annually from 1989 to 1991 during brood-rearing, but increased annually during fall staging. For some habitats, the trend of annual changes in density within the habitat was not consistent across seasons. For example, some habitats showed increasing annual densities in one season and decreasing annual densities in other seasons. These trends suggest that Northern Pintails are opportunistic in their use of habitats and can exploit suitable habitats as they become available.

Effects of Noise

Neither the abundance nor distribution of Northern Pintails changed because of increased noise from the GHX-1 facility (Tables 8 and 9). Noise levels at pintail locations did not differ significantly among years for any season except brood-rearing, when they were significantly higher in 1991 than in both 1989 and 1990. This difference probably occurred because pintail flocks were closer to CCP in 1991 than in the previous two years (Tables 8 and 10). In fact, pintails were the only species that actually used habitats closer to CCP in 1991 than in other years. This distributional pattern probably does not indicate an attraction to noisy areas, but merely that noise was not one of the important factors governing habitat choice by pintails.

OLDSQUAW

Seasonal Abundance, Distribution, and Habitat Use

Oldsquaw were less abundant than Northern Pintails, but consistently used the study area each year (Figure 24, Appendix 3). Numbers of Oldsquaw peaked during May and June and declined in early July in all years except 1991, when numbers did not decline until late July. Although Oldsquaw nest throughout the Prudhoe Bay area in low numbers, we never located a nest or saw a brood in the study area. Oldsquaw numbers were low in 1989 and occasional flocks were seen in July and August in 1990. Seasonal mean densities were significantly greater in 1990 than 1991 during pre-nesting (no pre-nesting counts were made in 1989; Table 8). During fall staging, mean densities also were significantly greater in 1990 than in both 1989 and 1991, because no Oldsquaw were recorded during fall staging in those two years. Although sightings were scattered throughout most of the study area, most observations were clustered north of NGI (Figure 27).

Oldsquaw occupied a narrow range of habitats dominated by water: Nearshore Waters, Open Waters, Water with Emergents, Impoundments, and Basin Wetland Complexes (Figure 28). During pre-nesting, the greatest densities occurred in Impoundments and substantially lower densities were seen in other habitats. Lower densities of pre-nesting Oldsquaw were recorded in 1990 than in 1991; most of those changes were due to an overall decrease in numbers in the study area, perhaps as a consequence of the colder spring weather and relative unavailability of open water early in the season in 1991. Water with Emergents supported the greatest densities during nesting each year, although densities declined annually from 1989 to 1991. Basin Wetland Complexes and Coastal Wetland Complexes were the only other habitats used in all three years during the nesting season. Only Basin Wetland Complexes received use each year during brood-rearing, but at lower densities in 1989 and 1990, than in 1991. Oldsquaw were seen in the study area during fall staging only in 1990 and used only Nearshore Waters and Water with Emergents.

Effects of Noise

Oldsquaw did not change either their abundance or distribution due the changes in the levels of noise emanating from CCP (Tables 8 and 10). Although the distribution of Oldsquaw during nesting changed significantly among years, the distance of Oldsquaw flocks to CCP actually was less in 1991 than in 1990. Noise levels were not significantly different among years for any season (Table 11).

KING EIDER

Seasonal Abundance, Distribution, and Habitat Use

King Eiders were most abundant in the study area during pre-nesting and nesting each year and declined in abundance by early July (Figure 29, Appendix 3). During pre-nesting, mean densities of King Eiders were significantly greater in 1990 than in 1991 (no counts made during pre-nesting in 1989; Table 8). Sightings during pre-nesting were clustered in wetlands in the northern third of the study area, particularly north of NGI

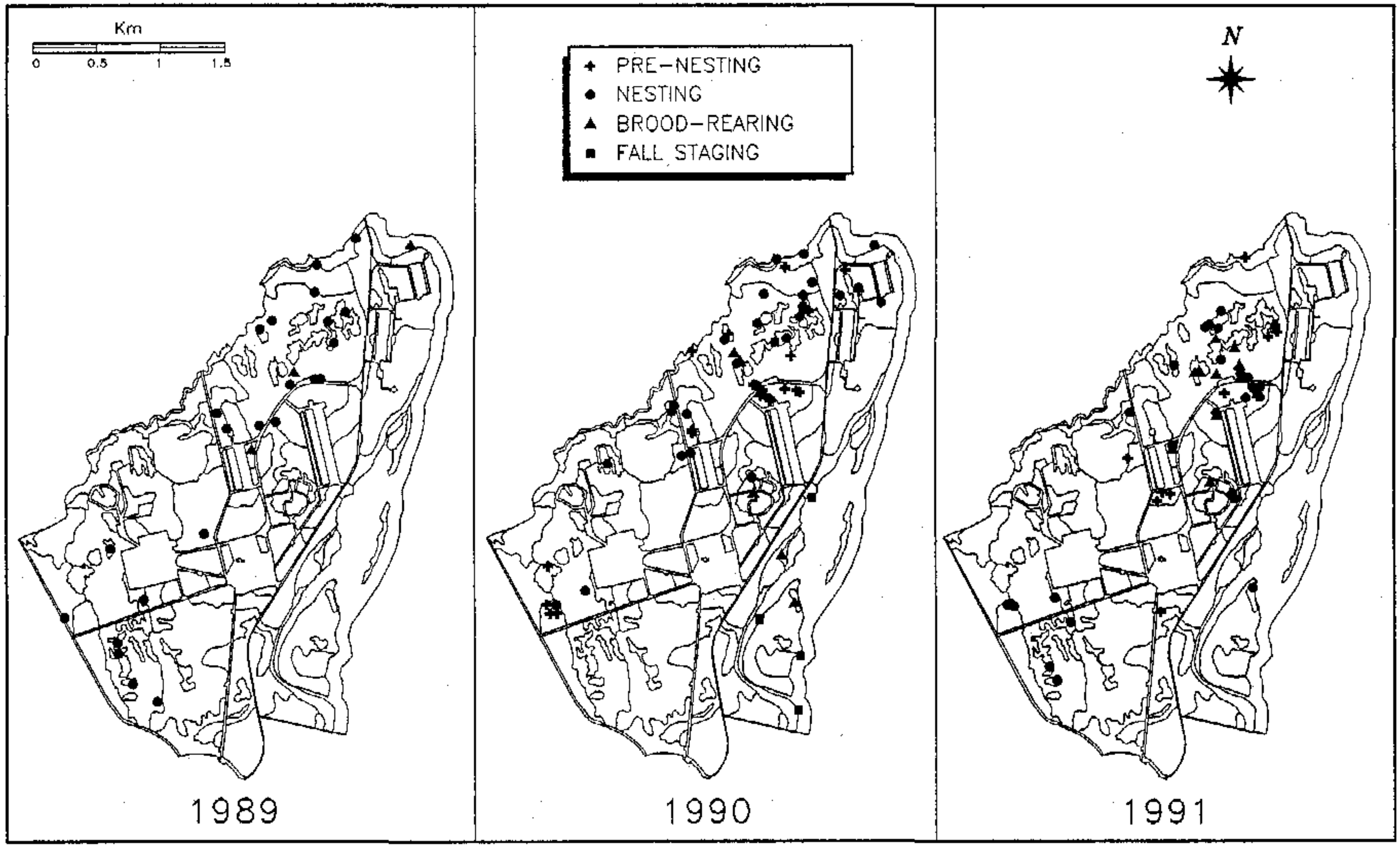

Figure 27. Distribution of Oldsquaw during all seasons in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Each flock sighting was of one or more birds.

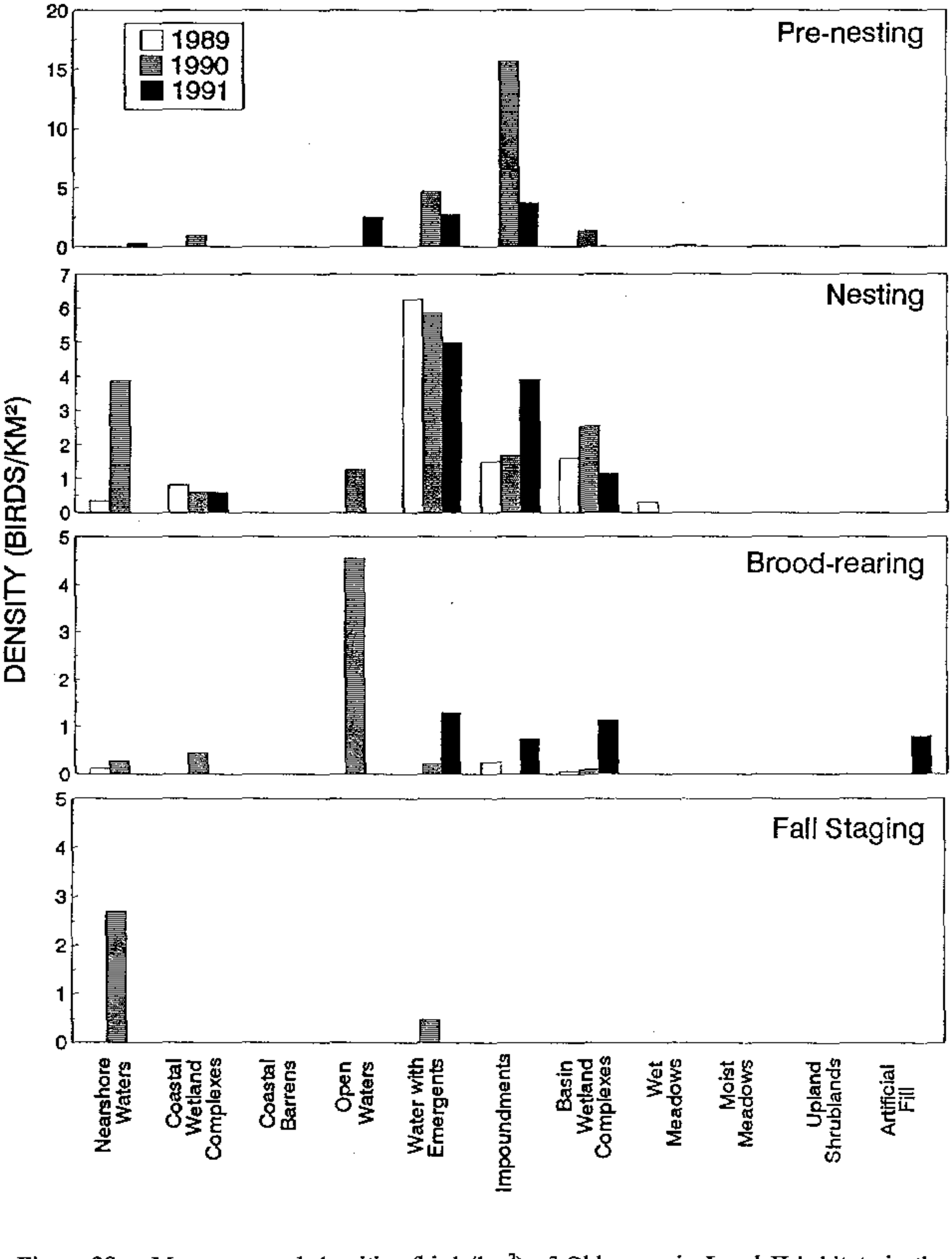

Figure 28. Mean seasonal densities (birds/km²) of Oldsquaw in Level II habitats in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

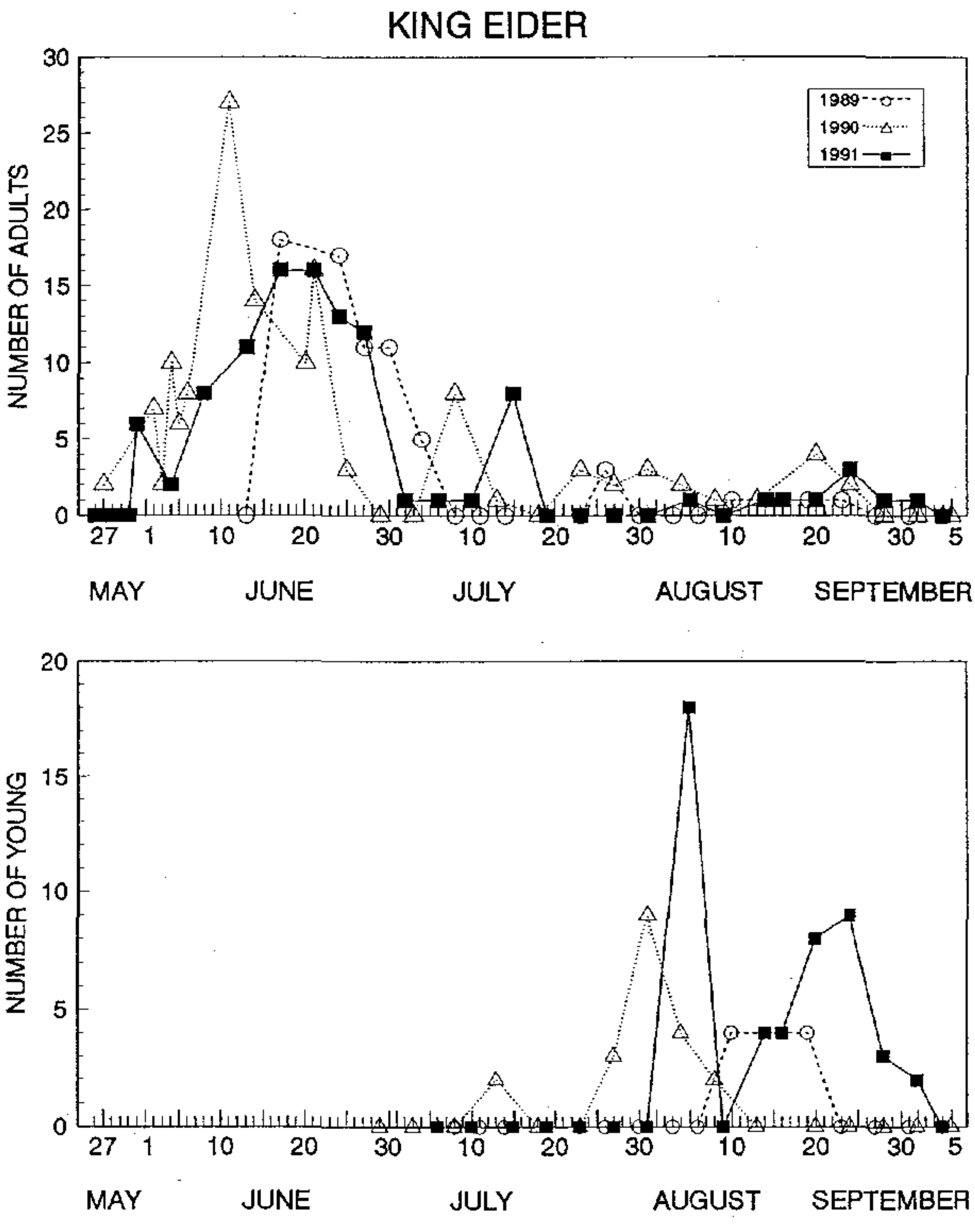

Figure 29. Counts of adult and young King Eiders from road and foot surveys in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

in both 1990 and 1991, and west of CGF in 1990 (Figure 30). King Eiders were seen in only three habitats (Impoundments, Water with Emergents, and Basin Wetland Complexes) during pre-nesting in 1990 and in only one habitat (Water with Emergents) in 1991 (Figure 31).

King Eiders were seen frequently during nesting, although no nests were found in the study area (Figures 29 and 30). During nesting, King Eiders occurred throughout most of the study area in all years but occurred most often north of NGI and south and west of CGF; eiders also used coastal tundra southeast and east of CCP. King Eiders used a more diverse group of habitats during the nesting season than they did during pre-nesting, with aquatic habitat types predominating (Figure 31). Annual differences in the level of habitat use were apparent for Water with Emergents, where densities decreased markedly in 1991 from those in 1989 and 1990. This decline in use cannot be attributed entirely to differences in abundance, because mean densities during nesting were similar among years (Table 8).

Although we found no nests, one or two broods of King Eiders were sighted annually (Figures 29 and 30). The total number of young per brood fluctuated between 2 and 18 during the study, primarily because of the tendency for brood aggregation (creching) in eiders, where more than one brood will be attended by one or more females. The presence of broods in the study area indicated either that nests were missed during the nest searches or that broods moved into the study area. Mean densities of both adults and young did not differ significantly among years (Table 8). Broods were seen primarily in the vicinity of NGI and west and south of CGF (Figure 30). During brood-rearing, only three habitats (Water with Emergents, Impoundments, and Basin Wetland Complexes) were used by King Eiders, and only Basin Wetland Complexes was used annually (Figure 31).

Low numbers of King Eiders remained in the study area during fall staging in any year (Table 8). Fall-staging eiders were seen in scattered locations, usually in areas also frequented during brood-rearing (Figure 30). Water with Emergents was the only habitat used annually by fall-staging eiders, and densities increased each year between 1989 and 1991 (Figure 31). The only other habitats used during fall staging were Nearshore Waters and Basin Wetland Complexes.

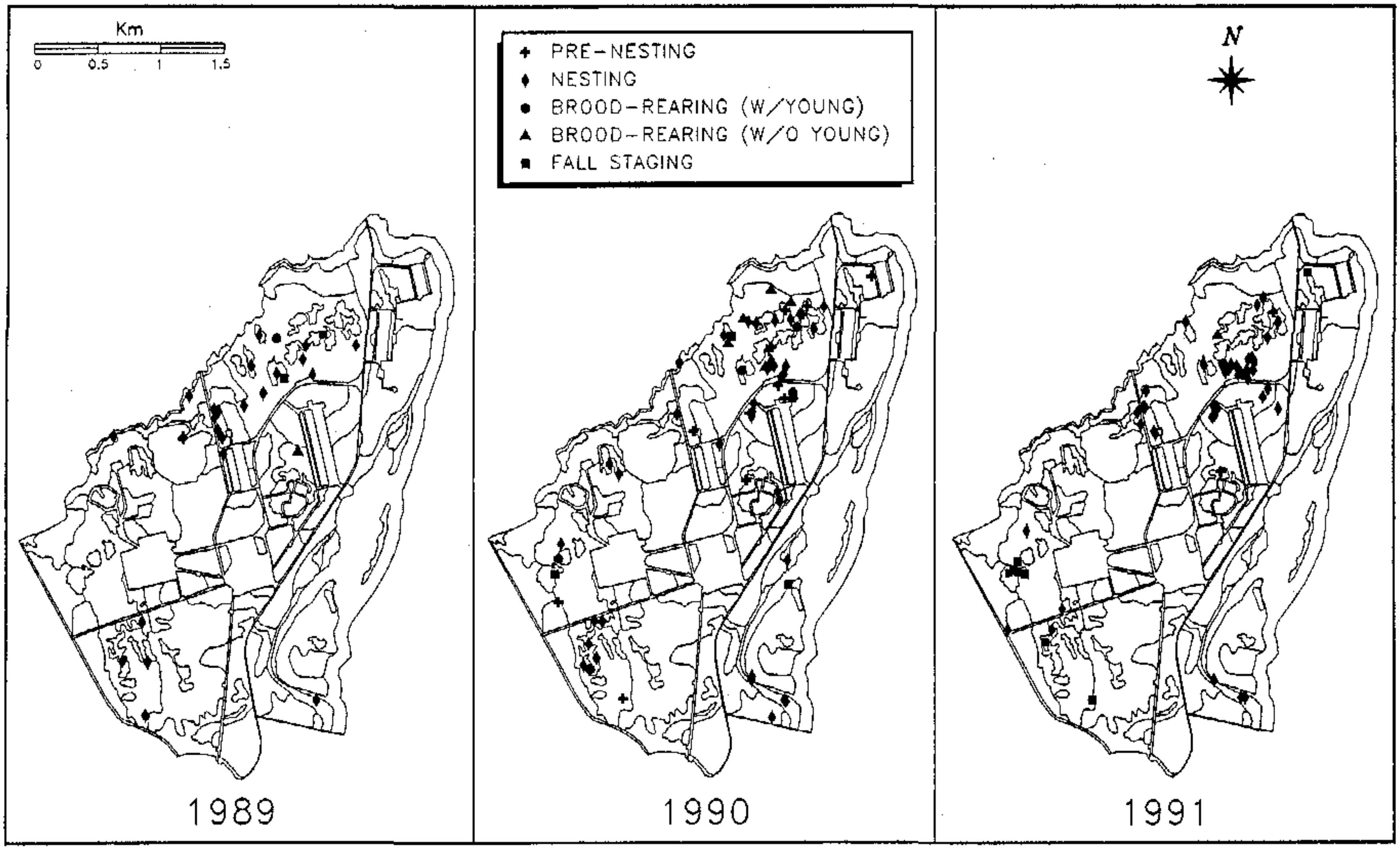

Figure 30. Distribution of King Eiders during all seasons in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Each flock sighting was of one or more birds.

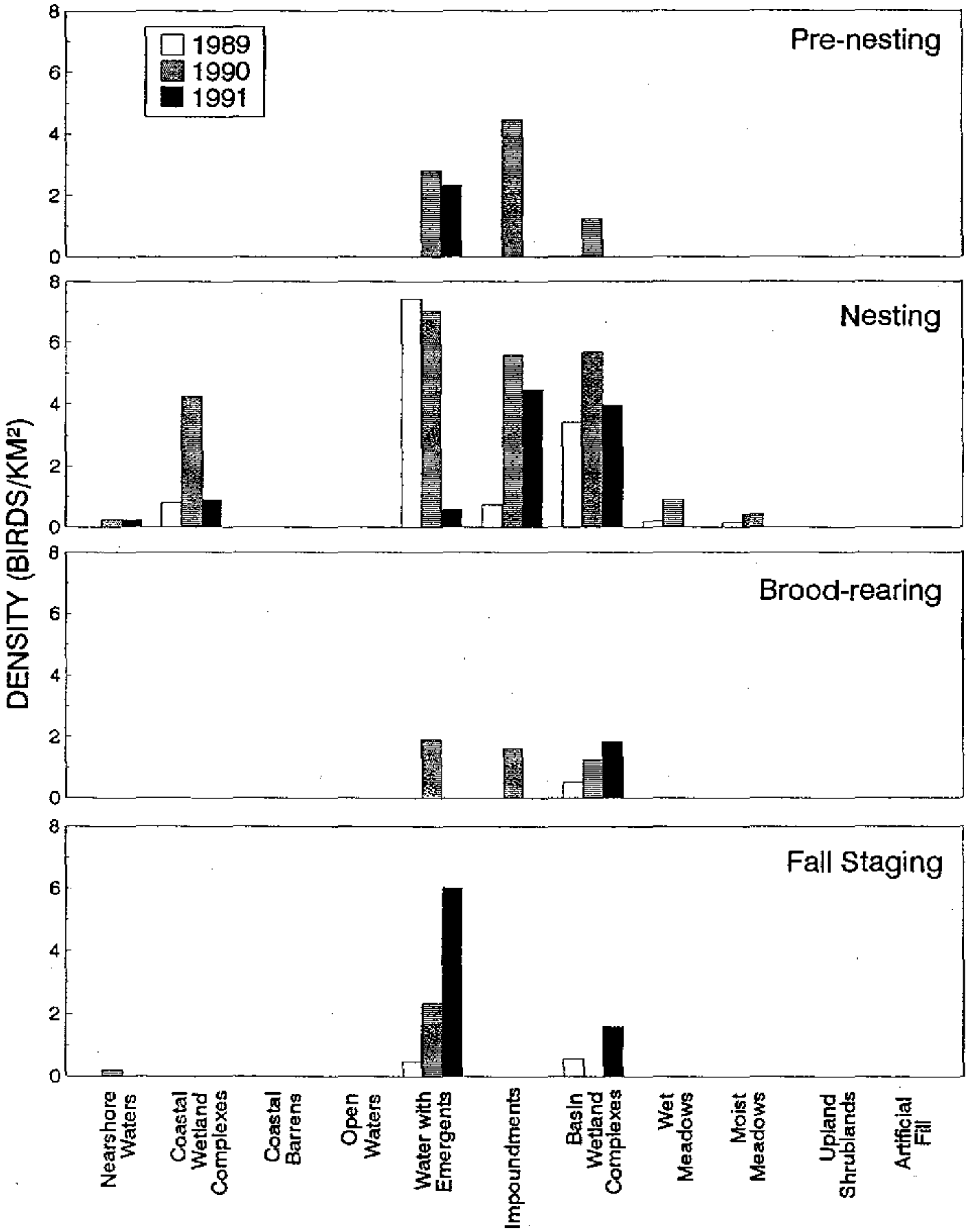

Figure 31. Mean seasonal densities (birds/km²) of King Eiders in Level II habitats in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

Effects of Noise

King Eiders changed in abundance only during pre-nesting, when fewer eiders were seen in 1991 than in 1990 (Table 8). This difference probably was related more to the later spring breakup in 1991 than to changes in noise levels. Mean estimated noise levels at King Eider locations did not differ significantly among years for any season, and the distribution of those eiders relative to CCP and the GHX-1 facility also did not differ significantly among years (Tables 9 and 11).

SPECTACLED EIDER

Seasonal Abundance, Distribution, and Habitat Use

Spectacled Eiders were less abundant than King Eiders during most seasons and years (Figure 32, Appendix 3). The only consistent trend in numbers of Spectacled Eiders was a tendency for numbers to be high during late May and early June. This trend would be expected, because this is the period when male eiders are still present on the breeding grounds and would be counted during surveys. An evaluation of annual trends in abundance, distribution, and habitat use of pre-nesting Spectacled Eiders were hampered, because we did not count them during pre-nesting in 1989 and none used the study area during pre-nesting in 1991. In 1990, however, Spectacled Eiders often were seen with King Eiders and were distributed similarly in the study area: north of NGI, near the CCP flarepit , and southwest of CGF (Figure 33). Spectacled Eiders used only four habitats during pre-nesting, with the greatest density occurring in Impoundments (Figure 34).

Low numbers of Spectacled Eiders were seen during nesting, and densities were not significantly different among years (Figure 32, Table 8). In all three years, Spectacled Eiders used the northern half of the study area, around NGI and northwest of WGI; in 1990, however, they also occurred west and south of CGF and along the coast southeast of CCP (Figure 33). Only Basin Wetland Complexes were used annually during nesting (Figure 34). Water with Emergents and Impoundments were used in two of three years, and Coastal Wetland Complexes and Open Waters were used in only one year.

