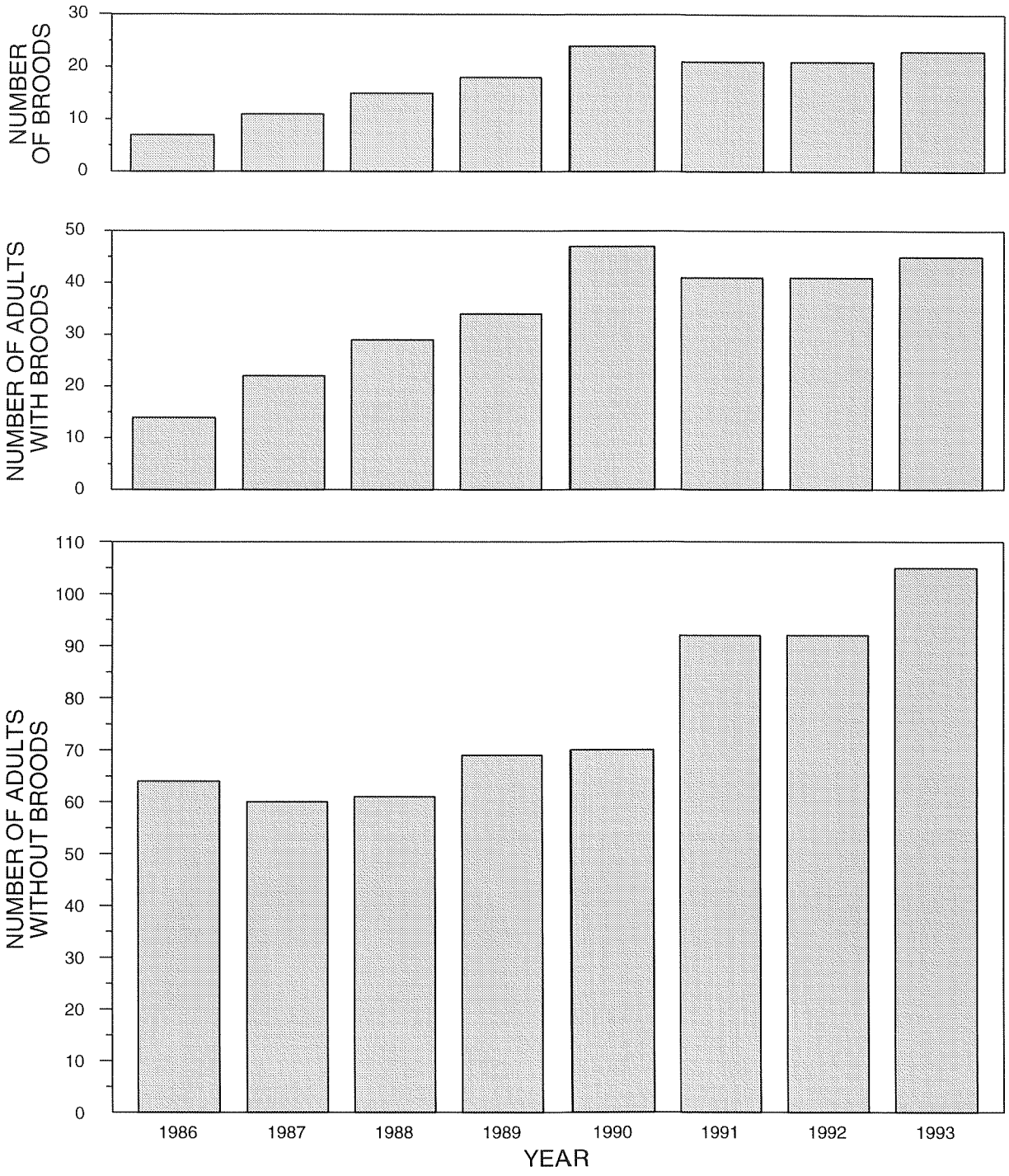


Figure 5. Number of Tundra Swans and broods observed during aerial surveys in the Beechey Point B-5 quadrangle (Central Kuparuk Oil Field), Alaska, August 1986-1993.

PART 1: TUNDRA SWAN SURVEYS

METHODS

Aerial survey methods in 1993 followed the U. S. Fish and Wildlife Service (USFWS) Tundra Swan Survey Protocol (USFWS 1987, 1991) and were similar to those used in previous years of this study (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993). A Cessna 185 aircraft was flown along fixed-width, east-west, 1.6 km-wide transects. The flightlines were oriented along township and section lines, and all observations were recorded on 1:63,360 USGS maps. An exception to this protocol was the White Hills section, where the survey followed a lake-to-lake route because waterbodies are few and scattered and it is inefficient to follow township and section lines. 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. A nesting survey was conducted between 22 and 25 June 1993, and a brood-rearing survey was conducted between 19 and 24 August 1993 (Appendix 1).

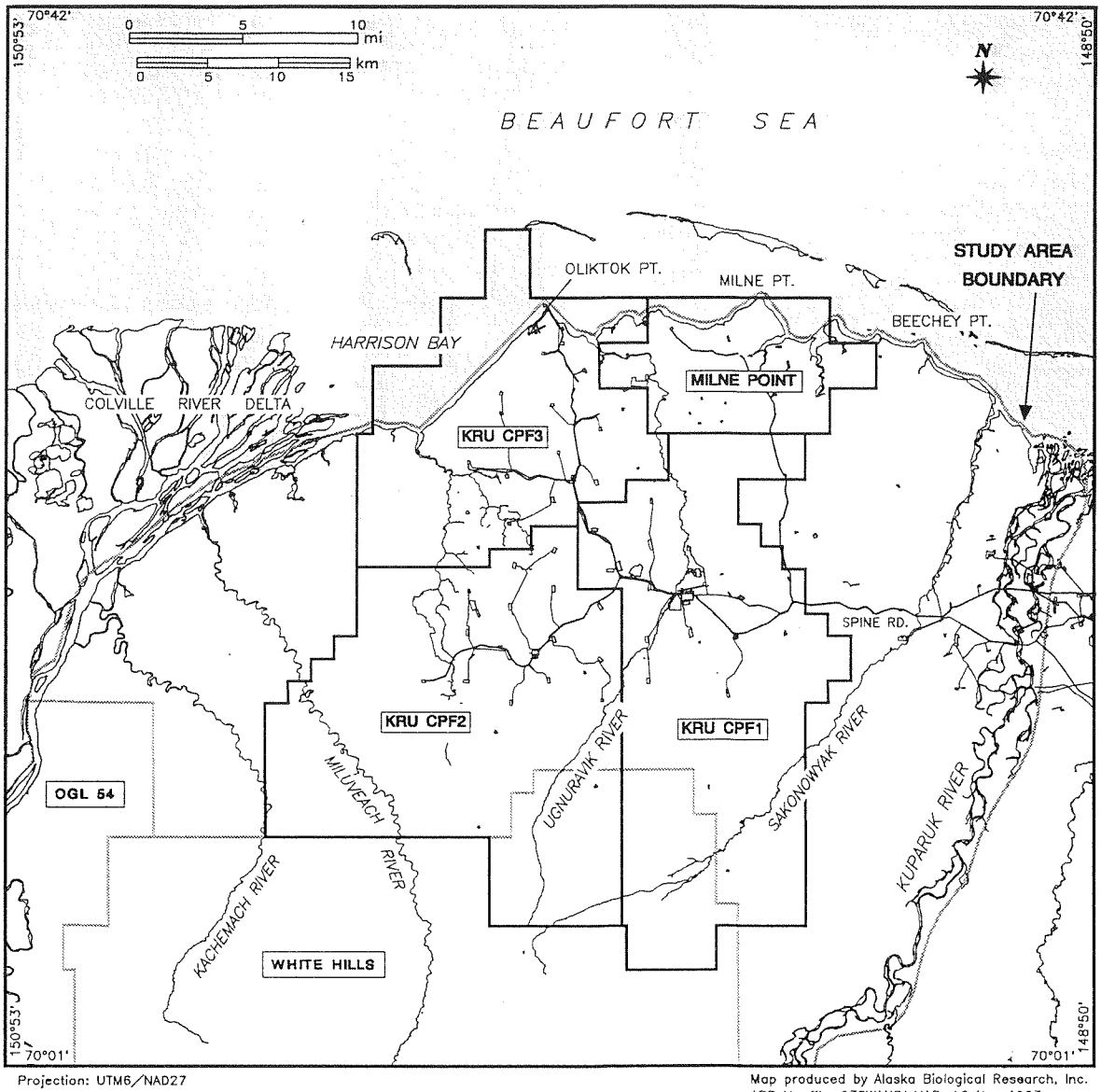
During the survey, each of two observers scanned a transect approximately 800-m wide on their side of the aircraft, while the pilot navigated and scanned ahead of the aircraft. A standardized set of codes for pairs of swans, single swans, flocks, nests, and broods was employed (USFWS 1987, 1991).

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). Prior to 1992, the areal estimates of survey coverage were obtained by less accurate means (i.e., hand-held planimeters), therefore, slight differences occur between densities calculated prior to 1992 and and those calculated after 1992. In addition, slight differences in absolute numbers and densities are due to the separation of survey data for the White Hills section, which previously was 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).

To assess whether swan densities differ in areas with oil development, in comparison with less developed areas, densities of nests and broods were computed for selected operating units within the Kuparuk Oil Field section of the study area (Figure 2). These operating units included the Milne Point Unit and the three central processing facility (CPF) units within the Kuparuk River Unit. Not included were operating units that were only partially within the study area, such as the Western Operating Area of the Prudhoe Bay Unit. The density of swans in the OGL 54 section, which is undeveloped, was included for comparison.

In the past, there was interest in the proximity of swan nests and broods to areas of proposed pads (Ritchie et al. 1989, 1990), and currently, the proximity of nests and broods to any oil-related facilities are of prime interest in oil spill response plans for the Kuparuk River Unit. Accordingly, the mean distances of swan nests and broods from the nearest oil-related facility were calculated for each operating unit. Included as "facilities" for the purpose of this analysis were all gravel roads, pads, and mine sites; peat roads were excluded. Only those nests and broods within 8 km of a facility were used to calculate mean distances; this restriction excluded nests in the OGL 54 section.

In an attempt to assess whether swans were avoiding oil-related facilities during nesting and brood-rearing, the distributional patterns of swans within developed and non-developed areas also were analyzed. Using a "nearest-neighbor" analysis, comparisons were made among the three CPF units, Milne Point unit, and OGL 54 of the mean minimum (nearest-neighbor) distance between nests, and the mean minimum distance between broods (Clark and



Projection: UTM6/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: 93SWANSA.MAP, 10 Nov 1993

Figure 2. Location of the three Central Processing Facility (CPF) units and the Milne Point unit that were used for analyses within the Kuparuk Oil Field section of the study area, Alaska, 1993.

Evans 1954). The mean minimum distances between nests and between broods in the operating units also were compared with the mean distances of nests and broods from facilities. The distribution pattern was derived by computing the ratio "R" which required dividing the sum of all nearest-neighbor distances (Σr) in the sample (N) by the mean of nearest-neighbor distances that would be expected in a random distribution:

$$R = \frac{\Sigma r/N}{(2\sqrt{p})^{-1}}$$

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 indicating a clumped distribution, and R = 2 indicating a uniform distribution (Clark and Evans 1954).

RESULTS AND DISCUSSION

NESTING

Abundance and Distribution of Adult Swans

During the nesting survey in June 1993, 559 Tundra Swans were recorded at 338 locations (Table 1, Appendix 3). Most (64%) were not associated with nests and probably were failed breeders or nonbreeders (hereafter referred to as nonbreeding swans). As in previous years, most (61%) swans were observed in the Kuparuk Oil Field (Figure 3), with 36% in OGL 54 and 3% in the White Hills section. In addition, densities of adults without nests were higher in the Kuparuk Oil Field than in OGL 54 (0.10 vs 0.7 adults/km^2; Appendix 6). The density of adults with nests, however, was similar between the two sections (0.05 adults/km^2). The density of swans was low (0.01 adults/km^2) in the White Hills section.

The number of Tundra Swans counted in June 1993 in the combined Kuparuk Oil Field and OGL 54 sections was 4% lower than in 1992 and 14% lower than 1991, although swans in all three years were more numerous than previous years (1988-1990; Table 1). The number of adults with nests in 1993 increased slightly over 1991-1992, but total numbers of swans (541) for the combined sections was lower in 1993 than during the two previous years because of a decline in the number of adults not associated with nests (a decrease of 8% and 22% from 1992 and 1991 numbers, respectively).

Numbers of swans decreased proportionately more in OGL 54 than in the Kuparuk Oil Field (Table 1). That is, the number of adult swans seen in OGL 54 in 1993 was 7-24% lower than those counted in the same area from 1990 to 1992. Again, the number of adults not associated with nests was responsible for the decline, with an 18-36% decrease from earlier counts. In contrast, the number of adults with nests in OGL 54 was the highest ever recorded in six years of surveys, although the increase from 1992 was slight.

In the Kuparuk Oil Field, the number of swans decreased 3-6% from 1991 and 1992, but was at least 18% higher than any year prior to 1991 (Table 1). As was the case in OGL 54, fewer nonbreeding swans in the section in 1993 contributed to the decrease (a 1% and 11% decline from 1992 and 1991, respectively); the number of adults with nests decreased 4% from 1992 numbers, but was at least 4% higher than in any other year.

Abundance and Distribution of Swan Nests

In 1993, 121 nests were observed in the entire study area, with 68 nests in the Kuparuk Oil Field and 52 nests in OGL 54. Only one nest was recorded in the White Hills section. In the Kuparuk Oil Field and OGL 54, the densities of nests (0.03 nests/km^2 in both sections) were similar (Appendix 6). The densities of nests within the Kuparuk Oil Field's three CPF units and the Milne Point unit ranged between 0.02 and 0.04 nests/km^2.

The number (120) of nests in the combined Kuparuk/OGL 54 sections increased by one over 1992 nest numbers, but was 5% less than the highest number of nests (126), recorded in 1991 (Figure 3). The numbers of nests observed during all four years in the 1990s have been at least 50% greater than 1988 or 1989. In the Kuparuk Oil Field, the number of nests

Table 1. Numbers of Tundra Swans and nests observed during June on aerial surveys in the Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54), and White Hills combined study area, Alaska, 1988-1993. A more detailed description of survey results for 1993 is presented in Appendix 3.

Section	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	73	73	169	289
	1991	112	78	252	364
	1992	121	75	228	349
	1993	**116**	**68**	**225**	**341**
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
	1993	**82**	**52**	**118**	**200**
White Hills[a]	1989	0	0	15	15
	1990	3	2	12	15
	1992	0	0	16	16
	1993	**2**	**1**	**16**	**18**
TOTAL	1988	95	54	333	428
	1989	123	78	356	479
	1990	204	123	335	539
	1991	192	126	434	626
	1992	193	119	388	571
	1993	**200**	**121**	**359**	**559**

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

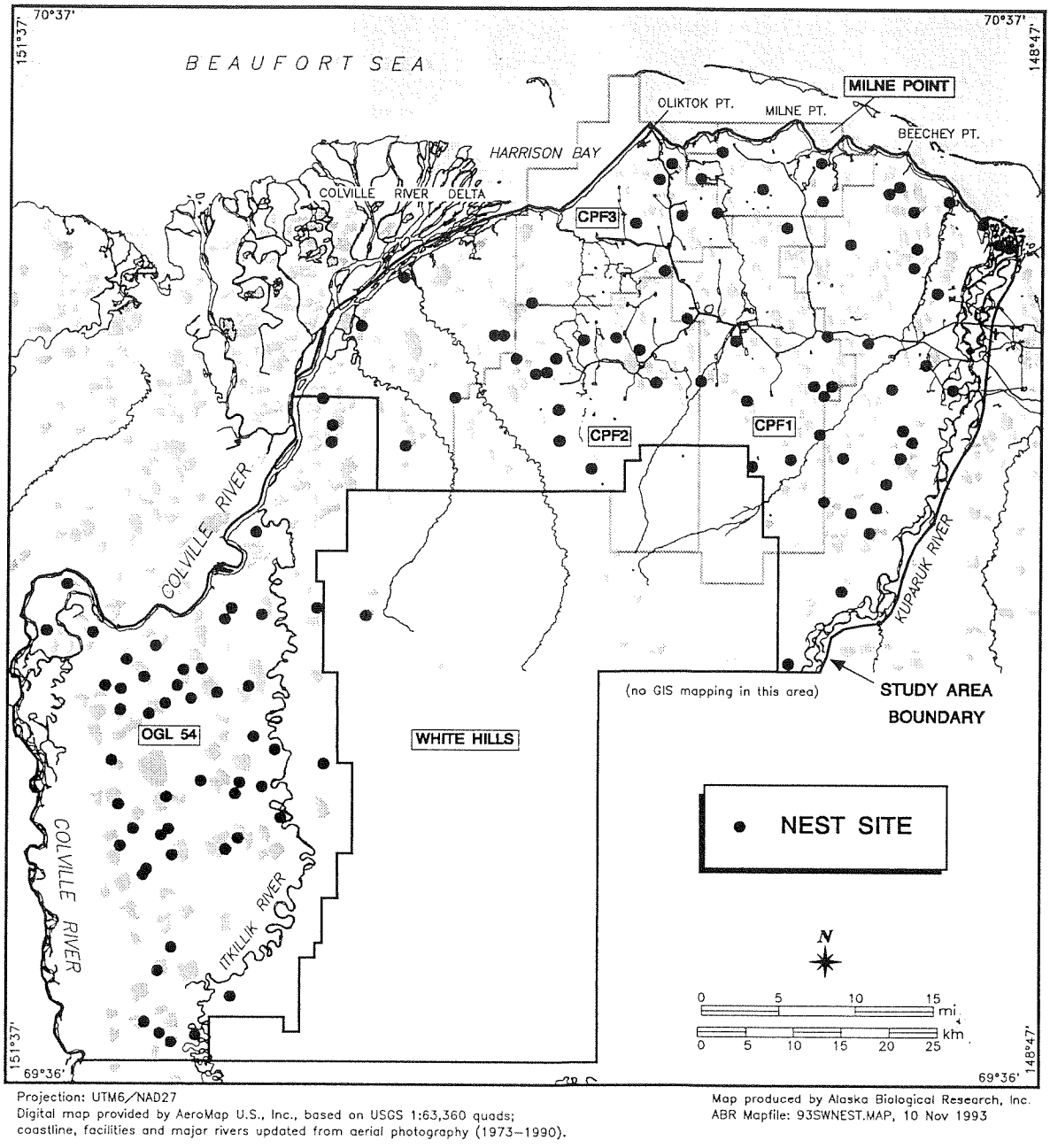


Figure 3. Location of Tundra Swan nests observed during aerial surveys in the entire Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54), and White Hills study area, Alaska, 22-25 June 1993.

in 1993 decreased 7-17% from the three previous years. Conversely, the number of nests in OGL 54 increased (6-16%) over numbers counted from 1990 to 1992, and increased >50% over nest numbers in 1988 and 1989.

Within the Kuparuk Oil Field, the Milne Point and Kuparuk CPF-3 units had the shortest mean distance between swan nests and the nearest oil facility, at 1.3 km and 1.8 km, respectively (Table 2). In both the CPF-1 and CPF-2 units, mean distances between swan nests and the nearest facility were between 2 and 2.6 km.

Swan nests appeared to be randomly distributed in most of the units considered (CPF-1, CPF-2, CPF-3, and OGL 54), but approached a uniform distribution in the Milne Point unit (R = 1.54, Appendix 7). The mean nearest-neighbor distances between swan nests in all units ranged between 2.7 km (CPF-2 and OGL 54) and 3.9 km (Milne Point). The mean nearest-neighbor distances between nests in all units were greater than the mean distances between nests and the nearest facility.