Although no Spectacled Eider nests were found in the study area, we recorded high counts of 19 young (one creche [several broods] of 15 young and a brood of four young)

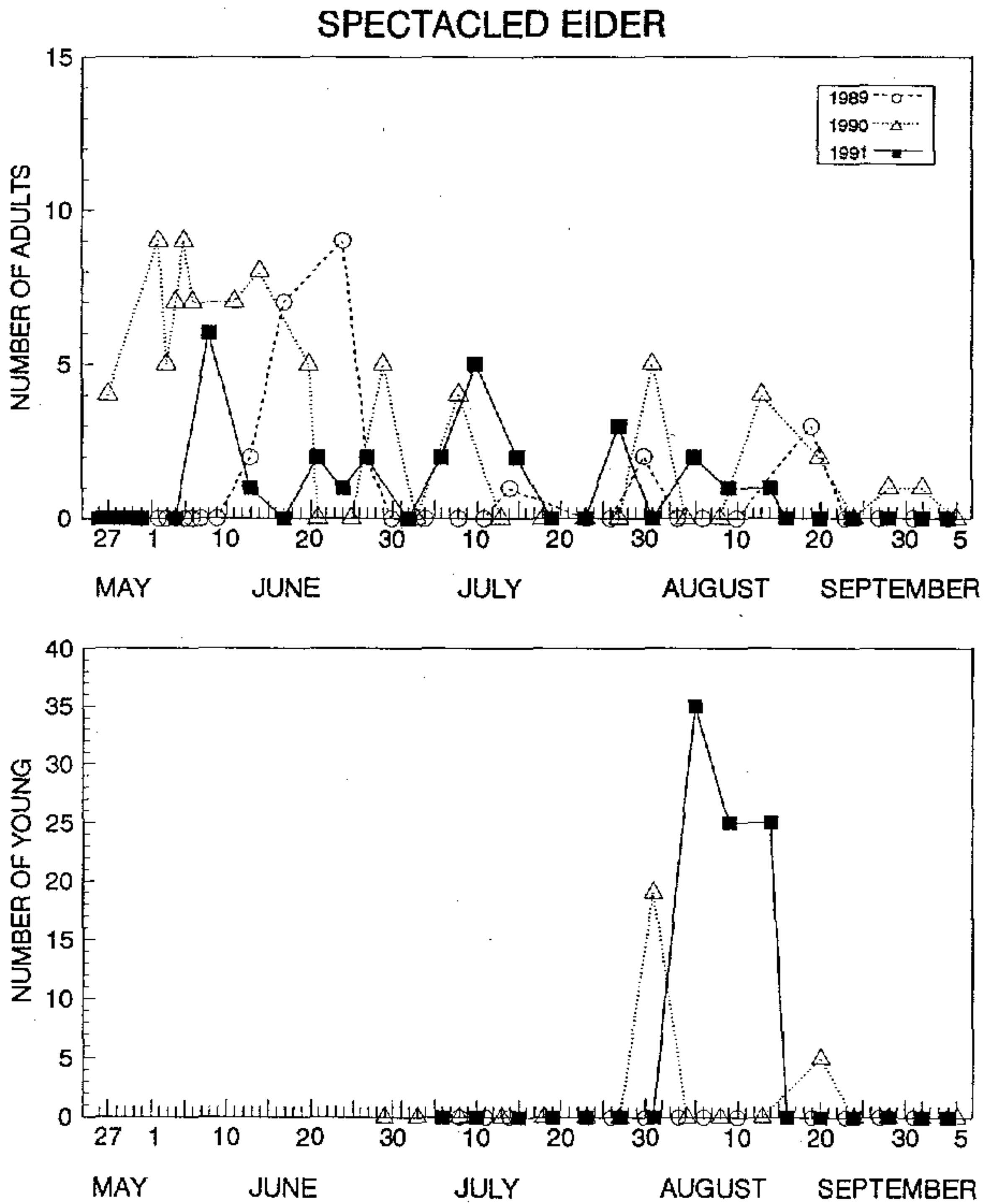

Figure 32. Counts of adult and young Spectacled Eiders from road and foot surveys in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

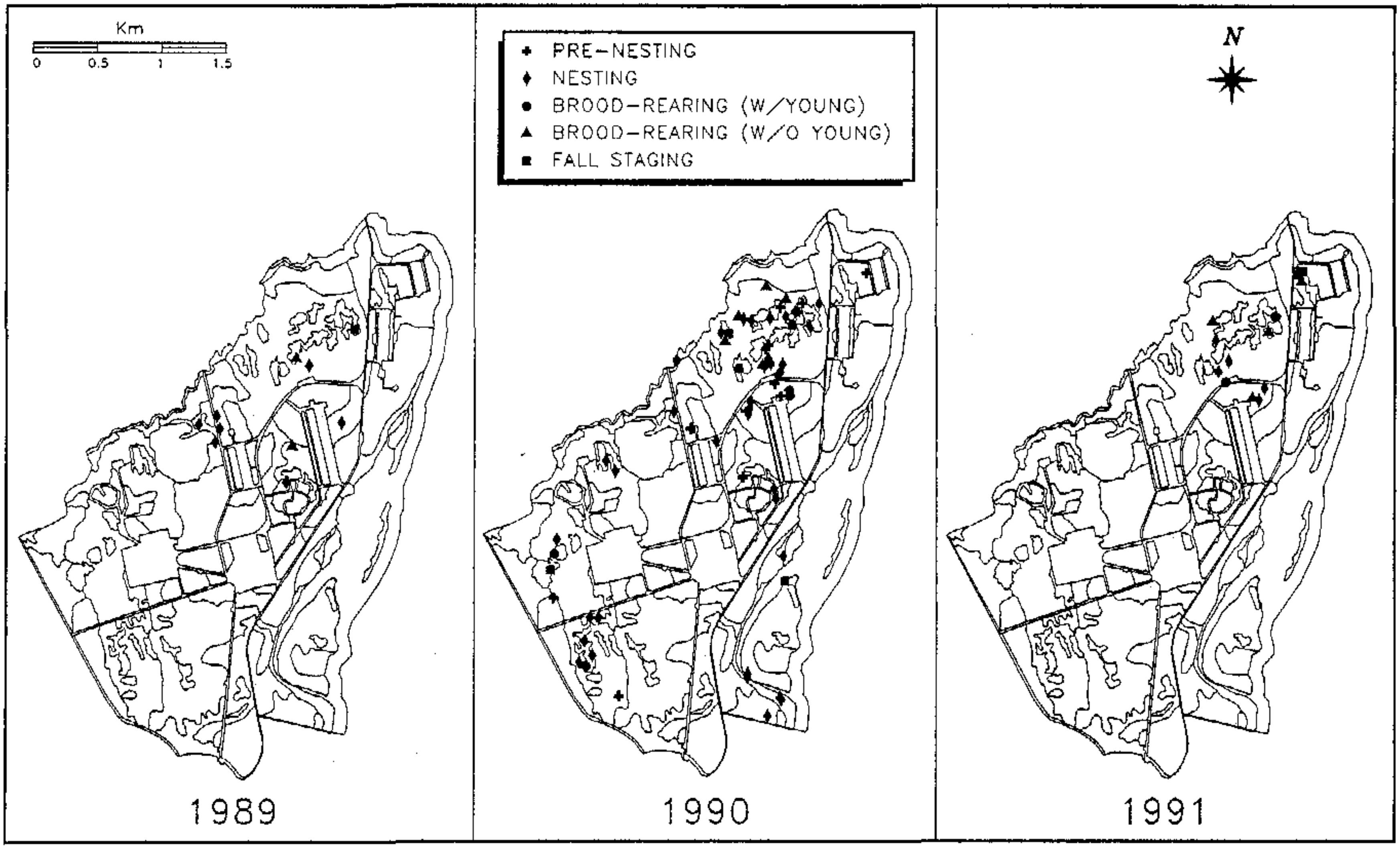

Figure 33. Distribution of Spectacled Eiders during all seasons in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Each flock sighting was of one or more birds.

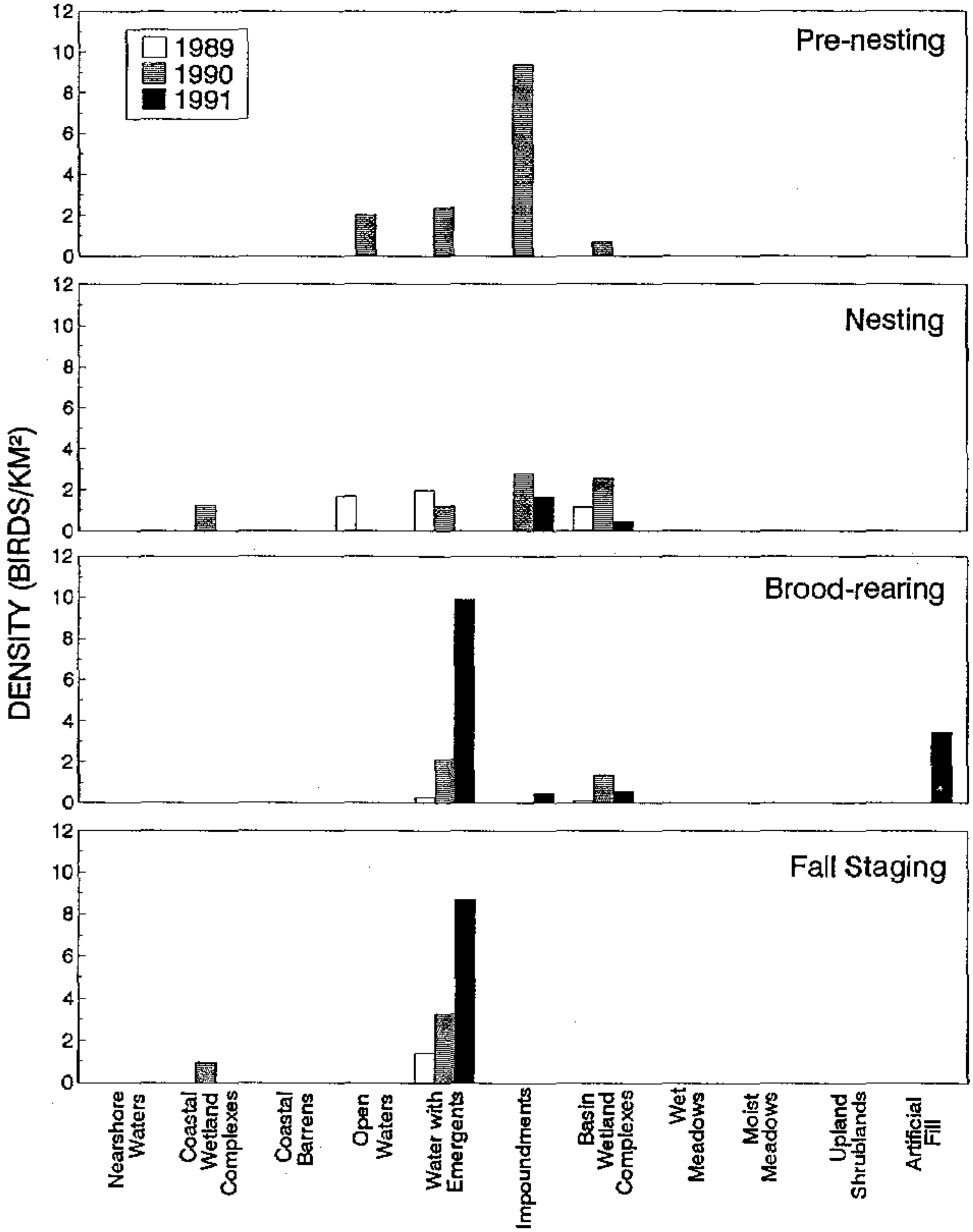

Figure 34. Mean seasonal densities (birds/km^2) of Spectacled Eiders in Level II habitats in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

on 31 July 1990 and of 35 young (in one creche attended by 2 adult females) on 5 August 1991; no broods were seen in 1989 (Figure 32, Appendix 3). The first appearance of these broods late in the brood-rearing season suggested that they had moved into the study area, rather than being from nests that were missed during nest searches. Broods were seen primarily in the northern half of the study area near NGI in both years and west of CGF in 1990 (Figure 33). Water with Emergents supported the greatest annual densities of Spectacled Eiders, although densities differed markedly among years (Figure 34). Only one other habitat, Basin Wetland Complexes, was used annually.

Few Spectacled Eiders were seen during fall staging in any year (Figure 32, Table 8). Fall-staging eiders occurred in wetlands north and west of DS-L1 in all years and on the mainland and coastal island southeast of CCP in 1990 (Figure 33). Coastal Wetland Complexes and Water with Emergents were the only habitats used during fall staging (Figure 34). Annual increases in density were recorded in Water with Emergents, but sample sizes were small for this season.

Effects of Noise

Mean distances of Spectacled Eider flocks to CCP during nesting were significantly different only between 1989 and 1991: flocks occurred farther from CCP in 1991 and thus experienced significantly lower noise levels that year (Tables 10 and 11), suggesting that Spectacled Eiders were exhibiting avoidance of the increased noise from the GHX-1 facility in 1991. A comparison of the distribution of Spectacled Eiders during nesting in 1989 and 1991 indicated that the changes between years were due primarily to lower use of areas north and northeast of CCP in areas where a 1-3 dBA increase in noise from GHX-1 turbines was apparent. The analysis of covariance model indicated that noise levels at eider locations were determined primarily by the distance of the flocks to CCP and that, although it was not a significant factor in the model, distance to CGF had a small contribution to those noise levels (Appendix 4). Although sample sizes are small for these analyses, a trend is apparent in these data indicating some avoidance of areas with increased noise levels in 1991.

PACIFIC LOON

Seasonal Abundance, Distribution, and Habitat Use

Pacific Loons arrived in the study area each year during the first ten days of June, and loon numbers increased rapidly during pre-nesting before stabilizing at about ten birds throughout the nesting season (Figure 35, Appendix 3). During pre-nesting, mean densities did not differ among years (Table 8). Pre-nesting loons were seen primarily in the northern and western halves of the study area, usually near subsequent nest sites (Figure 36). Pacific Loons primarily used habitats characterized by the presence of water (Figure 37). Observations in Basin Wetland Complexes were of loons using small ponds that were of insufficient size to be mapped as separate habitats. Pacific Loons occurred in the greatest densities in Water with Emergents during pre-nesting in both 1989 and 1990, but were present in greatest density in Open Waters in 1991. Only Water with Emergents and Impoundments received annual use. The major annual differences noted were a decline in use of Water with Emergents in 1991 from that in 1989 and 1990 and an slight increase in use of Open Waters in 1991 from that in 1990.

The number of pairs nesting in the study area varied between six (1989 and 1991) and eight (1990), whereas the number of nests varied between six (1989) and nine (1991). These additional three nests in 1991 were re-nesting attempts by pairs that had lost their first nest (Figure 38). Two of these re-nesting attempts were located within several meters of the previous nest site, and the third re-nesting attempt (north of NGI) was located about 50 m to the east of the first nest. Like Canada Geese, Pacific Loons reused nest sites during the three years of study: of the 18 different nest sites located in the study area, one (6%) site was reused in two years and two (11%) sites were used in all three years. Loon nests were located primarily in Water with Emergents (13 [57%] of 23 nests) (Table 9); all of those nests were in aquatic grass (*Arctophila*) ponds. Other habitats used for nesting included Impoundments (3 nests; 17%), Open Water (3 nests; 13%), and Basin Wetland Complexes (3 nests; 13%). These nest locations are reflected in the greatest densities of Pacific Loons occurring in Water with Emergents each year (Figure 37).

During brood-rearing, densities of both adult and young Pacific Loons differed significantly among years, with densities of both adults and young lower in 1989 than in

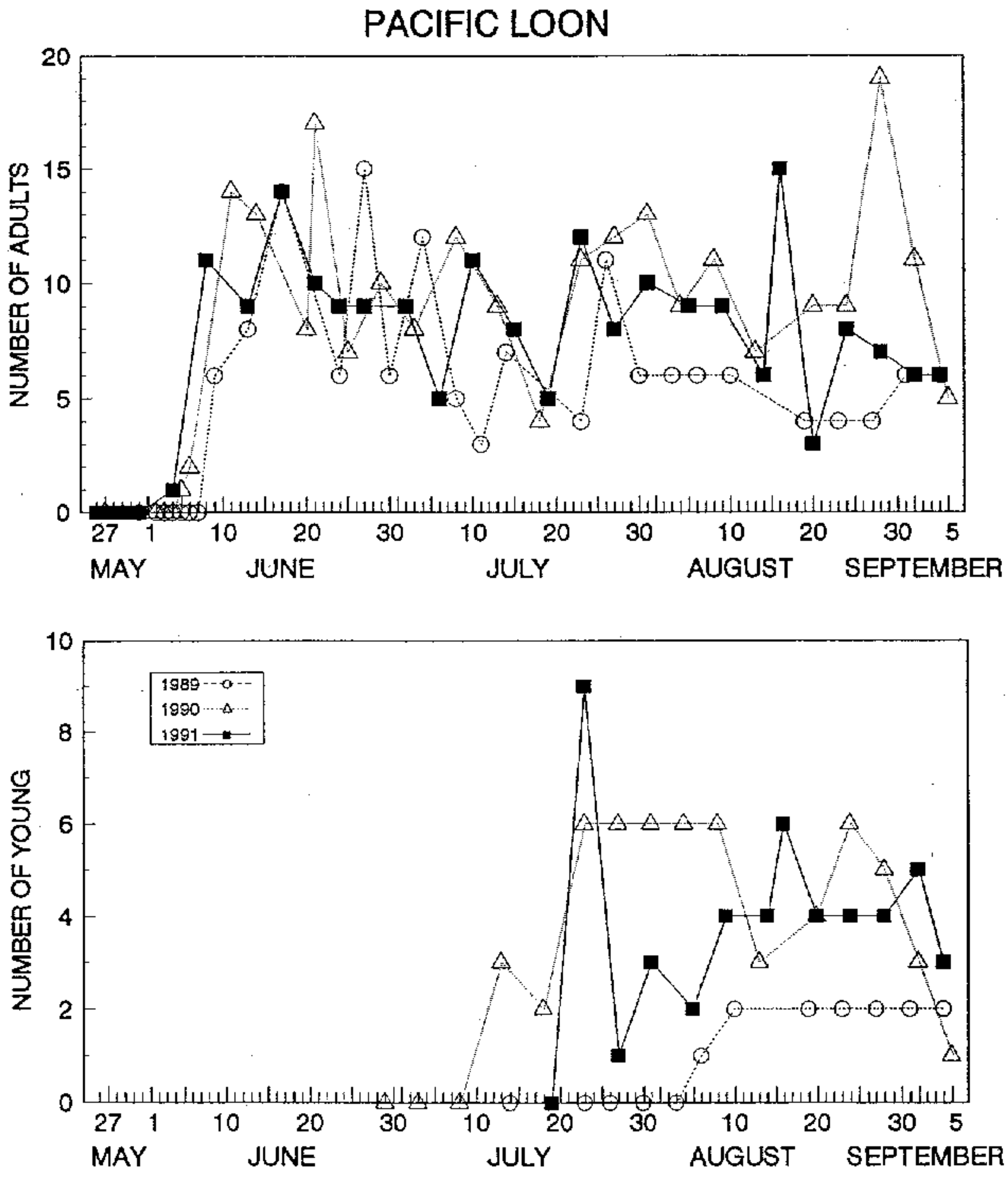

Figure 35. Counts of adult and young Pacific Loons from road and foot surveys in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

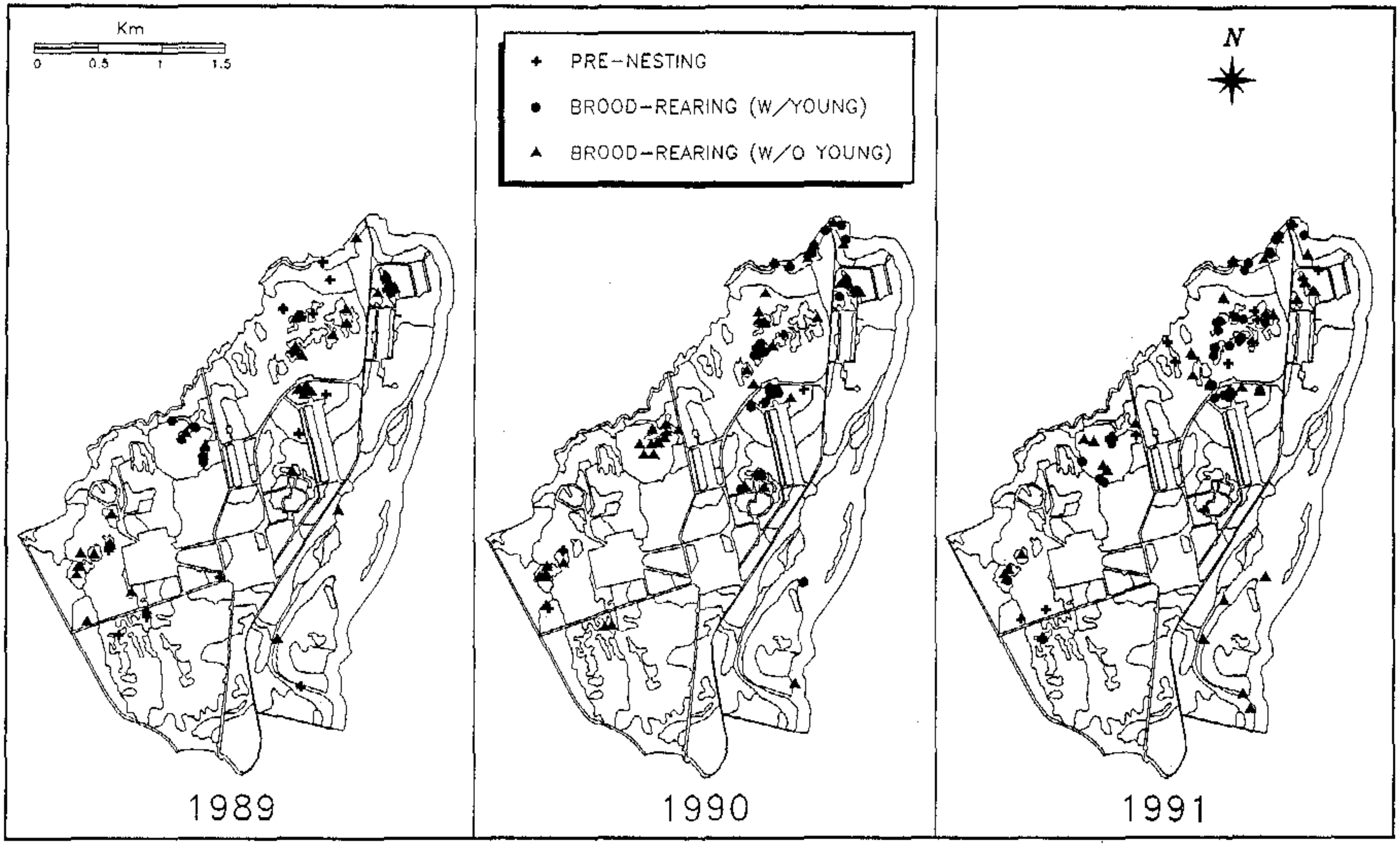

Figure 36. Distribution of Pacific Loons during pre-nesting and brood-rearing in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Each flock sighting was of one or more birds.

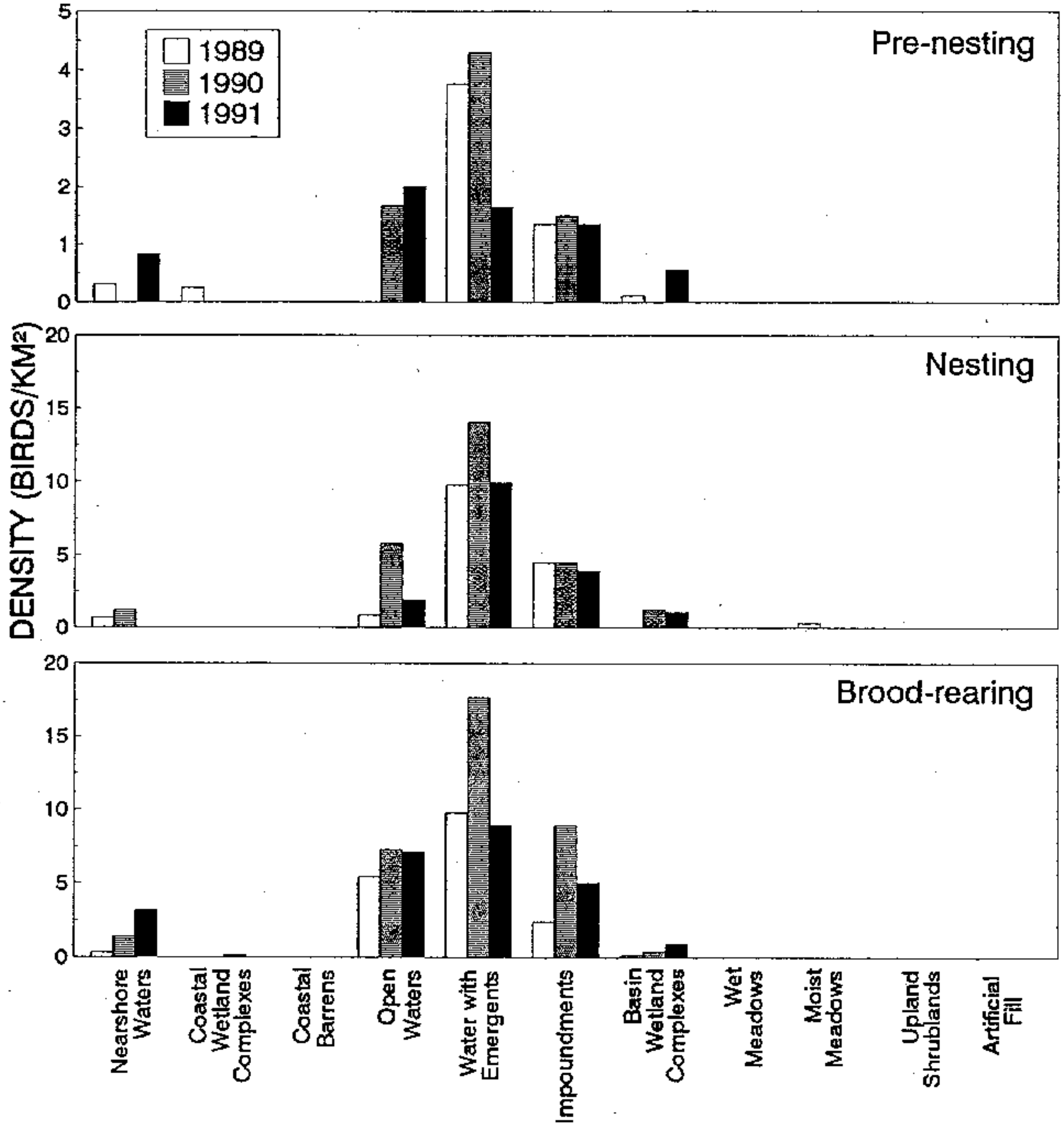

Figure 37. Mean seasonal densities (birds/km^2) of Pacific Loons in Level II habitats in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

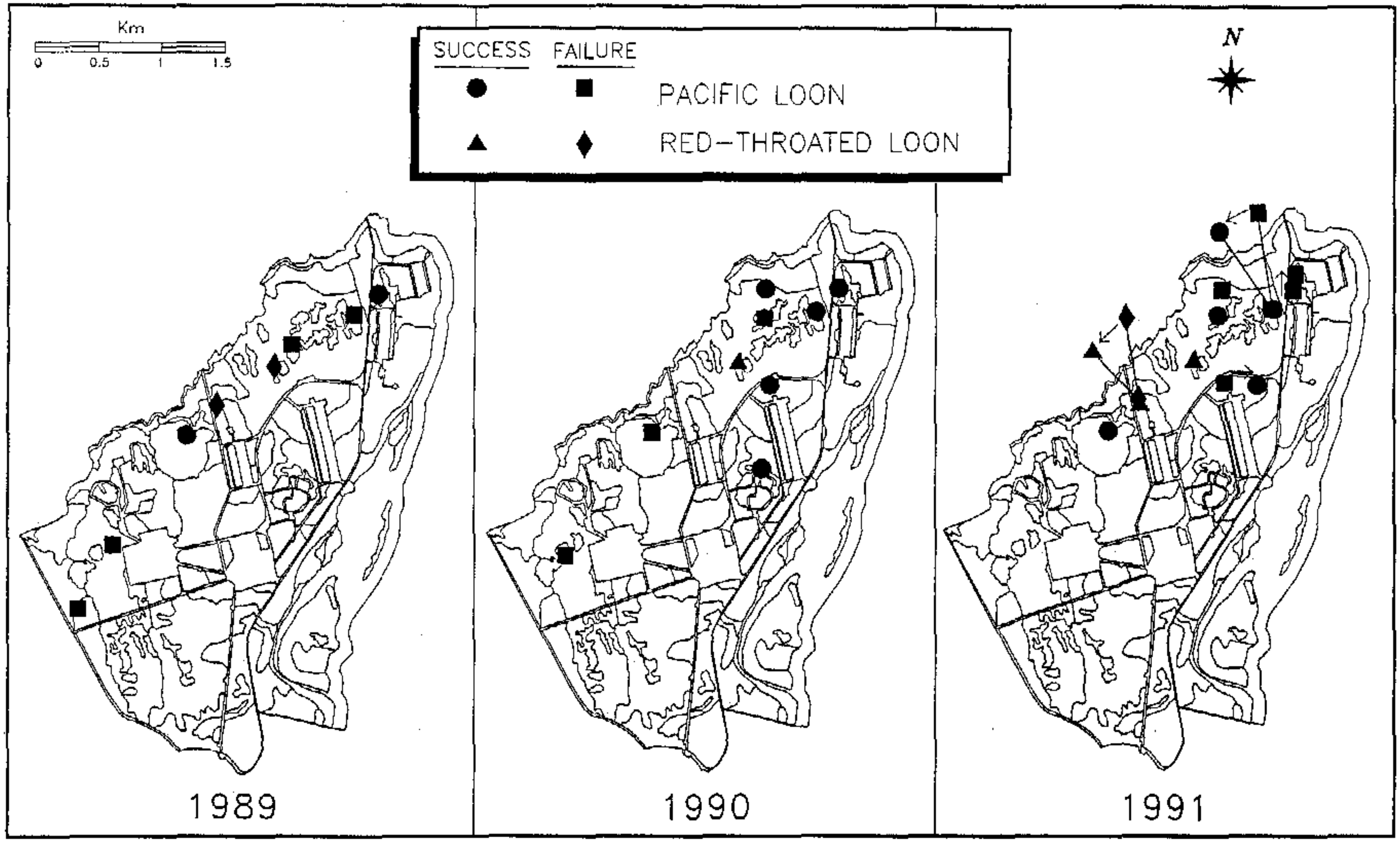

Figure 38. Location and nest fate of Pacific and Red-throated loon nests in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Arrows in 1991 indicate re-nesting attempts; the base of the arrow is the first nest site, the head of the arrow is the subsequent re-nesting site.

both 1990 and 1991 (Table 8). Within a year, the fluctuations in the number of young seen during the season could be attributed to mortality, but some of this variability also was due to the difficulty in seeing all young on each survey, particularly during weather conditions when young loons seek shelter along the grassy margins of their brood-rearing ponds (Figure 36). Most sightings during brood-rearing were clustered around the nest sites (Figure 38), because young loons cannot easily move across open tundra that separates ponds and tend to remain in their natal pond until fledging (Figure 36). Some young loons were seen in the unnamed stream north of LGI in both 1990 and 1991, however, suggesting that some movements away from natal ponds did take place. The major habitats used during brood-rearing were almost identical to those used during nesting, although some annual changes in density were apparent (Figure 37). Annual variations in densities in habitats used every year indicated that the level of use was greatest in 1990, with lower levels in other years for most habitats. Only Nearshore Waters showed increasing densities from 1989 to 1991.

Because of the early onset of nesting, only in 1990 were Pacific Loon young fledged before the end of our field season. Thus, only in that year did we collect data on fall-staging loons. Of the four habitats used during fall staging, Open Waters and Nearshore Waters supported the greatest densities (7.5 and 6.2 birds/km^2, respectively), with lower densities in Water with Emergents (4.7 birds/km^2) and Impoundments (1.1 birds/km^2).

Effects of Noise

Only during brood-rearing did the abundance of Pacific Loons change significantly among years; the trend was for more loons in 1991 and 1990 than in 1989, which was not the expected trend if noise was adversely affecting abundance (Table 8). During brood-rearing, mean estimated noise levels at the locations of loons were significantly higher in 1991 than in 1990, but were not higher than in 1989 (Table 11). The mean distance of flocks to CCP actually was greater in 1991 than in both 1989 and 1990, although not significantly greater (Table 10). This combination of increased noise and greater distance to CCP in 1991 suggested that not all the increase in noise experienced by Pacific Loon flocks could be accounted for by the new GHX-1 turbines alone. The location of many of the brood-rearing flocks near DS-L1 suggested that at least some of the differences in noise among years could be attributed to noise emanating this drill site, which is also a noise source in the study area. Pacific Loons were the only waterbirds that frequently used the Open Waters habitat type, which apparently received higher noise levels under north and northeast winds (see NOISE SURVEY AND MODELING OF THE GHX-1 FACILITY above). Densities of loons in the Open Waters habitat were annually variable in each seasons, but the trends in densities did not indicate substantial declines in 1991 when compared to 1989 or 1990 (Figure 37).

RED-THROATED LOON

Seasonal Abundance, Distribution, and Habitat Use

Red-throated Loons did not arrive in the study area until after 10 June in all three years (Figure 39 and Appendix 3). Red-throated Loons are rare in the GHX-1 study area during pre-nesting, and most pairs are seen near subsequent nest sites (Table 8, Figure 40). Red-throated Loons used only two habitats during pre-nesting: Water with Emergents and Impoundments (Figure 41); neither of those habitats was used all three years.

Approximately two pairs of Red-throated Loons attempted to nest in the study area during each year, although actual numbers of nests ranged from one in 1990 to three in 1991 (Figure 38). A second nest was probable in 1990, because of the presence of a young loon in an area where we did not find a nest during the nest searches, and the third nest in 1991 was a re-nesting attempt by a pair of loons that had their first nest destroyed by a predator (Figure 38). Of the six nesting attempts in the three years of this study, half were in Water with Emergents (a single nest site, reused each year) and half were in Basin Wetland Complexes (Table 9). As was the case for Pacific Loons, densities of Red-throated Loons by habitat during nesting simply reflected those habitats that supported nests (Figure 41).

Seasonal densities of both adults and young differed significantly among years, with lower densities in 1989 than in both 1990 and 1991 (Table 8). Sightings of adults with young were restricted to the natal pond (Figure 40). Given this distributional pattern, it was not unexpected that habitats used by brood-rearing Red-throated Loons reflected

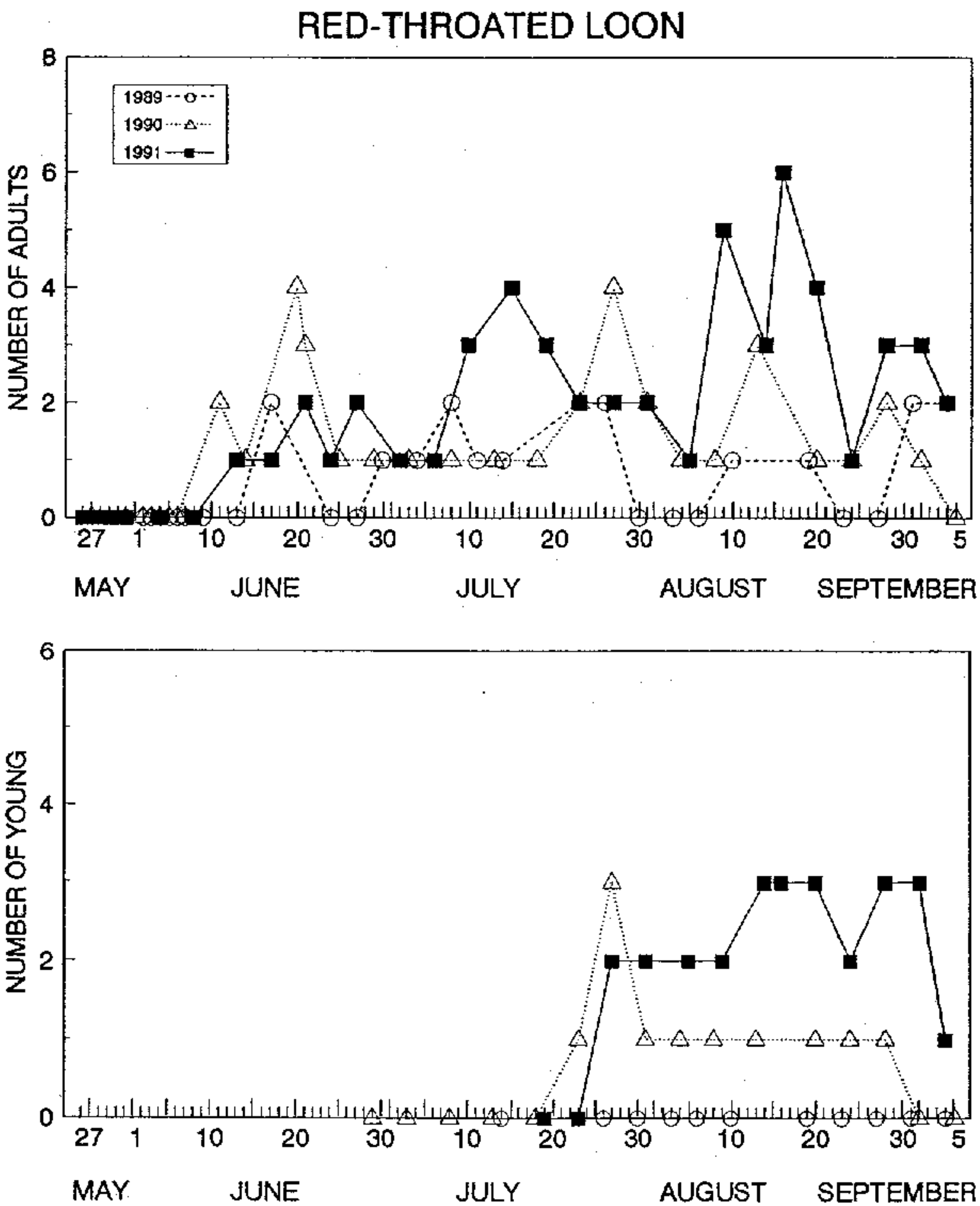

Figure 39. Counts of adult and young Red-throated Loons from road and foot surveys in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

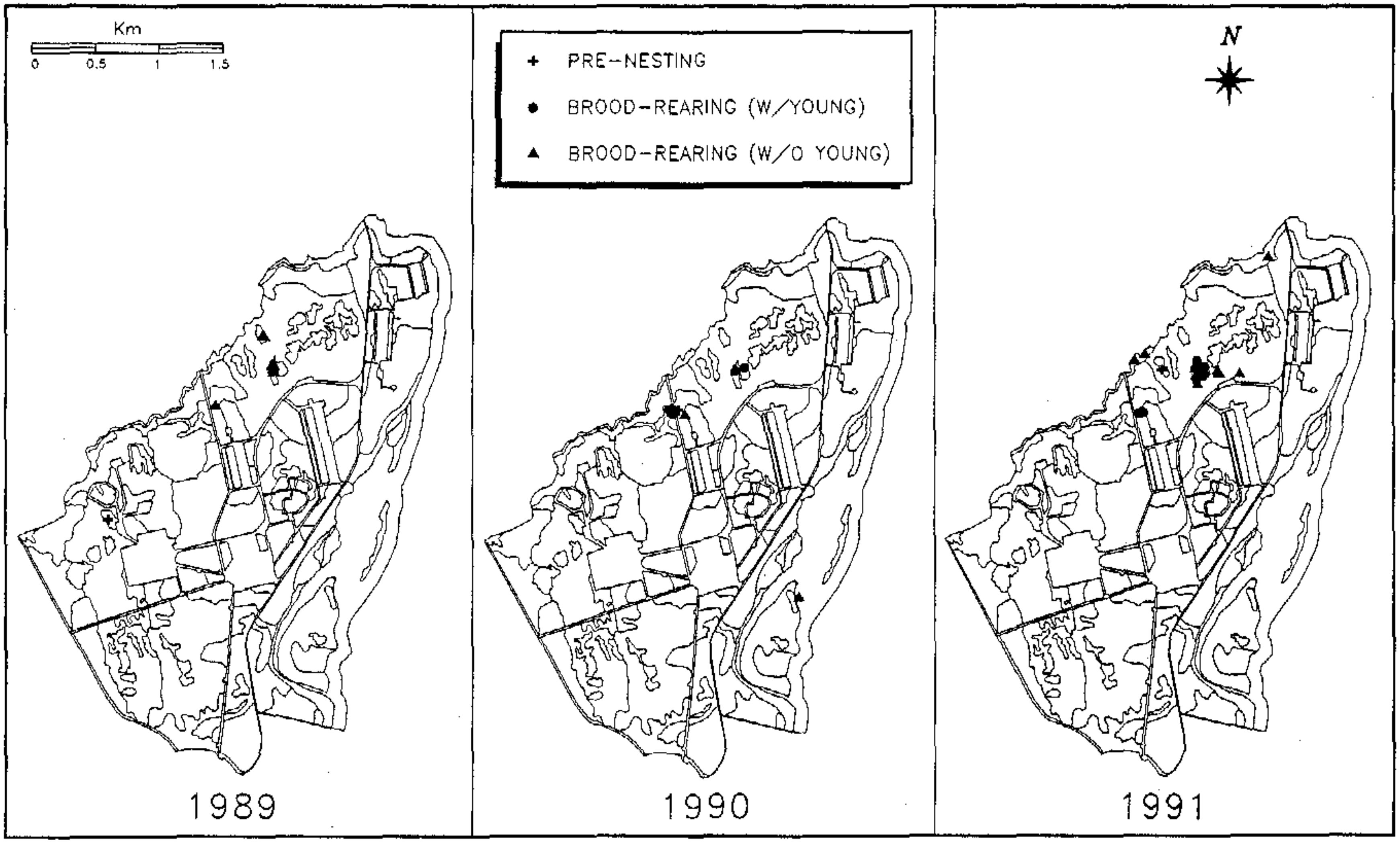

Figure 40. Distribution of Red-throated Loons during pre-nesting and brood-rearing in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Each flock sighting was of one or more birds.

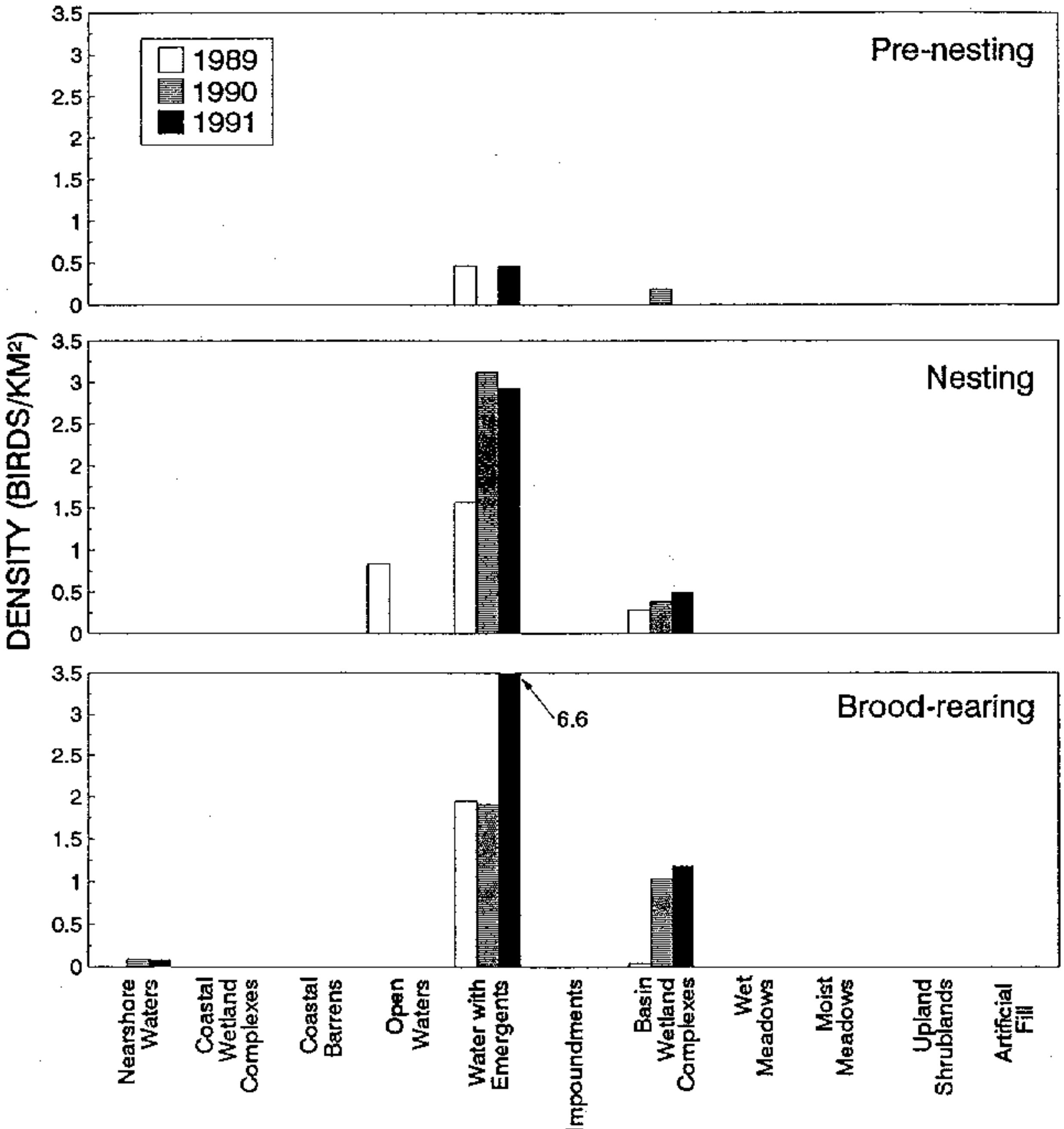

Figure 41. Mean seasonal densities (birds/km²) of Red-throated Loons in Level II habitats in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

the same patterns of nest locations (Figure 41). The large annual differences in the densities in Water with Emergents was the result of a greater number of both adults and young seen in that habitat in 1991 than in the two previous years. Only one other habitat, Basin Wetland Complexes, was used annually during brood-rearing. Only one Red-throated Loon was seen during fall staging in 1990 (Appendix 3). This loon was seen approximately 1300 m from CCP in a Basin Wetland Complex (Table 10).

Effects of Noise

Effects of noise from the GHX-1 facility on Red-throated Loons were difficult to assess, because of small sample sizes for most seasons and years. Only during brood-rearing was the sample adequate enough to make annual comparisons possible. Brood-rearing flocks occurred significantly farther from CCP in 1991 than in 1990; however, distances in 1991 were similar to those in 1989 (Table 10). Estimated mean noise levels at the locations of loon flocks also were significantly higher in 1991 than in 1989, but did not differ in 1990 and 1991. Most of these differences in both distances to CCP and noise levels resulted from changes in the distribution of brood-rearing flocks along the waterflood pipeline northwest of WGI and were not directly attributable to noise associated with the GHX-1 facility.

BREEDING BIRDS, NEST FATE, AND THE EFFECTS OF NOISE ON NESTING SUCCESS

Evaluating the level of breeding effort by waterbirds in the GHX-1 study area is one of the objectives of this study. In this section, we present the results of nest searches and evaluations of nest fates for all nests. In addition, we examine natural and development-related factors, such as increased noise from the GHX-1 facility, that could have influenced reproductive success.

We found nests of four species of waterbirds during the three years of study: Canada Goose, White-fronted Goose, Pacific Loon, and Red-throated Loon. The total number of nests increased annually for all species except Red-throated Loons, but overall nesting success was markedly higher in 1990 than in 1989 and 1991 (Table 12).

Table 12. Number of nests and nest fate (%) of waterbirds nesting in the GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991.

	Successful			Failed			All Fates		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Canada Goose	1 (16.7)	10 (90.9)	5 (45.5)	5 (83.3)	1 (9.1)	6 (54.5)	6	11	11
White-fronted Goose	0	1 (100)	2 (100)	0	0 (0)	0 (0)	0	1	2
Pacific Loon	2 (33.3)	5 (62.5)	4 (44.4)	4 (66.7)	3 (37.5)	5 (55.6)	6	8	9[a]
Red-throated Loon	0 (0)	1 (100)	2 (66.7)	2 (100)	0 (0)	1 (33.3)	2	1	3[b]
All Nests	3 (21.4)	18 (81.8)	13 (52.0)	11 (78.6)	4 (18.2)	12 (48.0)	14	22	25

[a] Three nests were re-nesting attempts (two were successful).
[b] One nest was a re-nesting attempt (successful).

CANADA GOOSE

The number of Canada Goose nests ranged from 6 in 1989 to 11 nests in both 1990 and 1991 (Table 12). Nesting success was highest in 1990 (90.9%) and lowest in 1989 (16.7%), and intermediate 1991 (45.5%). The causes of most (9 [75%] of 12 nests) nesting failures were unknown. In 1989, one nest was flooded and one was preyed upon by an avian predator. In 1991, one nest was destroyed by an arctic fox after the temporary impoundment surrounding the nest site dried up and allowed access to the site.

Mean distances of successful and failed nests to the nearest road, pad, and the center of the CCP and CGF facilities and mean estimated noise levels at those nests were compared among years for all Canada Goose nests and for successful and failed nests (Table 13). Mean distances to any of the facilities did not differ significantly among year for all nests, among years for successful nests, among years for failed nests, or between fates within each year. Mean estimated noise levels (dBA) at nests also did not differ significantly among years for all nests, successful nests or failed nests, and between fates within years (Table 14). Because only one nest was successful in 1989 and only one nest failed in 1990, sample sizes for the these tests were problematic, therefore, we combined those two years and tested for differences between 1989-1990 combined and 1991, both within nest fate and between fates within years. Once again, no significant differences in distances to facilities or in estimated noise levels were found among years or between fates within years for this combined data set.

The reliability of the estimated noise levels at Canada Goose nest sites could be evaluated by comparing the mean estimated noise level at two nests for which we actually measured noise levels in 1990. These two Canada Goose nests were located within 100 m of the CGF pad: the first nest was 25 m from the southwestern corner of the pad and approximately 225 m from the center of the CGF facility; the second nest was 85 m from the northwest corner of the pad and approximately 375 m from the center of the facility. The estimated noise level from the computer model for the closer site averaged 68.1 dBA during the nesting season and was measured at 68.4 dBA on 31 July 1990 (a mean of seven 5-min interval measurements). The second nest had an estimated mean noise level of 61.2 dBA during the nesting season and a measured level of 64.6 dBA on 31 July (a mean of six 5-min intervals). The estimated and measured noise levels agree closely for

Table 13. Mean distances (m) of successful and failed waterbird nests to the nearest road and pad and to the center of the Central Compressor Plant (CCP) and Central Gas Facility (CGF) complexes, GHX-1 study area, Prudhoe Bay, Alaska, 1989-1991. Means were rounded to the nearest 5 m.

	Road			Pad			CCP			CGF			Number of Nests		
	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991
Canada Goose	165	225	225	260	325	295	1325	1640	1610	1380	1595	1695	6	11	11
Successful	220	245	180	315	340	210	1180	1670	1725	1050	1620	1880	1	10	5
Failed	150	35	260	245	175	370	1350	1310	1515	1440	1315	1540	5	1	6
White-fronted Goose[•]	-	570	310	-	200	595	-	1160	1150	-	820	1050	0	1	2
Successful	-	570	310	-	200	595	-	1160	1150	-	820	1050	0	1	2
Pacific Loon	165	250	185	270	270	280	1680	1720	2010	1570	1820	2230	6	8	9
Successful	150	195	230	225	210	315	1810	1880	1770	1895	2170	1940	2	5	4
Failed	170	345	150	295	370	250	1615	1455	2200	1410	1240	2465	4	3	5
Red-throated Loon[•]	130	225	115	295	380	250	1500	1660	1440	1580	1820	1495	2	1	3
Successful	-	225	145	-	380	270	-	1660	1480	-	1820	1565	0	1	2
Failed	130	-	55	295	-	210	1500	-	1350	1580	-	1354	2	0	1
All Nests	160	250	205	270	300	310	1500	1650	1700	1490	1655	1800	14	21	25
Successful	175	250	210	260	300	310	1600	1700	1610	1615	1750	1720	3	17	13
Failed	155	270	200	270	320	305	1475	1420	1790	1455	1260	1910	11	4	12

* Distances differed significantly among years (Kruskal-Wallis test, $P \leq 0.05$).
+ Distances differed significantly between fates within a year (Mann-Whitney test, $P \leq 0.05$).
• No statistical tests performed due to small sample sizes.

Table 14. Mean estimated noise levels (dBA) at successful and failed nests of waterbird species nesting in the GHX-1 study area, Prudhoe Bay, 1989-1991, under actual weather conditions and under standardized weather conditions n = number of nests. Annual differences were evaluated with Kruskal-Wallis non-parametric tests ($P < 0.05$) and significant tests with a pairwise procedure. Identical superscripts indicate years that were not significantly different.

Species	Year	Successful Nests			Failed Nests			All Nests		
		$\overline{X}$	SD	n	$\overline{X}$	SD	n	$\overline{X}$	SD	n
ACTUAL WEATHER CONDITIONS										
Canada Goose										
	1989	48.9	0	1	48.4	5.0	5	48.4	4.5	6
	1990	48.9	9.6	10	49.3	0	1	48.9	9.1	11
	1991	42.6	5.0	5	48.4	13.1	6	45.8	10.2	11
White-fronted Goose										
	1989	-	-	-	-	-	-	-	-	-
	1990	52.6	0	1	-	-	-	52.6	0	1
	1991	52.8	6.7	2	-	-	-	52.8	6.7	2
Pacific Loon										
	1989	46.7	6.2	2	48.8	7.1	4	48.1[a]	4.9	6
	1990	40.4	2.3	5	48.1	10.1	3	43.3[ab]	6.9	8
	1991	41.6	3.8	4	39.1	1.7	5	40.2[b]	2.9	9
Red-throated Loon										
	1989	-	-	-	46.6	2.6	1	46.6	2.6	1
	1990	39.8	0	1	-	-	-	39.8	0	1
	1991	41.8	3.0	2	43.5	0	1	42.4	2.3	3
All Species										
	1989	47.4	4.6	3	48.2	5.1	11	48.0[a]	4.9	14
	1990	46.1	8.5	17	48.4	8.3	4	46.5[ab]	8.3	21
	1991	43.8	5.7	13	44.1	10.0	12	43.9[b]	7.9	25
STANDARDIZED WEATHER CONDITIONS[c]										
Canada Goose										
	1989	50.2	0	1	48.6	4.7	5	48.8	4.2	6
	1990	48.3	10.3	10	47.1	0	1	48.2	9.7	11
	1991	45.5	5.3	5	49.3	9.9	6	47.6	8.0	11
White-fronted Goose										
	1989	-	-	-	-	-	-	-	-	-
	1990	50.0	0	1	-	-	-	50.0	0	1
	1991	52.2	6.0	2	-	-	-	52.2	6.0	2

Table 14. Continued.

Species	Year	Successful Nests			Failed Nests			All Nests		
		$\overline{X}$	SD	n	$\overline{X}$	SD	n	$\overline{X}$	SD	n
Pacific Loon										
	1989	46.0	6.0	2	49.7	9.6	4	48.5	8.1	6
	1990	42.8	2.7	5	49.8	8.7	3	45.4	6.2	8
	1991	44.8	4.2	4	42.0	1.6	5	43.3	3.2	9
Red-throated Loon										
	1989	-	-	-	45.1	2.5	2	45.1	2.5	2
	1990	43.3	0	1	-	-	-	43.3	0	1
	1991	45.8	3.5	2	47.8	0	1	46.4	2.7	3
All Species										
	1989	47.4	4.9	14	48.4	6.3	11	48.2	5.9	14
	1990	46.5	8.3	17	49.2	7.2	4	47.0	8.0	21
	1991	46.3	5.0	13	46.2	7.7	12	46.2	6.3	25

[c] The same set (n=10) of standardized weather conditions was used for each year to standardize for annual changes in weather (temperature, humidity, wind direction, and wind speed) that affect noise levels.

the first nest, but the levels varied for the second nest, probably because of additional construction activities on the west edge of the CGF pad in 1990, which were not accounted for by the model. Of particular interest with respect to the effects of noise on nesting success was that, despite the high noise levels at those nests, both pairs successfully hatched young.