Nesting Summary

Since Tundra Swan surveys began in 1988, the numbers of swans and nests have increased in the Kuparuk/OGL 54 study area. Peak numbers occurred in 1991, following favorable conditions in 1990, when other waterfowl and bird species in the oil fields also realized increases in nests, nesting densities, and nesting success (Ritchie et al. 1991, TERA 1991, Burgess et al. 1992). In 1990, the number of swan nests in the study area was >120 for the first time, an increase of more than 50% from 1988 and 1989 values. In each subsequent year of the surveys, nest numbers have remained at approximately 120. Whether this 4-yr average represents a stabilization in nest numbers due to some population dynamic (e.g., saturation of preferred nesting habitat) is unknown. The increase in nest numbers corresponded with the increase in breeding adults in the early years of the surveys; however, after 1990, most change in numbers of adults was due to fluctuations in the number of nonbreeding adults. Regulation of the number of nonbreeding swans is probably due to a number of factors including productivity the year before, fall and winter conditions prior to the birds' return, winter mortality, the availability of nesting habitat upon return, conditions during the nesting season, and perhaps carrying capacity for these birds (Bart et al. 1991a, 1991b, Earnst 1991).

Table 2. The mean distance between Tundra Swan nests and the nearest oil-related facility in central processing facility (CPF) units of the Kuparuk Oil Field, and the Milne Point Unit, in June 1993. No distances were measured in Oil and Gas Lease 54 (OGL 54) because all nests were >8 km from facilities.

	Distance (km)		Number of
Operating Unit	Mean	Range	Nests
Kuparuk CPF-1	2.6	0.6 - 6.3	11
Kuparuk CPF-2	2.0	0.5 - 5.1	11
Kuparuk CPF-3	1.8	0.5 - 6.5	6
Milne Point Unit	1.3	0.6 - 2.2	6

Densities of nesting swans were similar in the Kuparuk Oil Field and OGL 54, suggesting that this oil field and its facilities do not affect the general distribution of Tundra Swans. Furthermore, mean distances of swan nests from oil facilities in the operating units within the Kuparuk Oil Field were less than the mean minimum distance between nests (Table 2, Appendix 7), indicating that avoidance of other swans and the availability of suitable nest sites may have been more important in nest site selection than facility avoidance.

BROOD-REARING

Abundance and Distribution of Adult Swans

During the brood-rearing survey in August, 999 Tundra Swans (755 adults and 244 cygnets) were observed at 381 locations in the entire Kuparuk/OGL 54 study area (Table 3, Appendix 4). Overall, adults with broods constituted 25% of all adult swans seen. In the Kuparuk Oil Field, brood-rearing adults represented 28% of all adults seen (Figure 4), whereas they only represented 18% of all adults seen in OGL 54. The densities of adults without broods were similar (between 0.14 and 0.15 adults/km^2) for the Kuparuk Oil Field and OGL 54. However, higher densities of breeding adults (0.06 adults/km^2) were present in the Kuparuk Oil Field than in OGL 54 (0.03 adults/km^2).

As in previous years, the number of adult Tundra Swans increased in the study area between June and August 1993 (Tables 1 and 3). The increase in the OGL 54 section (40%) was greater than in the Kuparuk Oil Field section (37%). Most of the increase in swans was due to increases in numbers of adults without broods: a 49% increase from June to August in the Kuparuk Oil Field and a 94% increase in the OGL 54. Although most of the swans not associated with broods were observed in pairs, the number of flocks (>2 swans) more than tripled (from 7 to 24) in the study area between June and August. In the Kuparuk Oil Field, the number of flocks increased from 4 to 16 flocks, and the average flock size increased from 3.3 birds/flock to 4.9 birds/flock. In OGL 54, the average flock size increased from 3.0 birds/flock in June (n = 2 flocks) to 5.8 birds/flock (range = 3 - 17 birds, n = 9 flocks) in August. No flocks of swans were recorded in the White Hills section.

Numbers of adult swans (with and without broods) in the entire study area were the lowest recorded in the 1990s, down 9% from peak numbers in 1991 (Table 3). The decrease was greater for adults with broods (-12%) than for adults without broods (-8%). As in 1992, most of the decrease in adult swans occurred in OGL 54. In 1993, the number of adults with broods was down 30% from peak numbers (1991), and down 11% from the number observed in 1992. The number of adults without broods in OGL 54 was 10% less than in either 1992 or 1991, and 19% less than the peak number in 1988. The decrease in the Kuparuk Oil Field was less dramatic for both adults with broods and those without broods: a decrease of 7% from the peak numbers observed in previous years of surveys. Although fewer adult swans were observed in 1993 than during the two previous years, they were still more numerous than in either 1988 or 1989.

Distribution of Swan Broods and Annual Productivity

During the August 1993 survey, 95 Tundra Swan broods were counted, comprising 244 young. Most broods (71%) were observed in the Kuparuk Oil Field (Table 3); only two broods were seen in the White Hills section. Mean brood sizes were 2.5, 2.8, and 1.5 young for the Kuparuk Oil Field, OGL 54, and White Hills sections, respectively.

Higher densities of young (0.08 young/km^2) were present in the Kuparuk Oil Field than in OGL 54 (0.04 young/km^2) (Appendix 6). Furthermore, the proportion of young in the total population was greater in the Kuparuk Oil Field (26.6%) than in the OGL 54 section (20.5%). Within the Kuparuk Oil Field (three CPF and the Milne Point units), the density of broods ranged between 0.02 and 0.05 broods/km^2.

The number of broods observed in the study area in August was less than the number of nests (121)

Table 3. Numbers of Tundra Swans and broods observed during August aerial surveys in the Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54), and White Hills combined study area, Alaska, 1988-1993. A more detailed description of survey results for 1993 is presented in Appendix 4.

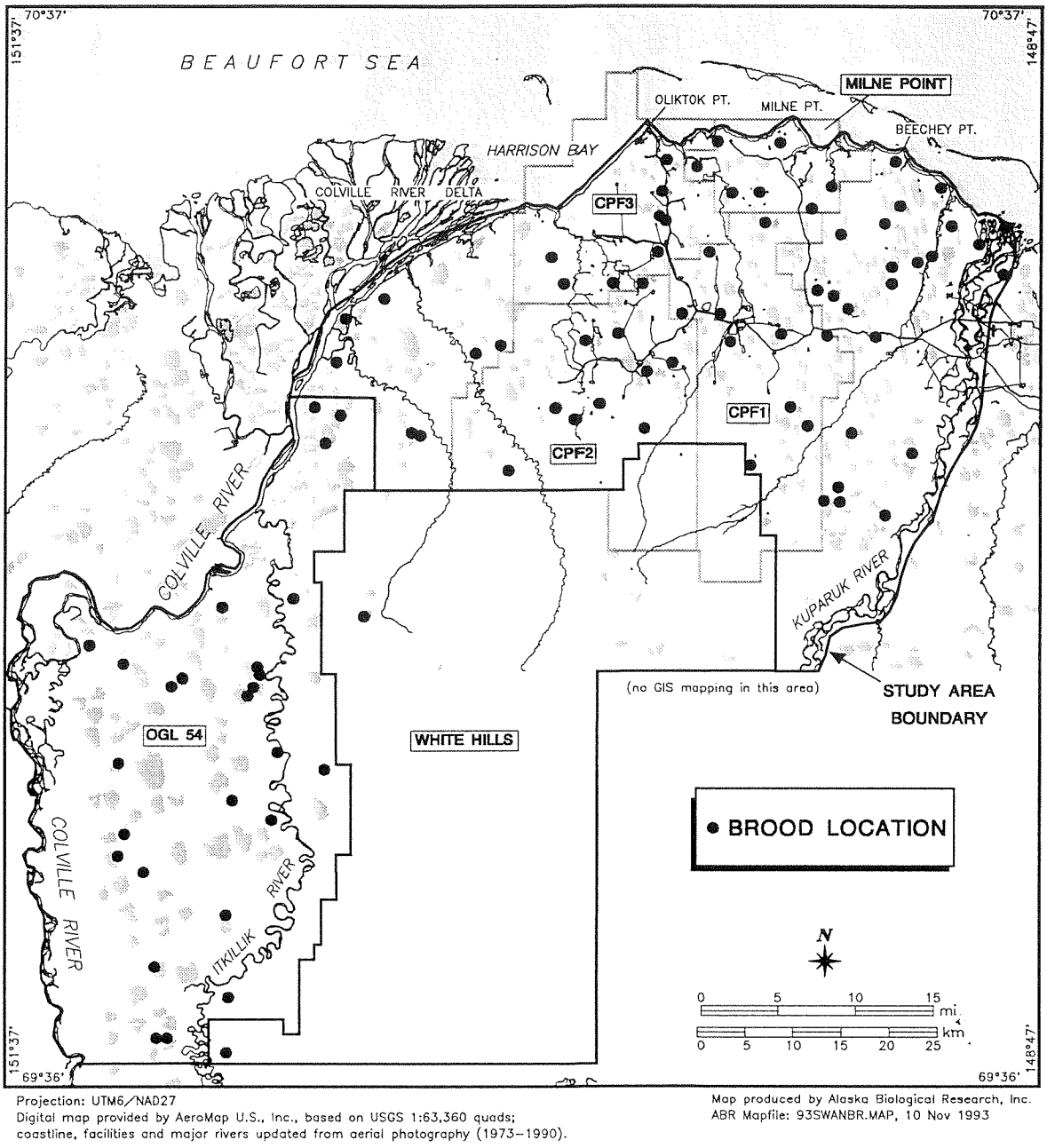
Section	Year	No. of Adults with Broods	Total Broods	Total Young	Mean Brood Size	No. of Adults without Broods	Total Adults	Total Swans	Percent Young
Kuparuk Oil Field	1988	86	44	93	2.1	225	311	404	23.0
	1989	84	45	103	2.3	304	388	491	21.0
	1990	141	72	199	2.8	285	426	625	31.8
	1991	134	69	175	2.5	359	493	668	26.2
	1992	135	68	185	2.7	334	469	654	28.3
	1993	**131**	**67**	**169**	**2.5**	**335**	**466**	**635**	**26.6**
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
	1993	**51**	**26**	**72**	**2.8**	**229**	**280**	**352**	**20.5**
White Hills[a]	1989	0	0	0	0	10	10	10	0
	1990	0	0	0	0	16	16	16	0
	1992	8	4	11	2.8	8	16	27	40.7
	1993	**4**	**2**	**3**	**1.5**	**5**	**9**	**12**	**25.0**
(Kuparuk/OGL 54)	1988	118	60	131	2.2	506	624	755	17.4
TOTAL	1989	122	64	142	2.2	549	671	813	17.5
	1990	205	104	296	2.8	511	716	1012	29.2
	1991	207	106	283	2.7	614	821	1104	25.6
	1992	200	101	268	2.7	597	797	1065	25.2
	1993	**186**	**95**	**244**	**2.6**	**569**	**754**	**999**	**24.4**

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

counted in June, indicating an approximate nesting success of 79%, which is somewhat lower than previous years (>80%; Table 3). Because a few nest sites are missed during nesting surveys (Stickney et al. 1992), and because we suspect that brood counts are more accurate than nest counts, our estimate of nesting success probably is high.

The mean brood size in 1993 was similar to the previous three years, and higher than the same categories in 1988 and 1989 (Table 3). The percentage of young observed during the survey in 1993 (24.4%) was slightly lower than the previous three years, but all four years had higher percentages of young than 1988 and 1989 (<18% young).

The mean distance between swan broods and the nearest oil-related facility ranged between 1.2 and 1.5 km for all the Kuparuk CPF units and the Milne Point Unit (Table 4). The spatial distribution of swan



Projection: UTM6/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: 93SWANBR.MAP, 10 Nov 1993

Figure 4. Location of Tundra Swan broods observed during aerial surveys in the entire Kuparuk Oil Field, Oil and Gas Lease 54 (OGL 54) and White Hills study area, Alaska, 19-24 August 1993.

broods in three of five units (OGL 54 included in analysis) appeared to be random, except in the CPF-3 and Milne Point units where swan broods approached uniform spacing (R > 1.40, Appendix 7). The mean nearest-neighbor distances between broods in all units ranged between 2.4 and 4 km.

Brood-rearing Summary

As a reflection of changes in numbers of nests, the number of broods in the Kuparuk Oil Field/OGL 54 study area increased substantially in 1990 (from 64 broods in 1989 to 104 broods). Since 1991, approximately 100 broods have occurred annually in the entire study area. In each year, the number of broods has been higher in the Kuparuk Oil Field section of the study area than in OGL 54. Some of this increase may be due to immigration from adjacent areas to more preferred habitat nearer the coast and some increase may be artificial due to nests missed during the June survey. As during nesting, the distance between swan broods and oil facilities in the Kuparuk Oil Field was less than the mean minimum distance between broods. Avoidance of other broods and suitable brood-rearing locations may be more important in habitat selection than facility avoidance.

An influx of >300 birds during August in the study area probably represented the immigration of failed or nonbreeders. The increases in the number and size of flocks were indications of this immigration. The origin and duration of use by these birds are unknown, so it is difficult to determine whether the increased population suggests short stays during migration, or whether there are habitats that serve as staging areas for increased numbers of nonbreeders as well as brood-rearing swans in August.

Table 4. The mean distance between Tundra Swan broods and the nearest oil-related facility in central processing facility (CPF) units in the Kuparuk Oil Field, and the Milne Point Unit, in August 1993. No distances were measured in Oil and Gas Lease 54 (OGL 54) because all broods were > 8 km from facilities.

	Distance (km)		Number of
Operating Unit	Mean	Range	Broods
Kuparuk CPF-1	1.5	0.3 - 5.1	9
Kuparuk CPF-2	1.2	0.4 - 3.3	9
Kuparuk CPF-3	1.3	0.3 - 3.3	8
Milne Point Unit	1.2	0.7 - 2.7	7

REGIONAL CLIMATIC CONDITIONS DURING 1993

Weather conditions, and spring snow and ice conditions in the study area appeared to be favorable for Tundra Swans during the 1993 breeding season. 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 1993]) and snow melt was not noticeably delayed. Conditions on possible spring-staging areas in northwestern Canada were normal and earlier than conditions recorded in 1992 (J. Hines, Canadian Wildlife Service, pers. commun.). No unusual weather events, which might have reduced productivity, occurred from June through fledging in September. Fall 1993 was unseasonably warm compared to an early freezeup in 1992 (Stickney et al. 1993).

COMPARISONS WITH OTHER EASTERN POPULATION TUNDRA SWANS

Mean densities of swans in 1993 in the entire study area were low compared with densities reported for other areas of northern Alaska (Table 5), such as the Colville River (Hawkins 1983, Campbell and Rothe 1990, Smith et al. 1993) and Sagavanirktok River deltas (Stickney et al. 1993; Welling and Sladen, unpubl. manusc.) and the Arctic National Wildlife Refuge (ANWR) (Platte and Brackney 1987, Brackney 1989, Monda 1991). Densities in our study area 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.).

Mean brood sizes in the Kuparuk/OGL 54 study area again were similar to those recorded in other northern Alaska areas (Table 5) (King 1970, Hawkins 1983, Bartels and Doyle 1984, Conant and Cain 1987, Platte and Brackney 1987, Campbell and Rothe 1990, Smith et al. 1993). Mean brood sizes in these northern Alaskan 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 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).

Table 5. Density and productivity information for Tundra Swan populations, northern Alaska. Adult density calculated for brood-rearing (July-August). This table supercedes the previous table in Stickney et al. (1993).

Location	Density (km^2)			Mean Brood Size	Percent Young	Years
	Adult	Young	Nest			
Colville Delta[a]	0.33	0.12	-	2.5	-	1970-1977
Colville Delta[b]	0.46	0.13	0.06	2.4	21	1982-1989
Colville Delta[c]	0.76	0.14	0.04	2.4	16	1992
ANWR[d]	0.22	0.12	0.05	2.6	26	1982-1988
Saganavirktok Delta[e]	0.43	0.21	0.09	3.2	32	1992
Saganavirktok Delta[a]	0.17	0.09	-	2.8	-	1970-1977
OGL 54[f]	0.17	0.04	0.03	2.6	19	1988-1993
Umiat[a]	0.16	0.02	-	2.3	-	1970-1977
Kuparuk[f]	0.19	0.07	0.03	2.5	26	1988-1993
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 Arctic National Wildlife Refuge (density estimates 1982-1985: Platte and Brackney 1987; mean brood size: Brackney 1989).
e ABR studies (Stickney et al. 1993, Sagavanirktok River section only).
f ABR studies.
g National Petroleum Reserve-Alaska; King 1979.

REGIONAL POPULATION STATUS

In 1992, we suggested that Tundra Swans were increasing in the region, based on substantial increases in numbers of adults and nests since 1986 (Stickney et al. 1993; Figure 5). A number of historical references indicated that Tundra Swans in the region were much less common in previous decades than they are today (Dixon 1943, Gabrielson and Lincoln 1959, Bartonek 1969, King 1970, Andersson 1973). However, more recent surveys indicate that trends in Tundra Swan populations vary by region, ranging from populations that fluctuate greatly (e.g., ANWR, Brackney 1989) to those that are more stable (e.g., northwestern Canada; J. Hines, CWS, pers. commun.).

Our surveys clearly show that swans have increased in our study area since at least 1986 (Figure 5). Substantial increases of swans also have been reported on their wintering areas. However, the numbers of adults and nests have fluctuated little in the study area in the past three years, suggesting that the increasing trend may be weakening and that the population is stabilizing. Reasons for the current plateau in numbers of Tundra Swans in the study areas may include factors such as reaching the carrying capacity of the region, or actual decreases in the population due to increased mortality of adults on wintering and staging areas.

The issue of carrying capacity is difficult to address because habitat requirements for breeding Tundra Swans have not been quantified. Densities of Tundra Swans are greater in northern delta regions (Platte and Brackney 1987, Campbell and Rothe 1990, Stickney et al. 1993) than in our study area, which is largely tundra with limited delta influences. While it is inappropriate to assume that our study area has a similar carrying capacity as delta regions, unoccupied basin-wetland complexes in the Kuparuk and OGL 54 sections do appear to offer room for expansion.

Weather conditions during the previous fall and winter may be more important in influencing the number of adults returning to the study area, rather than local environmental factors. Eastern population Tundra Swans, including the swans in the study area, winter in the mid-Atlantic states (Sladen 1973). This population has been increasing since the 1950s (Serie and Bartonek 1991), but the January 1993 population declined 30% from the peak population counted in January 1992 (J. Serie, Flyway Biologist, pers. commun.). Some of this observed decline may be due to differences in the distribution of swans on their wintering grounds between years. However, the early, and rapid, freeze-up in Alaska during the fall of 1992 also may have affected the condition of juveniles and adults prior to migration to the wintering areas and increased the potential for mortality on the wintering grounds. Consequently, fewer adults may have returned to breed in the study area, at least in 1993.

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 three designated coastal sections between the Colville and Sagavanirktok rivers (Figure 6) in 1993. (The two sections [Sections 1 and 2] that comprise the Sagavanirktok River delta and Foggy Island Bay regions were not surveyed as part of this study in 1993.) A "Supercub" PA-18 aircraft with a pilot and one observer was used for all surveys. Surveys were flown at approximately 100-150 m agl and at approximately 80-100 km/h airspeed. Methods were similar to those used from 1989-1992 (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993).

The aerial survey to locate nesting Brant was conducted on 28 June 1993. Generally, this survey was flown from lake to lake within a broad predetermined path that was designed to revisit traditional colony sites (1988-1992) and lakes with numerous islands. The area surveyed extended inland to approximately 70°10'N. The survey also included more intensive coverage (i.e., transects ~0.8 km apart) of the Kuparuk River delta.

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 (1989-1993) used data from previous years' reports (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993) and data from 1993.

Three separate aerial surveys were conducted on 9 July, 26-27 July, and 29-30 July 1993 to locate and enumerate brood-rearing Brant. The survey route followed the coastline as closely as possible extending inland along the shorelines of deltaic islands and bays. Nesting areas used in June that were located within 5 km of the coast were revisited during the survey on 26-27 July, to identify possible use of non-coastal areas. The early survey located Brant as they were dispersing from their nesting areas to brood-rearing areas. The later surveys were more representative of brood-rearing use of coastal habitats.

Brant in small brood-rearing groups (<50 individuals) were counted directly, whereas individuals in larger groups 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 each of the three sections (Figure 6). 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.