These results indicate that the locations of Canada Goose nests and their ultimate fates were not affected by noise generated from CCP or CGF and that other factors, such as weather conditions, influenced nesting success more strongly than did oilfield disturbance. This conclusion was supported by a logistic regression analysis of the possible factors affecting nesting success of Canada Geese in the study area. (Logistic regression is a multivariate statistical technique that evaluates a set of factors to determine those that best predict the probability of a dichotomous dependent variable, in our case, nest fate -- successful or failed). Only two variables, average May temperature and cumulative degree days in May, entered into the logistic regression model (Appendix 5). These two variables were able to predict accurately the outcome of 75% of all nests (62% of successful nests predicted correctly and 92% of failed nests predicted correctly). The interpretation of this logistic regression model is that the probability of nesting success increases with increasing May temperatures and increasing cumulative degree days. Because the model was based on only the three years of Canada Goose nests in the study area, this result was not unexpected, considering the higher nesting success in the warm spring of 1990 (Figure 4, Table 12).

WHITE-FRONTED GOOSE

The number of White-fronted Goose nests increased annually from zero in 1989 to three in 1991 (Table 12). Nesting success was 100% in each year that White-fronted Geese nested in the study area; thus, no comparisons of differences among nest fate were possible. Only a discussion of general trends in the distances of nests to facilities was possible because the limited number of nests precluded any statistical analyses. A comparison nests in 1990 and 1991 revealed that the two nests in 1991 (the GHX-1 operational year) were closer to roads, farther from pad, about the same distance from CCP, and farther from CGF than the 1990 nest (Table 13). Estimated noise levels at the nests were similar between years and only slightly higher than noise levels at Canada Goose nests (Table 14). Results of these analyses indicated that for our small sample of nests that the operation of GHX-1 in 1991 did not affect nest location or nesting success.

PACIFIC LOON

The number of Pacific Loon nests in the GHX-1 study area was not entirely an accurate assessment of the number of nesting pairs because loons, unlike geese, will attempt to re-nest if their first nest fails (Bergman and Derksen 1977). Until 1991, this possibility had not materialized, but in 1991 three re-nesting attempts occurred. With this caveat in mind, the number of nesting pairs in the study area remained relatively constant at between six and eight each year (Table 12). Nesting success varied annually, although not at the magnitude noted for geese; success peaked (62.5%) in 1990, was lowest (33.3%) in 1989, and was intermediate (44.4%) in 1991. Two of the three re-nesting attempts in 1991 were successful, but the likelihood that those pairs fledged young was low, considering the late hatching dates (approximately 1 August at both nests) and the resulting probability that the young would not be able to fly before freeze-up. Causes of nest failure were impossible to assess, because of the limited nest structure and the lack of down (the conditions of which often provides clues about the cause of failure). Thus, causes of failure for all nests were classified as unknown, but two observations of Common Ravens carrying large eggs in 1991 suggest that they could be an egg predator at loon nests.

Mean distances of Pacific Loon nests to the nearest road, nearest pad, and centers of CCP and CGF did not differ significantly among years for all fates, among years within fate, and between fate within years (Table 13). Estimated noise levels at nests also were evaluated for all nests and by nest fate (Table 14). Only for all fates combined was there a significant difference in the mean estimated noise level (noise in 1991 was significantly lower than in 1989). Most of this difference, however, resulted from a shift in nesting distribution among years (see Figure 38): in both 1989 and 1990, nests located west of CGF were in areas of relatively loud noise, but nests were not located there in 1991. The resulting change in nest distribution could not, therefore, be attributed to increased noise from the GHX-1 facility, which is located on the CCP pad, not the CGF pad. In addition, it was possible that differences in weather conditions among years also contributed to this significant difference in noise levels, because estimated noise levels did not differ significantly using the standardized weather data, (Table 14). Due to the limited sample sizes for all years, we did not attempt to use a logistic regression analysis to evaluate factors influencing nest fate.

RED-THROATED LOON

Observations of both nesting pairs and broods suggested that two pairs of Red-throated Loons nested annually in the study area (Table 12). Simply looking at the number of nests in the study area gave a biased estimate of the number of nesting pairs because of two factors. First, a second brood located in July 1990 strongly suggested that a second nest was missed on the nest searches (Anderson et al. 1991). Second, one of the three nests in 1991 was a re-nesting attempt by a pair that lost its first nest. During the first two years of the study nesting success varied between 0% in 1989 to 100% in 1990 (Table 12). In 1991, however, two of the three nesting attempts were successful, but this should be considered as 100% success for the two nesting pairs in the study area. It was unlikely, however, that the pair that re-nested was able to fledge its young before freeze-up, considering both the extremely late hatching date (approximately 10 August) and the resulting probability that the young would not be able to fly before freeze-up. Because the sample of nests was small, analyses of distances to oilfield facilities were not possible. In general, however, successful nests appeared to be somewhat farther from all types of facilities, and estimated noise levels also were lower than at failed nests (Tables 12 and 13).

CONCLUSIONS

The results of the noise survey and computer model of the GHX-1 facility indicated that noise generated by this new installation on the CCP pad did not cause uniform increases in noise levels throughout the study area. The angular nature of the dispersion of noise generated by the GHX-1 compressors resulted in most noise being directed to the north and northwest of CCP. Furthermore, analyses of predicted noise levels in different habitat types in the study area indicated that only one habitat type, Open Waters, had higher noise levels in 1991 than in previous years. These results do not imply, however, that some patches of habitats close to CCP did not receive higher noise levels in 1991, only that the overall noise levels within all patches of a particular habitat did not differ between pre-operational and operational conditions.

We found few detrimental effects of noise on waterbirds in the area. For only two species during two seasons, Canada Goose (pre-nesting) and Spectacled Eider (nesting), did we find strong indications that birds had adjusted their use of the study area in response to noise from GHX-1. All other changes in abundance, distribution, and habitat use were attributable more to annual variations in spring weather conditions and species-specific shifts that were not attributable directly to noise from GHX-1.

One of the specific objectives of this study was to evaluate the effects of GHX-1 noise on nesting Canada Geese in the wetlands north of NGI and on brood-rearing Brant on the coastal island southeast of CCP. Nesting Canada Geese were not affected by noise generated by GHX-1, in fact, the locations of nests in 1990 within several hundred meters of CGF suggest that noise was not a factor in either nest site selection or in nesting success, at least in some years. Brood-rearing Brant using the coastal island southeast of CCP did experience significantly higher noise levels in 1991 than in previous years, but they did not shift their use of the island to the quieter southeastern end or increase their use of the halophytic wet meadows on the mainland near the Lisburne pipeline crossing over the Putuligayuk River (this was the quietest habitat available to Brant that did not move out of the study area).

Several factors could explain why noise from the GHX-1 facility had little effect on waterbird use of the study area. First, noise from the GHX-1 facility was additive in nature (i.e., it incrementally increased noise already being generated by the CCP and CGF facilities) and also was highly directional, thus its contribution to the total noise being generated by both the CCP and CGF facilities was not great. Second, GHX-1 was placed next to a facility (CCP) that has been generating high levels of noise for at least ten years and that probably had already affected the distribution of waterbirds. The results of this study suggest that waterbirds have become habituated to the steady noise emanating from both the CCP and CGF pads and that any adjustments that they made in reaction to noise occurred well prior to the onset of this study. Finally, a complicating factor when assessing possible changes in distribution is that the complex of gravel pads, gravel roads, flarepits, and pipelines in the CCP and CGF vicinity has markedly reduced the availability to waterbirds of natural habitats close to those facilities. Thus, it was not surprising that most waterbird flocks were seen at distances greater than 1000 m from CCP.

In conclusion, noise from the GHX-1 facility made only a small contribution to the total noise environment around the CCP and CGF facilities and had little effect on use of the study area by waterbirds.

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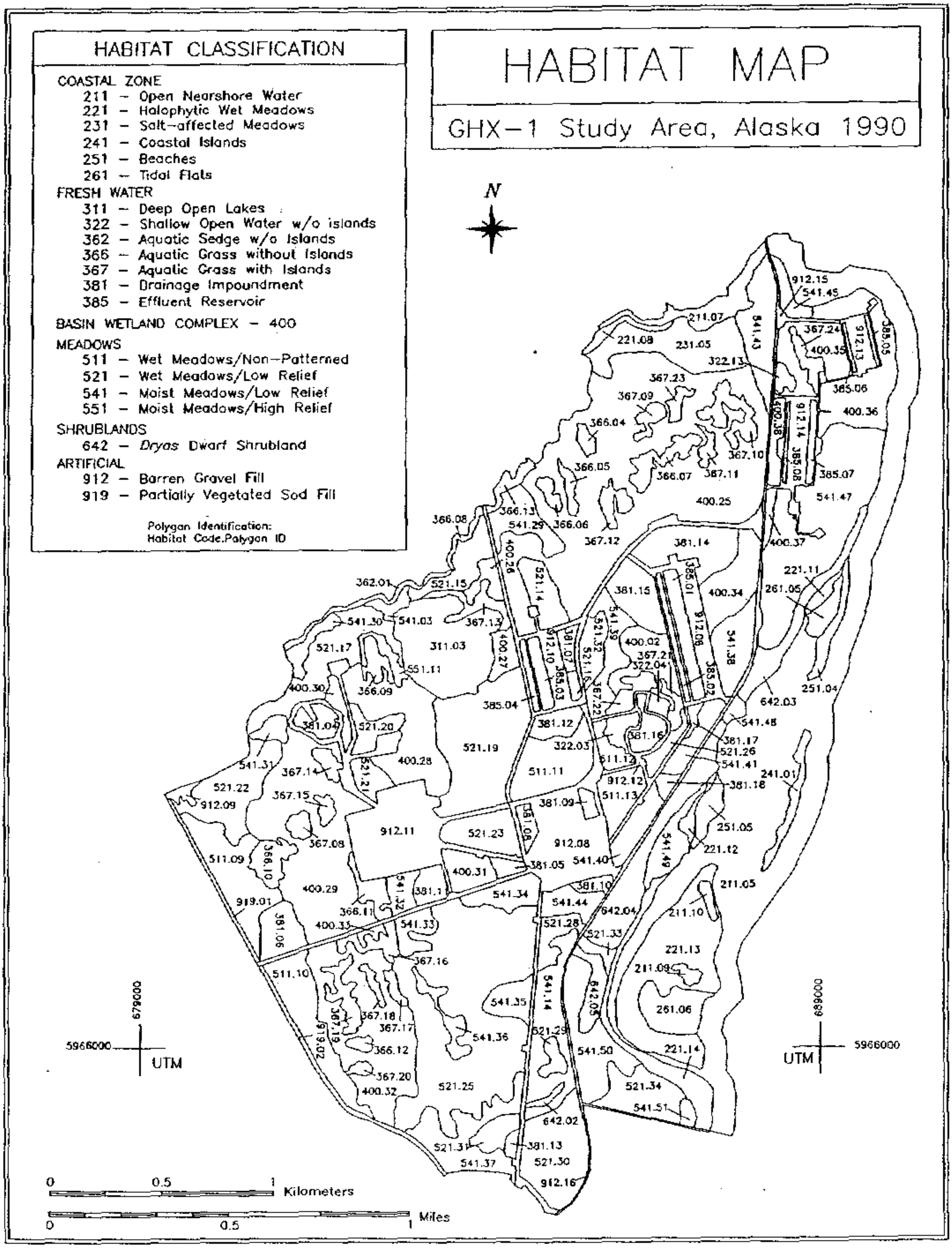
Appendix 1. Habitat map of the GHX-1 study area, hierarchical classification system, and areas of habitats in the study area.


HABITAT MAP
GHX−1 Study Area, Alaska 1990
HABITAT CLASSIFICATION
COASTAL ZONE
211 – Open Nearshore Water
221 – Halophytic Wet Meadows
231 – Salt-affected Meadows
241 – Coastal Islands
251 – Beaches
261 – Tidal Flats
FRESH WATER
311 – Deep Open Lakes
322 – Shallow Open Water w/o islands
362 – Aquatic Sedge w/o Islands
366 – Aquatic Grass without Islands
367 – Aquatic Grass with Islands
381 – Drainage Impoundment
385 – Effluent Reservoir
BASIN WETLAND COMPLEX – 400
MEADOWS
511 – Wet Meadows/Non-Patterned
521 – Wet Meadows/Low Relief
541 – Moist Meadows/Low Relief
551 – Moist Meadows/High Relief
SHRUBLANDS
642 – *Dryas* Dwarf Shrubland
ARTIFICIAL
912 – Barren Gravel Fill
919 – Partially Vegetated Sod Fill
Polygon Identification:
Habitat Code.Polygon ID
N
912.15
541.45
211.07
541.43
221.08
231.05
367.24
400.35
912.13
385.05
322.13
385.06
367.23
367.09
400.36
366.04
400.38
912.14
367.10
385.08
366.05
366.07
367.11
385.07
400.25
541.47
366.13
366.08
541.29
366.06
367.12
400.37
381.14
400.26
521.14
385.01
400.34
221.11
261.05
362.01
521.15
381.15
912.06
541.39
541.38
541.30
541.03
367.13
400.02
521.17
311.03
400.27
912.10
381.07
521.32
367.21
322.04
551.11
385.03
385.02
400.30
366.09
367.22
251.04
642.03
385.04
381.12
541.48
381.04
521.20
381.16
381.17
521.19
322.03
521.26
541.31
367.14
400.28
511.11
511.12
541.41
521.21
912.12
241.01
381.18
521.22
912.09
367.15
381.09
511.13
381.08
251.05
912.11
521.23
367.08
912.08
541.49
221.12
511.09
366.10
541.40
381.05
400.31
381.10
211.05
400.29
541.32
381.11
541.34
541.44
919.01
366.11
642.04
211.10
381.06
400.33
541.33
521.28
521.33
221.13
367.16
211.09
511.10
541.14
642.05
541.35
261.06
367.19
367.18
367.17
541.36
521.29
919.02
366.12
541.50
221.14
367.20
521.34
400.32
521.25
541.51
642.02
521.31
381.13
541.37
521.30
912.16
0
0.5
1
Kilometers
0
0.5
1
Miles
679000
5966000
UTM
689000
5966000
UTM

Appendix 1A. A provisional hierarchical classification of bird habitats for Alaska's North Slope. Each level of indentation of the table represents a level of the classification system. Classes denoted with * were found in the GHX study area.

Class	Codes
MARINE WATERS	100 O
Inshore waters	110 On
Offshore waters	120 Oo
Sea Ice	130 Oi
Ice	131 Oii
Ice edge	135 Oie
COASTAL ZONE	200 C
Nearshore Water (estuarine)	210 Cn
Open nearshore water *	211 Cno
Brackish ponds	215 Cnp
Coastal Wetland Complex	220 Cm
Halophytic wet meadows *	221 Cmh
sedge	222 Cmhs
grass	225 Cmhg
herb	228 Cmhh
Salt-affected meadows *	231 Cma
Barren	240 Cb
Coastal islands *	241 Cbi
Coastal beaches *	251 Cbb
cobble-gravel	252 Cbbc
sand	256 Cbbs
Tidal flats *	261 Cbt
Coastal rocky shores	271 Cbr
low	272 Cbrl
cliffs	275 Cbrc
Causeway	281 Cbc
FRESH WATERS	300 W
Open Water	310 Wo
Deep open lakes *	311 Wod
Shallow open water	321 Wos
without islands *	322 Wosw
with islands	323 Wosi
Rivers and Streams	330 Wr
Tidal	331 Wrt
Lower perennial	341 Wrl
Upper perennial	346 Wru
Intermittent	351 Wri
Water with Emergents	360 We
Aquatic sedge	361 Wes
without islands *	362 Wesw
with islands	363 Wesi
Aquatic grass	365 Weg
without islands *	366 Wegw
with islands *	367 Wegi
Aquatic sedge-herb	371 Weh
without islands	372 Wehw
with islands	373 Wehi
Impoundment	380 Wi
Drainage impoundment *	381 Wid
Effluent reservoir *	385 Wic
BASIN WETLAND COMPLEXES *	400 B
MEADOWS	500 M
Wet Meadows	510 Mw
Nonpatterned *	511 Mwn
sedge (Carex, Erioph.)	512 Mwns
sedge-grass (Dupontia)	516 Mwng
Low relief *	521 Mwl
sedge	522 Mwls
sedge-grass	526 Mwlg
High relief	531 Mwh
sedge	532 Mwhs
MEADOWS (Continued)	
Moist Meadows	540 Mm
Low relief *	541 Mml
sedge-dwarf shrub tundra	542 Mmls
tussock tundra	546 Mmlt
herb	548 Mmlh
High relief *	551 Mmh
sedge-dwarf shrub tundra	552 Mmhd
tussock tundra	556 Mmht
Dry Meadows	560 Md
Grass	561 Mdg
Herb	566 Mdh
SHRUBLANDS	600 S
Riparian Shrub	610 Sr
Riparian low shrub	611 Srl
willow	612 Srlw
birch	615 Srlb
alder	618 Srla
Riparian dwarf shrub	621 Srd
Dryas	622 Srdd
Upland Shrub	630 Su
Upland low shrub	631 Sul
mixed shrub tundra	632 Sulm
willow	635 Sulw
alder	638 Sula
Upland dwarf shrub	641 Sud
Dryas *	642 Sudd
ericaceous	645 Sude
Shrubby Bogs	650 Sb
Low shrub bog	651 Sbl
mixed shrub	652 Sblm
Dwarf shrub bog	661 Sbd
ericaceous	662 Sble
PARTIALLY VEGETATED	800 P
Floodplains	810 Pf
Barren	811 Pfb
Partially vegetated	815 Pfp
Eolian Deposits	820 Pe
Barren	821 Peb
Partially vegetated	825 Pep
Uplands (talus, ridges, etc.)	830 Pu
Barren	831 Pub
Partially vegetated	835 Pup
Alpine	840 Pa
Cliffs	850 Pc
Burned Areas (barren)	860 Pb
ARTIFICIAL	900 A
Fill	910 Af
Gravel	911 Afg
barren *	912 Afgb
partially vegetated	913 Afgp
Medium-grained	914 Afm
barren	915 Afmb
partially vegetated	916 Afmp
Sod (organic-mineral)	917 Afs
barren	918 Afsb
partially vegetated *	919 Afsp
Excavations	920 Ae
Gravel	921 Aeg
barren	922 Aegb
partially vegetated	923 Aegp
Structures and Debris	930 As

Appendix 1B. Areas (ha) of habitats (Levels I and II) within the GHX study area, Prudhoe Bay, Alaska, 1990.

Habitat Level I	Area %	Area ha	Level II	Area %	Area ha
COASTAL ZONE	18.5	152.3	Nearshore Waters	11.7	96.7
			Coastal Wetland Complexes	5.0	41.3
			Coastal Barrens	1.7	14.3
FRESH WATERS	13.0	107.4	Open Waters	2.4	20.0
			Water with Emergents	5.2	42.7
			Impoundments	5.4	44.7
BASIN WETLAND COMPLEXES	21.4	176.3	Basin Wetland Complexes	21.4	176.3
MEADOWS	34.5	284.3	Wet Meadows	20.4	168.0
			Moist Meadows	14.1	116.3
SHRUBLANDS	2.4	19.7	Upland Shrublands	2.4	19.7
ARTIFICIAL	10.2	83.9	Artificial Fill	10.2	83.9
TOTAL	100.0	823.8		100.0	823.8

Appendix 1C. Areas of habitats (Level IV) within the GHX study area, Prudhoe Bay, Alaska, 1990.

Habitat (Level I and Level IV)	Area %	Area ha	Habitat Polygon Size (ha) Mean	Habitat Polygon Size (ha) Range	n[a]
COASTAL ZONE					
open nearshore waters	11.7	96.7	24.2	0.7 - 89.6	4
halophytic wet meadows	3.6	29.7	5.9	1.0 - 19.7	5
salt-affected meadows	0.4	11.6	11.6	11.6 - 11.6	1
coastal islands	0.3	2.4	2.4	2.4 - 2.4	1
coastal beaches	0.5	4.5	2.3	2.2 - 2.3	2
tidal flats	0.9	7.4	3.7	2.0 - 5.4	2
FRESH WATER					
deep open lakes	2.0	16.8	16.8	16.8 - 16.8	1
shallow open water w/o islands	0.4	3.2	1.1	0.7 - 1.6	3
aquatic sedge w/o islands	0.2	1.9	1.9	1.9 - 1.9	1
aquatic grass w/o islands	1.9	15.5	1.5	0.7 - 2.8	10
aquatic grass w/ islands	3.1	25.3	1.5	0.8 - 3.5	17
drainage impoundments	4.2	34.3	2.3	0.6 - 8.0	15
effluent reservoirs	1.3	10.4	1.3	0.4 - 3.7	8
BASIN WETLAND COMPLEXES	21.4	176.3	11.8	0.6 69.0	15
MEADOWS					
wet meadows/nonpatterned	4.1	33.9	6.8	2.0 - 10.2	5
wet meadows/low relief	16.2	134.1	7.4	0.6 - 43.5	18
moist meadows/low relief	13.9	114.7	5.0	0.8 - 26.9	23
moist meadows/high relief	0.2	1.6	1.6	1.6 - 1.6	1
SHRUBLANDS					
Dryas dwarf shrublands	2.4	19.7	4.9	0.5 - 10.7	4
ARTIFICIAL					
barren gravel fill	9.7	80.1	8.1	0.8 - 21.7	10
partially vegetated sod fill	0.5	3.8	1.9	1.3 - 2.5	2
TOTAL	100.0	823.8	5.5	0.4 - 89.6	150

[a] n = number of discrete habitat units (polygons).

Appendix 2. Published records or estimates of incubation and brood-rearing periods for waterbirds seen in the GHX study area, Prudhoe Bay, Alaska, 1989-1991. Data from Palmer (1962, 1976a, 1976b), Bellrose (1978), and Johnson and Herter (1989).

Species	Length of Incubation Period (days)	Length of Brood-rearing Period (days)	Estimated Duration of Breeding Activities (days)[a]
Canada Goose	25-28	45-50	70-78
White-fronted Goose	24-28	42-45	66-73
Brant	24	40-45	64-69
Snow Goose	22-23	42-49	64-72
Tundra Swan	30-32	60-70	90-102
Northern Pintail	22-23	38-45	60-68
King Eider	22-24	35-50	57-74
Spectacled Eider	24	50-53	74-77
Oldsquaw	23-26	35	58-61
Red-throated Loon	24-26	50-60	74-86
Pacific Loon	24-27	43-55	67-82

[a] Incubation and brood-rearing combined, excluding egg-laying.

Appendix 3. Road and survey counts of waterbirds in the GHX-1 study area, 1989-1991.

Appendix 3a. Road and foot survey counts of waterbirds in the GHX-1 study area, 31 May-4 September 1989. Counts in parentheses are unfledged young and counts in brackets are flying birds; all other counts are of adult birds on the ground. Dashes indicate that data were not collected.

Survey Dates	Red-throated Loon	Pacific Loon	Tundra Swan	White-fronted Goose	Snow Goose	Brant	Canada Goose	Northern Pintail	American Wigeon	King Eider	Spectacled Eider	Oldsquaw	Unidentified Eider	Daily Total
31 MY	0	0	2	49 [1]	0	2	35	-	-	-	-	-	-	88 [1]
2 JN	0	0	2	227	2	2	42	-	-	-	-	-	-	275
3 JN	0	0	2	176	7	34	41	-	-	-	-	-	-	260
4 JN	0	0	0	98 [2]	2 [2]	15	51	-	-	-	-	-	-	166 [4]
5 JN	0	0	3	100	0	12	45	-	-	-	-	-	-	160
6 JN	0	0	0	75	0	28	33	-	-	-	-	-	-	136
7 JN	0	0	0	60	0	12	25	-	-	-	-	-	-	97
9 JN	0	6	0	36	0	0	34	-	-	-	-	-	-	76
13 JN	0	8	0	14	0	0	43	23	0	0	2	5	0	95
17 JN[a]	2	14	0	11	0	5	42	60	0	18	7	18	1	178
24 JN[a]	0	6	2	1	0	5	8	8	0	17	9	4	0	60
27 JN	0 [3]	15	0	8 [20]	0	0	41	24 [12]	0	11 [1]	2	14	1	116 [36]
30 JN	1	6	0	18	0	52	22	13	0	11	0	2	0	125
4 JL	1	12	0	1	0	45	27	1	0	5	0	3	0	109
8 JL	2	5	1	0	0	51 (4)	7	7	18	0	0	1	3	95 (4)
11 JL	1	3	6	0	2 (3)	146 (46)	22 (3)	0	7	0	0	1	0	187 (52)
14 JL	1	7	2	3 (3)	2 (2)	175 (64)	15	0	5	0	1	1	0	212 (69)
23 JL	2	4	0	14 (20)	2 (2)	249 (67)	0	0	0	0	0	0	0	271 (89)
26 JL	2	11	0	0	0	20 (7)	2 (4)	3	0	3	0	0	0	41 (11)
30 JL	0	6	0	0	0	0	0	10	0	0	2	0	0	18
3 AU	0	6	0	0	0	160 (78)	5	76	0	0	0	0	15	262 (78)
6 AU	0	6 (1)	0	2	0	207 (100)	17	58	0	0	0	0	0	290 (101)
10 AU	1	6 (2)	0	0	0	88 (16)	17	71	0	1 (4)	0	0	0	184 (22)
19 AU	1	4 (2)	1	28	0	155	7	51	8	1 (4)	3	0	0	259 (6)
23 AU	0	4 (2)	2	47	0	0	44	14	0	1	0	0	0	112 (2)
27 AU	0	4	2	41	0	0	9	0	0	0	0	0	0	56 (2)
31 AU	2	6 (2)	0	62	0	0	0	0	0	0	0	0	0	70 (2)
4 SE	2	6 (2)	2 (4)	32	0	6	7	4	0	0	0	0	0	59 (6)

[a] Foot surveys (nest searches).

Appendix 3b. Counts of waterbirds from road and foot surveys in the GHX-1 study area, 27 May - 5 September 1990. Counts in parentheses are unfledged young; all other counts are of adults or adults and juveniles.

Survey Dates	Canada Goose	White-fronted Goose	Brant	Tundra Swan	Northern Pintail	Amer. Wigeon	Eura.[a] Wigeon	Old-squaw	Green-winged Teal	Mallard	Northern Shoveler	King Eider	Spectacled Eider	Pacific Loon	Red-throated Loon	Daily Total
27 May	12	28	0	0	6	0	0	8	0	0	0	2	4	0	0	60
2 June	24	9	3	2	31	6	0	13	0	0	0	7	9	0	0	104
3 June	26	5	11	1	5	0	0	20	0	2	0	2	5	0	0	77
4 June	23	7	5	0	14	0	2	13	0	4	0	10	7	0	0	85
5 June	24	6	0	1	11	0	0	5	0	3	0	6	9	1	0	66
6 June	23	13	0	0	5	0	2	18	0	0	0	8	7	2	0	78
11 June[b]	25	19	0	1	52	0	0	16	2	10	0	27	7	14	2	175
14 June	31	1	17	1	14	0	0	3	0	1	0	14	8	13	1	104
20 June	26	2	60	0	30	0	0	3	0	0	0	10	5	8	4	148
21 June[b]	38	16	37	0	44	0	0	7	2	3	2	16	0	17	3	185
25 June	19	4	28	4	26	0	0	1	0	0	0	3	0	7	1	93
29 June	18 (2)	1	79 (3)	0	22	0	0	1	0	0	0	0	5	10	1	137 (5)
3 July	3	2 (2)	149 (20)	2	13	0	0	0	0	0	0	0	0	8	1	178 (22)
8 July	10 (3)	6 (1)	201 (101)	2	12	2	0	0	0	0	0	8	4	12	1	258 (105)
13 July	28 (20)	6 (7)	199 (95)	2	18	0	0	2	0	0	0	1 (2)	0	9 (3)	1	266 (127)
18 July	32 (40)	2 (2)	275 (172)	2 (4)	0	0	0	0	0	1	0	0	0	4 (2)	1	317 (220)
23 July	0	2 (2)	277 (132)	2 (4)	3	0	0	0	0	0	0	3	0	11 (6)	2 (1)	300 (145)
27 July	48 (64)	2 (5)	293 (196)	2 (4)	24	0	0	3	0	0	0	2 (3)	0	12 (6)	4 (3)	390 (281)
31 July	6 (8)	0	241 (189)	2 (4)	19	0	0	0	0	0	0	3 (9)	5 (19)	13 (6)	2 (1)	291 (236)
4 August	46 (42)	0	195 (110)	2 (4)	33	12	0	0	0	0	0	2 (4)	0	9 (6)	1 (1)	300 (167)
8 August	39 (30)	0	106 (63)	2 (4)	49	0	0	12	0	1	0	1 (2)	0	11 (6)	1 (1)	222 (106)
13 August	16	2 (4)	40 (26)	2 (4)	39	0	0	0	0	0	0	1	4	7 (3)	3 (1)	114 (38)
20 August	3	84	5 (4)	1	35	0	0	1	0	2	0	4	7	9 (4)	1 (1)	152 (9)
24 August	0	37	0	0	41	0	0	0	2	0	1	2	0	9 (6)	1 (1)	93 (7)
28 August	0	30	0	1	28	0	0	7	0	0	1	0	1	19 (5)	2 (1)	85 (6)
1 September	11	0	0	4 (2)	45	0	0	6	4	0	0	0	1	12 (2)	1	84 (4)
5 September	5	0	0	3 (2)	24	0	0	0	2	0	0	0	0	6	0	40 (2)

[a] Eurasian Wigeon.