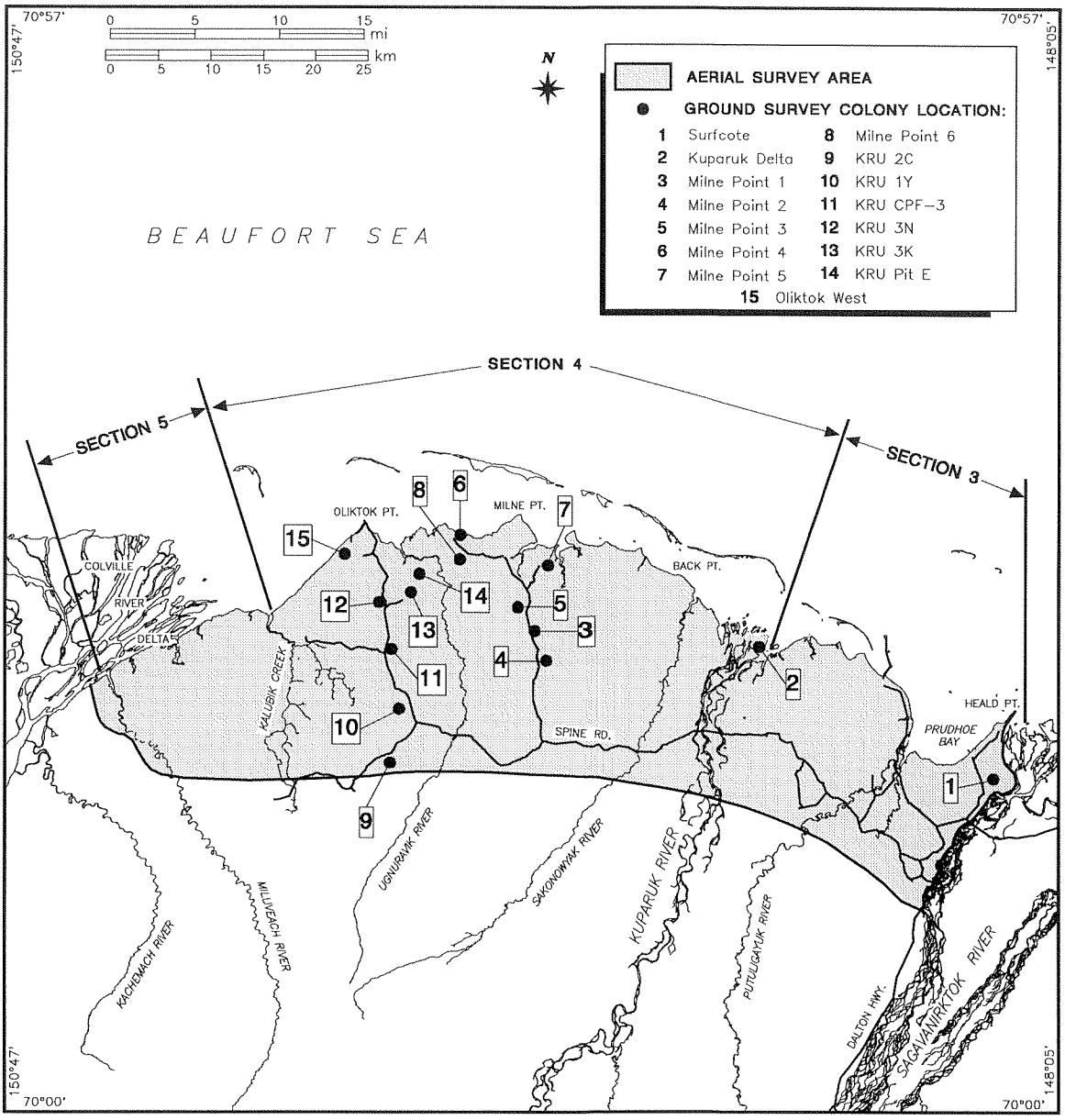
Comparisons were made among years (1989-1993) for the number of adults (both with and without broods), number of broods, and brood sizes. For other statistical analyses, data from the brood-rearing surveys (i.e., numbers of adults, goslings, and groups) were summarized by survey number (up to three surveys), coastal section, and group location.

The data from the aerial surveys, 1989-1993 (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; this report), were used to test two hypotheses about Brant in the study area:

H_o1: Numbers of Brant did not differ among coastal sections during brood-rearing; and

H_o2: The proportion of young Brant did not differ among coastal sections during brood-rearing.

The two hypotheses were tested using analysis of covariance (ANCOVA) using SuperAnova software (V.1.1, Abacus Concepts, 1989). The ANCOVA models for both H_o1 and H_o2 used the same independent variables, but different dependent variables. The independent variables were coastline length, year, and section. The dependent variables



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: 93BRSURV.MAP, 11 Nov 1993

Figure 6. Study area for aerial and ground surveys for Brant between the Colville and Sagavanirktok rivers, Alaska, 1993. The three sections of coastline are described in Ritchie et al (1991).

were total Brant ($H_0$1) and proportion of goslings ($H_0$2). Type 1 (sequential) sums 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 were considered as a factor 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). Results of all tests were considered significant at $P \leq 0.05$.

GROUND SURVEYS

Ground surveys in 1993 were conducted in selected colonies in the Kuparuk and Milne Point oil fields, as well as at the Surfcote colony in Prudhoe Bay, 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 6). Ground surveys included reconnaissance visits in June, some monitoring during hatching, and post-hatch visits in July. Visits to a few colonies immediately prior to, and during hatching, were in conjunction with a U.S. Fish and Wildlife Service project to mark (web-tag) goslings to determine movements within the Kuparuk Oil Field.

Between the mid-1980s and 1992, phenological information on Brant was collected at colonies in the Sagavanirktok River delta and near Prudhoe Bay (Stickney et al. 1993). In 1993, phenological information was collected at Brant colonies in the Kuparuk Oil Field and at Surfcote. Nesting locations also were visited in mid-June (Kuparuk River delta, one of two islands near the mouth) or after hatching (mid-July) in the Kuparuk and Milne Point oil fields (locations along the road system where nesting Brant had been observed during a preliminary survey in June) (Section 4; Figure 6). The Surfcote colony near Prudhoe Bay (Section 3) also was visited.

Methods used for 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 1993.

BANDING

Brant were banded at four locations in the Kuparuk and Prudhoe Bay oil fields between 31 July and 3 August 1993: Milne Point - C Pad, Ugnuravik River mouth, West Prudhoe Bay Coast (north of the Apex pad), and Putuligayuk River (near the mouth). A Bell 206 helicopter was used to deploy a 4-5-person ground crew and to assist in herding Brant into traps at each location. Traps were constructed from 25-mm mesh nylon nets to form a corral with "wings" made of black plastic netting (Stickney et al. 1993).

The trap was erected on dry ground near a group of Brant, and then both helicopter and ground crew herded the Brant into the trap (Stickney et al. 1993). Each Brant was aged by plumage characteristics, sexed by cloacal examination, and marked with two tarsal bands: a stainless-steel (size 7A) band, and an aqua-colored plastic band, with engraved black, alpha-numeric codes (ABR 1992). All Brant were weighed and a sample of 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).

In general, goslings were banded first because they are more vulnerable to injuries from crowding and trampling in the holding pens and adults were banded second. Any recaptured birds were noted on banding forms and all recaptured adults were weighed and measured, if time allowed. After all birds had been banded and placed in the release pen, the sides of

the pen were lowered slowly and the Brant were allowed to move as a group towards open water. The birds were observed following their release and any injuries were noted.

After 1993 banding data were compiled, 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 in Alaska and to LGL Alaska Research Associates, the other cooperator in this banding study.

After two years of banding, preliminary analysis of the data suggested that distinct subpopulations of Brant might exist in the study area (Stickney et al. 1993). Therefore, with a third year of data available, the following hypothesis was examined:

> H_O3 : No interchange or movement of Brant occurs among banding regions within the oil fields or among banding regions ouside of the oil fields.

RESULTS AND DISCUSSION

NESTING

Abundance and Distribution

The distribution of Brant nesting colonies in 1993 was similar to previous years and no new large colonies were found. Ground and aerial surveys between the Colville and Staines rivers located 261 Brant nests at 43 sites (Figure 7, Table 6). Of the total nests counted, 95 were identified during aerial surveys at 36 locations (19 solitary nests and 17 sites with ≥ 2 nests); only six of these locations had ≥5 nests. Ground crews found 182 nests at 15 sites; 166 of these nests had not been recorded previously by aerial surveys. The 15 sites included colonies that intentionally were not surveyed from the air (e.g., CPF-3 in the Kuparuk Oil Field [25 nests]), and colonies that had failed by the time the aerial surveys were conducted (Kuparuk Delta #1 [75 nests]). Because of the difficulty in detecting colonies and nests that had failed prior to our surveys, and because not all colonies were ground-truthed, our estimate of the total number of nests is conservative.

Except for one nest observed on the Niakuk Islands, most Brant nests were located in wet tundra vegetation, including islets in ponds and lakes, and flooded tundra in basin wetland complexes. Most nest locations (75%; 27 of 36) found during the aerial surveys were within 5 km of the coast, and the mean distance was 4.8 km (range = <0.5 - 17 km) from the coast.

The number of Brant nests in the three sections surveyed in 1993 (261 nests) decreased from the number counted in 1992 (329 nests), but was similar to most other years (Table 6). The decrease in nest numbers in 1993 compared to 1992 was due partially to the early loss of the large (>80 nests combined) colony on two islands at the mouth of the Kuparuk River delta, and was partially an artifact of the timing of the aerial survey in late June. By that date, many nests in colonies had already failed, and probably would not have been observed from the air. The number of Brant nests was greatest in Section 4 (Kuparuk River to Kalubik Creek); Sections 3 and 5 had less than 50 nests each. The number of nests recorded in Section 4 in 1993 was the second largest in five years of surveys, and nest numbers in Section 5 were similar to previous years, but Section 3 had the fewest number of nest locations and nests ever recorded during this study. Brant were not observed at several traditional locations, and other locations had few nests in comparison to previous years. Conditions for nesting were favorable (see Nesting Phenology), so factors contributing to the decreased number of nests were unknown.

During the aerial survey in late June at least 222 adult Brant were counted in the study area. Only 32 adults were observed without nests and were assumed to be failed breeders or nonbreeders. However, much of the coastal area where nonbreeding Brant have been observed in the past was not flown because of persistent fog. Therefore, the count of Brant should be considered as an minimum estimate only. Most (30

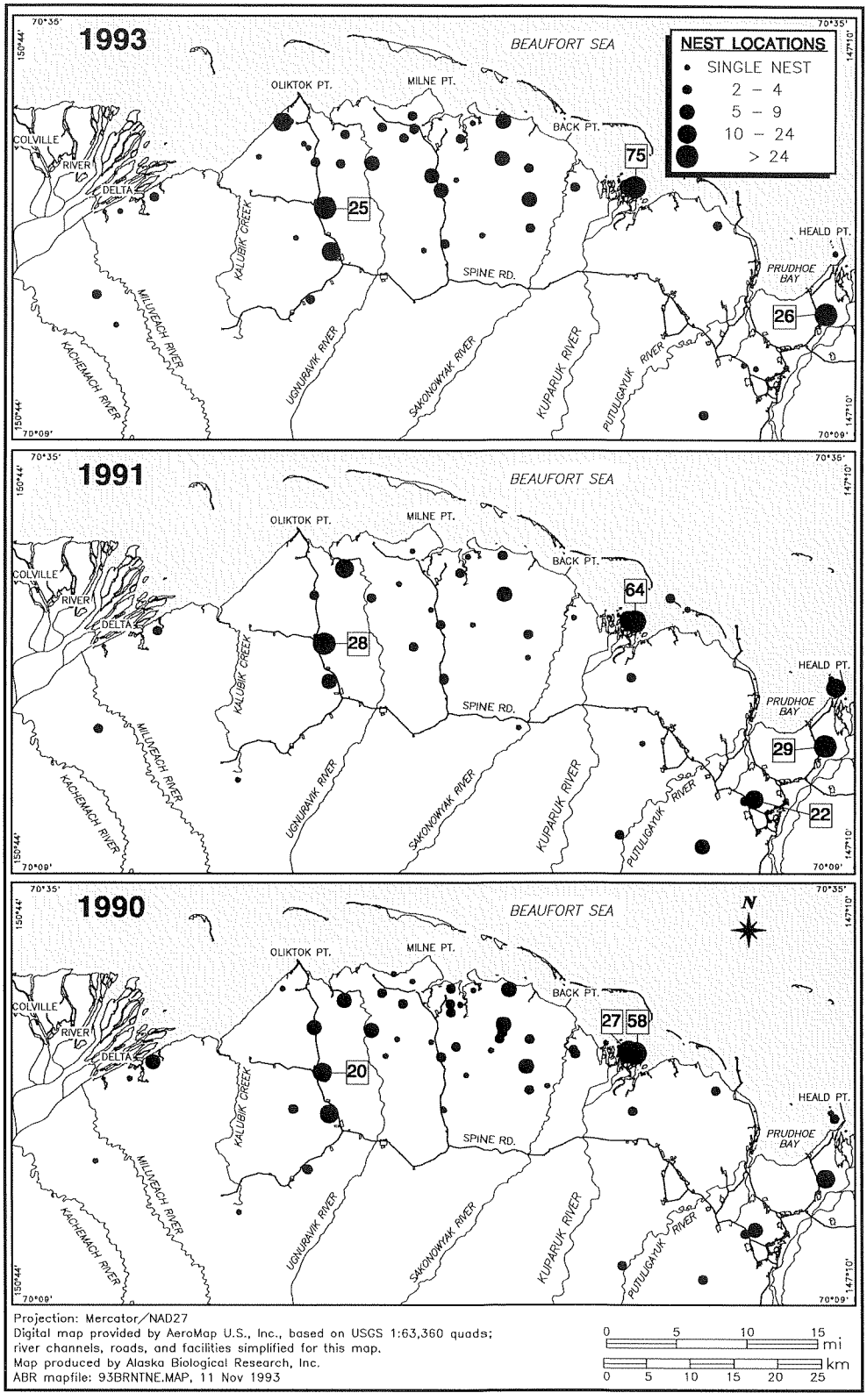


Figure 7. Locations and sizes of Brant colonies and solitary nests during June in 1990, 1991, and 1993, between the Colville and Sagavanirktok rivers, Alaska. The numbers indicate the number of nests in the largest colonies. The years other than 1993 are for comparison: 1990 for high numbers of nests and locations, and 1991 for low numbers.

Table 6. Distribution of Brant nests in June in sections of the Arctic Coastal Plain between the Colville and Sagavanirktok rivers, Alaska, 1989-1993. Sections are delineated in Figure 6 and nesting locations in Figure 7. Data for previous years from Ritchie et al. (1990, 1991) and Stickney et al. (1992, 1993).

Coastal Section	Year	Number of Brant Nests (No. of Locations) Aerial Survey		Ground Survey		Combined[a]	
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)
	1993	13	(6)	26	(1)	34	(6)
4. Kuparuk R. to Kalubik Cr.	1989	151	(39)	-	(-)	151	(39)
	1990	130	(38)	143	(13)	208	(38)
	1991	58	(18)	143	(10)	172	(26)
	1992	143	(24)	191	(10)	240	(24)
	1993	74	(26)	156	(14)	219	(33)
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)
	1993	8	(4)	-	(-)	8	(4)
Total	1989	185	(50)	16	(5)	201	(55)
	1990	162	(50)	160	(14)	257	(51)
	1991	97	(30)	210	(14)	262	(40)
	1992	176	(35)	260	(15)	329	(36)
	1993	95	(36)	182	(15)	261	(43)

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

birds) nonbreeding Brant were observed at the mouth of the Putuligayak River.

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

During combined ground and aerial surveys in 1993, 219 nests were recorded at 33 locations in Section 4 (Figure 7, Table 6). Greater than 70% of all nesting locations and nests identified during the aerial surveys were located in this section. Ground surveys counted 156 nests at 14 locations at the mouth of the Kuparuk river and along the road system in the Kuparuk and Milne Point oil fields (Table 7). The largest number of nests (75) counted on the ground in this section were located on one island at the mouth of the Kuparuk River delta, 57 nests were located at seven locations in the Kuparuk River Unit and 24 nests occurred at six locations along the Milne Point road system.

The general distribution of nests was similar to other years of the study for this section. Ground surveys identified one new nesting location with two nests, but all other sites used were traditional locations. At least eight locations had more nests in 1993 than in 1992, although the largest colonies, KRU CPF-3 and Kuparuk Delta 1, had fewer nests than last year. The colony on the Kuparuk River delta was destroyed sometime prior to 18 June, apparently by foxes. The second island in the colony (Kuparuk Delta 2) was surveyed only from a helicopter, with an estimate of nine nests.

Only one Brant was observed without a nest at an inland location in Section 4. However, the coastal areas where nonbreeding Brant have been located in the past could not be flown due to fog, so an accurate estimate of the number of failed and nonbreeding Brant was not possible. This area traditionally has contained the largest numbers of nonbreeding Brant.

Table 7. Numbers of Brant nests located during ground surveys and percent nesting success in two sections between the Colville and Sagavanirktok rivers, Alaska, July 1993. Most nesting locations shown in Figure 6.

Nesting Location	Total Nests	Nest Fate (No.)			Percent Nesting Success
		Successful	Failed	Unknown	
Kuparuk/Milne Pt. oil fields (Section 4)					
Milne Pt. 1	5	1	4	0	20
Milne Pt. 2	2	0	2	0	0
Milne Pt. 3	9	0	8	1	0
Milne Pt. 4	2	0	2	0	0
Milne Pt. 5	2	1	1	0	50
Milne Pt. 6	4	1	3	0	25
Kuparuk Delta 1	75	0	75	0	0
KRU[a] CPF-3	25	6	18	1	24
KRU 3N	4	1	3	0	25
KRU Pit E	3	1	2	0	33
KRU 3K	2	1	1	0	50
KRU 1Y	10	5	5	0	50
KRU 2C	3	3	0	0	100
Oliktok West	10	6	4	0	60
Subtotal	156	26	128	2	17
Prudhoe Bay (Section 3)					
Surfcote	26	22	2	2	85
TOTAL	182	48	130	4	26

a KRU - Kuparuk River Unit.

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

Thirty-four Brant nests were recorded at six locations in 1993 in Section 3 (Figure 7, Table 6). Thirteen nests were recorded during aerial surveys. Only the Surfcote colony was surveyed on the ground and had 26 nests. Other nesting locations included the Niakuk Islands (1 nest), two lakes northwest of Lake Coleen, as well as lakes south of Point McIntyre and Pump Station 1 (Appendix 9).

The number of Brant nests in 1993 was the lowest recorded in Section 3 since our surveys began (Table 6). The Surfcote colony had fewer nests than in either 1991 or 1992, but had the fourth highest number of nests since the colony was first monitored in 1983 (Table 8, Murphy et al. 1992, this study). The decrease in numbers in Section 3 can be attributed only partially to a less intensive ground survey effort (compared to the previous two years). The number of nests and nesting locations recorded in the section in 1993 also were lower than those recorded in either 1989 and 1990, when survey methodology was similar.

Only one group of 30 nonbreeding Brant was observed at the mouth of Putuligayak River. In previous years the number of nonbreeders in this section has ranged between 50 and 230 in 2-8 flocks (Stickney et al. 1993).

West of Kuparuk Oil Field (Section 5: Kalubik Creek to Miluveach River)

Only eight Brant nests were recorded during 1993 at four locations in Section 5 (Figure 7, Table 6); ground surveys were not conducted in this section. Brant had been recorded at these locations in previous years (Ritchie et al. 1990, 1991). The number of nests in this section typically has been small compared to other sections, with few breeding birds compared to the number of Brant in nonbreeding flocks.

Only one nonbreeding Brant was recorded in Section 5. For the reasons noted previously, an accurate estimate of nonbreeding Brant was not possible. This area has supported between 20 and 100 nonbreeders in previous years (Stickney et al. 1993).

Table 8. The number of total and successful nests in the Surfcote colony, near Prudhoe Bay, Alaska, 1983-1993.

Year[a]	Total Nests	Successful Nests
1983	18	unknown
1984	28	unknown
1985	23	1
1986	21	20
1987	17	0
1988	12	5
1989	12	7
1990	17	16
1991	29	19
1992	32	20
1993	26	22

a. Data for 1983-1984 from Woodward-Clyde Consultants (1983, 1985), 1985-1989 from Murphy et al. (1992), and 1991-1993 from this study.