[b] Foot surveys (nest searches).

Appendix 3c. Counts of waterbirds from road surveys in the GHX-1 study area, 27 May - 5 September 1991. Counts in parentheses are unfledged young or juveniles; all other counts are of adults. Species observed on less than three survey dates are included in the daily total but are listed as footnotes[a].

Survey Dates	Canada Goose	White-fronted Goose	Brant	Tundra Swan	Northern Pintail	Amer. Wigeon	Old-squaw	Green-winged Teal	Mallard	King Eider	Spectacled Eider	Pacific Loon	Red-throated Loon	Daily Total
26 May	27	52	0	4	27	2	0	0	0	0	0	0	0	113
27 May	44	114	5	2	20	0	0	0	0	0	0	0	0	185
28 May	41	155	7	2	13	1	2	4	0	0	0	0	0	225
28 May	46	145	5	4	27	7	2	0	0	0	0	0	0	239
30 May	42	113	2	0	11	0	8	0	0	6	0	0	0	176
31 May	34	87	13	0	24	8	12	2	0	0	0	0	0	186
4 June	34	29	42	9	21	0	11	0	0	2	0	1	0	149
8 June	36	19	15	0	11	1	10	0	2	8	6	11	0	119
13 June	30	8	16	1	9	0	7	0	0	11	1	9	1	93
17 June	26	9	45	0	34	5	5	0	0	16	0	14	1	162
21 June	33	32	57	0	44	0	6	0	0	16	2	10	2	202
24 June	37	16	163	0	22	0	2	0	0	13	1	9	1	264
27 June	27	6	135	2	26	0	4	0	1	12	2	9	2	226
2 July	26	6	114	1	24	0	4	0	0	1	0	9	1	186
6 July	13 (8)	4	52 (13)	2	5	0	4	0	0	1	2	5	1	89 (21)
10 July	12 (4)	5	213 (11)	2	16	0	4	0	0	1	5	11	3	277 (15)
15 July	8	2 (1)	189 (29)	2	2	0	5	0	0	8	2	8	4	230 (30)
19 July	7 (3)	10 (5)	206 (14)	0	1	0	11	0	0	0	0	5	3	243 (22)
23 July	6 (4)	4 (2)	318 (75)	0	9	0	8	0	0	0	0	12 (9)	2	361 (90)
27 July	17	7 (12)	138 (13)	0	26	0	0	1	4	0	3	8 (1)	2 (2)	207 (28)
31 July	20 (14)	14 (18)	159 (20)	0	51	0	0	0	0	0	0	10 (3)	2 (2)	256 (57)
5 August	71 (4)	20 (3)	214 (45)	2	53	0	0	0	0	1 (18)	2 (35)	9 (2)	1 (2)	373 (109)
9 August	23 (13)	25	93 (30)	2	59	0	0	0	0	0	1 (25)	9 (4)	5 (2)	217 (74)
14 August	4	17	89 (15)	1	97	1	0	1	0	1 (4)	1 (25)	6 (4)	3 (3)	221 (51)
16 August	15	21 (8)	54 (23)	2	84	0	0	0	3	1 (4)	0	15 (6)	6 (3)	201 (44)
20 August	2 (1)	10	18 (15)	0	39	0	0	0	0	1 (8)	0	3 (4)	4 (3)	77 (31)
24 August	6 (8)	20 (12)	14 (12)	2	15	0	0	0	0	3 (9)	0	8 (4)	1 (2)	71 (47)
28 August	2 (4)	34 (30)	0	2	20	0	0	0	0	1 (3)	0	7 (4)	3 (3)	69 (44)
1 September	113 (17)	6 (9)	0	0	20	0	0	0	0	1 (2)	0	6 (5)	3 (3)	49 (36)
4 September	0	18 (7)	6	0	13	0	0	0	0	0	0	6 (3)	2 (1)	45 (11)

[a] Snow Goose: 1 adults, 26 May; 3 adults, 29 May
Red-breasted Merganser: 2 adults (pair), 24 August
Northern Shoveler: 7 adults, 17 June; 1 adult, 27 July
Unidentified Eider: 5 adults, 10 July; 2 adults, 23 July

Appendix 4. Analysis of covariance tests for selected species and seasons.

Canada Goose -- Pre-nesting Model 1 (3way)

Type I Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
CCPDIST	1	9465.499	9465.499	457.079	.0001
CGFDIST	1	3087.963	3087.963	149.114	.0001
YEAR	2	25.857	12.928	.624	.5363
CCPDIST * YEAR	2	51.526	25.763	1.244	.2897
CGFDIST * YEAR	2	378.103	189.051	9.129	.0001
CCPDIST * CGFDIST * Y...	3	323.291	107.764	5.204	.0016
Residual	302	6254.022	20.709		

Dependent: DBA

Model Summary
Dependent: DBA

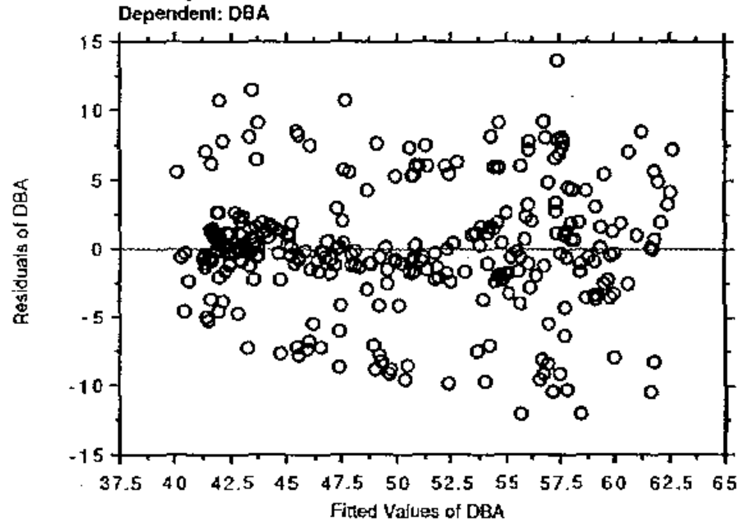
Count	314
R	.825
R-Squared	.681
Adj. R-Squared	.669
RMS Residual	4.551

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	11	13332.239	1212.022	58.527	.0001
Error	302	6254.022	20.709		
Total	313	19586.261			

Model Coefficient Table
Dependent: DBA

		Beta	Std. Error	t-Test	P-Value
Intercept		67.955	3.513	19.346	.0001
CCPDIST		-.001	.001	-1.074	.2838
CGFDIST		-.005	.001	-7.228	.0001
YEAR	89	-3.222	3.867	-.833	.4054
	90	-5.545	6.180	-.897	.3703
	91	0.000	•	•	•
CCPDIST * YEAR	CCPDIST, 89	-4.766E-4	.001	-.406	.6851
	CCPDIST, 90	.002	.002	1.281	.2011
	CCPDIST, 91	0.000	•	•	•
CGFDIST * YEAR	CGFDIST, 89	.002	.001	2.449	.0149
	CGFDIST, 90	-.001	.001	-.524	.6007
	CGFDIST, 91	0.000	•	•	•
CCPDIST * CGFDIST * YEAR	CCPDIST, CGFDIST, 89	1.807E-7	7.860E-8	2.299	.0222
	CCPDIST, CGFDIST, 90	2.096E-7	1.590E-7	1.318	.1884
	CCPDIST, CGFDIST, 91	3.332E-7	1.137E-7	2.930	.0036

Scattergram of Residuals versus Fitted Y
Dependent: DBA



Canada Goose -- Pre-nesting ,
Model 2 (2-way CCP model)

Type I Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
CCPDIST	1	7165.540	7165.540	270.578	.0001
YEAR	1	21.569	21.569	.814	.3677
CCPDIST * YEAR	1	22.775	22.775	.860	.3547
Residual	239	6329.279	26.482		

Dependent: DBA

Model Summary
Dependent: DBA

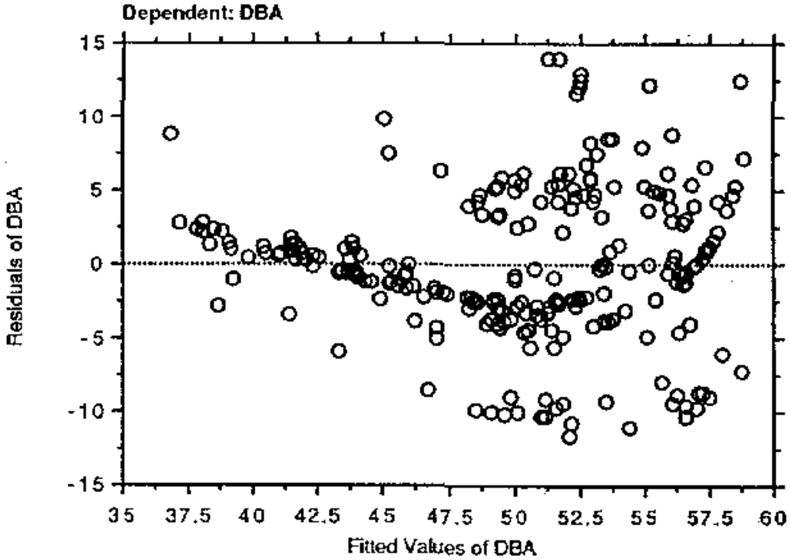
Count	243
R	.730
R-Squared	.533
Adj. R-Squared	.527
RMS Residual	5.146

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	3	7209.883	2403.294	90.751	.0001
Error	239	6329.279	26.482		
Total	242	13539.162			

Model Coefficient Table
Dependent: DBA

		Beta	Std. Error	t-Test	P-Value
Intercept		62.825	1.582	39.712	.0001
CCPDIST		-.003	2.808E-4	-10.169	.0001
YEAR	89	-2.203	1.812	-1.216	.2253
	91	0.000	•	•	•
CCPDIST * YEAR	CCPDIST, 89	3.310E-4	3.569E-4	.927	.3547
	CCPDIST, 91	0.000	•	•	•

Scattergram of Residuals versus Fitted Y
Dependent: DBA



Type I Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
CGFDIST	1	8812.270	8812.270	446.561	.0001
YEAR	1	10.025	10.025	.508	.4767
CGFDIST * YEAR	1	.534	.534	.027	.8695
Residual	239	4716.333	19.734		

Dependent: DBA

Model Summary
Dependent: DBA

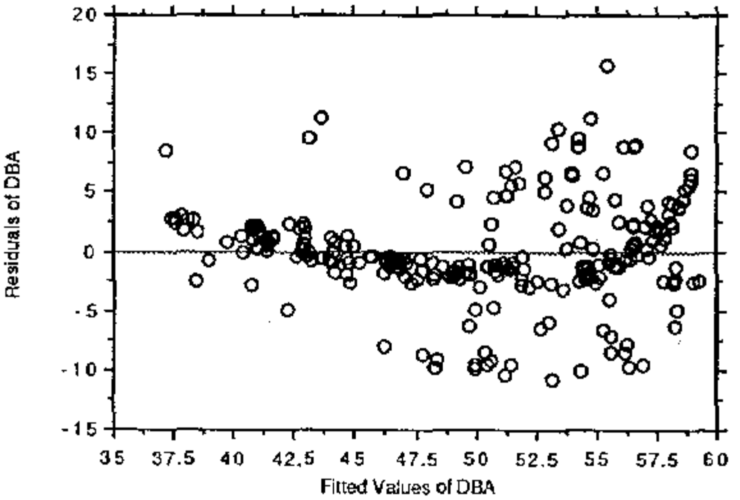
Count	243
R	.807
R-Squared	.652
Adj. R-Squared	.647
RMS Residual	4.442

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	3	8822.829	2940.943	149.032	.0001
Error	239	4716.333	19.734		
Total	242	13539.162			

Model Coefficient Table
Dependent: DBA

		Beta	Std. Error	t-Test	P-Value
Intercept		60.921	1.058	57.598	.0001
CGFDIST		-.002	1.727E-4	-13.876	.0001
YEAR	89	.246	1.299	.189	.8501
	91	0.000	•	•	•
CGFDIST * YEAR	CGFDIST, 89	3.929E-5	2.388E-4	.164	.8695
	CGFDIST, 91	0.000	•	•	•

Scattergram of Residuals versus Fitted Y
Dependent: DBA



Type I Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
CCPDIST	1	441.117	441.117	15.743	.0011
CGFDIST	1	99.624	99.624	3.556	.0776
YEAR	2	24.052	12.026	.429	.6583
CCPDIST * YEAR	2	26.862	13.431	.479	.6278
CGFDIST * YEAR	2	2.757	1.379	.049	.9521
CCPDIST * CGFDIST * Y...	3	134.496	44.832	1.600	.2286
Residual	16	448.306	28.019		

Dependent: DBA

Model Summary
Dependent: DBA

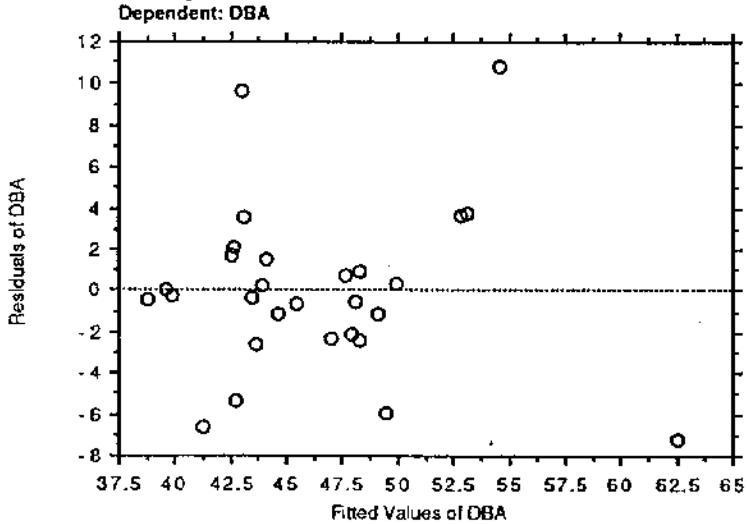
Count	28
R	.787
R-Squared	.619
Adj. R-Squared	.357
RMS Residual	5.293

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	11	728.908	66.264	2.365	.0574
Error	16	448.306	28.019		
Total	27	1177.214			

Model Coefficient Table
Dependent: DBA

		Beta	Std. Error	t-Test	P-Value
Intercept		-147.072	203.808	-.722	.4809
CCPDIST		.023	.024	.961	.3507
CGFDIST		.029	.035	.838	.4143
YEAR	89	205.306	215.041	.955	.3539
	90	223.649	204.039	1.096	.2893
	91	0.000	•	•	•
CCPDIST * YEAR	CCPDIST, 89	-.025	.029	-.878	.3929
	CCPDIST, 90	-.029	.024	-1.166	.2607
	CCPDIST, 91	0.000	•	•	•
CGFDIST * YEAR	CGFDIST, 89	-.030	.038	-.791	.4404
	CGFDIST, 90	-.033	.035	-.957	.3526
	CGFDIST, 91	0.000	•	•	•
CCPDIST * CGFDIST * YEAR	CCPDIST, CGFDIST, 89	8.006E-8	3.219E-6	.025	.9805
	CCPDIST, CGFDIST, 90	6.123E-7	3.102E-7	1.974	.0659
	CCPDIST, CGFDIST, 91	-3.551E-6	3.735E-6	-.951	.3559

Scattergram of Residuals versus Fitted Y
Dependent: DBA



Canada Goose -- Pre-nesting Model 2 (2-way CCP/CGF model)

Type I Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
CGFDIST	1	8812.270	8812.270	476.472	.0001
CCPDIST	1	3.996	3.996	.216	.6425
CGFDIST * CCPDIST	1	302.629	302.629	16.363	.0001
Residual	239	4420.268	18.495		

Dependent: DBA

Model Summary
Dependent: DBA

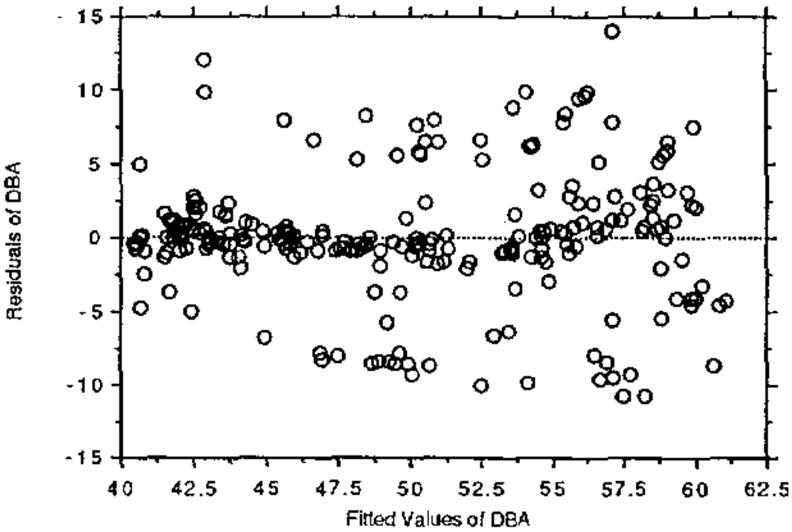
Count	243
R	.821
R-Squared	.674
Adj. R-Squared	.669
RMS Residual	4.301

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	3	9118.695	3039.632	164.350	.0001
Error	239	4420.268	18.495		
Total	242	13539.162			

Model Coefficient Table
Dependent: DBA

	Beta	Std. Error	t-Test	P-Value
Intercept	65.982	1.316	50.156	.0001
CGFDIST	-.003	3.651E-4	-9.315	.0001
CCPDIST	-.001	4.203E-4	-3.244	.0013
CGFDIST * CCPDI...	2.307E-7	5.704E-8	4.045	.0001

Scattergram of Residuals versus Fitted Y
Dependent: DBA



Appendix 5. Logistic regression model results for Canada Goose nest sites.

Appendix 5.:

GHX-1 -- LOGISTIC REGRESSION MODEL RESULTS FOR CANADA GOOSE NESTS

Estimation terminated at iteration number 4 because
Log Likelihood decreased by less than .01 percent.

	Chi-Square	df	Significance
-2 Log Likelihood	27.267	25	.3427
Model Chi-Square	10.976	2	.0041
Improvement	4.764	1	.0291
Goodness of Fit	28.000	25	.3079

[Note: A significant model has a -2LL significance level of P>0.05]

Classification Table for FATE

		Predicted 0	Predicted 1	Percent Correct
Observed		0	1	
0	0	11	1	91.67%
1	1	6	10	62.50%
			Overall	75.00%

--------------------- Variables in the Equation------------

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
MYSM [a]	.5437	.2135	6.4831	1	.0109	.3424	1.7224
CDDMY [b]	.1604	.0837	3.6733	1	.0553	.2092	1.1739
Constant	-16.2508	6.2200	6.8261	1	.0090		

-------------- Variables not in the Equation ----------------

Variable	Score	df	Sig	R
PADDISTM - distance to nearest pad (m)	.3697	1	.5432	.0000
HABITAT	4.7721	3	.1893	.0000
HABITAT(1)	3.0686	1	.0798	.1672
HABITAT(2)	.1096	1	.7406	.0000
HABITAT(3)	2.9435	1	.0862	.1571
CCPDISTM - distance to CCP (m)	.4146	1	.5196	.0000
CGFDISTM - distance to CGF (m)	.2992	1	.5844	.0000
AP - power level (sound) - actual weather	.8238	1	.3641	.0000
PAD2 - pad distance²	.4602	1	.4975	.0000
CCP2 - CCP distance²	.3034	1	.5818	.0000
CGF2 - CGF distance²	.3445	1	.5573	.0000
CCPDISTM by AP	.6265	1	.4287	.0000
CGFDISTM by CCPDISTM	.3184	1	.5726	.0000
CGFDISTM by AP	1.8737	1	.1711	.0000

[a] May Seasonal Mean Temperatures (°C)
[b] Cumulative Degree-Days -- May

ABUNDANCE AND DISTRIBUTION OF WATERBIRDS IN THE GHX-2 STUDY AREA

FINAL REPORT

Prepared for:

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September 1992

EXECUTIVE SUMMARY

- The second phase of the Gas Handling Expansion Project (GHX-2) will involve the construction of a new pad (Apex Gas Injection [AGI]) located north of the Lisburne Gas Injection Pad along the coast of Prudhoe Bay. Prior to the construction of this new pad in 1992, ARCO Alaska, Inc., contracted with Alaska Biological Research, Inc., to assess the abundance and distribution of waterbirds in the area between May and September 1991.

- Fourteen species of waterbirds were seen during 30 road surveys of the GHX-2 study area between 26 May and 4 September 1991. Of those 14 species, five occurred on $\leq$ 5 surveys: Snow Goose, Mallard, American Wigeon, Northern Shoveler, and Spectacled Eider. Daily counts of all waterbirds ranged from a high of 317 (292 adults, 25 young) on 23 July to a low of four (2 adults, 2 young) on 4 September, the last survey date.

- The distribution and abundance of waterbirds varied between the eastern and western sections of the study area. Prior to 8 June, no birds used the the eastern side of West Dock Road because of snow cover. After mid-July, we saw more birds in the eastern section, except for two large peaks in bird numbers in the western section in late July and early August. Those peaks were due to large (200+), molting flocks of Canada Geese that temporarily moved to the eastern shore of the deep, open lake.

- Canada Geese and Brant were the most common goose species in the area. Canada Geese with broods were seen periodically during July and August and a flock of brood-rearing Brant used coastal wetlands north of West Beach State No. 1 during July and August. Peak count for this flocks was 68 adults and 56 young on 9 August. Neither species nested in the area, however. Although Greater White-fronted Geese were less common than these other geese, one pair nested successfully in the study area.

- Seven species of ducks occurred in the study area, but only three species were common: Northern Pintail, Oldsquaw, and King Eider. All of the four (Mallard, American Wigeon, Northern Shoveler and Spectacled Eider) remaining species were uncommon. We did not locate any nests of ducks in the study area and also did not seen any broods.

- Pacific and Red-throated loons were seen regularly and both species nested in the study area. The single pair of Pacific Loons that nested in the area successfully hatched one young in their second (re-nest) attempt, but it disappeared shortly after hatch. Two pairs of Red-throated Loons attempted to nest; both pairs lost their first nest. One pair re-nested and produced two young, which probably did not fledge due to their late hatch date.

- In conclusion, both the diversity and abundance of waterbirds in the GHX-2 study area are representative of other coastal areas in the Prudhoe Bay. Habitats in the area, except for the halophytic wet meadows north of WBS-1, are available elsewhere, and loss of some tundra habitats to gravel placement for the new pad would not be detrimental to waterbirds from a regional perspective. Only a few waterbird species are likely to be affected by construction and operation of the AGI pad and those effects can be minimized by proper planning and scheduling of construction activities.

ACKNOWLEDGMENTS

This project was funded by ARCO Alaska, Inc., and the Prudhoe Bay Unit Owners and administered by ARCO Alaska, Inc. The authors would like to thank Mike Joyce, Senior Environmental Consultant, ARCO Alaska, Inc., for his support and valuable input during all phases of the study. We also are grateful to ARCO Alaska personnel Bob Elder and Rod Hoffman for their logistical support in Prudhoe Bay.

A number of ABR personnel contributed to this project. For assistance with fieldwork we thank John Rose, Paul Banyas, and Alice Stickney; for editing we thank Bob Day; and for graphical and clerical support we thank Allison Zusi-Cobb and Terrence Davis.

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INTRODUCTION

The second phase of the Gas Handling Expansion Project (GHX-2) will further increase the capacity for processing and re-injecting of natural gas in the Prudhoe Bay Oilfield begun by the GHX-1 project. GHX-2 also will require the expansion of the CGF and CCP facilities and the construction of a new gravel pad on the coast of Prudhoe Bay immediately south of the West Beach State No. 1 (WBS-1) exploratory pad. This new pad, the Apex Gas Injection (AGI) pad, will support facilities for re-injection of gas produced at the CGF to help maintain oil production. The AGI pad is scheduled for construction in 1992, therefore, prior to its construction, ARCO Alaska, Inc., requested that we conduct surveys for waterbirds (geese, swans, ducks, and loons) in the vicinity of the new pad in conjunction with our regular GHX-1 surveys. Because the major construction activities will take place east of West Dock Road, we evaluated abundance and distribution of waterbirds in two sections: the eastern section (i.e., east of West Dock Road) and the western section (west of West Dock Road) of the study area.

The eastern section of the GHX-2 study area was surveyed in 1985-1989 for geese during the Lisburne Terrestrial Monitoring Program (Murphy et al. 1986, 1987, 1988, 1989, 1990) and the western section was surveyed for waterbirds in 1989 during the Point McIntyre Waterbird Noise Monitoring Program (Johnson et al. 1990).

The two major objectives of our GHX-2 waterbird study were 1) to record the seasonal abundance and distribution of waterbirds in the study area surrounding the proposed AGI pad during May-September 1991; and 2) to locate nests and monitor nesting success of waterbirds in the study area.

STUDY AREA

The GHX-2 study area comprises 2 km^2 of land located on both sides of West Dock Road and extends north from the unnamed stream near the Lisburne Gas Injection (LGI) pad to the point at which West Dock Road curves west towards the base of the West Dock Causeway (Figure 1). The study area was divided into east and west sections along

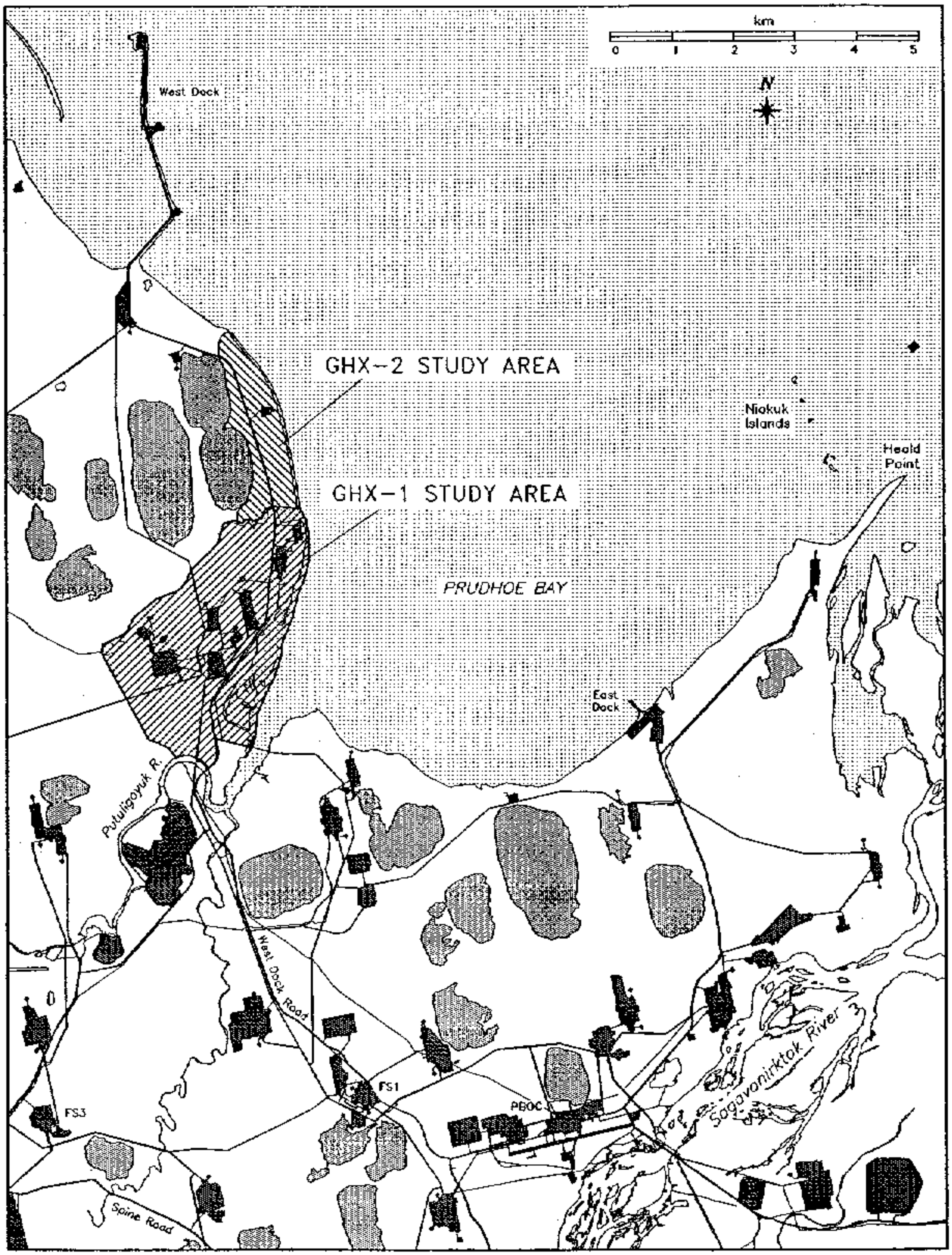

Figure 1. Location of the GHX-2 study area relative to the GHX-1 study area and other oilfield facilities, Prudhoe Bay, Alaska, 1991.

West Dock Road with 1.3 km^2 (64% of the total study area) located between the road and Prudhoe Bay (eastern section), and 0.7 km^2 (35%) between the road and the large deep, open lake to the west (western section). The new AGI pad will be located in the eastern section of the study area south of WBS-1 (Figure 2). The southern boundary of the study area directly abuts the northern boundary of the GHX-1 study area (Anderson et al. 1992).

Basic landforms, vegetation, and hydrology in the study area are similar to those described for the GHX-1 study. Waterbird habitat types in the study area were mapped previously and the eastern section was described in the 1988 Lisburne Terrestrial Monitoring Program annual report (Murphy et al. 1989), and the western section was described in the Point McIntyre Waterbird and Noise Monitoring Program (Johnson 1990).

METHODS

Methods for the road surveys followed those described for the GHX-1 study area (Anderson et al. 1992). The survey route included West Dock Road and the WBS-1 road and pad.

Methodology for nest searches was modified because of the limited extent of the study area. All suitable waterbodies for nesting waterbirds were visible from the road system and from the WBS-1 pad, therefore, no systematic ground searches were conducted for waterbird nests. Nest fate was determined using the same criteria outlined in the GHX-1 study.

RESULTS

We saw 14 species of waterbirds during 30 road surveys of the GHX-2 study area between 26 May and 4 September 1991 (Table 1). Of those 14 species, five occurred on $\leq$ 5 surveys: Snow Goose, Mallard, American Wigeon, Northern Shoveler, and Spectacled Eider. Daily counts of all waterbirds ranged from a high of 317 (292 adults,

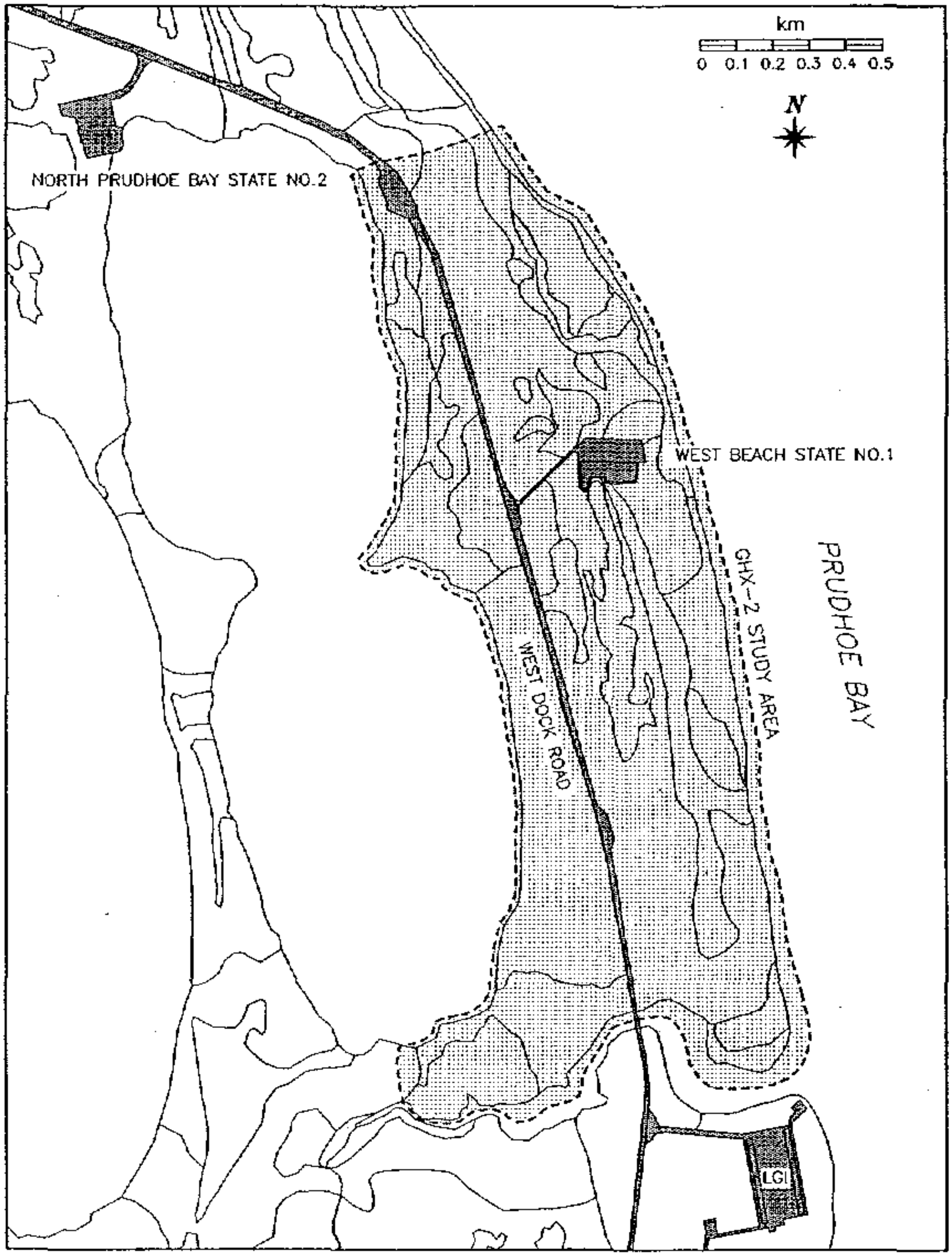

Figure 2. The GHX-2 study area (shaded area) and the location of the proposed Apex Gas Injection pad, Prudhoe Bay, Alaska, 1991. The footprint for the Apex Gas Injection pad indicates the location of gravel placement that will take place in 1992.

Table 1. Counts of waterbirds from road surveys in the GHX-2 study area, 27 May - 5 September 1991. Counts in parentheses are unfledged young or juveniles; all other counts are of adults. Species observed on less than three survey dates are included in the daily total but are listed as footnotes[a].

Survey Dates	Canada Goose	White-fronted Goose	Brant	Tundra Swan	Northern Pintail	Old-squaw	Northern Shoveler	King Eider	Spectacled Eider	Pacific Loon	Red-throated Loon	Daily Total
26 May	5	0	0	0	2	0	0	0	0	0	0	7
27 May	11	3	0	2	3	0	0	0	0	0	0	19
28 May	2	23	0	0	4	0	0	0	0	0	0	29
29 May	4	14	0	2	1	0	1	0	0	0	0	22
30 May	4	35	0	2	22	7	2	5	0	0	0	77
31 May	3	14	4	2	8	6	1	4	0	0	0	42
4 June	1	1	0	0	15	26	0	15	2	0	0	60
8 June	2	2	2	2	9	12	2	14	0	0	0	43
13 June	0	1	8	1	2	13	2	6	2	7	0	45
17 June	7	2	46	0	0	14	0	10	0	4	2	94
21 June	10	2	50	0	3	12	0	9	1	5	2	98
24 June	2	6	17	0	2	26	0	13	0	5	2	73
27 June	10	5	13	4	1	6	0	4	0	1	1	45
2 July	29	8	5	0	1	0	0	5	0	0	1	49
6 July	37	2 (1)	4	0	1	3	0	0	0	0	0	52 (1)
10 July	37 (6)	0	17 (6)	0	2	2	0	11	0	0	2	69 (12)
15 July	8 (7)	4 (7)	9 (3)	4	0	0	0	0	0	3	0	25 (17)
19 July	2 (4)	0	16 (3)	0	2	3	0	0	0	2	1	29 (7)
23 July	241 (8)	0	24 (17)	0	17	8	0	0	0	1	1	292 (25)
27 July	0	0	42 (38)	0	22	3	0	0	0	3	1	71 (38)
31 July	215 (14)	0	38 (20)	0	4	1	0	0	1	4	1	264 (34)
5 August	20	0	58 (33)	0	29	0	0	0	0	2	1	110 (33)
9 August	12	0	71 (56)	0	7	0	0	0	0	1 (1)	2 (1)	93 (58)
14 August	1	0	34 (13)	0	18	0	0	0	0	1 (1)	2 (2)	56 (16)
16 August	14 (13)	0	0	0	7	0	0	0	0	1 (1)	4 (2)	26 (16)
20 August	8 (12)	0	4 (6)	0	13	0	0	0	0	1	2 (2)	28 (20)
24 August	2 (4)	0	14 (11)	0	3	0	0	0	0	0	0 (2)	19 (17)
28 August	0	0	3 (2)	0	5	0	0	0	0	0	1 (2)	9 (4)
1 September	0	0	6	0	6	0	0	0	0	0	1 (2)	13 (2)
4 September	0	0	0	0	0	0	0	0	0	2	0 (2)	2 (2)

[a] Snow Goose: 9 adults, 17 June
American Wigeon: 4 adults, 21 June
Mallard: 1 adult, 13 June
Unidentified Eider: 5 adults, 6 July; 6 adults, 19 July

25 young) on 23 July to a low of four (2 adults, 2 young) on 4 September, the last survey date.

The abundance of waterbirds varied between the eastern and western sections of the study area throughout the study period (Figure 3). Differential snow melt between the eastern and western sides of West Dock Road accounted for the lack of bird sightings east of the road prior to 8 June. The eastern, coastal section was upwind of the road and did not develop a large "dust shadow", therefore, snow tended to melt later there than on the western section, which was downwind from the road and had an extensive dust shadow. After mid-July, we saw more birds in the eastern section, except for two large peaks in bird numbers in the western section in late July and early August. Those peaks were due to large, molting flocks of Canada Geese that temporarily moved around the south edge of the deep, open lake and into the study area.

GEESE AND SWANS

Canada Geese already were present in the study area on the first survey (26 May) and were one of the more common bird during all surveys (Table 1). We did not find any nests of Canada Geese in the study area, but they have nested south of the WBS-1 pad in the past (Murphy et al. 1986, 1988, 1990). Although Canada Geese did not nest in 1991, we regularly saw broods during July and August. Canada Geese with broods used both the eastern and western sections of the study area, but occurred most often east of the road (8 of 13 flocks). Brood sightings prior to 16 August were clustered along the banks of the unnamed stream north of LGI and the appearance of broods on both sides of West Dock Road indicated that the geese crossed the road with some regularity. After 16 August, all broods used habitats south of the WBS-1 in the area of the proposed AGI pad; those broods were mostly older age classes and some were flight capable. A large flock (200-250 birds) of molting Canada Geese used the southern and western margins of the large lakes west of West Dock Road during July and August and were seen in the study area on 23 July (235 birds) and 31 July (170 birds). None of those molting birds was seen east of West Dock Road. This molting flock is an annual occurrence in the area with total numbers of geese ranging from 75-300 birds (Johnson et al. 1990). We did not see any Canada Geese in the study area after 24 August.

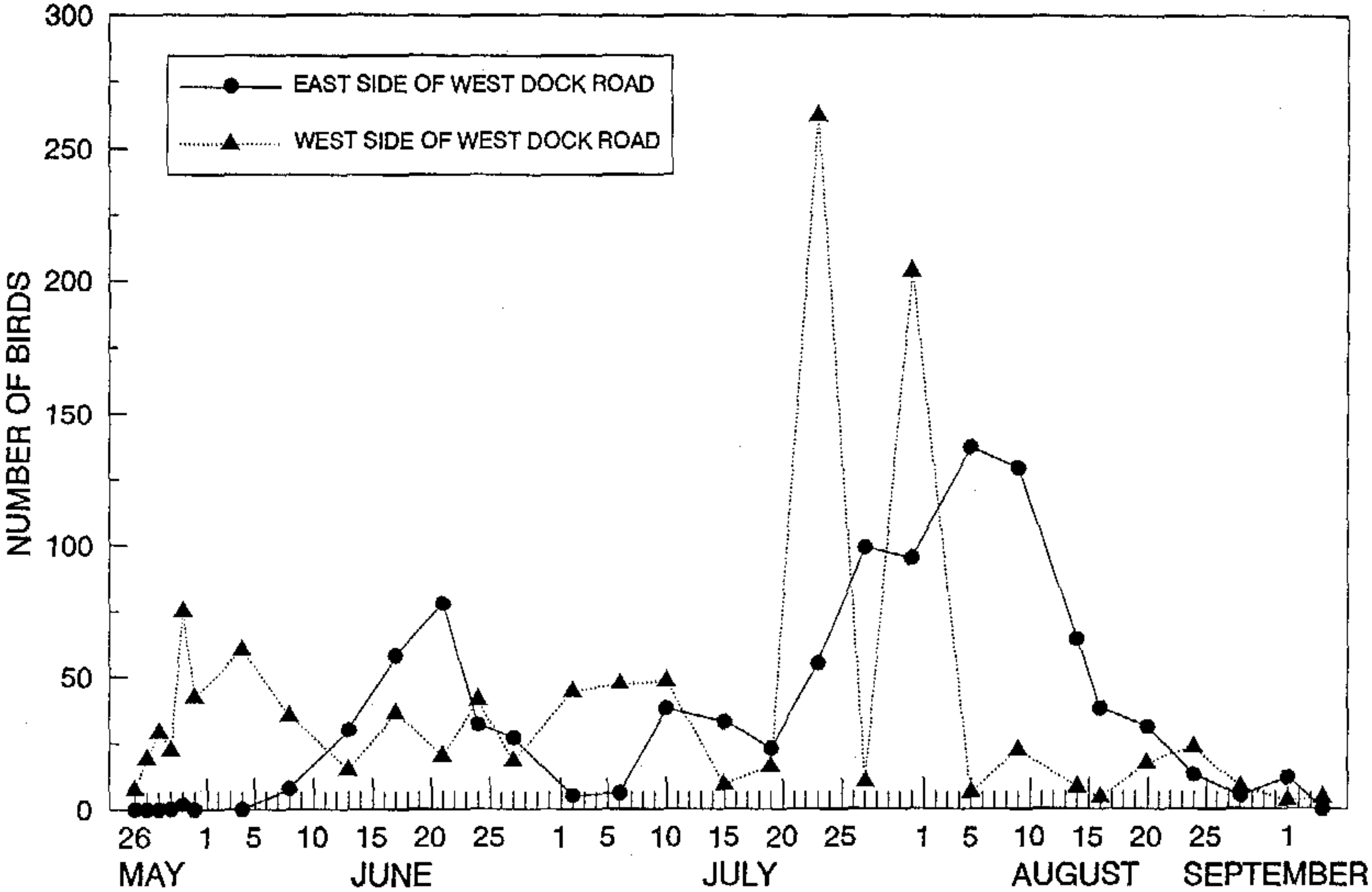

Figure 3. Road survey counts of all waterbirds seen on the east and west sides of West Dock Road in the GHX-2 study area, Prudhoe Bay, Alaska, 1991.

Greater White-fronted Geese were less common than Canada Geese and were most abundant during May (Table 1). The peak count was 35 birds on 30 May. We found one Greater White-fronted Goose nest in the study area, approximately 5 m west of a gravel pull-off on West Dock Road (Figure 4). This pair hatched one gosling, which was seen (with the pair) near the nest on 6 July. We saw brood-rearing White-fronted Geese only one other time, on 15 July, when we saw four adults with seven goslings (two broods of 5 and 2 young) on the bank of the unnamed stream north of LGI (west of the road).

Brant were the most common goose species in the area from mid-June until late August (Table 1). Brant concentrated their use of the study area east of the road and north of WBS-1 (Figure 5). The first brood of Brant was seen on 10 July and the brood-rearing flock peaked at 68 adults and 56 young on 9 August. We also saw broods of Brant along the edge of the unnamed stream north of LGI on 27 July (18 adults/16 young), 20 August (4 adults/6 young), and 24 August (10 adults/8 juveniles). Most Brant had left the brood-rearing area north of WBS-1 by mid August.

Snow Geese occurred in the study area on only one date, 17 June. Nine (7 adults/2 subadults) Snow Geese, in a mixed flock with two Brant, were feeding in a small *Arctophila* pond west of the road and northwest of WBS-1.

Tundra Swans occurred regularly in the study area from 27 May until 8 June, but only twice after mid-June (Table 1). We only saw swans west of the road, usually in small ponds located between the edge of the large lake and West Dock Road. Most (5 of 8 sightings) swans were concentrated near the northern edge of the study area. Although Tundra Swans did not nest in the area in 1991, a nest site was located on a small mound approximately 500 m south of WBS-1 in 1990; four cygnets were hatched at this nest. This site was located within the footprint of the new AGI pad.

DUCKS

Seven species of ducks occurred in the GHX-2 study area, but only three species were common: Northern Pintail, Oldsquaw, and King Eider (Table 1). All of the four (Mallard, American Wigeon, Northern Shoveler and Spectacled Eider) remaining species were uncommon. We did not locate any nests of ducks in the study area and also did

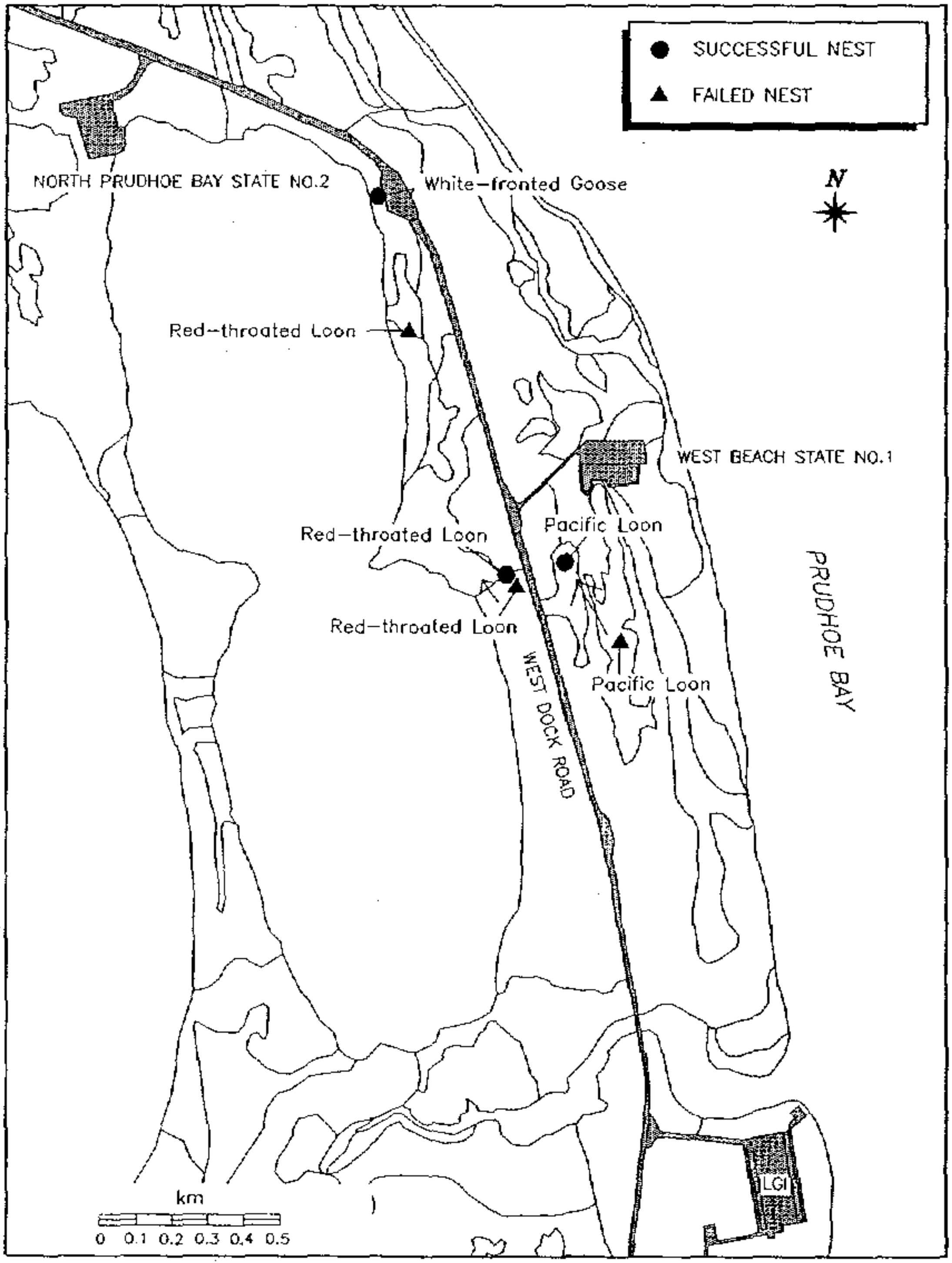

Figure 4. Locations of successful and failed waterbird nests in the GHX-2 study area, Prudhoe Bay, Alaska, 1991. Arrows between nest sites indicate re-nesting attempts.

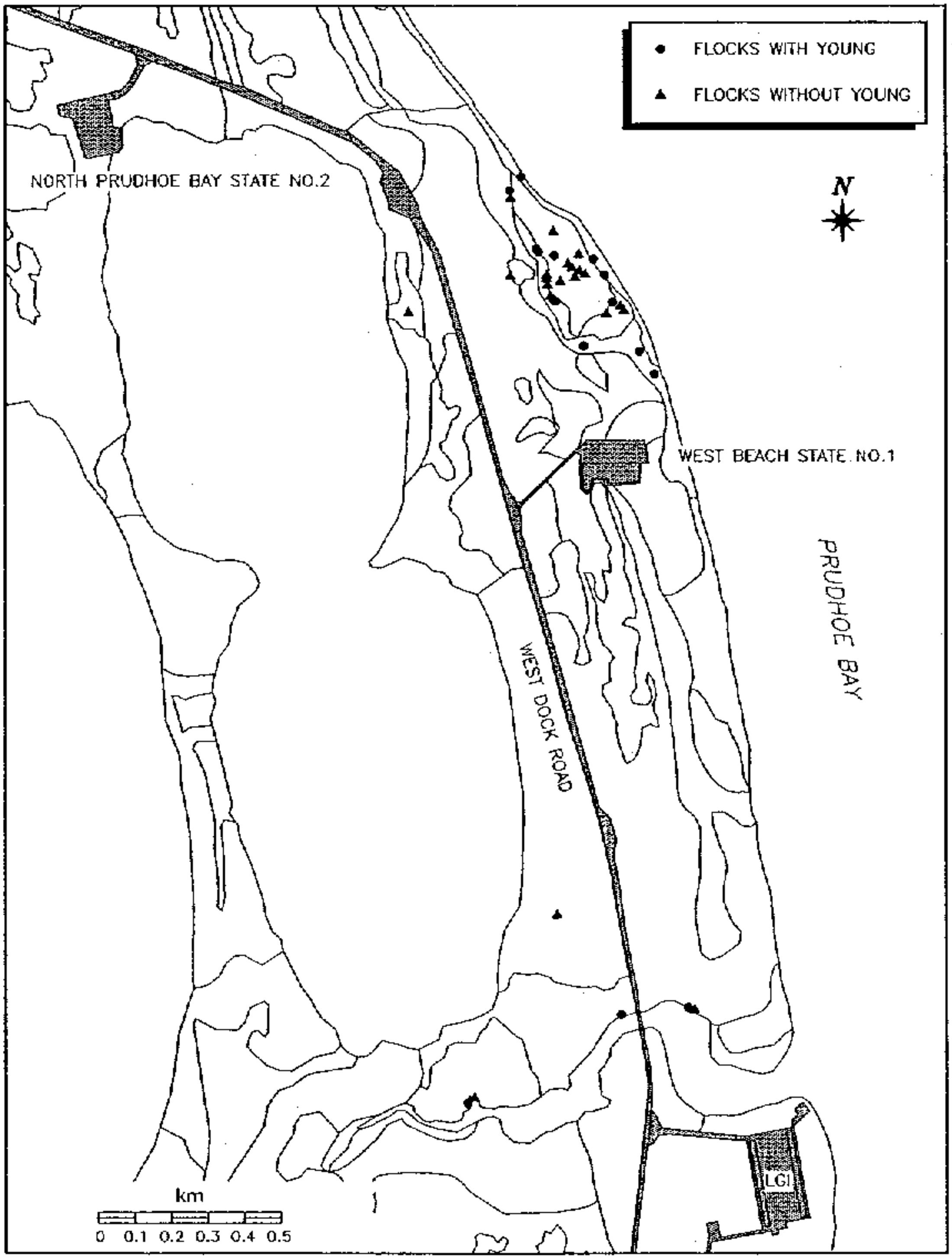

Figure 5. Locations of Brant flocks (with and without young) in the GHX-2 study area, Prudhoe Bay, Alaska, May-September 1991.

not seen any broods.

Northern Pintails showed both early and late peaks in abundance, but tended to be more abundant in early August (Table 1). Almost equal numbers of pintails occurred in the eastern and western sections of the study area (109 and 105 birds, respectively). We saw Northern Pintails in most of the shallow-water habitats in the study area: shallow ponds near the WBS-1 pad and road, brackish ponds used by brood-rearing Brant, and small ponds and impoundments west of the road.

Oldsquaw peaked in abundance during June and rarely occurred in the study area after mid-July (Table 1). Most (98 of 142 birds) Oldsquaw occurred west of the road, primarily in small ponds and near the large lake, where we often saw small flocks loafing on the lake shore.

King Eiders first appeared in the study area on 30 May and numbers peaked at 15 on 4 June (Table 1). We did not see any King Eiders in the study area after 10 July. As with Oldsquaw, more (65 of 95 birds) King Eiders used the western section of the study area than the eastern section. West of the road, King Eiders primarily used small ponds located between the large lake and West Dock Road, usually south of the entrance to WBS-1. King Eiders east of the road used small ponds both north and south of WBS-1.