Nesting Phenology

Weather in the study area during 1993 generally was favorable for Brant nesting. Mean monthly temperatures for May through July were 1-3° C warmer than the long-term (20 yr) means (NOAA 1993). Snow coverage in the Kuparuk Oil Field in early June was estimated at ≥50%, but was light and melted rapidly in ensuing days. Most of the shallow lakes used by Brant for nesting were ice-free by early June, with moderate levels of meltwater, therefore, nesting habitat was available as Brant arrived. Only the deep-open lakes had extensive ice coverage through early June and nesting may have been delayed for birds using these lakes. The Kuparuk River broke up on 24 May, four days earlier than the 14-yr average of 28 May (ARCO Kuparuk River Unit, unpubl. data).

The timing of Brant arrival and nest initiation were similar to previous years (Stickney et al. 1993). Brant were observed in the CPF-3 colony on 30 May and nests already had been initiated at both Surfcote and CPF-3 by 4 June. Most Brant in the Kuparuk Oil Field were incubating nests by 14 June. Nest initiation may have been more synchronous in 1993 because of the amount of nesting habitat available when the birds first arrived.

Nest failures became apparent by 15 June and continued through hatching. Some nests and colonies failed because of fox predation (Kuparuk Delta 1 and Milne Point 4) and others failed or were abandoned for unknown reasons. Between 7 and 18 June, two to four arctic foxes were observed each day within the Kuparuk Oil Field. Although some observations suggested that lemming numbers were moderate to high through mid-June, foxes were observed to be active within some of the colonies as well.

The first estimated day of hatching in the Kuparuk Oil Field was 29 June (1 nest), although peak hatching occurred a few days later. Hatching of Brant in the oil fields was slightly behind that in the Colville River delta, where hatching was approximately 50% complete by 30 June (Mark Lindberg, University of Alaska, pers. commun.). Hatching was relatively synchronous in the oil fields, with all hatching completed before 12 July, compared to 1992 when a few nests remained active at Surfcote until 15 July.

Nesting Success

The mean percentage of nesting success of Brant at selected colonies in Sections 3 and 4 (Prudhoe Bay to the Kuparuk Oil Field) was 26% (Table 7). Although the destruction of the large colony at the mouth of the Kuparuk River delta reduced the overall nesting success, other nesting locations also had poor success. Surfcote had the highest (85%) nesting success of all locations with more than five nests surveyed.

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

Brant nesting in Section 4 had much lower success (17%) than in 1992 (59%), but had similar success to 1991 (Table 7). Although the destruction of the large Kuparuk colony lowered the overall nesting success for this section, other locations also did poorly. The CPF-3 colony, the largest colony within the Kuparuk Oil Field road system, only had six (24%) successful nests out of the 25 nests were found during the ground survey. The highest nesting success (60%) in this section was achieved at the Oliktok West colony, southwest of the DEW line site at Oliktok Point. Examination of nests during the ground surveys and observations during incubation indicated that fox predation was a large factor in nest failure in this section in 1993. Most nests that survived were on small islands with active Glaucous Gull nests.

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

In 1993, only the Surfcote colony in Section 2 was surveyed on the ground (Tables 7 and 8). Observations from both the aerial survey and from other researchers (P. Martin, USFWS, Fairbanks, pers. commun.) indicated that the Guardshack West colony near Lake Coleen either had few nests in 1993 or had failed early. Although Surfcote had fewer (26) nests

in 1993 than in 1992 (32 nests), nesting success was better (85% in 1993 compared to 63% in 1992).

Nesting Summary

Although a number of nesting locations in the Kuparuk and Milne Point oil fields had increased numbers of nests in 1993, nesting success generally was poor in the study area. Cold spring temperatures, and persistent snow and ice cover are known to adversely influence nesting success (Barry 1962, de Boer and Drent 1989). However, weather conditions in the region were mostly favorable for early, synchronous nesting; therefore, factors other than weather were probably the major determinants of nesting success in 1993.

We suspect that predation by arctic foxes may have been a primary factor in reduced nesting success of Brant in 1993. Although the extent of fox predation was unknown, observations suggested that foxes were relatively common in the oilfields. Furthermore, large colonies on the Kuparuk River (and Howe Island [S. Johnson, LGL, pers. commun.]) were devastated by them.

The potentially severe impact of fox predation on waterfowl nesting has been recognized in other studies (Barry 1967, MacInnes and Misra 1972, Stickney 1991). The amount of predation on waterfowl nests has been related to low population levels of microtines, a primary prey of arctic foxes (Eberhardt 1977, Burgess 1984, Summers and Underhill 1987), but in some circumstances, foxes will prey on bird nests regardless of the population status of microtines (Stickney 1989). It is safe to conclude that when the fox population is high within a region, foxes may have an adverse impact on nesting birds.

BROOD-REARING/MOLTING BRANT

Abundance and Distribution

Counts from aerial surveys and photo censuses indicated that more than 1800 Brant used coastal habitats between the Colville and Sagavanirktok rivers in late July 1993 (Figure 8, Table 9). Goslings made up approximately 36-40% of the Brant observed, a higher percentage than in 1992 (26%), but comparable to 1989 and 1991 (Table 10). The percentage of goslings observed was highest in 1990. Densities of adult and gosling Brant in 1993 were the second highest recorded for these three sections and were comparable to linear densities in 1991 (~6.0 adults/km and 3.8 goslings/km; Figure 9). The number of brood-rearing Brant using coastal habitats in the study area was greater than can be accounted for by the numbers of nesting adults and nests in June. The increase in numbers between June and July probably was due to the immigration of broods from the large Brant colony on the Colville River delta, where nesting success was moderate to high (>60% for most of the large nesting aggregations; L. Smith, ABR, unpubl. data). In Section 3, the only section that would not have been influenced by brood-rearing Brant from the Colville River, the number of goslings observed was the lowest in five years of surveys. This decrease was due in part to the low numbers of adults and nests in this section during June, and due to the destruction of >200 Brant nests on Howe Island immediately prior to hatching (Steve Johnson, LGL Alaska Research Assoc., pers. commun.).

Except for a few small groups (10 adults, 12 goslings in two groups), most Brant 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 8). Brood-rearing groups of Brant in 1993 used similar areas to those used in previous years, with the largest groups found at the mouth of the Putuligayak River, and between Beechey and Oliktok points.

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

An average of 1234 Brant (548 goslings, 44% of the section total) were observed in Section 4 in 1993 (Figure 8, Table 9). One large group (>300 birds), observed at the mouth of the Ugnuravik River during the first survey, was not detected during the second survey, resulting in an artificial decrease in the total for the section between the two surveys. The largest

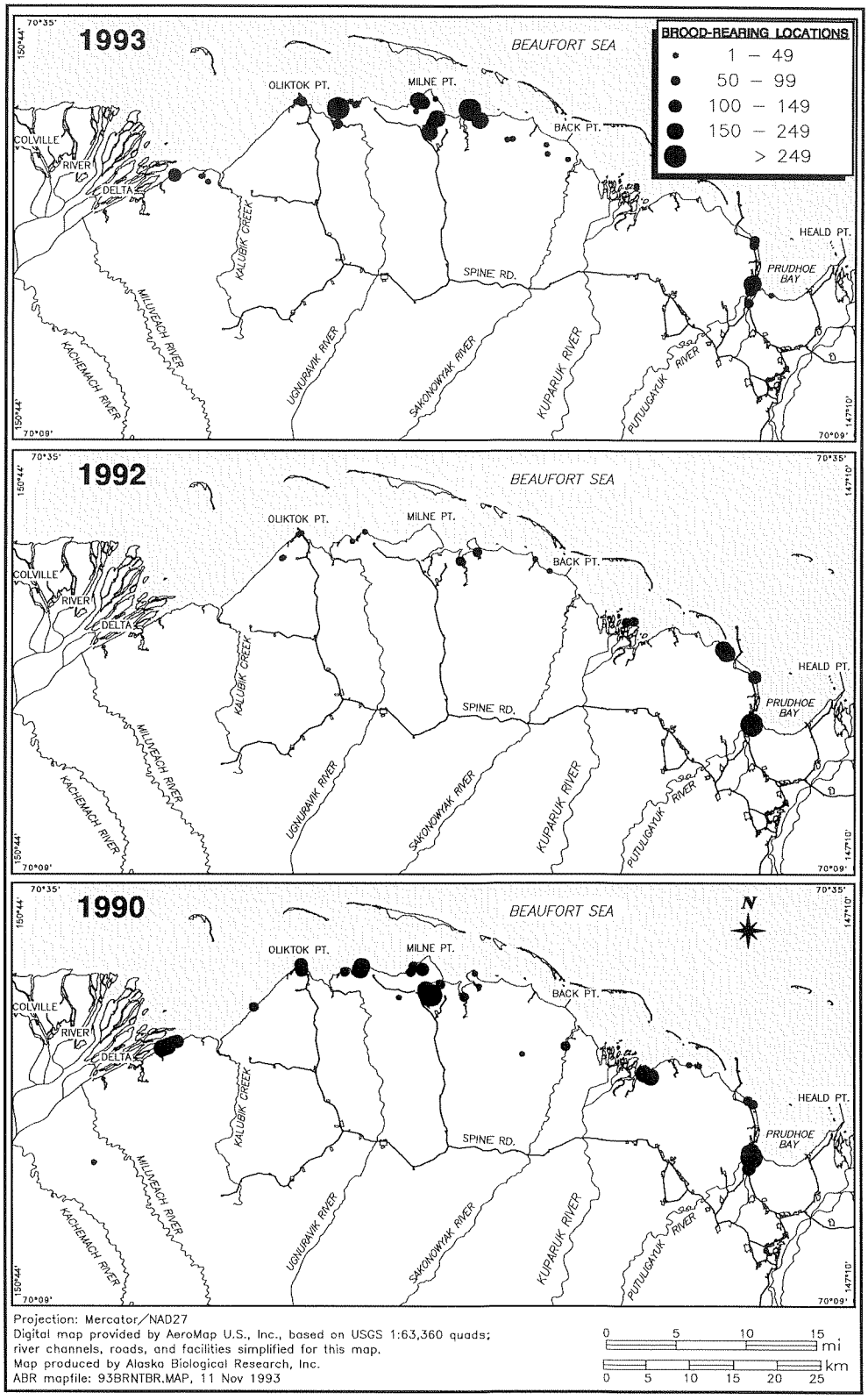


Figure 8. Location and sizes of Brant brood-rearing groups between the Colville and Sagavanirktok rivers, Alaska, in 1990, 1992, and 1993. The years other than 1993 are for comparison: 1990 for high numbers of brood-rearing Brant, and 1992 for low numbers.

Table 9. 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 Sagavanirktok rivers, Alaska, 1993.

Coastal Section	Length (km) of Coastline	26-27 July Survey			29-30 July Survey		
		Adults	Goslings	Total	Adults	Goslings	Total
3. Heald Pt. to Kuparuk R.	45	343	65	408	333	71	404
4. Kuparuk R. to Kalubik Cr.	80	731	649	1380	620	423	1043[a]
5. Kalubik Cr. to Miluveach R.	48	16	11	27	47	80	127
TOTAL	173	1090	725	1815	1000	574	1574

[a] Count does not include large group (> 300 birds) observed at mouth of Ugnuravik River during 26-27 July survey.

groups used bays and salt marshes near Milne and Oliktok points, and at the mouth of the Ugnuravik River. Small groups occurred at the mouth of the Kuparuk River delta, and lakes near the coast. Two additional small brood-rearing groups (10 adults, 12 goslings total) were observed at inland lakes where they had nested in June, by ground observers.

Numbers of Brant, and consequently linear densities (8.5 adults/km, 6.7 goslings/km, Figure 9), were the second largest recorded in five years of surveys. In 1992, the low count of Brant in this section (284 birds) was attributed to the almost total failure of the Colville River delta colony (Stickney et al. 1993). Likewise, the large number of birds found in this section during brood-rearing in 1993 were mostly from the Colville River delta, which is the largest Brant colony on the North Slope (Derksen et al. 1981).

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

A mean of 406 Brant (68 goslings, 17% of section total) were recorded in this section during aerial surveys (Figure 8, Table 9). As in previous years, most birds (>300 adults, >30 goslings) were observed at the mouth of the Putuligayuk River. Most (>200) of the adults at the mouth of the Putuligayak were nonbreeders. A small brood-rearing group of approximately 60 birds was observed along the West Dock Road; none was observed near Point McIntyre.

The number of adults recorded in this section in 1993 was the second lowest, and the number of goslings the lowest recorded in five years of surveys (Table 10); these decreased numbers were reflected in the densities (Figure 9). This decrease was probably a reflection of low numbers of nesting Brant within the section, poor nesting success (due to failure) of the Brant colonies on the Kuparuk River delta and Howe Island, which are major contributors to brood-rearing groups in the Prudhoe Bay region (Ritchie et al. 1991).

West of Kuparuk Oil Field (Section 5: Kalubik Creek to Miluveach River)

The number of Brant observed on the aerial surveys in Section 5 during late July ranged between 27 and 127 (Table 9), although >260 birds were observed during the dispersal survey on 9 July. These counts, and consequently the densities, were the second lowest in five years of surveys (Figure 9). In previous years, counts of Brant in this section have ranged between 196 and 510 birds (Table 10) (Stickney et al. 1993). Although this section is the closest to the Colville River Delta colony, brood-rearing groups in 1993 apparently moved further east to Section 4 during dispersal.

Table 10. 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 Sagavanirktok rivers, Alaska, 1989-1993.

Coastal Section	Mean Number of Adults					Mean Number of Goslings				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
3. Heald Pt. to Kuparuk R.	234	439	360	510[a]	338	121	315	102	112[a]	68
4. Kuparuk R. to Kalubik Cr.	406	684	430	160	686[a]	294	701	279	124	548[a]
5. Kalubik Cr. to Miluveach R.	109	176	234	0	32	87	203	276	0	46
TOTAL	749	1299	1024	670	1060	502	1219	657	236	662

[a] Includes an inland group seen by ground observers.

Brood-rearing Trends

We could not reject the hypothesis ($H_0 1$) that the number of brood-rearing Brant did not vary among coastal sections and among years because there was a significant interaction between section and year ($H_0 1$; ANCOVA, $F_{8,11} = 14.89$, $P = 0.0001$; Figure 10; Appendix 8). The interaction term indicated that each of the sections showed variation in numbers among years, but with no consistent trend. Section 4 (Kuparuk River to Kalubik Creek) generally had the highest numbers of brood-rearing birds, but in 1992 the number of birds (284) in that section was lower than the number (624) in Section 3.

A significant interaction between year and section also existed in the analysis of the proportion of goslings among sections and among years, therefore, we could not reject $H_0 2$ (ANCOVA, $F_{7,11} = 3.49$, $P = 0.0319$; Figure 10; Appendix 8). Again, no consistent trend could be discerned in any section. Section 3 (Heald Point to the Kuparuk River) had a high proportion of goslings in 1989 and 1990 when the Brant colony on Howe Island was active and was a major contributor to brood-rearing groups in the section. However, in subsequent years when the Howe Island colony had been destroyed or abandoned, the largest groups using Section 3 were failed breeders or nonbreeders. Section 5 (Kalubik Creek to Miluveach River) had consistently high proportions of goslings in the brood-rearing groups, except in 1992, when no birds were present in the section in late July. The highest proportion of goslings in all sections was observed in 1990, which had the highest nesting success and apparent gosling survival during the course of this study (Ritchie et al. 1991).

Fluctuations in numbers of brood-rearing Brant among years are not unusual. Extreme annual variation in productivity has been reported for 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 throughout the breeding range. The number of brood-rearing Brant are influenced by the number of nests established, nesting success, and survivorship of young following hatching.

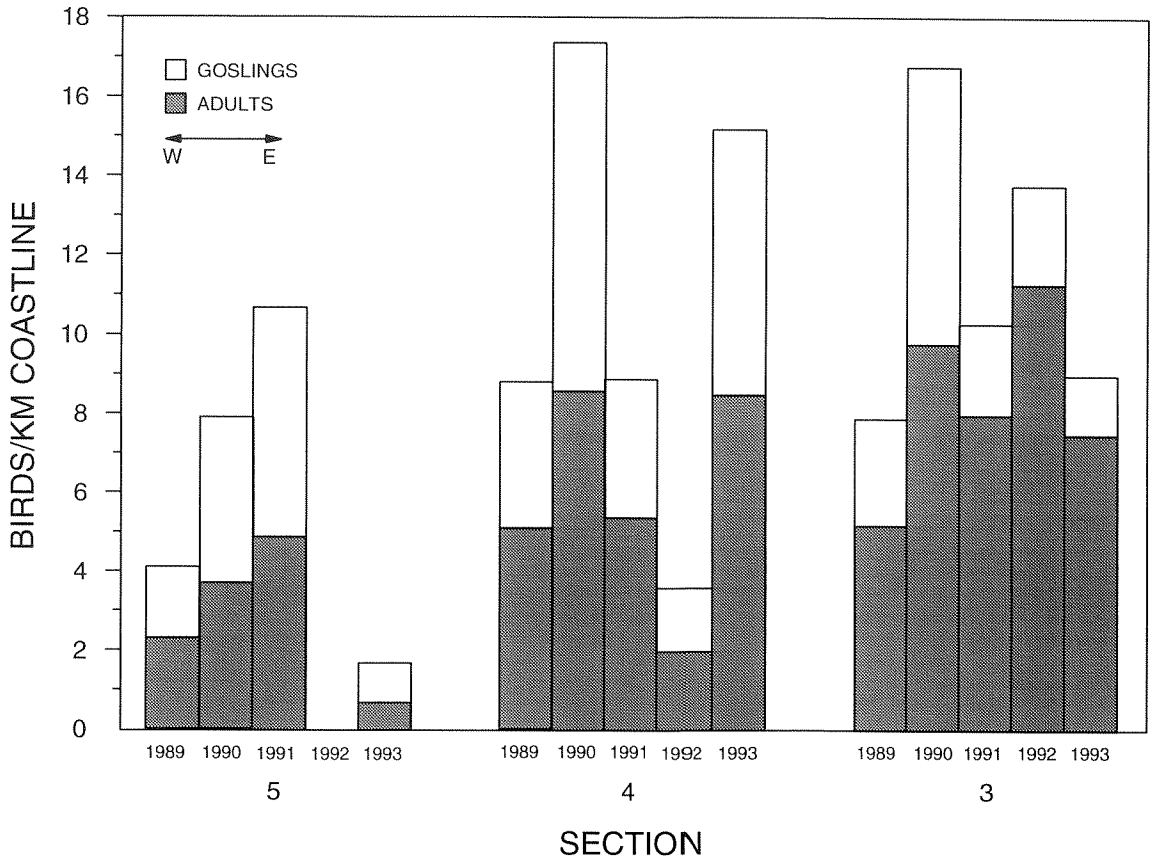


Figure 9. Linear densities of adult Brant and goslings during late July-early August in each of three coastal sections of the study area between the Colville and Sagavanirktok rivers, 1989-1993. Data for years 1989-1992 from Ritchie et al. (1990, 1991), and from Stickney et al. (1992, 1993).

BRANT BANDING

Banding Summary

During late July and early August 1993, 1004 unbanded Brant were captured and banded with uniquely numbered, aqua-colored tarsal bands, at 11 locations between the Kadleroshilik River and Oliktok Point (Figure 11, Table 11). ABR was able to capture Brant at two locations in Region 3 that were inaccessible to the USFWS banding crew (Milne Pt. - C Pad, and Ugnuravik River mouth) with helicopters, in addition to capturing Brant at two locations in Region 2 (N. Putuligayuk River and West Prudhoe Bay coast). The USFWS banded Brant in Region 3 at two locations at Oliktok Point (Oliktok Point lagoon and Oliktok Point - east of the road) and at three locations in the Milne Point Oil Field (East Arm, East Creek, and Central Creek). LGL Alaska Research Associates banded 22 Brant at two locations (Kadleroshilik River and Sagavanirktok River delta) in Region 1, east of Heald Point. In addition to unbanded birds that were captured, 89 Brant previously banded in the oilfields were recaptured, and 112 Brant were recaptured that had been banded at areas outside the oil fields (Table 12). Weights were obtained for 930 unbanded Brant and standard body measurements were taken on a subsample of 239 birds.