LOONS

Pacific Loons first occurred in the study area on 13 June and numbers peaked on that date at seven birds (Table 1). Only one pair of loons nested in the study area (south of WBS-1) and lost their first nest for unknown reasons (Figure 4). This pair then moved northwest to an adjacent pond, re-nested, and successfully hatched one young in early August. This brood was seen on two subsequent surveys before disappearing in mid-August. Pacific Loons occurred on both sides of West Dock Road in approximately equal numbers (24 birds east of the road and 22 birds west of the road).

Red-throated Loons did not arrive in the study area until 17 June and pairs or single loons occurred on most surveys (Table 1). Two pairs of Red-throated Loons nested in the study area, both west of the road (Figure 4). Although both nesting efforts failed by late June, one pair re-nested several meters northwest of its original nest. This second nesting attempt was successful and we saw two young on 9 August; the adult apparently was still incubating the second egg on 5 August when we saw the first young. Unlike Pacific Loons, Red-throated Loons occurred almost exclusively in the western section of the study area (39 of 42 birds).

DISCUSSION

The GHX-2 study area, although of limited areal extent, supported a waterbird avifauna representative of the Prudhoe Bay region. Many species, however, were present in low numbers or during only part of the summer in 1991. Construction and operation of the new AGI pad will affect waterbird use of the area south of WBS-1 through direct habitat loss and could affect use in nearby areas because of disturbance. Waterbird species most likely to be affected by these activities would be those that were most abundant or that used habitats covered by gravel for the new pad. The primary waterbird species that could be adversely affected by GHX-2 activities are Brant, Canada Goose, and Pacific Loon. The main impacts would be direct coverage of habitats by gravel during construction, and potentially noise disturbance during construction and operation.

The occurrence of brood-rearing Brant in coastal habitats north of WBS-1 in 1991 was unusual only in the length of time (June-August) that they occupied the area. Brant used this area during all five years of the Lisburne study, but prior to 1988 most use occurred in mid- to late August and early September, when birds began dispersing from the major brood-rearing area southeast of CCP (Murphy et al. 1986, 1987, 1988, 1989, 1990). Brant with broods used the area only during early August in 1988 and during both late July and early August in 1989. Although systematic ground surveys were not conducted in 1990, adults with broods were seen north of WBS-1 during two aerial surveys for Brant in late July (Ritchie et al. 1991). These observations suggest that Brant use of this coastal habitat north of WBS-1 is now an annual event and, although the area does not support the same level of use seen at the major brood-rearing island southeast of CCP, it does provide suitable habitats for a smaller brood-rearing flock. The distance of these coastal habitats from the AGI pad and the buffering effect of the WBS-1 pad probably will moderate the effects of disturbance from the new pad, at least during operation. Disturbance during construction and drilling would be more severe and could adversely affect use of the area by brood-rearing Brant if they were present during those activities.

Canada Geese are present in the GHX-2 study area throughout the summer, but only during the nesting and brood-rearing seasons are they likely to be affected by construction or operation of the AGI pad. Although the shallow pond south of the WBS-1 entrance has supported nesting by Canada Geese in the past, this pond is marginal habitat in most years due to late snow melt. The large flock of molting Canada Geese that uses the deep, open lakes west of West Dock Road have been observed annually since 1985. These two large lakes provide an abundant amount of suitable habitat for these molting birds that is well removed from disturbance on West Dock Road and any possible disturbance from the AGI pad. In addition, these molting geese are only present in the area for approximately 4-6 weeks during July and August and move out of the area as soon as they are able to fly.

The new AGI pad will be placed almost entirely on tundra habitats, therefore, direct loss of ponds used by loons and ducks will be minimal. However, the northern entrance road to AGI will cross the pond used by nesting Pacific Loons in 1991 and probably will result in loss of the nest site. Because other ponds in the vicinity have been used by Pacific Loons in the past, including ponds west of the road, the loss of one nest site would not adversely affect nesting effort. In the GHX-1 study area, the location of Pacific Loon nests near DS-L1 and NGI indicate that nearby pads do not always cause abandonment of suitable nest sites and that nesting success is not always adversely affected by nearby pads.

In conclusion, both the diversity and abundance of waterbirds in the GHX-2 study area are representative of other coastal areas in the Prudhoe Bay. The habitats in the GHX-2 study area, except for the halophytic wet meadows north of WBS-1, are available elsewhere, and loss of some tundra habitats to gravel placement would not be detrimental to waterbirds from a regional perspective. Only a few waterbird species are likely to be affected by construction and operation of the AGI pad and those effects can be minimized by proper planning and scheduling of construction activities.

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THE EFFECTS OF POINT McINTYRE/GHX-2 GRAVEL HAULING ON BRANT

FINAL REPORT

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September 1992

EXECUTIVE SUMMARY

- In August and September 1991, construction of a new road to the Point McIntyre pad and construction activities associated with the second phase of the Gas Handling Expansion Project (GHX-2) required the transport of gravel in large, trucks past brood-rearing habitats used by Brant. The objectives of this study were to assess the effects of these gravel-hauling activities on the distribution, abundance, and behavior of Brant along the western shore of Prudhoe Bay.

- Gravel-hauling trucks transported gravel from the mine site (Put 23) near the Putuligayuk River to the Point McIntyre road commencing on 10 August and continuing through 15 September. Early in construction, most gravel for the road was reclaimed from the North Prudhoe Bay State No. 2 pad, which eliminated the need for gravel-hauling traffic to pass Brant using the brood-rearing area near the Central Compressor Plant (CCP). When gravel was transported from the Put 23 site, gravel-hauling trucks moved along West Dock Road at an average rate of 14.8 full trucks/h and 12.4 empty trucks/h. Additional gravel was hauled in August to expand the Central Gas Facility, add to the West Dock Road, and to expand roads near MCC and in Deadhorse.

- Noise associated with gravel-hauling trucks was monitored at a permanent monitoring station used for the GHX-1 bird and noise study. This station was located approximately 250 m east of West Dock Road on the mainland adjacent to the brood-rearing island used by Brant near CCP. A comparison of two 4-day periods before and during gravel-hauling indicated that noise levels increased from a mean of 52.3 dBA (decibels, A-scale) before gravel-hauling to a mean of 57.2 dBA during gravel-hauling.

- At a distance of approximately 25 m, gravel-hauling trucks (Euclids) produced an average of 97.6 dBA when full and an average of 95.8 dBA when empty. Maxi-Haul trucks were substantially less noisy than Euclids (81.9 dBA for a full load).

- Brant used brood-rearing habitats on the coastal island southeast of CCP and along the coast north of West Beach State No. 1 from early July through mid-August. Annual comparisons of Brant numbers near CCP indicated that, although the number of adults in 1991 was comparable to those recorded in previous years, the number of young was down compared to previous years, probably due to low productivity of Brant in the Prudhoe Bay region.

- The distribution of Brant in coastal habitats along the western shoreline of Prudhoe Bay was similar in 1991 to that recorded in previous years except for increased use of the area north of West Beach State No. 1 by brood-rearing birds. Distribution of Brant in the area was not affected by disturbance from gravel-hauling trucks. Although few Brant were recorded near CCP after 20 August,

similar movements of Brant out of the area have been recorded in previous years.

- Reactions of Brant to fully loaded and empty gravel-hauling trucks were observed on three occasions. All flocks were 200-300 m from the West Dock Road. No overt reactions by Brant to gravel-hauling trucks were observed.

- In conclusion, based on our observations in the CCP vicinity and north along the Prudhoe Bay coastline, the relatively moderate levels of disturbance caused by Point McIntyre road construction and construction activities associated with GHX-2 did not have detrimental effects on the brood-rearing activities of Brant.

ACKNOWLEDGMENTS

This project was funded by ARCO Alaska, Inc., and the Prudhoe Bay Unit Owners and administered by ARCO Alaska, Inc. I would like to thank Mike Joyce, Senior Environmental Consultant, ARCO Alaska, Inc., for his support and valuable input during all phases of the study. I also would like to thank Gary Abbas, PMC, for information on gravel-hauling schedules. I would like to thank Bob Elder and Rod Hoffman of ARCO Alaska for providing logistical support in Prudhoe Bay and Allison Zusi-Cobb and Terrence Davis at ABR for graphical and clerical support.

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INTRODUCTION

During August and September 1991, gravel was hauled for construction of a new road to the Point McIntyre pad located west of the West Dock Causeway and to support construction activities for the second phase of the Gas Handling Expansion (GHX-2) at the Central Compressor Plant (CCP). Because these activities required the transportation of gravel past brood-rearing habitats used by Brant (*Branta bernicla*) near the mouth of the Putuligayuk River and along the western shore of Prudhoe Bay north of CCP, ARCO Alaska, Inc., on behalf of the Prudhoe Bay Unit Owners and the Point McIntyre Owners, contracted with Alaska Biological Research, Inc., to monitor the effects of these activities on brood-rearing Brant. The study was initiated because of concerns that gravel-hauling trucks and the noise they generate could affect the use of coastal habitats by brood-rearing Brant and affect their normal behavior. The objectives of the study were to monitor the abundance and distribution of Brant before and during gravel hauling and to assess behavioral reactions of Brant to the gravel-hauling vehicles (Euclid and Maxi-Haul trucks).

STUDY AREA

The study area encompassed the entire western shoreline of Prudhoe Bay from the mouth of the Putuligayuk River north to the base of the West Dock causeway and Point McIntyre (Figure 1). The major gravel source for construction of the Point McIntyre road was the pit (Put 23) near the North Slope Borough Landfill and adjacent to the Putuligayuk River. Habitat types in the study area have been described previously by Murphy et al. (1989), Anderson et al. (1990), and Johnson et al. (1990).

METHODS

GRAVEL-HAULING ACTIVITY

The amount of disturbance associated with gravel-hauling trucks was determined by counting the number of passes of trucks (full and empty) past the major Brant brood-

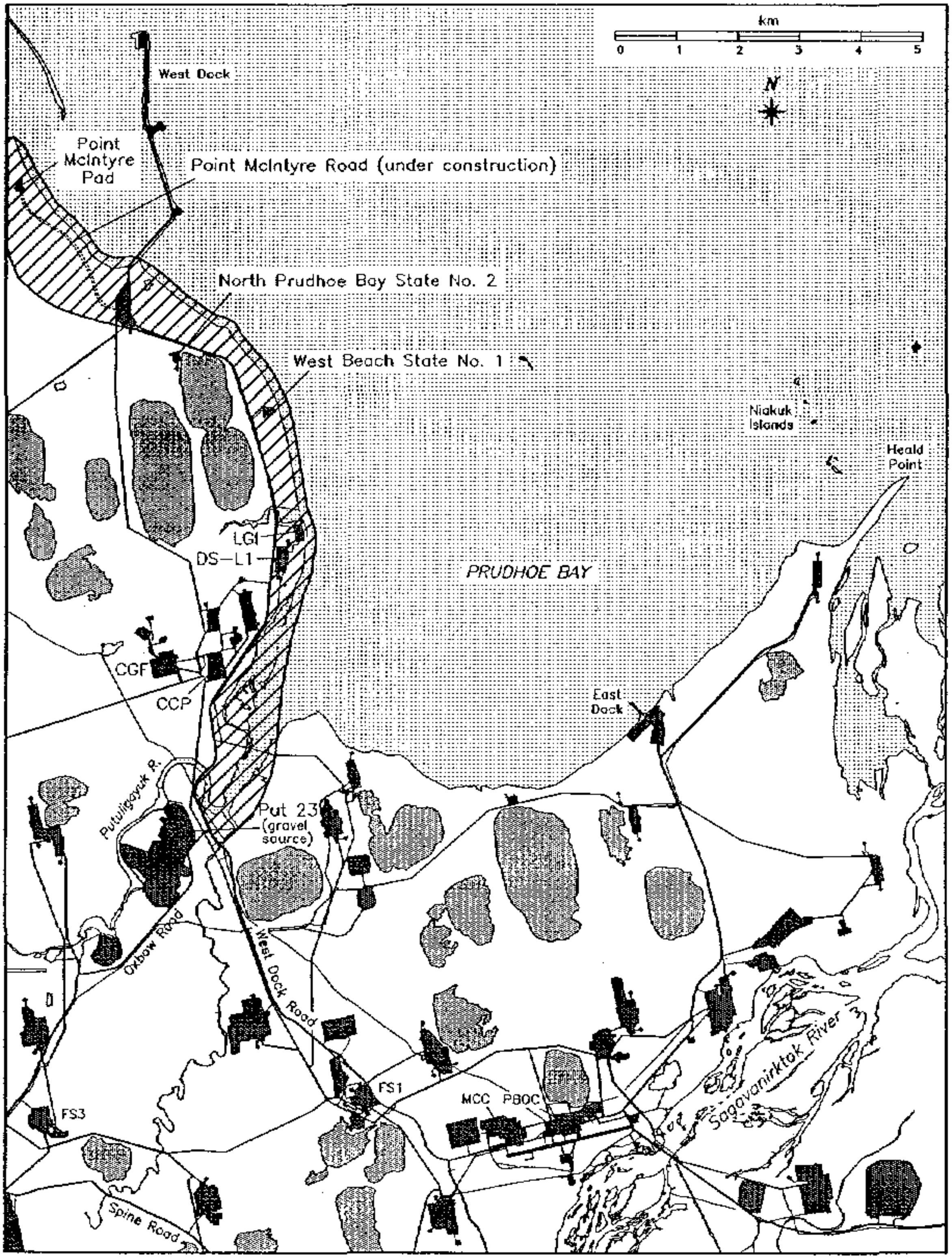

Figure 1. Location of the study area on the western shore of Prudhoe Bay, Alaska. Striped area was surveyed for Brant during gravel-hauling activities in August and September 1991.

rearing areas during 15-min periods. An hourly traffic rate was calculated for the different types of gravel-hauling trucks and for other truck types. Gravel trucks included Euclid bellydumps, Euclid dump trucks, and Maxi-Haul semi-type trucks. Other truck types included pickup trucks and Suburban-type vehicles (classified as Light Trucks), larger-than-Suburban trucks (Heavy Trucks), and road maintenance vehicles (e.g., operating graders).

SOUND LEVELS NEAR CCP AND FROM GRAVEL-HAULING TRUCKS

In addition to counting trucks, the increase in sound levels in the CCP vicinity due to these trucks was assessed using sound measurements from the permanent noise monitor, used for the GHX-1 noise study (Anderson et al. 1992), located along the coast southeast of CCP. Sound readings were recorded continuously at the monitor and integrated over 1-h intervals. I compared mean sound levels (hourly Equivalent Sound Level [L_{eq}], measured in decibels, A-scale [dBA]) from the permanent monitor for a sample of four days before (28-31 July 1991) and during (28-31 August 1991) gravel hauling. To estimate the sound levels generated by gravel-hauling trucks, I recorded single event levels (SEL) with a Larson-Davis Sound Meter (Model 870) of a variety of truck and load types at approximately 25 m from the road.

DISTRIBUTION AND ABUNDANCE OF BRANT

The distribution and abundance of Brant in the CCP area were recorded during road surveys conducted approximately every 4 days between late May and late September for the GHX-1 Bird Noise Monitoring Program (Anderson et al. 1992). Only data for the time period (approximately 1 August - 4 September) when both gravel hauling and road surveys were taking place are included in this report. The locations of all Brant seen in the area were recorded on maps of the study area and the number of adults and young were recorded on data sheets keyed to the appropriate maps. In addition to observations of Brant in the GHX-1 study area, the distribution and abundance of Brant along the coast north of Drill Site L1 (DS-L1) were recorded in conjunction with surveys of the GHX-2 study area (an addition to the GHX-1 study in 1991). The number and location of Brant in coastal habitats at the base of the West Dock Causeway also were recorded between 27 July and 4 September 1991.

BEHAVIORAL REACTIONS OF BRANT TO GRAVEL-HAULING TRUCKS

The behavioral reactions of Brant to gravel-hauling trucks were determined during passage of trucks on West Dock Road near CCP and along the coast north of CCP. I opportunistically recorded reactions using the methodology for instantaneous reactions to disturbance developed for the Lisburne Terrestrial Monitoring Program (Murphy et al. 1990). These observations were opportunistic in that Brant had to be visible from the road and gravel-hauling trucks had to be operating at the same time in order for me to behavioral reactions. If both Brant and gravel-hauling trucks were present, behavioral reactions were recorded during regular surveys and during a 15-min period after the survey was completed. Behaviors included no reaction, alert, walk/swim, run/swim-escape, and fly/swim-with-wing-flap. These reactions are listed in order of increasing severity of reaction to the disturbing stimulus.

RESULTS AND DISCUSSION

GRAVEL-HAULING ACTIVITY

POINT MCINTYRE ROAD

Although gravel hauling for the Point McIntyre road was permitted as of 1 August 1991, gravel hauling did not commence until 10 August (Figure 2). Installation of culverts around the Waterflood pipeline was necessary before the placement of a road across the pipeline. Welders were working on these culverts from approximately 5 August until 14 August. The Point McIntyre road was constructed primarily with gravel reclaimed from the North Prudhoe Bay State No. 2 (NPBS-2) pad located about 1 km south of the West Dock staging area. Use of NPBS-2 pad as a gravel source allowed most of the Point McIntyre road to be constructed without driving large, gravel trucks past the major brood-rearing habitat near CCP. Gravel was hauled from the Putuligayuk gravel pit (Put 23) to the Point McIntyre road, and past the brood-rearing habitat, beginning on 10 August and continuing through 15 September.

The rate of passage of gravel-hauling trucks to Point McIntyre was assessed during

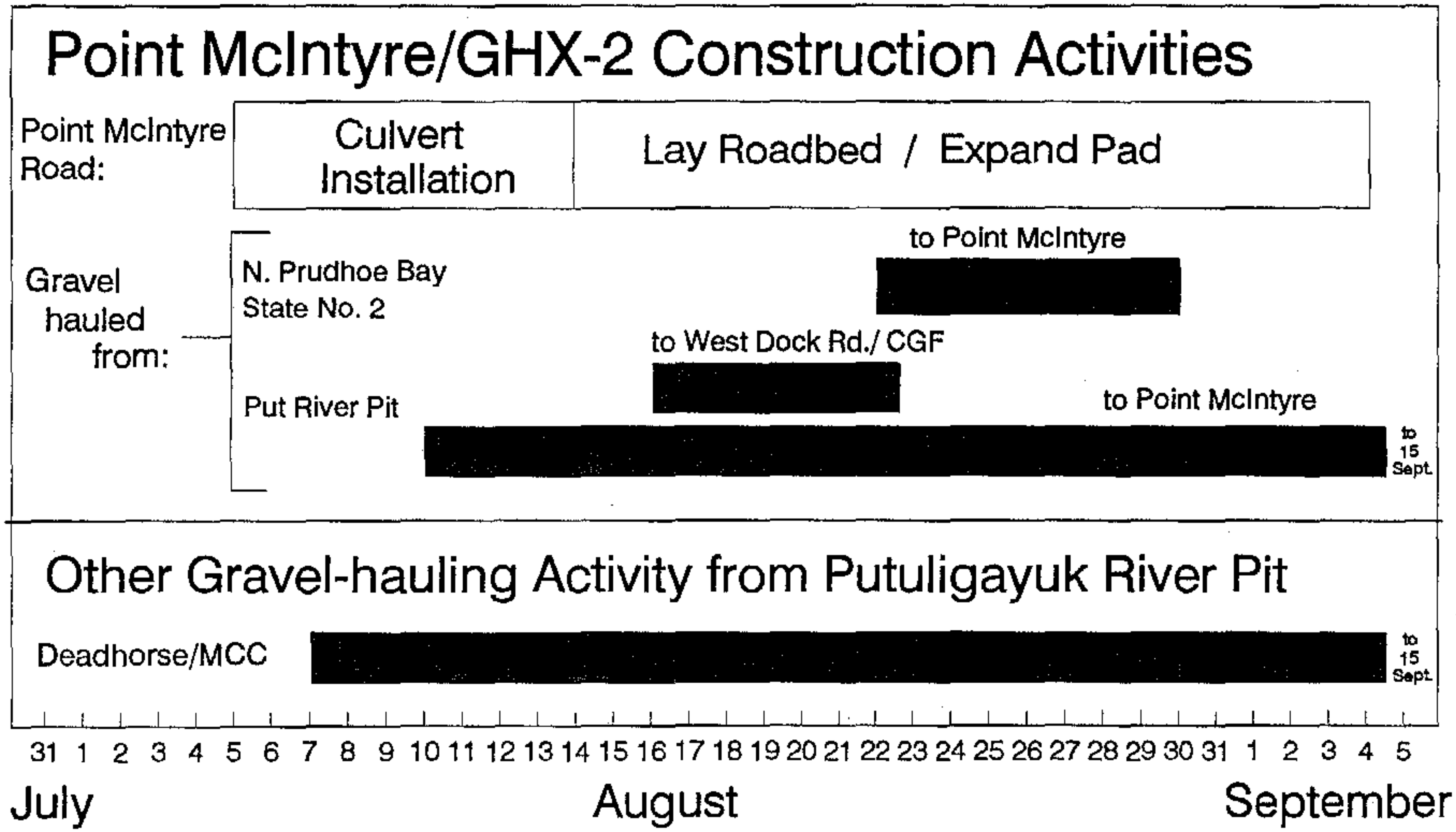

Figure 2. Time table of construction and gravel-hauling activities for the Point McIntyre road and GHX-2 program.

15-min traffic counts on 28 August, 1 September, and 4 September (n = 15). Euclid bellydumps passed by the CCP brood-rearing area and the brood-rearing area near the West Beach State No. 1 pad (WBS-1) at an average rate of 14.8 full trucks/h and 12.4 empty trucks/h (Table 1). Maxi-Haul bellydumps were less numerous (1.2 full trucks/h and 0.4 empty trucks/h).

GHX-2 PROJECT

Gravel hauling for the GHX-2 Project was permitted as of 15 August 1991, but did not commence until 16 August and had been substantially completed by 24 August (Figure 2). Gravel for this project was taken from the Put 23 and used for expansion of the south side of the pad at the Central Gas Facility (CGF), widening of the access road between West Dock Road and CGF/CCP, and for minor widening of curves on the West Dock Road north of CCP. Traffic counts for these gravel-hauling trucks were obtained on only one day (20 August) and indicated a rate for Euclid bellydumps of 4.0 full vehicles/h and 4.5 empty vehicles/h (Table 1); no Maxi-Haul trucks were observed. Additional gravel also was added to West Dock Road between the Oxbow Road and FS-1; this activity was completed by 15 September.

OTHER AREAS

In addition to gravel for the Point McIntyre Road and the GHX-2 Project, gravel was hauled beginning 7 August to expand the Spine Road in front of the Main Construction Camp and the Prudhoe Bay Operations Center, and for road widening near Lake Colleen in Deadhorse (Figure 2). This gravel hauling continued until 19 August. Although those gravel trucks did not pass by brood-rearing habitats used by Brant, noise from the trucks leaving Put 23 was heard by the observer at the brood-rearing habitat near CCP.

SOUND LEVELS NEAR CCP AND FROM GRAVEL-HAULING TRUCKS

Sound levels recorded at the permanent sound meter, located on the mainland shoreline southeast of CCP, generally were higher during gravel hauling than before gravel hauling (Figure 3). The mean hourly L_{eq} reading during a 4-day period (28-31 July 1991) before gravel hauling commenced was 52.3 dBA (SD = 1.85 dBA, n = 96

Table 1. Traffic counts (15-min duration) of gravel-hauling trucks and other vehicles on West Dock Road during construction activities for the Point McIntyre road and GHX-2 project, August - September 1991.

			Gravel-hauling Trucks				
			Euclid		Maxi-Haul		
Project/ Date of Count	Light Trucks	Heavy Trucks	Full	Empty	Full	Empty	Location of Count[a]
GHX-2[b]							
20 August	11	4	4	4	0	0	CCP/S
	4	0	3	5	0	0	CCP/N
	13	2	3	5	0	0	CCP/S
	6	3	6	4	0	0	CCP/N
$\bar{x}$	8.5	2.2	4.0	4.5	0	0	
SD	4.20	1.71	1.41	0.58	0	0	
$\bar{x}$ vehicles/h	34	9	16	18	0	0	
Point McIntyre[c]							
28 August	8	3	2	3	0	0	CCP/S
	3	0	2	3	0	0	CCP/N
	6	3	3	2	0	0	CCP/N
	0	0	4	3	0	0	WBS-1
	0	0	3	7	0	0	WBS-1
1 September	11	2	4	3	2[d]	0	CCP/S
	5	0	4	3	1[d]	0	CCP/N
	0	0	4	5	1[d]	1	WBS-1
4 September	13	3	5	1	0	0	CCP/S
	2	1	5	1	0	0	CCP/N
	4	1	5	3	0	0	CCP/N
$\bar{x}$	4.7	1.2	3.7	3.1	0.3	0.1	
SD	4.45	1.33	1.10	1.70	0.65	0.30	
$\bar{x}$ vehicles/h	18.8	4.8	14.8	12.4	1.2	0.4	

[a] CCP/S - south of Central Compressor Plant (CCP)
CCP/N - north of CCP
WBS-1 - north of West Beach State #1 (WBS-1).

[b] Destination of gravel was access road between West Dock Road and the Central Compressor Plant - Central Gas Facility.

[c] Destination of gravel was the Point McIntyre Road.

[d] Full loads going south from Point McIntyre (i.e., removing gravel).

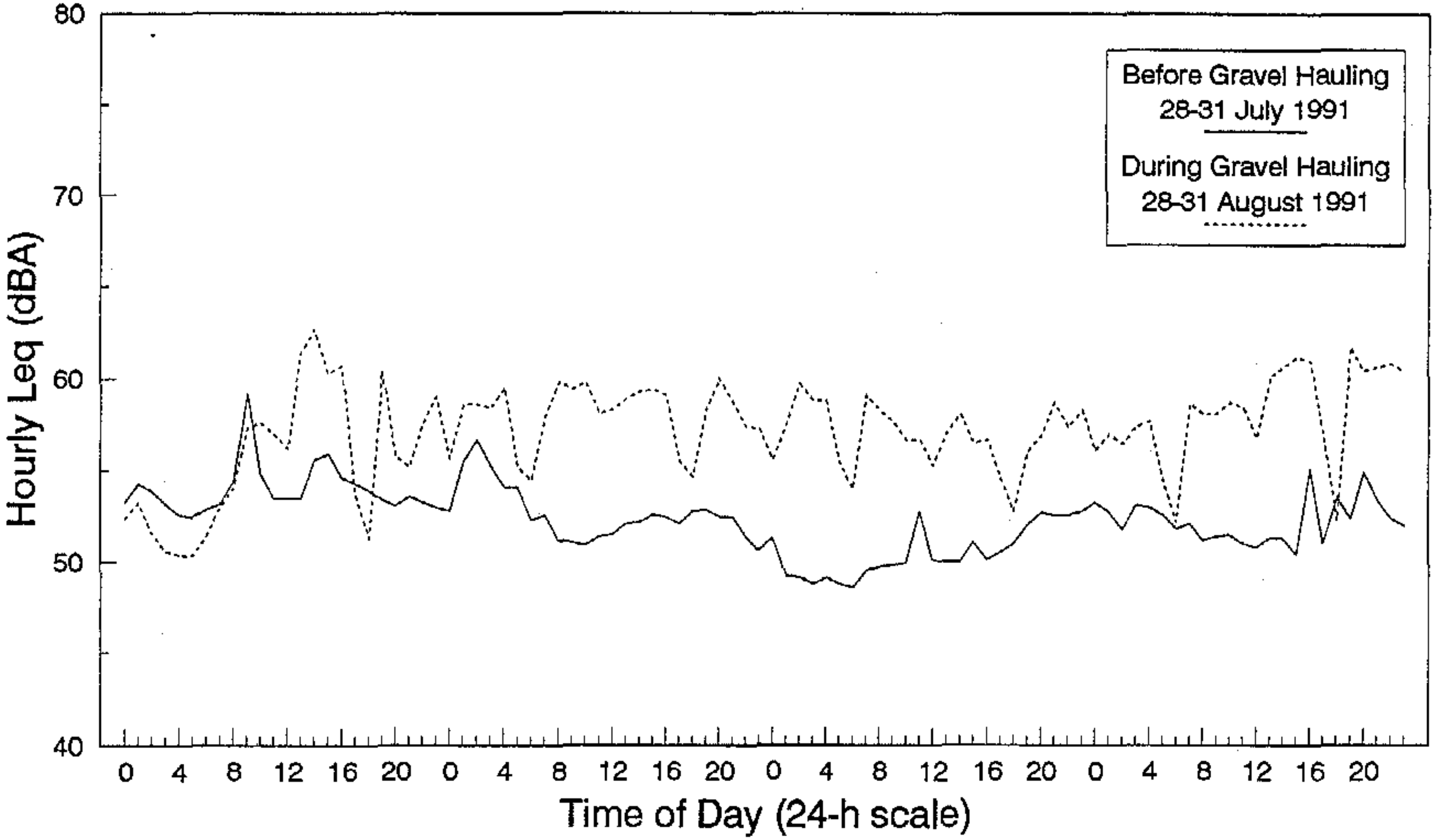

Figure 3. Hourly sound levels (L_{eq}, dBA) at the permanent sound monitoring station near the Central Compressor Plant during a four-day period before (28-31 July 1991) and during (28-31 August 1991) gravel hauling for the Point McIntyre road.

hourly intervals), but increased to 57.2 dBA (SD = 2.78 dBA, n = 96) during a 4-day period (28-31 August 1991) when gravel hauling occurred. Wind velocities, recorded at the weather station located north of the Western Gas Injection pad, were <15 mph during both time periods, therefore, wind probably did not affect the sound readings. Although sound levels increased during gravel hauling, they still were within the range (45.9 dBA to 64.5 dBA) of hourly L_{eq} sound levels recorded throughout the summer (27 June - 27 August 1991), when gravel-hauling activities were not taking place.