Distribution of the banding effort in 1993 among the three banding regions was similar to that in 1992, although Brant were absent from some locations where they occurred in 1992 (e.g., Back Point, Point McIntyre) and Brant again were captured in Region 1 (Table 13). The small number (22 birds) of Brant captured in Region 1 in 1993 apparently was due to failed nesting on Howe Island and probably movement

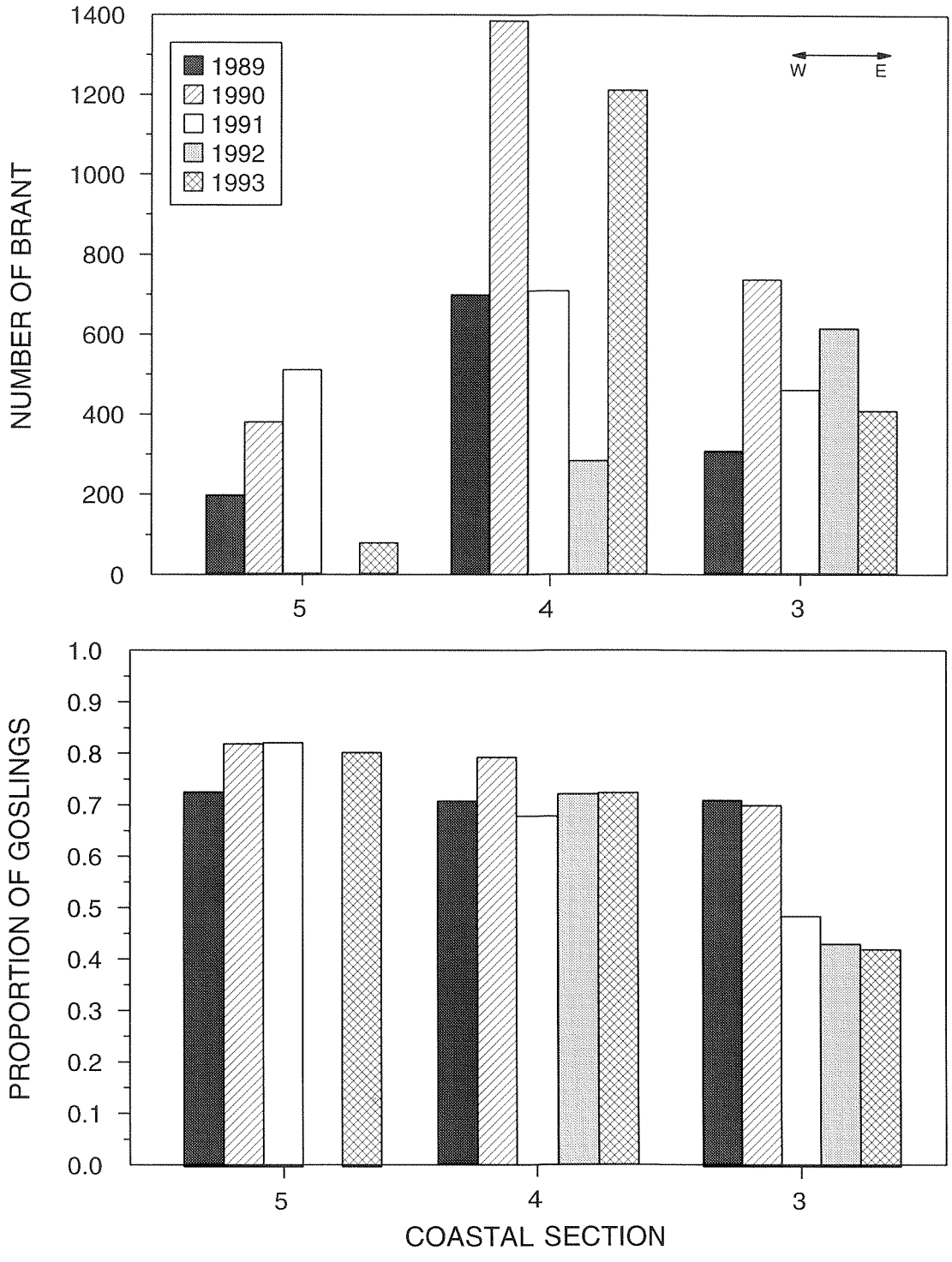


Figure 10. The number of Brant and proportion of goslings during late July-early August by coastal section and year in the study area between the Colville and Sagavanirktok rivers, Alaska, 1989-1993. Data for years 1989-1992 from Ritchie et al. (1990, 1991), and from Stickney et al. (1992, 1993).

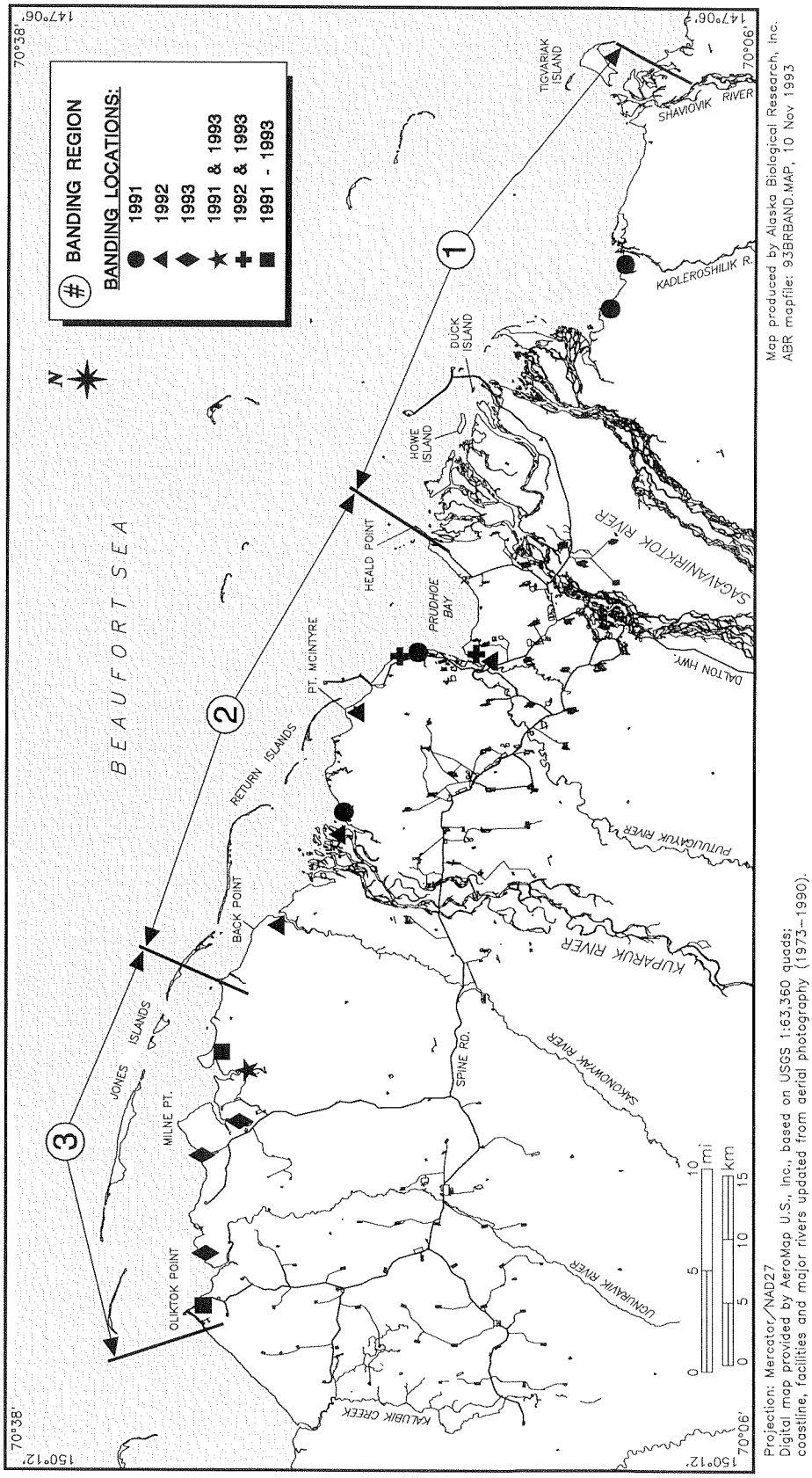


Figure 11. Banding regions and banding locations for Brant in the North Slope oil fields, 1991-1993.

Table 11. Sex- and age-composition of unbanded Brant captured and banded in the Prudhoe Bay, Milne Point, and Kuparuk oil fields, Alaska, July-August 1993. Banding locations are depicted in Figure 11.

Banding Location	Age[a]	Female	Male	Unknown	Total
Kadleroshilik River[b]	Goslings	3	4	0	7
	Subadults	0	1	0	1
	Adults	8	5	0	13
	Total	11	10	0	21
Sagavanirktok River[b]	Goslings	0	0	0	0
	Subadults	0	0	0	0
	Adults	0	1	0	1
	Total	0	1	0	1
N. Putuligayuk River	Goslings	29	19	0	48
	Subadults	7	3	0	10
	Adults	60	55	1	116
	Total	96	77	1	174
W. Prudhoe Bay Coast	Goslings	15	9	0	24
	Subadults	1	0	0	1
	Adults	6	10	0	16
	Total	22	19	0	41
Milne Pt. - East Arm[c]	Goslings	31	34	0	65
	Subadults	0	0	0	0
	Adults	14	18	0	32
	Total	45	52	0	97
Milne Pt. - East Creek[c]	Goslings	48	46	0	94
	Subadults	0	0	0	0
	Adults	29	32	0	61
	Total	77	78	0	155
Milne Pt. - Central Creek[c]	Goslings	16	20	0	36
	Subadults	0	0	0	0
	Adults	13	15	0	28
	Total	29	35	0	64
Milne Pt. - C Pad	Goslings	22	12	0	34
	Subadults	4	1	0	5
	Adults	32	32	0	64
	Total	58	45	0	103

Table 11. Continued

Banding Location	Age[a]	Female	Male	Unknown	Total
Ugnuravik River Mouth	Goslings	51	64	2	117
	Subadults	2	0	0	2
	Adults	47	44	0	91
	Total	100	108	2	210
Oliktok Pt. - East[c]	Goslings	15	13	0	28
	Subadults	0	0	0	0
	Adults	3	4	0	7
	Total	18	17	0	35
Oliktok Point[c]	Goslings	15	12	0	27
	Subadults	0	1	0	1
	Adults	40	35	0	75
	Total	55	48	0	103
All Locations	Goslings	245	233	2	480
	Subadults	14	6	0	20
	Adults	252	251	1	504
	Total	511	490	3	1004

[a] Subadults are second-year (SY) birds, classified according to plumage characteristics.
[b] Banding date provided by LGL Alaska Research Assoc. (S. R. Johnson, pers. commun.)
[c] Banding data provided by USFWS (P. D. Martin, pers. commun.).

of nonbreeders or failed breeders from Region 1 to brood-rearing/molting areas in Regions 2 and 3, or to locations outside the study area. The number (1179 birds) of Brant captured in Regions 2 and 3 during banding in 1993 represented about 65% of the Brant counted between Heald Point and the Colville River during an aerial survey on 26-27 July (1815 birds) (Table 9).

In 1993, 39.8% of the 1205 Brant captured were goslings, a similar percentage to that recorded in 1991 (the first year of banding) and about a 11% increase over 1992 (Table 13). As in the previous two years, some flocks of captured Brant were predominately nonbreeders or failed breeders; other flocks contained both brood-rearing families and nonbreeders or failed breeders. At the time of banding, many nonbreeders had regained flight capability; almost half of the 250 Brant at the mouth of the Putuligayuk River escaped capture during the banding drive by flying away.

Recaptured Brant

The composition of Brant recaptured during banding drives in 1993 varied among banding regions in the oil fields (Table 12). In the Prudhoe Bay area (Region 2), most (83.6%) recaptured Brant were originally banded in the oil fields, with relatively few (9 of 73 birds; 12.3%) originally banded at other North Slope locations (the Colville River delta or Teshekpuk Lake). In Region 1, two of four recaptured birds were originally banded in the oil fields. In contrast, the percentage of Brant recaptured in Region 3 that had been originally banded in the oil fields

Table 12. Original banding locations and recapture locations for Brant recaptured in the North Slope oil fields, Alaska, 1993.

	Banding Location (Tarsus Band Color)									
	North Slope Oil Fields	Colville River Delta	Teshekpuk Lake	Yukon-Kuskokwim Delta		Western Canada	Unknown		%	
Recapture Location	(Aqua)	(Green)	(Green)	(Yellow)	(White)	(Blue)	(None)	(Aqua*)[a]	Aqua	TOTAL
Kadleroshilik River[b]	2	0	0	1	0	0	1	0	50.0	4
N. Putuligayuk River	45	1	5	1	0	0	2	1	81.8	55
W. Prudhoe Bay Coast	16	0	0	1	0	0	0	1	88.9	18
Milne Pt. - East Arm[c]	6	2	1	0	0	0	3	0	50.0	12
Milne Pt. - East Creek[c]	2	6	4	0	1	1	3	0	11.8	17
Milne Pt. - Central Creek[c]	4	6	3	0	0	0	0	0	30.8	13
Milne Pt. - C Pad	2	6	2	0	0	0	1	0	18.2	11
Ugnuravik River Mouth	4	20	3	1	1	0	11	0	10.0	40
Oliktok Pt. - East[c]	0	2	0	0	0	1	0	0	0.0	3
Oliktok Point[c]	8	9	4	0	1	3	3	0	28.6	28
Total Females	54	32	12	1	1	3	15	0	45.8	118
Total Males	35	20	10	3	2	2	9	2	42.2	83
TOTAL	89	52	22	4	3	5	24	2	44.3	201

a Aqua* refers to birds recaptured in 1992 that had metal USFWS bands (but no color band) to which was added an aqua-colored tarsal band.
b Data provided by LGL Alaska Research Associates (S. R. Johnson, pers. commun.).
c Data provided by USFWS (P. D. Martin, pers. commun.).

ranged from 0% to 50% at the seven banding sites and accounted for only 21% (26 of 124 birds) of all recaptures in the region. Instead, Brant originally banded on the Colville River delta and at Teshekpuk Lake accounted for 54.8% of all recaptures in Region 3 (Table 13). This distribution suggests that the greatest exchange of banded individuals occurs between adjacent banding regions, such as between the Kuparuk Oil Field and the Colville River delta immediately to the west.

The sex composition of all recaptured birds revealed that significantly more females (118 birds) were recaptured than males (83 birds) based on an expected 1:1 sex ratio (Chi-square test, $0.025 > P > 0.01$; Table 12). Further analysis revealed that this significant difference was due primarily to a skew in the sex ratio of aqua- banded recaptures (54 females : 35 males, Chi-square test, $0.05 > P > 0.025$), rather than to a skewed sex ratio among other recaptured birds (Chi-square test, $0.25 > P > 0.10$). In Brant, females return to breed in the same area (and often the same colony) where they were raised as gosling (i.e., site fidelity or philopatry [Greenwood 1980]). Because Brant form pairs in winter/spring when birds from different breeding populations are intermixed, and males return to the female's natal colony to breed, it would be expected that females are more likely to be recaptured in the area where they were born than males. Thus, the recapture of more female aqua-banded Brant than males supports this expected difference in philopatry between the sexes. Evidence of philopatry also was supported by recaptures of "foreign" (i.e., non-aqua) birds because more males were recaptured than females. These "foreign" males returned to the oil fields with females born either in the oil fields or, perhaps, in the nearby colonies on the Colville River delta. We observed several mixed pairs of Brant (i.e., one aqua-banded bird and a mate with a non-aqua band).

The age composition of the recaptured birds indicated that few subadults were recaptured in 1993. Only 4 of 89 aqua-banded Brant recaptured in 1993 were banded as goslings (2 in 1991 and 2 in 1992). Because Brant take about three years to reach sexual maturity and return to breed in their natal area, it is not surprising that so few birds banded as goslings in the oil fields subsequently have been recaptured in the oil fields. The first year when substantial numbers of goslings banded in 1991 would be expected to return to the oil fields to breed would be 1994. For non-aqua recaptures (excluding those without color bands), only 7 of 88 Brant were banded as goslings (all females): six (four 2-yr olds, two 3-yr olds) on the Colville River delta; and one (2-yr old) on the Yukon-Kuskokwim Delta.

For Brant banded in the oil fields, the mean distance between the original banding location in 1992 and the recapture location in 1993 was 4.4 km (Table 14). The distance between 1992 banding and 1993 recapture locations was greater for males than for females, although not statistically significant. Sixteen Brant (11 males, 5 females) banded in 1991 were recaptured in both 1992 and 1993. For both sexes, the mean distance between the original banding location and the 1992 recapture location was greater than the mean distance between the recapture locations in 1992 and 1993. Except for three birds banded on the Kadleroshilik River, all of these Brant were banded and recaptured within Prudhoe Bay (Region 2). This fidelity to the general area, although not always to the exact brood-rearing location, suggests that shifts between years among adjacent brood-rearing sites is relatively common.

To evaluate the relationship between breeding colonies and brood-rearing locations, the USFWS web-tagged 18 newly hatched chicks at two colonies in the Kuparuk Oil Field (CPF-3 and Oliktok West) in 1993 (Figure 6). Of the six goslings that were later recaptured, four were recaptured at Milne Pt. - East Arm (two from the CPF-3 colony, two from the Oliktok West colony) and two were recaptured at the Ugnuravik River mouth (originally tagged at the Oliktok West colony). The dispersal of broods from the Oliktok West colony to two different brood-rearing locations indicates that not all broods from the same colony necessarily move to the same brood-

Table 13. Numbers of unbanded Brant captured and banded, and numbers of Brant recaptured, in banding regions in the North Slope oil fields, Alaska, during 1991-1993. Banding regions are delineated in Figure 11.

		Recaptured	Unbanded		%		
Banding Location	Year	Adults	Adults	Goslings	Goslings	Recaptures	Total
REGION 1[a]							
Kadleroshilik River	1991	4	18	0	0.00	18.2	22
	1993	4	14	7	28.0	16.0	25
Foggy Island Bay	1991	2	40	15	26.3	3.5	57
Sagavanirktok River	1993	0	1	0	0.0	0.0	1
Region Subtotal		10	73	22	21.0	9.5	105
REGION 2							
N. Putuligayuk River	1992	26	201	0	0.0	11.5	227
	1993	55	126	48	21.0	24.0	229
S. Putuligayuk River	1992	9	37	25	35.2	12.7	71
W. Prudhoe Bay Coast	1991	1	64	56	46.3	0.8	121
	1992	7	15	9	29.0	22.6	31
	1993	18	17	24	40.7	30.5	59
Point McIntyre	1992	14	90	66	38.8	8.2	170
Kuparuk River Delta	1991	1	6	7	50.0	7.1	14
	1992	6	52	52	47.3	5.4	110
Back Point	1992	0	18	22	55.0	0.0	40
Region Subtotal		137	626	309	28.8	12.8	1072
REGION 3[b]							
Milne Pt. - East Arm	1991	1	23	42	63.6	1.5	66
	1992	5	35	42	51.2	6.1	82
	1993	12	32	65	59.6	11.0	109
Milne Pt. - East Creek	1991	0	0	2	100.0	0.0	2
	1993	17	61	94	54.6	9.9	172
Milne Pt.-Central Creek	1993	13	28	36	46.7	16.9	77
Milne Pt. - C Pad	1993	11	69	34	29.8	9.6	114
Ugnuravik River Mouth	1993	40	93	117	46.8	16.0	250
Oliktok Point	1991	2	36	16	29.6	3.7	54
	1992	1	21	2	8.3	4.2	24
	1993	28	76	27	20.6	21.4	131
Oliktok Pt. - East	1993	3	7	28	73.7	7.9	38
Region Subtotal		133	481	505	45.1	11.9	1119
ALL REGIONS COMBINED							
	1991	11	187	138	41.1	3.3	336
	1992	68	469	218	28.9	9.0	755
	1993	201	524	480	39.8	16.7	1205
TOTAL		280	1180	836	36.4	12.2	2297

a Banding data provided by LGL Alaska Research Associates (S. R. Johnson, pers. commun.)

b Banding data provided by USFWS (P. D. Martin, pers. commun.), except for Milne Pt. - C Pad and Ugnuravik River Mouth where banding was conducted by ABR.

Table 14. Distance (km) between original banding location and subsequent recapture location for Brant banded in the North Slope oil fields, 1991-1993. Only Brant originally banded and recaptured in the oil fields are included.

	Males				Females				Mann-Whitney[a]	All Birds			
	Mean	SD	Range	n	Mean	SD	Range	n	*P*	Mean	SD	Range	n
1992 RECAPTURES													
1991 Banding Location													
1992 Recapture Location	11.8	15.1	0-47.8	13	11.4	12.4	0.5-34	19	0.88	11.5	13.3	0.5-47.8	32
1993 RECAPTURES													
1992 Banding Location													
1993 Recapture Location	1.0	1.9	0-6.2	16	6.0	10.1	0-37.8	35	0.24	4.4	8.7	0-37.8	51
RECAPTURED IN BOTH YEARS													
1991 Banding Location													
1992 Recapture Location	10.3	13.4	0.5-34	5	9.4	12.4	0.5-34	11	0.56	9.7	12.3	0.5-34	16
1992 Recapture Location													
1993 Recapture Location	3.5	3.2	0-6.2	5	4.4	3.9	0-10.2	11	0.68	4.2	3.6	0-10.2	16

[a] Two-tailed probability for a Mann-Whitney test for differences in distance between males and females.

rearing location. A previous study of Brant at the CPF-3 colony had concluded that Brant from that colony move north to the Oliktok Point area to raise broods (Hampton et al. 1988), however, recapture at Milne Point of goslings from the CPF-3 colony reveals that dispersal to other brood-rearing areas also occurs from that colony. Although no goslings were web-tagged at the Milne Point colonies, band numbers were recorded for one pair (an aqua-banded male and a green-banded female) with a single gosling at the Milne Pt. 5 colony on 6 July; this pair was recaptured later at Milne Pt. - East Creek.

Resightings of Banded Brant

In 1993, resightings of banded Brant were collected systematically at Oliktok Point during late June to mid-July by USFWS personnel, and opportunistically at Oliktok Point during late May to mid-June and mid-July to early August by ABR personnel. Fewer observations were made in the Prudhoe Bay area than in 1992, but Brant at the Putuligayuk River and along West Dock Road were checked sporadically for banded birds. Banded Brant also were observed near the Endicott Road from late May-late June (S. Johnson, LGL Alaska Research Associates; pers. commun.). The breeding colonies on the Colville River delta were checked during nesting by USFWS personnel and near hatch (28-30 June) by Mark Lindberg (graduate student, University of Alaska Fairbanks). Colored tarsal bands were read on 268 individuals during 1993 and most (61.6%, 165 birds) were not recaptured during banding in late July-early August. In contrast to recaptured Brant, most resightings were of green-banded birds (55.2%, 148 birds) rather than aqua-banded birds (31.3%, 84 birds). Brant banded at locations other than the North Slope also were resighted in 1993: 20 birds from the Yukon-Kuskokwim Delta (12 yellow bands, 5 white bands, and 3 orange bands), 12 birds from Western Canada (blue bands), and two birds from Wrangel Island, Russia (red bands). Two birds with red bands (whose codes were not read) also were seen near the Endicott Road; it is unknown if these were the same birds as above. Two birds also were resighted with aqua bands that were attached in 1992 (referred to as "aqua*" in tables, these birds already had a USFWS metal band when captured, but no color band; therefore, we attached aqua bands in 1992).

Two of the major objectives of the banding program are to better understand the distribution of Brant within the oil fields and to determine the fidelity of Brant to different breeding colonies and brood-rearing sites in the oil fields. At present, we have little information on the second objective. Understanding the fidelity of Brant to breeding colonies and the links between specific breeding colonies to brood-rearing areas would vastly improve knowledge about the dynamics of Brant in the oil fields and would aid in any management. It is important that more effort be made to collect band information within the colonies and to continue monitoring efforts between the colonies and brood-rearing locations.

However, with two years of recapture and resighting data, some patterns are emerging concerning use of the oil fields by Brant. In 1992, apparently no exchange occurred across the Kuparuk River between Brant banded east of the river and those banded west of the river (Stickney et al. 1993). Analysis of recaptures and resightings in 1993 have revealed that interchange does occur, although it is not common. Only three birds (all females) recaptured in 1993 shifted their brood-rearing/molting locations between Regions 2 and 3 (Table 15).

Additional evidence for exchange among banding regions was revealed by repeated resightings of Brant throughout the summer. The coastal lagoon at Oliktok Point apparently served as a staging area prior to nesting and as a stopover location for birds moving between nesting colonies and brood-rearing or molting areas. Two Brant observed at Oliktok Point in late May subsequently were seen at a nesting colony on the Colville River delta and then observed again at Oliktok Point after hatch (early July); they eventually were recaptured at the Ugnuravik River mouth, approximately 4 km east of Oliktok Point. Five other

Table 15. Original banding location, year of banding, and recapture locations for aqua-banded Brant recaptured in the North Slope oil fields, Alaska, 1993. Banding regions are delineated in Figure 11.

		Recapture Location									
		Region 1	Region 2		Region 3						
Banding Location	Year	Kadleroshilik River[a]	N. Putuligayuk River	W. Prudhoe Bay Coast	Milne Pt. - East Arm[b]	Milne Pt. - East Creek[b]	Milne Pt. - Central Creek[b]	Milne Pt. - C Pad	Ugnuravik River Mouth	Oliktok Point[b]	Total
REGION 1											
Kadleroshilik River	1991	2	3	0	0	0	0	0	0	0	5
REGION 2											
N. Putuligayuk River	1992	0	25	3	0	0	0	0	0	0	28
S. Putuligayuk River	1992	0	8	0	0	1	0	0	0	0	9
W. Prudhoe Bay Coast	1991	0	7	10	0	0	0	0	0	1	18
	1992	0	0	1	0	0	0	0	0	0	1
Point McIntyre	1992	0	2	2	0	0	1	0	0	0	5
REGION 3											
Milne Pt. - East Arm	1991	0	0	0	0	0	0	1	4	1	6
	1992	0	0	0	2	0	0	0	0	2	4
Oliktok Point	1991	0	0	0	2	1	2	1	0	3	9
	1992	0	0	0	2	0	1	0	0	1	4
Total		2	45	16	6	2	4	2	4	8	89

[a] Recapture data provided by LGL Alaska Research Associates (S. R. Johnson, pers. commun.).
[b] Recapture data provided by USFWS (P. D. Martin, pers. commun.).

Brant were observed at nesting colonies on the Colville River delta in late June, then at Oliktok Point in early to mid-July. Four of the five birds were later recaptured: one at the Ugnuravik River mouth, two at Milne Point - East Arm, and one at Milne Point - East Creek. Longer distance movements also were observed for three Brant (probably nonbreeders or failed breeders) that were seen at Oliktok Point and later seen in Prudhoe Bay. Two of the three Brant were seen at Oliktok Point on 9 July and then seen two days later (11 July) at the mouth of the Putuligayuk River in Prudhoe Bay; one bird was recaptured at the Putuligayuk River and the other was recaptured just to the north on the West Prudhoe Bay coast. The third Brant was seen at Oliktok Point on 27 June, then at a coastal embayment near DS-L1 in Prudhoe Bay on 8 July, and was recaptured at the Putuligayuk River on 31 July. Observations of such movements across the oil fields suggests that the use of brood-rearing and molting areas is not restricted to just those Brant nesting in the immediate vicinity and that, at least for nonbreeders or failed breeders, longer distance movements within the oil fields occur during summer. Although some Brant return annually to the same brood-rearing location, it also was apparent that some birds shift among adjacent brood-rearing areas or can move several kilometers to another brood-rearing location. Thus, we can reject our hypothesis (H_O3) that no interchange occurs among brood-rearing locations within the oil fields or with brood-rearing locations outside the oil fields.

Resightings of Brant Banded in the Oil Fields

Aqua-banded Brant have been resighted at other locations in Alaska, in western Canada, and at migratory stopovers and wintering areas to the south (Figure 12). Four Brant banded by ABR in the oil fields were reported as hunter-kills to the USFWS Bird Banding Laboratory: one bird banded as a gosling in 1992 was killed near Samish Bay, Washington, in December 1992; two birds (an adult and a gosling banded in 1992) were killed at Bahia San Quintin, Baja Mexico, in February 1993; and one bird (a gosling banded in 1992) was killed at Bahia Yavaros, Sonora, on the western mainland of Mexico, in February 1993.

Of the three wintering sites monitored by USFWS personnel in Baja Mexico, Brant banded in the oil fields were seen most commonly at Bahia San Quintin (41 of 50 individuals in winter 1991-1992; 201 of 232 individuals in winter 1992-1993). In winter 1992-1993, fewer Brant were seen at the other two wintering sites, San Ignacio Lagoon (21 individuals) and Scammon's Lagoon (21 individuals), but at least 11 individuals were observed at two of the three sites during the winter, suggesting that some movement occurs among the wintering areas on the western coast of Baja Mexico. In winter 1991-1992, preliminary analysis of the resighting data from Mexico indicated that populations of Brant from western and northern Alaska used different wintering areas on Baja, although some overlap occurred (Ward et. al. 1992). This pattern did not continue in winter 1992-1993, however, perhaps because unusually heavy rains during January and February disrupted the distribution of wintering Brant in Baja and even caused some birds to move north into California (Morro Bay and Humboldt Bay) for part of the winter (Ward et al. 1993). The recovery of the hunter-killed Brant (with an aqua tarsal band) from the western mainland of Mexico indicated that at least some proportion of the Brant from the oil fields may winter in that area.

Continued observations of color-banded Brant in the oil fields and at staging and wintering areas will enable us to better determine the life-history patterns for Brant breeding in the oil fields. Observations of color-banded Brant in the oil fields in 1992-1993 proved that collecting systematic data during the pre-nesting, nesting, and brood-rearing periods can establish links between pre-nesting staging areas (such as Oliktok Point), nesting colonies, and brood-rearing/molting areas.

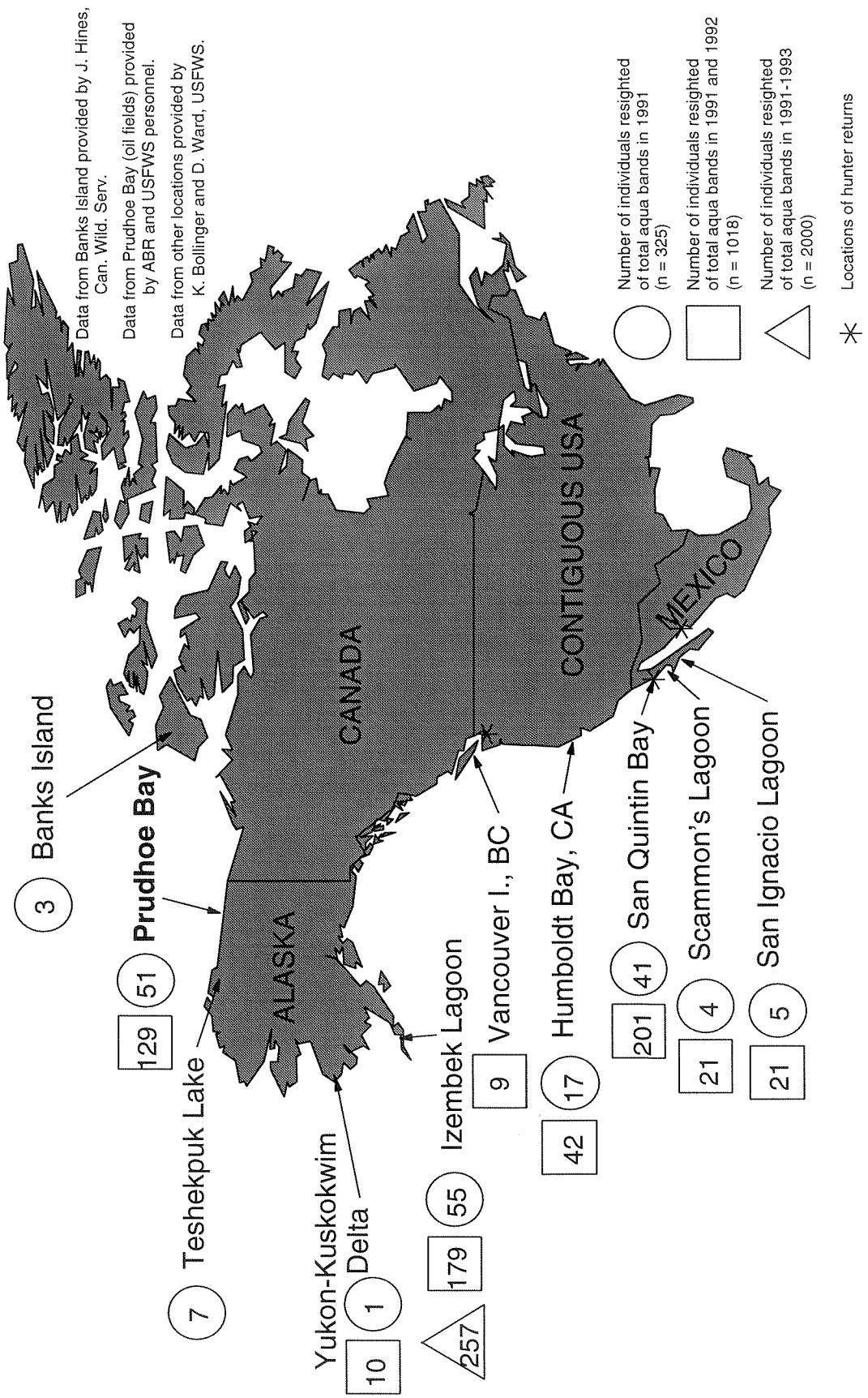


Figure 12. Locations where Brant banded (with aqua bands) in the oil fields in 1991-1993 were resighted.

LITERATURE CITED

Abacus Concepts, Inc. 1989. SuperAnova, v.1.1. Abacus Concepts, Berkeley, CA.

Alaska Biological Research, Inc. 1992. Procedures manual for Brant banding in the North Slope oil fields, 1992. Working draft prepared for 1992 Brant Banding Cooperators by Alaska Biological Research, Inc., Fairbanks, AK.

Andersson, M. 1973. Birds of Nuvagapak Point, Northern Alaska. Arctic 26: 186-197.

Bailey, A. M., C. D. Brower, and L. B. Bishop. 1933. Birds of the region of Point Barrow, Alaska. Program of Activities, Chicago Acad. Sci. 4: 13-40.

Barry, T. W. 1962. Effect of late seasons on Atlantic Brant reproduction. J. Wildl. Manage. 26: 19-26.

Barry, T. W. 1967., The geese of the Anderson River Delta. Ph.D. Thesis, Univ. of Alberta. 212 pp.

Bart, J., S. Earnst, and P. J. Bacon. 1991a. Comparative demography of the swans: a review. Wildfowl (Suppl. 1): 15-21.

Bart, J., R. Limpert, S. Earnst, W. Sladen, J. Hines, and T. Rothe. 1991b. Demography of Eastern Population Tundra Swans (*Cygnus columbianus columbianus*). Wildfowl (Suppl. 1): 178-184.

Bartels, R. F., and T. J. Doyle. 1984. Distribution, abundance, and productivity of Tundra Swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1983. Pages 202-209 *in* G. W. Garner and P. E. Reynolds, eds. 1983 Update Report: baseline study of fish, wildlife, and their habitats. ANWR Prog. Rep. No. FY 84-8. USFWS, Fairbanks, AK.

Bartonek, J. C. 1969. Arctic Slope and Trans-Alaska Pipeline Task Force Report: the bird resources of Alaska's Arctic Slope and petroleum development. Unpubl. rep. U. S. Fish and Wildl. Serv. 37 pp.

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska. USFWS, Resour. Publ. 129. 38 pp.

Brackney, A. W. 1989. Abundance and productivity of Tundra Swans in the coastal wetlands of the Arctic National Wildlife Refuge. Pages 14-17 *in* T. R. McCabe, ed. Annual wildlife inventories. Arctic National Wildlife Refuge. U.S. Fish and Wildl. Serv., Anchorage, AK. 168 pp.

Burgess, R. M. 1984. Investigations of patterns of vegetation, distribution and abundance of small mammals and nesting birds, and behavioral ecology of arctic foxes at Demarcation Bay, Alaska. M.S. Thesis. Univ. Alaska, Fairbanks. 191 pp.

Burgess, R. M., A. A. Stickney, J. R. Rose and R. J. Ritchie. 1992. Snow Goose Monitoring Program, 1990 Endicott Monitoring Program. Chap. 3 *in* Final Rep. prepared for the Army Corps Eng., Anchorage, AK, SAIC, Anchorage, AK.

Campbell, B. H., and T. C. Rothe. 1990. Annual report of survey inventory activities, Vol. XIX, Part XIII: Waterfowl. Fed. Aid Wildl. Restor. Proj. W-23-2, Job 11.0. Alaska Dept. Fish & Game, Juneau, AK.

Carson, C. E., and K. M. Hussey. 1962. The oriented lakes of arctic Alaska. J. Geol. 70: 74-81.

Clark, P. J., and F. C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 35: 445-453.

Conant, B. 1989. Alaska productivity surveys of geese, swans, and Brant. Unpubl. rep. prepared by USFWS, Off. Migr. Bird Manage., Juneau, AK. 28 pp.

Conant, B., and S. L. Cain. 1987. Alaska Tundra Swan status report, 1987. Unpubl. rep. prepared by USFWS, Off. Migr. Bird Manage., Juneau, AK. 17 pp.

de Boer, W. F., and R. H. Drent. 1989. A matter of eating or being eaten? The breeding performance of arctic geese and its implications for waders. Wader Study Group Bull. 55: 11-17.

Derksen, D. V., W. D. Eldridge, and T. C. Rothe. 1979. Waterbird and wetland habitat studies. Pages 229-311 *in* NPR-A Work Group 3: studies of selected wildlife and fish and their use of habitats on and adjacent to the NPR-A, 1977-1978. Vol. 2. USFWS, Anchorage, AK.

Derksen, D. V., T. C. Rothe, and W. D. Eldridge. 1981. Use of wetland habitats by birds in the National Petroleum Reserve-Alaska. U.S. Dep. Int., Fish and Wildl. Serv., Resour. Publ. No. 141. 27 pp.

Dixon, J. S. 1943. Birds observed between Point Barrow and Herschel Island on the arctic coast of Alaska. Condor 45: 49-57.

Divoky, G. J. 1978. Identification, documentation, and delineation of coastal migratory bird habitat in Alaska: Breeding bird use of barrier islands in the northern Chukchi and Beaufort seas. Pages 482-548 *in* Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Principal Invest., Vol. 1, OCSEAP BLM/NOAA, Boulder, CO.

Dzubin, A., and E. G. Cooch. 1992. Measurements of geese: general field methods. California Waterfowl Assoc. Sacramento, CA. 20 pp.

Earnst, S. 1991. The third international swan symp.: a synthesis. Wildfowl (Suppl. 1): 7-14.

Eberhardt, W. L. 1977. The biology of arctic and red foxes on the North Slope. M.S. Thesis, Univ. Alaska, Fairbanks. 125 pp.

Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. The Stackpole Company and the Wildlife Management Institute, Harrisburg, PA. and Washington, DC. 922 pp.

Gavin, A. 1977. Ecological and environmental report: Prudhoe Bay region, North Slope of Alaska 1977. Unpubl. report prepared for ARCO Alaska, Inc., Anchorage, AK. 17 pp.

Gavin, A. 1980. An arctic coastal environment, Prudhoe Bay, Alaska. Paper presented to Second Symposium on Management, Conservation, and Utilization of the Coastal Zone, 17-20 November 1980. 20 pp.

Greenwood, P. L. 1980. Mating systems, philopatry and dispersal in birds and mammals. Anim. Behav. 28: 1140-1162.

Hampton, P. D., L. C. Orr, and L. C. Byrne. 1988. an evaluation of the effects of noise on waterfowl in the vicinity of CPF-3, Kuparuk Field, Alaska. Unpubl. Rep. prepared for ARCO Alaska, Inc., Anchorage by ESE, Anchorage, AK.

Hansen, H. A. 1957. Annual waterfowl report, Alaska. Unpubl. rep. prepared by U. S. Bur. Sport Fish. and Wildl., Fairbanks, AK. 7 pp.

Hawkins, L. 1983. Tundra Swan study, 1983 progress report. Unpubl. report prepared by USFWS, Anchorage, AK. 6 pp.

Johnson, S. R., and W. J. Richardson. 1980. Beaufort Sea barrier island-lagoon ecological process studies: Final rep., Simpson Lagoon. Part 3, Birds. LGL Limited, Edmonton, AB, Canada.

Johnson, S. R., D. M. Troy, and J. G. Cole. 1985. The status of Snow Geese in the Endicott Development Unit, Sagavanirktok River delta, Alaska: a 5-year summary. Pages 1-53 *in* B. J. Gallaway and S. R Johnson, eds., Environmental Monitoring Studies (Summer 1984) for the Endicott Development. Unpubl. rep. prepared for Sohio Alaska Petroleum Company, Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

King, J. G. 1970. The swans and geese of Alaska's Arctic Slope. Wildfowl 21: 11-17.

King, J. G. 1973. The use of small airplanes to gather swan data in Alaska. Wildfowl 24: 15-20.

King, J. G., and J. I. Hodges. 1980. A correlation between *Cygnus columbianus columbianus* territories and water bodies in western Alaska. Pages 26-33 *in* G. V. T. Matthews and M. Smart. eds. Proc. 2nd International Swan Symposium, Sapporo, Japan. IWRB Slimbridge, Gloucester, England.

King, R. 1979. Results of aerial surveys of migrating birds on NPR-A in 1977 and 1978. Pages 183-226 *in* NPR-A Work Group 3: studies of selected wildlife and fish and their use of habitats on and adjacent to the NPR-A, 1977-1978. Vol. 1. USFWS, Anchorage, AK.

MacInnes, C. D., and R. K. Misra. 1972. Predation on Canada goose nests at McConnell River, Northwest Territories. J. Wildl. Manage. 36: 414-422

McLaren, M. A., and P. L. McLaren. 1984. Tundra Swans in northeastern Keewatin District, N.W.T. Wilson Bull. 96: 6-11.

Monda, M. J. 1991. Reproductive ecology of Tundra Swans on the Arctic National Wildlife Refuge, Alaska. Ph. D. Thesis, Univ. Idaho, Moscow. 95 pp.

Murphy, S. M., and B. A. Anderson. 1992. Lisburne terrestrial monitoring program: the effects of the Lisburne Development Project on geese and swans, 1985-1989. Final synthesis rep. prepared for ARCO Alaska, Inc., Anchorage by Alaska Biological Research, Inc., Fairbanks. 193 pp.

National Oceanic and Atmospheric Administration (NOAA). 1993. Local climatological data: monthly summaries for Prudhoe Bay, Alaska. National Oceanic and Atmospheric Admin., Ntnl. Climatic Data Center, Asheville, NC.

O'Neill, E. J. 1979. Fourteen years of goose populations and trends at Klamath Basin refuges. Pages 316-322 *in* R. L. Jarvis and J. C. Bartonek, eds. Management and biology of Pacific Flyway geese. Oregon State Univ. Press, Inc., Corvallis, OR.

Pacific Waterfowl Flyway Council. 1981. Management plan, Pacific coast Brant. Unpubl. rep. prepared for Pacific Waterfowl Flyway Council Technical Committee. 75 pp.

Platte, R. M., and A. W. Brackney. 1987. Tundra Swan surveys. Pages 16-17 *in* G. W. Garner and P. E. Reynolds, eds. 1985 Update Report: baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildl. Serv., Anchorage, AK. 481 pp.

Raveling, D. G. 1984. Geese and hunters of Alaska's Yukon Delta: management problems and political dilemmas. Trans. N. Am. Wildl. Nat. Resour. Conf. 49: 555-575.

Ritchie, R. J., J. G. King, and P. W. Banyas. 1989. Aerial waterfowl surveys in the Kuparuk River Unit and Oil and Gas Lease Sale 54. Unpubl. rep. prepared for ARCO, Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 26 pp.

Ritchie, R. J., P. W. Banyas, A. A. Stickney, R. M. Burgess, and J. G. King. 1990. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1989. Unpubl. rep. prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 138 pp.

Ritchie, R. J., A. A. Stickney, P. W. Banyas, and J. G. King. 1991. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1990. Unpubl. rep. prepared for ARCO Alaska, Inc. and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 103 pp.

Salter, R. E., M. A. Gollop, S. R. Johnson, W. R. Koski, and C. E. Tull. 1980. Distribution and abundance of birds on the Arctic Coastal Plain of northern Yukon and adjacent Northwest Territories, 1971-1976. Can. Field-Nat. 94: 219-238.

Serie, J. R., and J. C. Bartonek. 1991. Population status and productivity of Tundra Swan in North America. Wildfowl Suppl. No. 1: 172-177.

Shepherd, P. E. K. 1961. Distribution and abundance of the Black Brant in Alaska. Pages 58-60 *in* Alaska Dep. Fish and Game, 1960-61 Pittman-Robertson Proj. Rep. 2. Div. Game, Juneau, AK.

Sladen, W. J. L. 1973. A continental study of Whistling Swans using neck collars. Wildfowl 24: 8-14.

Smith, L. N., L. C. Byrne, and R. J. Ritchie. 1993. Wildlife studies on the Colville River Delta, Alaska, 1992. Final rep. prepared for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 70 pp.

Spindler, M. A. 1978. Bird populations and habitat use on the Okpilak River Delta area, Arctic National Wildlife Range, 1978. Unpubl. rep. prepared by U. S. Fish and Wildl. Serv., Fairbanks, AK. 83 pp.

Steel, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics. Second ed. McGraw-Hill Book Co., New York, NY. 633 pp.

Stewart, D. B., and L. M. J. Bernier. 1989. Distribution, habitat, and productivity of Tundra Swans on Victoria Island, King William Island, and southwestern Boothia Peninsula, NWT. Arctic 42: 333-338.

Stickney, A. A. 1989. The foraging behaviour, havitat use and diet of arctic foxes (*Alopex lagopus*) in a goose nesting area near Kokechik Bay, Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK. 81 pp.

Stickney, A. A. 1991. Seasonal patterns of prey availability and the foraging behavior of arctic foxes (*Alopex lagopus*) in a waterfowl nesting area. Can. J. Zool. 69: 2853-2859.

Stickney, A. A., R. J. Ritchie, P. W. Banyas, and J. G. King. 1992. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1991. Unpubl. rep. prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 81 pp.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, D. A. Flint, P. W. Banyas, and J. G. King. 1993. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1992. Unpubl. rep. prepared for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks. 83 pp.

Summers, R. W., and L. G. Underhill. 1987. Factors related to breeding production of Brent Geese *Branta b. bernicla* and waders *Charadrii* on the Taimyr Peninsula. Bird Study 34: 161-171.

Troy Ecological Research Associates (TERA). 1991. Trends in bird use of the Pt. McIntyre Reference Area: 1990 update. Unpubl. rep. prepared for BP Exploration (Alaska) Inc. by Troy Ecological Research Associates, Anchorage. 47 pp.

U.S. Fish and Wildlife Service (USFWS). 1987. Trumpeter and Tundra swan survey protocol update. Unpubl. memo. prepared by Off. Migr. Bird Manage., Juneau, AK. 8 pp.

U.S. Fish and Wildlife Service (USFWS). 1991. Trumpeter and Tundra swan survey protocol. Unpubl. memo. prepared by Off. Migr. Bird Manage., Juneau, AK. 4 pp.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geol. Surv. Prof. Pap. 482. 52 pp.

Walker, D. A., K. R. Everett, P. J. Webber, and J. Brown. 1980. Geobotanical atlas of the Prudhoe Bay region, Alaska. Cold Reg. Res. and Eng. Lab. (CRREL) Rep. 80-14, U.S. Army Corps of Engineering, Hanover, NH. 69 pp.

Ward, D. H., T. L. Tibbitts, J. D. Mason, A. L. Seidl, T. J. Fenske, J. A. Pratt, K. S. Bollinger, D. V. Derksen, J. L. Aguilar, F. U. Heredia, and A. A.Gerardo. 1992. Migration patterns and distribution of Brant subpopulations in Mexico. Unpubl. rep., U.S. Fish and Wildl. Serv., Alaska Fish and Wildl. Res. Center, Anchorage, and Univ. Autonoma de Baja Calif., Ensenada, Mexico. 27 pp.

Ward, D. H., T. L. Tibbitts, J. D. Mason, K. S. Bollinger, J. A. Pratt, J. M. Pearce, N. Chelgren, L. Lipinski, C. Solek, D. V. Derksen, M. M. Martinez, F. U. Heredia, and A. A. Gerardo. 1992. Migration patterns and distribution of Brant subpopulations in Mexico. Unpubl. rep., U.S. Fish and Wildl. Serv., Alaska Fish and Wildl. Res. Center, Anchorage, AK, and Univ. Autonoma de Baja Calif., Ensenada, Mexico. 30 pp.

Welling, C. H., and W. J. L. Sladen. n.d. Densities of Whistling Swan populations of the central Alaska Arctic Slope. Unpubl. manu.

Wilk, R. J. 1988. Distribution, abundance, population structure, and productivity of Tundra Swans in Bristol Bay, Alaska. Arctic 41: 288-292.

Woodward-Clyde Consultants. 1983. Lisburne Development Area: 1983 environmental studies. Final rep. prepared for ARCO Alaska, Inc., Anchorage.

Woodward-Clyde Consultants. 1985. Lisburne development environmental studies: 1984. Vol. 2--caribou, birds and oceanography. Final rep. prepared for ARCO Alaska, Inc., Anchorage.

Appendix 1. Dates and locations of Tundra Swan and Brant aerial surveys conducted in the Kuparuk Oil Field and Oil and Gas Lease 54 (OGL 54), Alaska, June-August 1993.

Survey Type	Location[1]	Date	Aircraft
Swan			
Nesting	Kuparuk Oil Field and OGL 54	22-25 June	C-185
Brood-rearing	Kuparuk Oil Field and OGL 54	19-24 August	C-185
Brant			
Nesting	Miluveach R. to Heald Point inland	28 June	PA-18
Brood-rearing	Coastline, Miluveach R. to Heald Point	10 July 26-27 July 29-30 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, 1993.

USGS Quadrangle		Transect Lengths (km)	Aerial Coverage (km^2) Kuparuk Oil Field	OGL 54	White Hills
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[a]	+	+	-	-
	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	-
TOTAL		3332	2182.0	1684.4	2167.7

[a] = < 1.6 km^2.

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, 22-25 June 1993.

Location (USGS Quadrangle)		Adults with Nests				Adults without Nests					
		Pair	Single Adult	Total	Total Nests	Pair	Single Adult	Flocks	Flocked Swans	Total	Total Swans
Beechey Point	A-4	6	5	17	11	5	5	0	0	15	32
	A-5	3	0	6	3	5	5	0	0	15	21
	B-4	18	3	39	21	27	15	1	4	73	112
	B-5	9	9	27	18	21	14	1	3	59	86
	C-4	-	-	-	-	-	-	-	-	-	-
	C-5	-	-	-	-	-	-	-	-	-	-
Harrison Bay	A-1	3	1	7	4	12	4	2	3	31	38
	A-2	4	6	14	10	10	5	0	0	25	39
	A-3	3	2	8	5	1	0	0	0	2	10
	B-1	7	3	17	10	11	8	1	3	33	50
	B-2	1	1	3	2	4	1	0	0	9	12
Umiat	C-1	-	-	-	-	-	-	-	-	-	-
	C-2	5	0	10	5	6	5	1	3	20	30
	C-3	1	1	3	2	5	2	0	0	12	15
	D-2	13	6	32	19	14	11	2	6	45	77
	D-3	6	5	17	11	6	8	0	0	20	37
Total		79	42	200	121	127	83	7	22	359	559

Appendix 4. 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, 19-24 August 1993.

Location (USGS Quadrangle)	Adults with Broods						Adults without Broods							
	Pair	Single Adult	Total	Total Broods	Total Young	Mean Brood Size	Pair	Single Adult	Flocks	Flocked Swans	Total	Total Adults	Total Swans	Percent Young
Beechey Point														
A-4	6	0	12	6	17	2.8	15	1	2	10	41	53	70	24.3
A-5	4	0	8	4	10	2.5	3	2	0	0	8	16	26	38.5
B-4	19	2	40	21	52	2.5	33	8	4	19	93	133	185	28.1
B-5	22	1	45	23	58	2.5	36	15	5	18	105	150	208	27.9
Harrison Bay														
A-1	5	0	10	5	11	2.2	8	1	0	0	17	27	38	34.5
A-2	7	0	14	7	17	2.4	12	4	4	31	59	73	90	18.8
A-3	2	0	4	2	9	4.5	2	0	1	4	8	12	21	42.9
B-1	6	0	12	6	16	2.6	20	10	3	12	62	74	90	17.8
B-2	2	0	4	2	5	2.5	3	2	1	4	12	16	21	23.8
Umiat														
C-2	3	0	6	3	5	1.7	5	7	0	0	17	23	28	17.9
C-3	1	1	3	2	7	3.5	9	4	0	0	22	25	32	21.9
D-2	10	0	20	10	27	2.7	28	9	3	14	79	99	126	21.4
D-3	4	0	8	4	10	2.5	18	7	1	3	46	54	64	15.6
Total	91	4	186	95	244	2.6	199	70	24	115	569	755	999	24.4

Appendix 5. Tundra Swan counts during brood-rearing in a portion of the Kuparuk Oil Field (Beechey Point, B-5 quadrangle), Alaska, August 1986-1993.

	Adults with Broods						Adults without Broods							
Year	Pair	Single Adult	Total	Total Broods	Total Young	Mean Brood Size	Pair	Single Adult	Flocks	Flocked Swans	Total	Total Adults	Total Swans	Percent Young
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[g]	20	1	41	21	63	3.0	24	16	8	28	92	133	196	32.1
1993	22	1	45	23	58	2.5	36	15	5	18	105	150	208	27.9
Mean ($\bar{x}$)	16.6	1	34.1	17.5	43.9	2.5	25.6	11.5	3.9	14.4	76.6	110.6	154.1	27.4

[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
[g] Stickney et al. 1993

Appendix 6. 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 1993.

	Nesting Survey (June)				Productivity Survey (August)					
Location	Adults With Nests	Nests	Adults Without Nests	Total Adults	Adults With Broods	Broods	Young	Adults Without Broods	Total Adults	Total Swans
Kuparuk Oil Field	0.05	0.03	0.10	0.16	0.06	0.03	0.08	0.16	0.21	0.29
OGL 54	0.05	0.03	0.07	0.12	0.03	0.02	0.04	0.14	0.17	0.21
Kuparuk/OGL 54 Total	0.05	0.03	0.09	0.14	0.05	0.02	0.06	0.15	0.19	0.26

Appendix 7. Summary of the nearest neighbor analysis for Tundra Swan nests and broods in three Central Processing Facility (CPF) and Milne Point units within the Kuparuk Oil Field, and Oil and Gas Lease 54 (OGL 54) study areas, Alaska, 1993. The distribution function is computed as $R = \frac{\Sigma r/N}{(2\sqrt{p})^{-1}}$ where $\sum r$ = sum of the individual nearest neighbor distances and $\frac{1}{2\sqrt{\rho}}$ is the expected distribution (Clark and Evans 1954).

1. Nests

Operating Unit	Number of Nests	Nearest Neighbor Distance (km) $\bar{x}$	SD	R
KRU CPF-1	12	3.7	1.6	1.3
KRU CPF-2	11	2.7	1.0	0.8
KRU CPF-3	6	3.8	1.4	1.1
Milne Point	6	3.9	0.5	1.6
OGL 54	48	2.7	1.4	0.9

2. Broods

Operating Unit	Number of Broods	Nearest Neighbor Distance (km) $\bar{x}$	SD	R
KRU CPF-1	9	4.0	1.5	1.1
KRU CPF-2	10	3.6	1.8	1.0
KRU CPF-3	8	2.4	1.0	1.4
Milne Point	7	3.4	1.0	1.5
OGL 54	27	3.9	2.7	0.9

Appendix 8. 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 6 and the years are 1989-1993. The proportions of goslings were transformed using the arcsin of the square root. Coastline length was used as the covariate. Data for 1989-1993 are from Ritchie et al. (1990, 1991) and Stickney et al. (1992, 1993).

1. Brant Numbers

Model Summary

Count: 30
r: 0.989
Adjusted r^2: 0.942

Source	df	MS	*F*	*P*	Error Term
Coastline Length	1	1,478,586.6	175.8	0.0001	MSE
Year	4	1,025,752.7	30.5	0.0001	MSE
Section	2	606,519.0	63.7	0.0035	MS Survey (Within Section)
Survey No. (Within Section)	3	14,273.0	0.6	0.6489	MSE
Year*Section	8	1,008,450.7	15.0	0.0001	MSE
Residual	11	92,509.0			

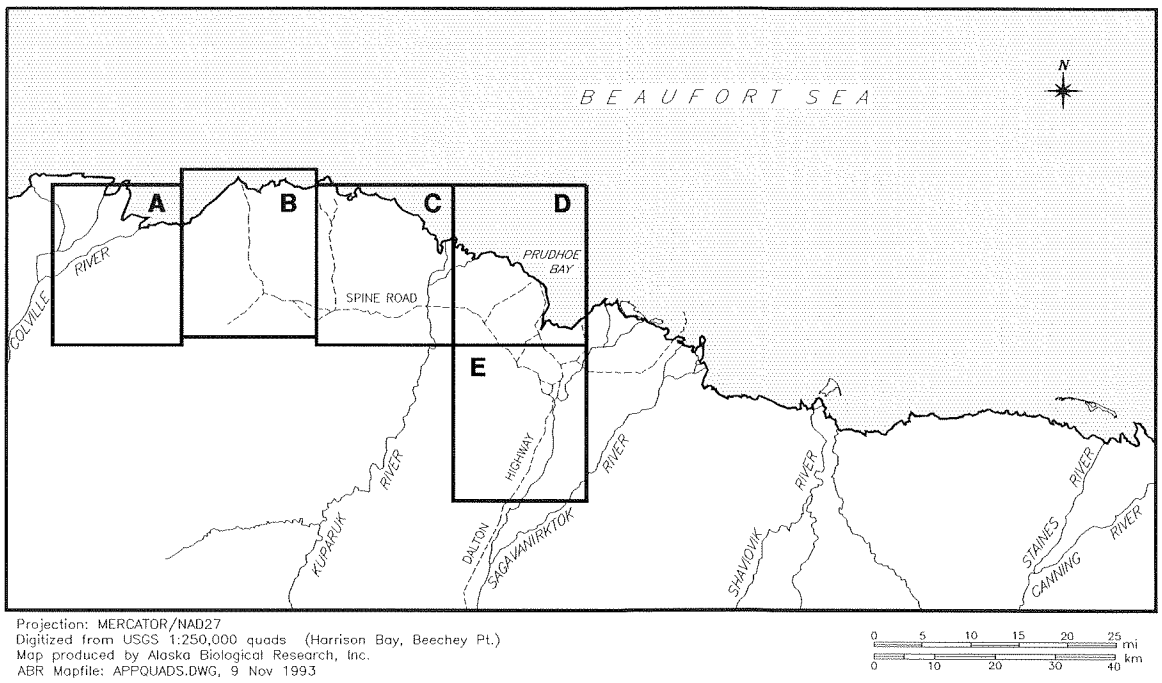
Appendix 8. (Continued)

2. Proportion of Goslings

Model Summary

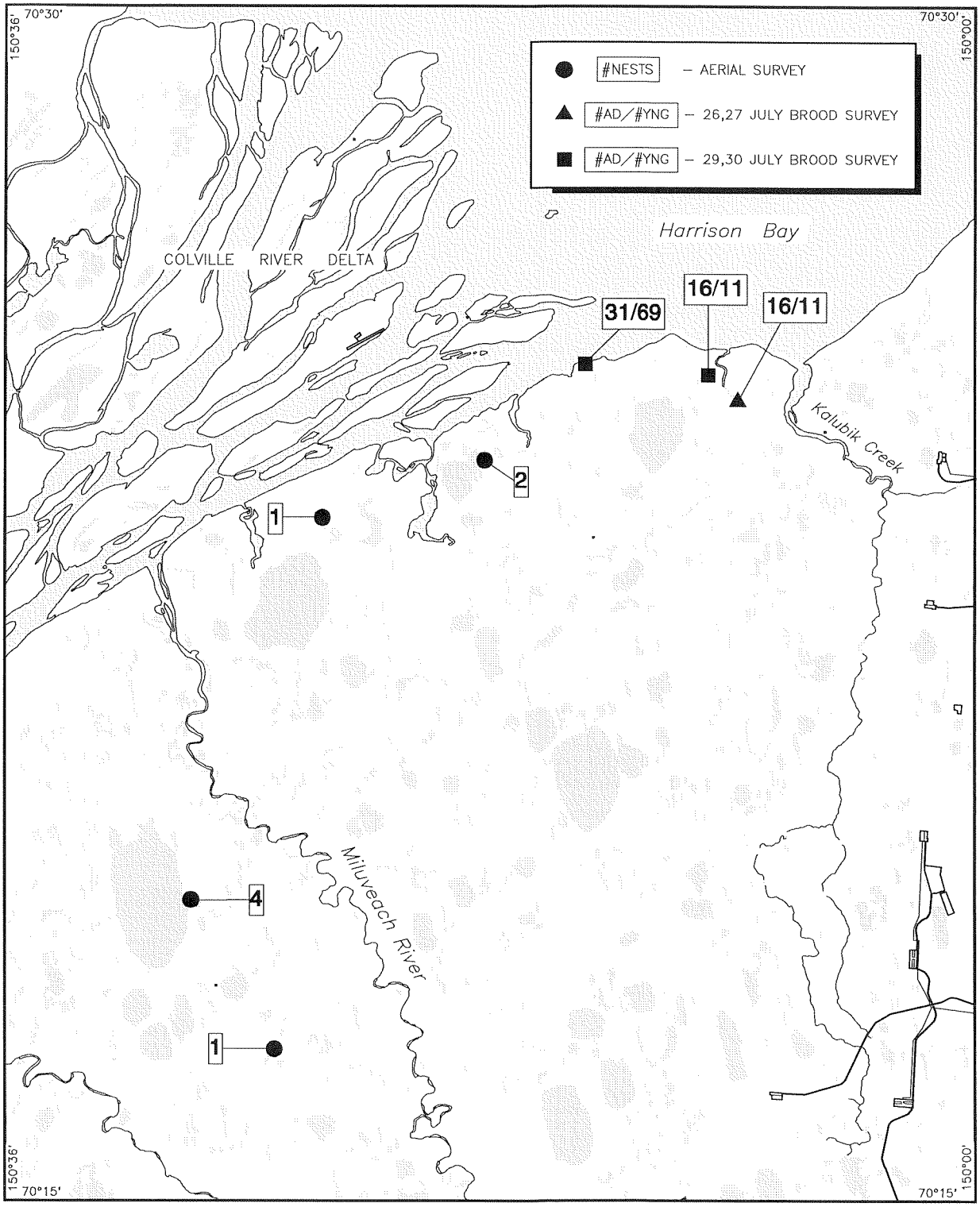
Count: 28
r: 0.950
Adjusted r^2: 0.762

Source	df	MS	*F*	*P*	Error Term
Coastline Length	1	0.041	8.4	0.0146	MSE
Year	4	0.188	6.1	0.0080	MSE
Section	1	0.205	36.6	0.0091	MS Survey (Within Section)
Survey No. (Within Section)	3	0.017	1.1	0.3727	MSE
Year*Section	7	0.119	9.279	0.0319	MSE
Residual	11	0.054			



Appendix 9. Map locations of Brant nests and brood-rearing groups between the Colville and Staines rivers, Alaska, as determined from aerial and ground surveys in June and late July-early August, 1993.

9A

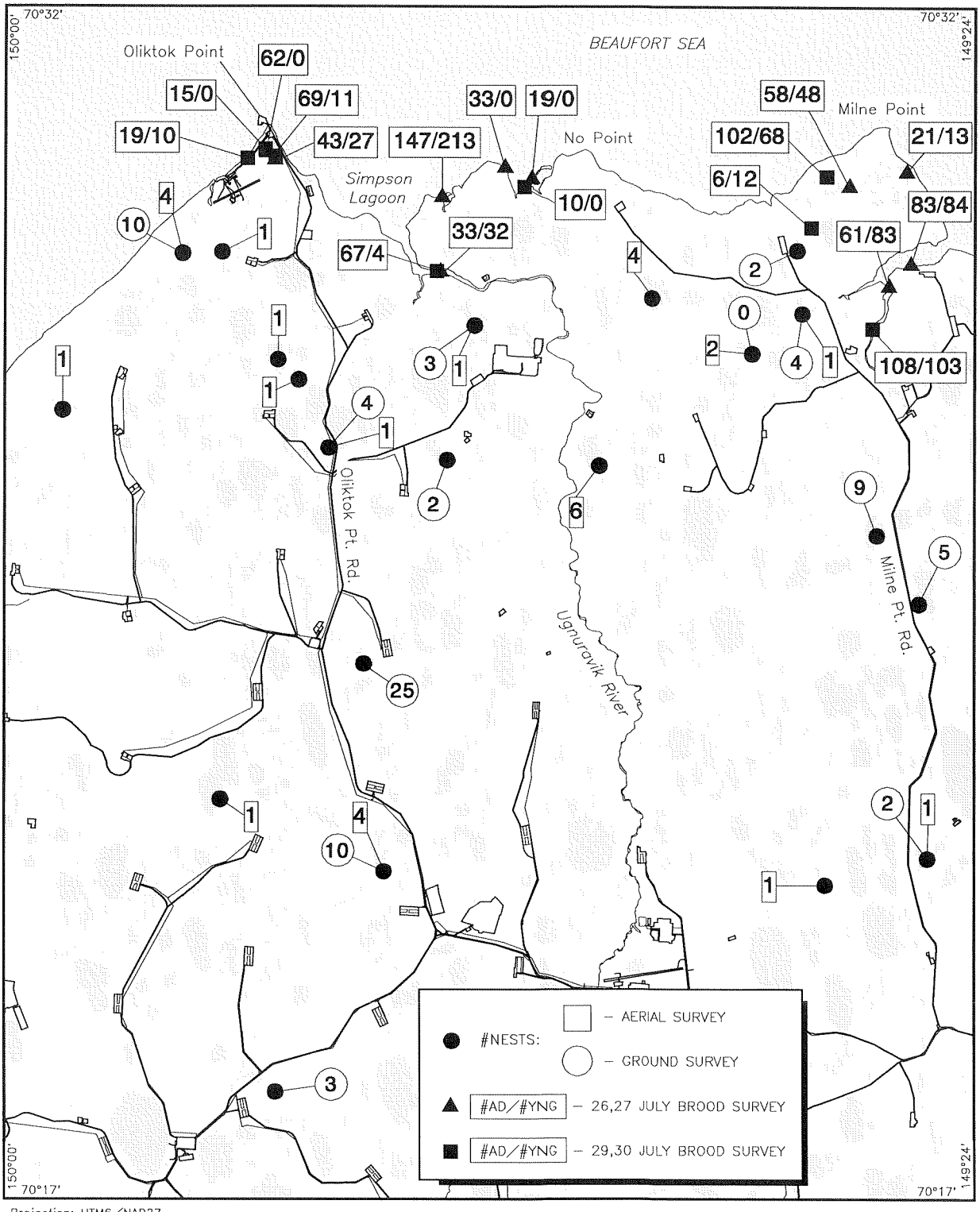


Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Harrison Bay B-1); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 93HBB-1.MAP, 9 Nov 1993

N

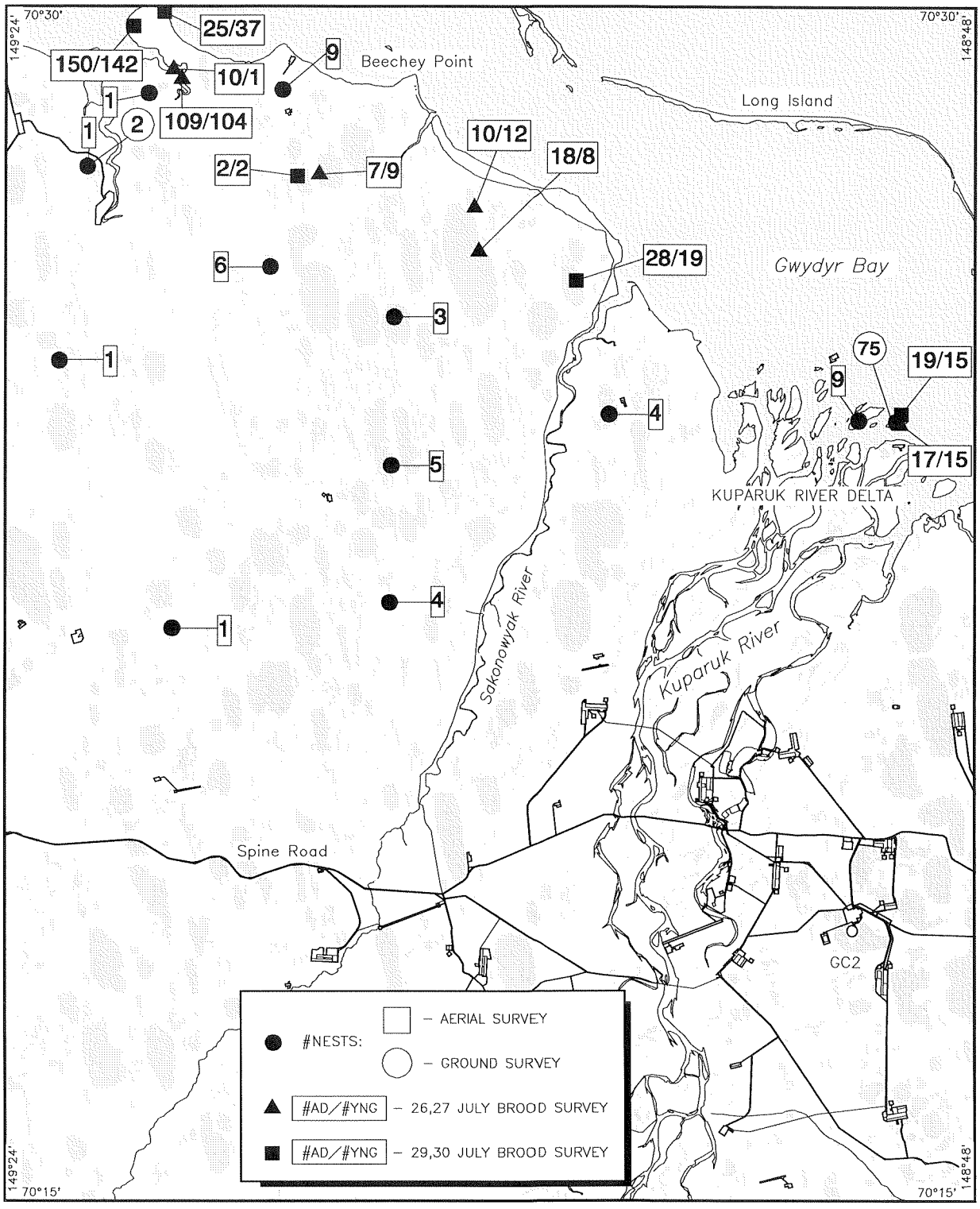
0 1 2 3 mi
0 1 2 3 4 5 km

9B



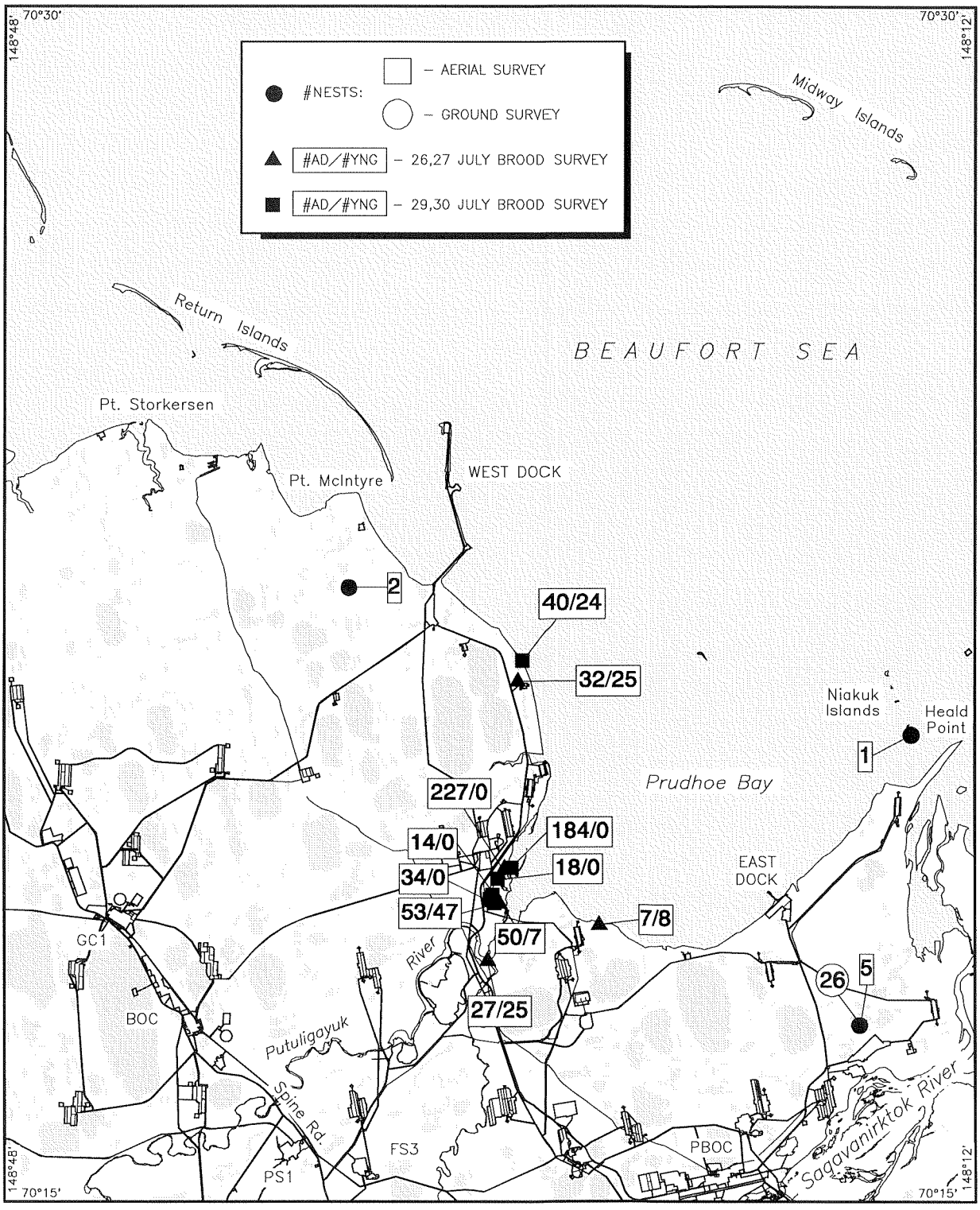
Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-5 & C-5); coastline, facilities and major rivers updated from aerial photography (1973-1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 93BPB-5.MAP, 9 Nov 1993

9C



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: 93BPB–4.MAP, 3 Nov 1993

9D

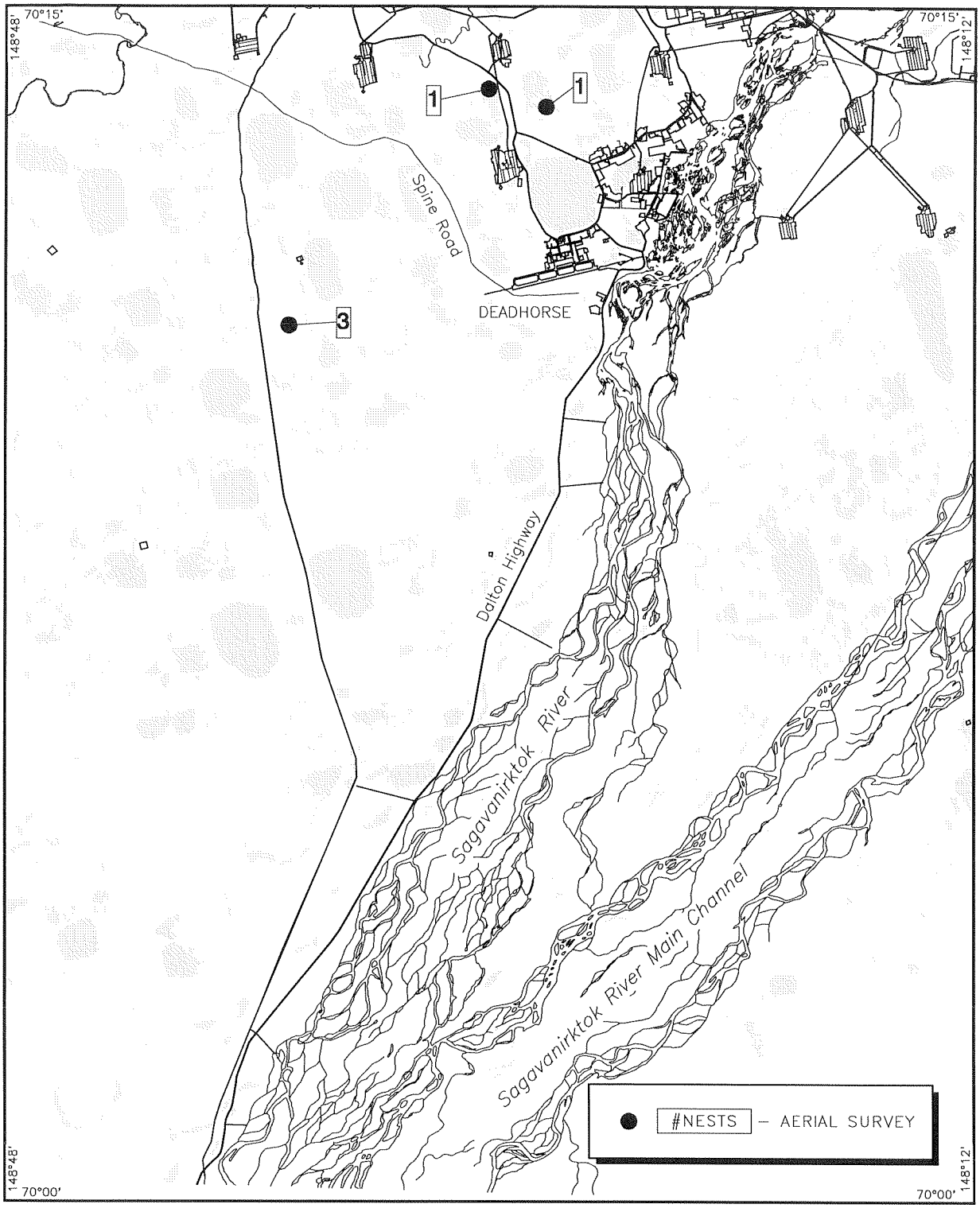


Projection: UTM6/NAD27
Digital map provided by AeroMap U.S., Inc., based on USGS 1:63,360 quad (Beechey Pt. B-3); coastline, facilities and major rivers updated from aerial photography (1973–1990).
Map produced by Alaska Biological Research, Inc.
ABR Mapfile: 93BPB-3.MAP, 3 Nov 1993

N

0 1 2 3 mi
0 1 2 3 4 5 km

9E



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: 93BPA–3.MAP, 9 Nov 1993

N

0 1 2 3 mi
0 1 2 3 4 5 km