Sound measurements (single event levels [SEL]) of both full and empty gravel trucks indicated a difference in noise generation both between load types and between truck types. Euclids carrying full loads of gravel produced an average of 97.6 dBA (SD = 1.41, n = 10) at approximately 50 m. Empty Euclids were slightly less noisy (mean = 95.8 dBA, SD = 1.54 n = 10) than fully loaded Euclids. Although the sample size was limited, Maxi-Haul bellydumps were substantially less noisy than Euclids, even with a full load (81.9 dBA, n = 1).

DISTRIBUTION AND ABUNDANCE OF BRANT

As in previous years, both adult and young Brant used brood-rearing habitats near the Putuligayuk River in 1991 (Appendix 1), but at somewhat lower levels than recorded in the past several years (Murphy et al. 1990, Anderson et al. 1991). Decreased use of the area probably was due to poor nesting success in the region (particularly Howe Island) that apparently was unrelated to oilfield activities. This decrease in nesting effort resulted in a substantial drop in the number of broods of Brant appearing at the Putuligayuk River mouth in July, although the number of adults present in the area was comparable to earlier years (Figure 4). The pattern of use of this area was similar to that observed in previous years, with groups of brood-rearing Brant using halophytic wet meadow habitats on the island and mainland shore near CCP, as well as intermittently using habitats along the coast of Prudhoe Bay north of CCP (Appendix 2). Unlike previous years, however, a flock of brood-rearing Brant occupied the coastal wetlands north of the West Beach State No. 1 pad by 15 July and remained in that general area throughout the brood-rearing period (Appendix 1). Brant previously have used this area, but not annually and not for the entire brood-rearing period (Murphy et al. 1991). The

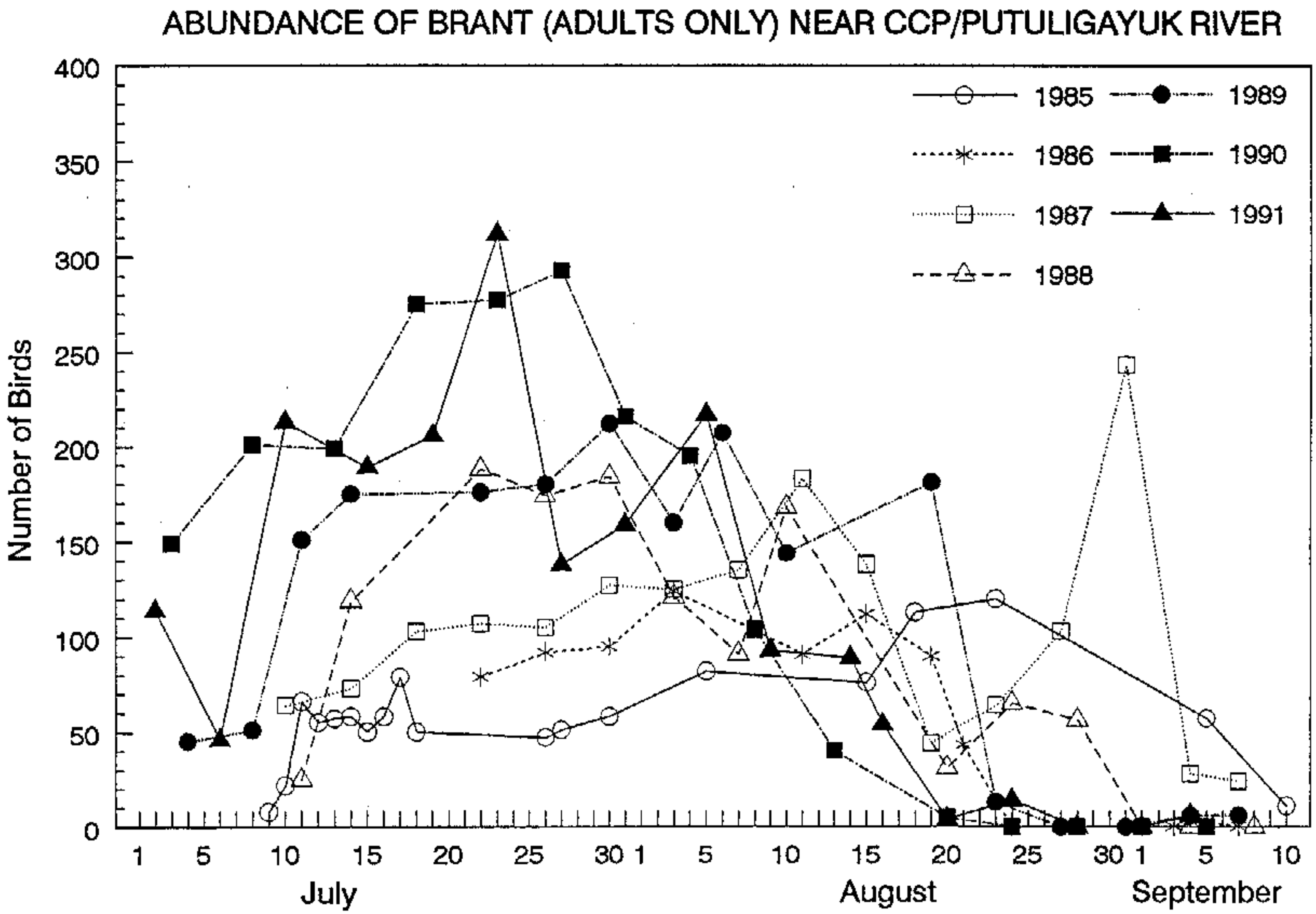

Figure 4. Counts of adult Brant using the brood-rearing areas near the Central Compressor Plant (CCP) and the Putuligayuk River, July - September, 1985 - 1991. Data for 1985 - 1990 are from Murphy et al. (1986, 1987, 1988, 1989, 1990); and Anderson et al. (1991).

peak count of Brant at the CCP brood-rearing area was 312 adults and 67 young on 23 July (Appendix 1). By 31 July, the number of adults and young had decreased to 159 adults and 20 young (Figure 5). Numbers of Brant in the area continued to decline throughout August and were essentially absent by late August. This pattern has been observed in previous years (Murphy et al. 1986, 1987, 1988, 1989, 1990; Anderson et al. 1991) and probably is not attributable to disturbance from gravel-hauling activities (Figure 4).

The presence of small flocks of Brant at the unnamed stream north of DS-L1/LGI during mid August indicates movements of some Brant north from near CCP and possibly some Brant south from near WBS-1 (Appendices 1 and 2). The decline in the number of Brant near CCP on 5 August and the increased number of Brant north of WBS-1 on 9 August indicated both movements of birds north from the CCP area and departure from the CCP area by adults (without broods) that had completed molt. On 9 August, several adult Brant in the flock north of WBS-1 were able to fly. ABR personnel color-marked Brant in the flock north of WBS-1 on 9 August as part of a cooperative Brant banding program with the U.S. Fish and Wildlife Service. This banding program was sponsored and funded by the Prudhoe Bay Unit owners and the Endicott Unit Owners and was a cooperative effort involving industry and agencies. Movements of these banded birds during the remainder of the brood-rearing season and into fall staging indicated that interchange took place among the various brood-rearing habitats along the western shore of Prudhoe Bay (Figure 5). During late August and early September, I saw banded Brant near CCP, along the unnamed stream north of DS-L1/LGI, and near the base of the West Dock causeway. The use of the coastal wetlands at the base of the West Dock causeway occurred while road construction to the Point McIntyre pad was underway. Brant used the small lagoon near the base of the causeway, the moist tundra habitats east of the causeway, and coastal wetlands along the coast west of the lagoon (closer to Point McIntyre). Brant were never closer than 500 m to road construction at any of these locations.

BEHAVIORAL REACTIONS OF BRANT TO GRAVEL-HAULING TRUCKS

The reactions of Brant to both fully loaded and empty bellydumps were observed on

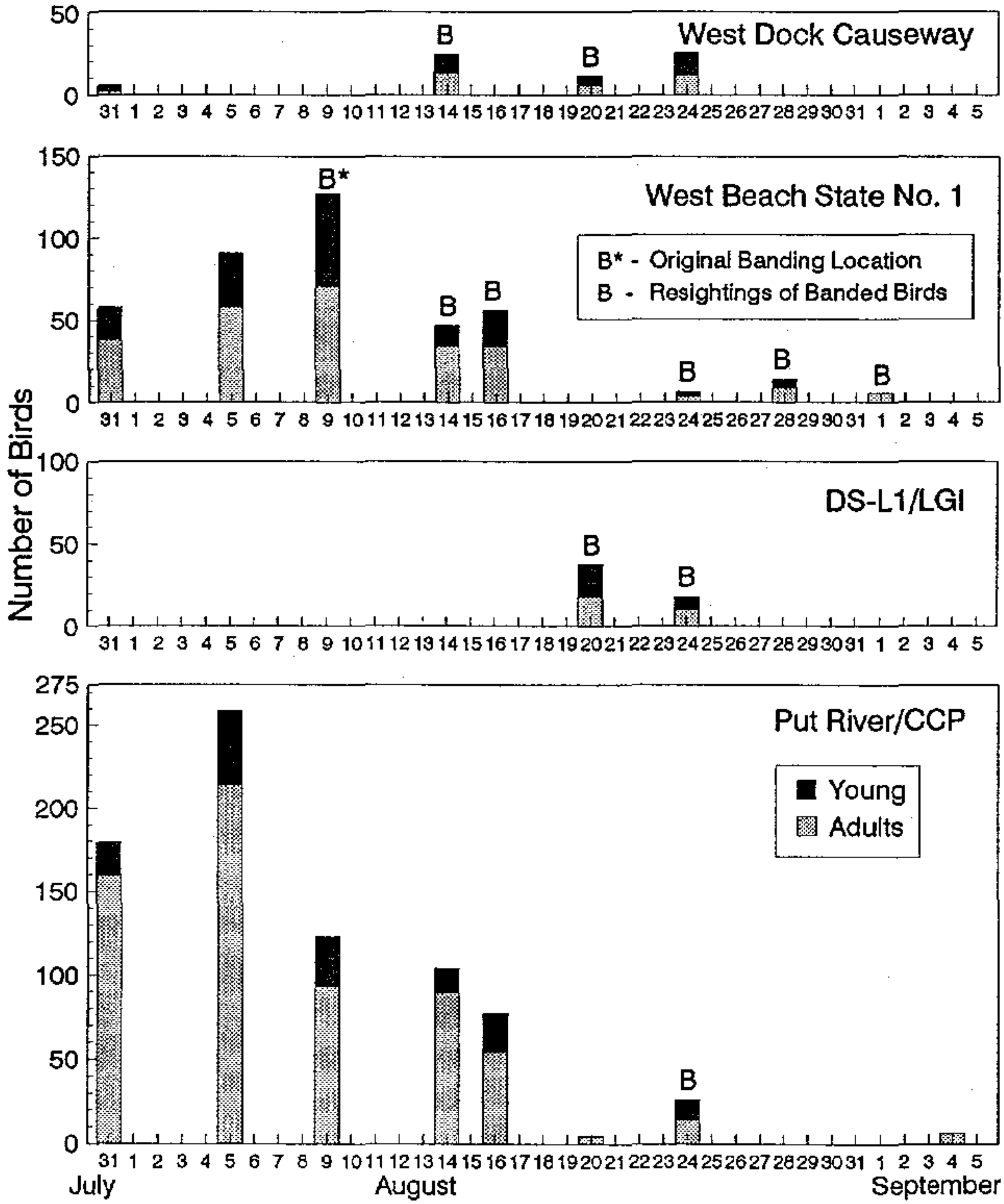

Figure 5. Counts of adult and young Brant in brood-rearing areas near the Central Compressor Plant (CCP) and at several locations along the western shore of Prudhoe Bay, 31 July - 4 September 1991. B above a histogram bar indicates that color-marked birds were present in the flock.

three separate occasions: 20 August, 28 August, and 1 September 1991. On 20 August, a flock of four adults and one juvenile was feeding on the island southeast of CCP approximately 300 m from West Dock Road. These Brant did not react to the passage of four full and four empty Euclids on West Dock Road during one 15-min period. On 28 August, I observed the reactions of a flock of three adults and two juvenile Brant north of WBS-1 to trucks on West Dock Road at an approximate distance of 300 m. These Brant did not react to four full Euclids and three empty Euclids during a 15-min observation period. A second flock of six adults and three juveniles also displayed no reactions to gravel trucks (three full and seven empty Euclids) during a subsequent 15-min period. This flock was located 600 m north of the smaller flock and was approximately 200 m from West Dock Road. In both flocks, adult and young Brant appeared to ignore all vehicular activity on the West Dock Road and continued normal feeding and social behavior (bathing, preening). This pattern also was apparent on 1 September when I observed a flock of six adult Brant approximately 350 m from West Dock Road and 450 m north of WBS-1. Again, these Brant did not react to passing gravel-hauling trucks (four full, five empty Euclids; one full, one empty Maxi-Haul) during one 15-min period.

In addition to these systematic observations, on 14 August, Brant (13 adults/12 young) were observed feeding in the coastal lagoon at the base of West Dock causeway while road construction took place approximately 500 m to the west. This flock did not display any obvious reactions to construction activity on the road, which included constant bulldozer noise and periodic Euclid dump trucks.

CONCLUSIONS

Based on our observations in the CCP vicinity and north along the Prudhoe Bay coastline, the relatively moderate levels of disturbance caused by Point McIntyre road construction and construction activities associated with GHX-2 did not have detrimental effects on the brood-rearing activities of Brant. The only possible effect on Brant may have been a decline in use of the brood-rearing area near CCP during late August, but this type of decline has been observed in previous years when construction activities were not taking place and is more likely to be normal movements of Brant out of the area at the completion of molt and as young become able to fly. The somewhat earlier onset of this movement in 1991, as compared to some other years, could be due to the earlier arrival of Brant in June and consequently an earlier completion of the molt.

Reclamation of gravel from the North Prudhoe Bay State No. 2 pad for use in construction of the Point McIntyre Road substantially reduced the movement of loaded gravel-hauling trucks past the main Brant brood-rearing area near CCP during early August, thus greatly reducing any potential disturbance of Brant when broods were flightless. Although sound levels at the brood-rearing habitats near CCP were somewhat elevated during gravel hauling, they still were within the range of sound levels recorded when gravel-hauling trucks were not active and apparently did not affect the use of the area by Brant. The presence of Brant in the coastal wetlands near the base of the West Dock causeway during construction of the road to Point McIntyre also indicated that disturbance associated with road construction was not detrimental to Brant when the disturbance was >400-500 m from the birds. Reactions of Brant in the WBS-1 area indicated that at even closer distances gravel-hauling trucks did not elicit reactions from birds.

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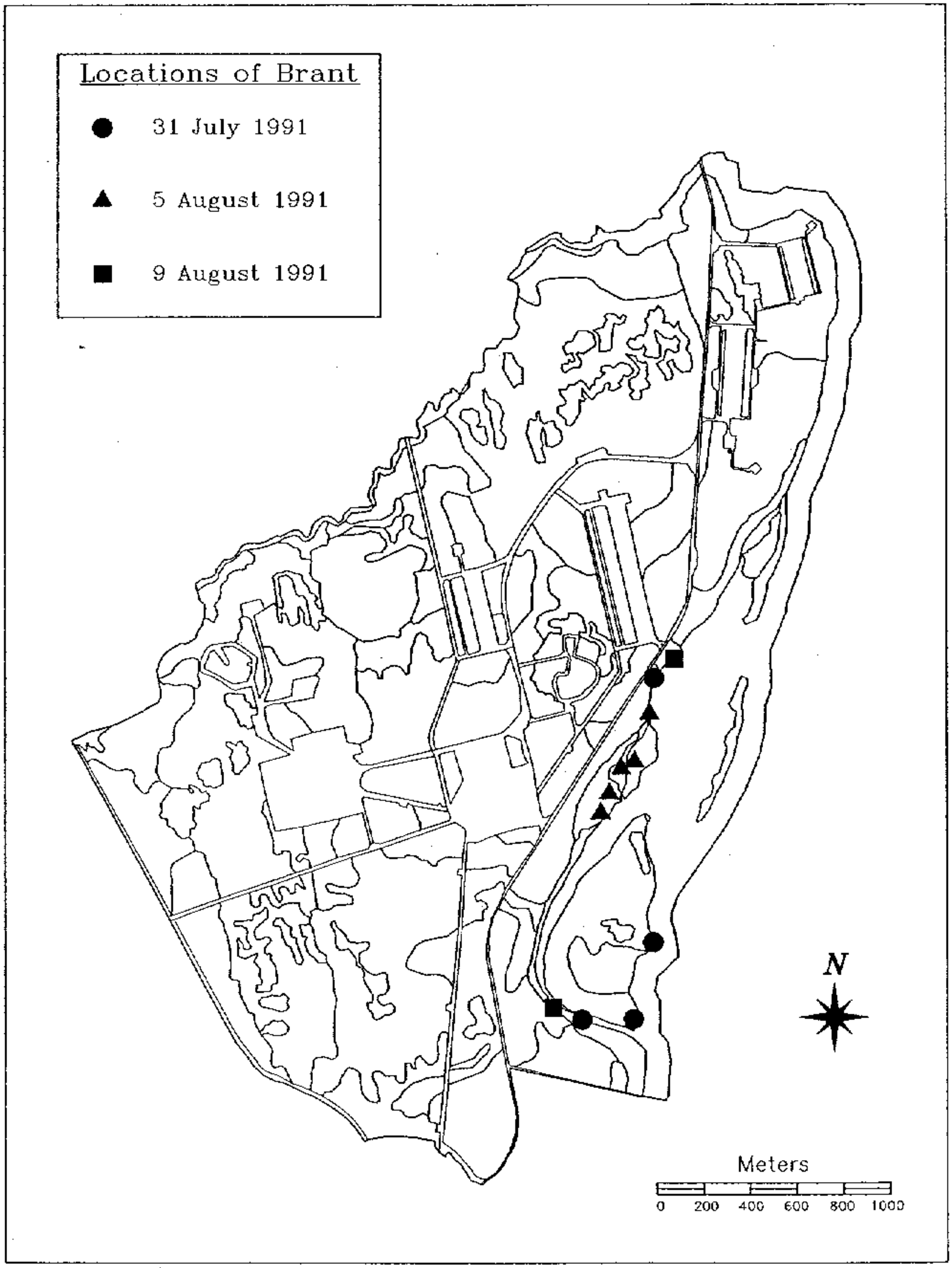
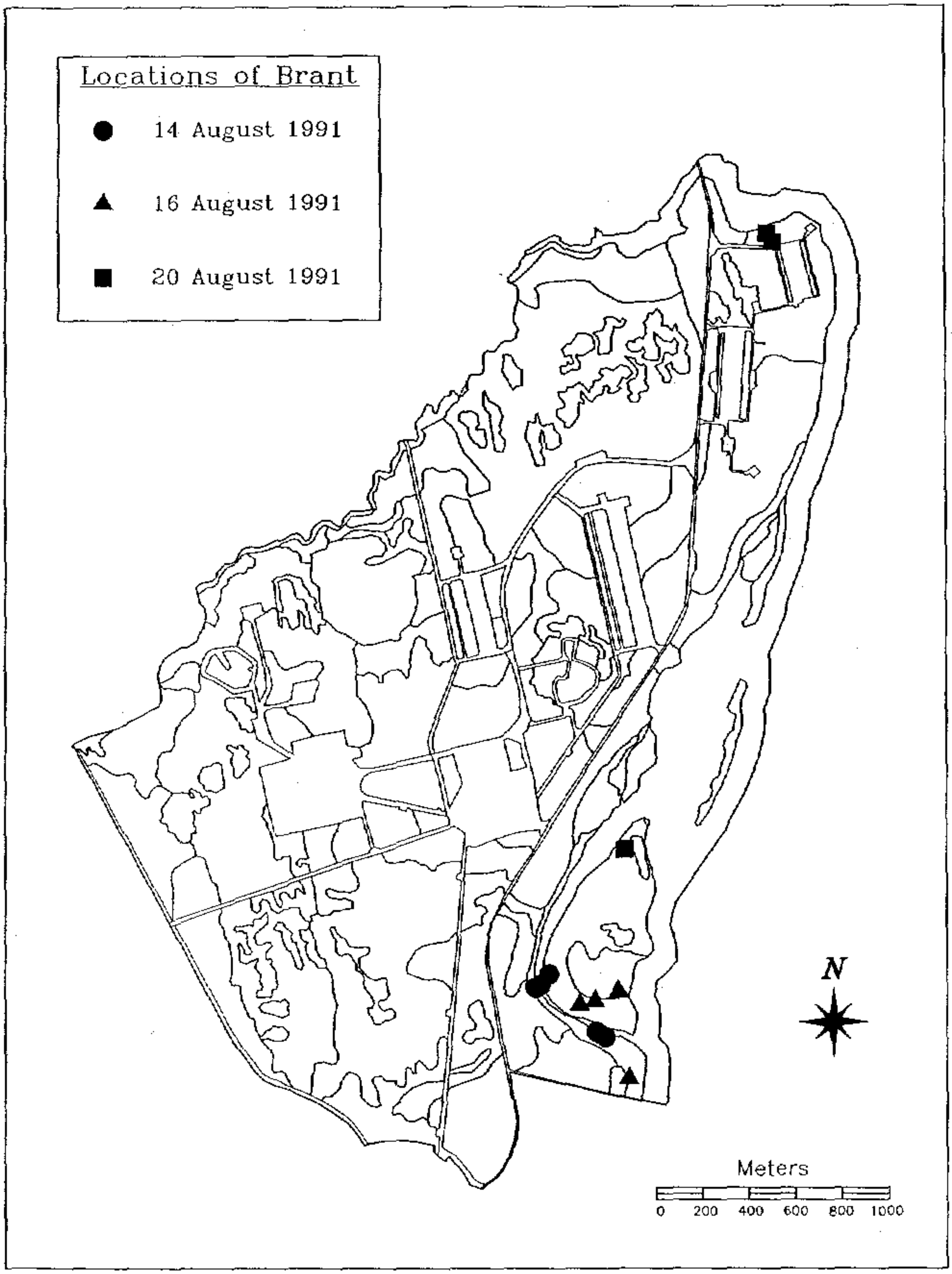
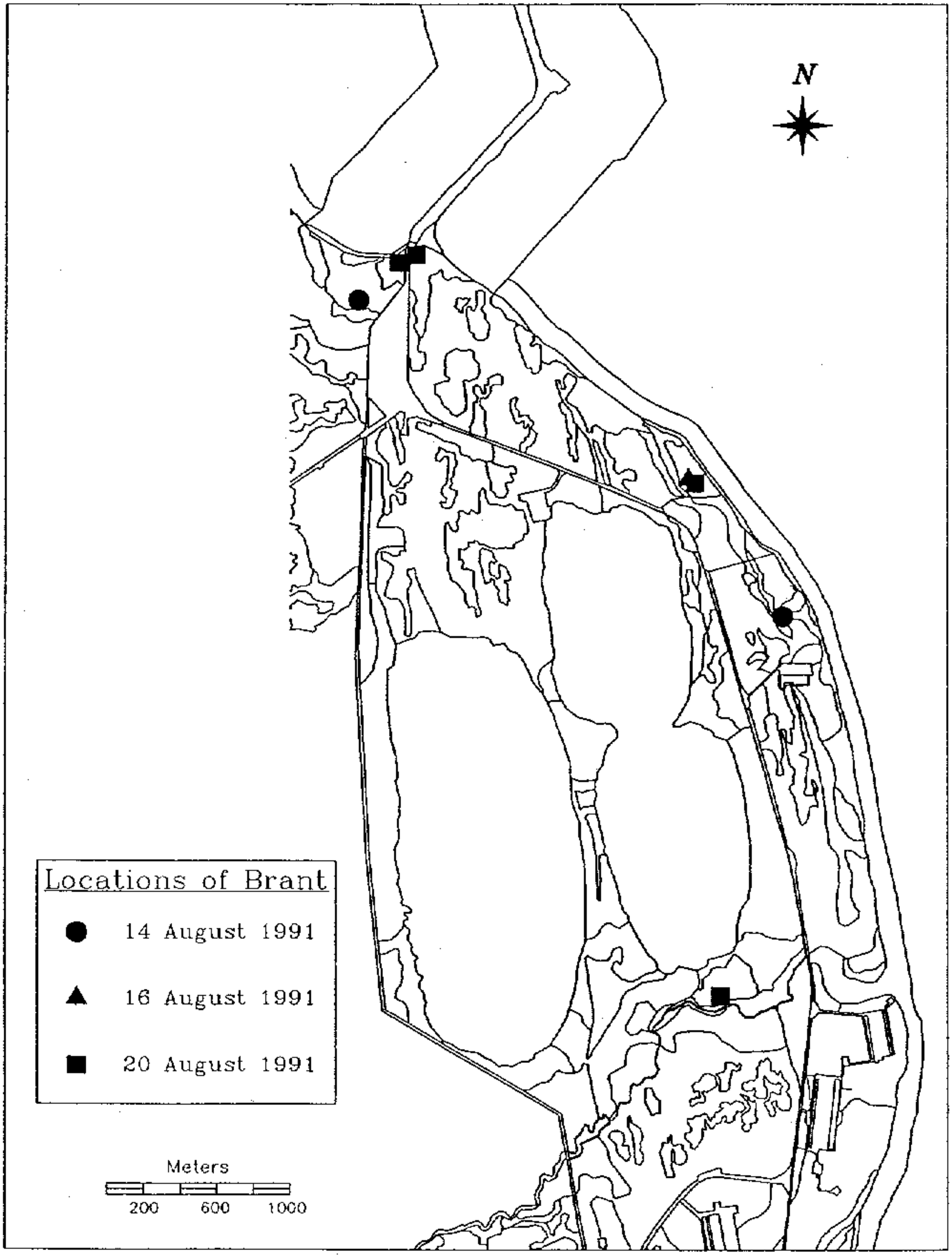
Appendix 1. Number of adult and young Brant at brood-rearing areas along the western shore of Prudhoe Bay, July - September 1991.

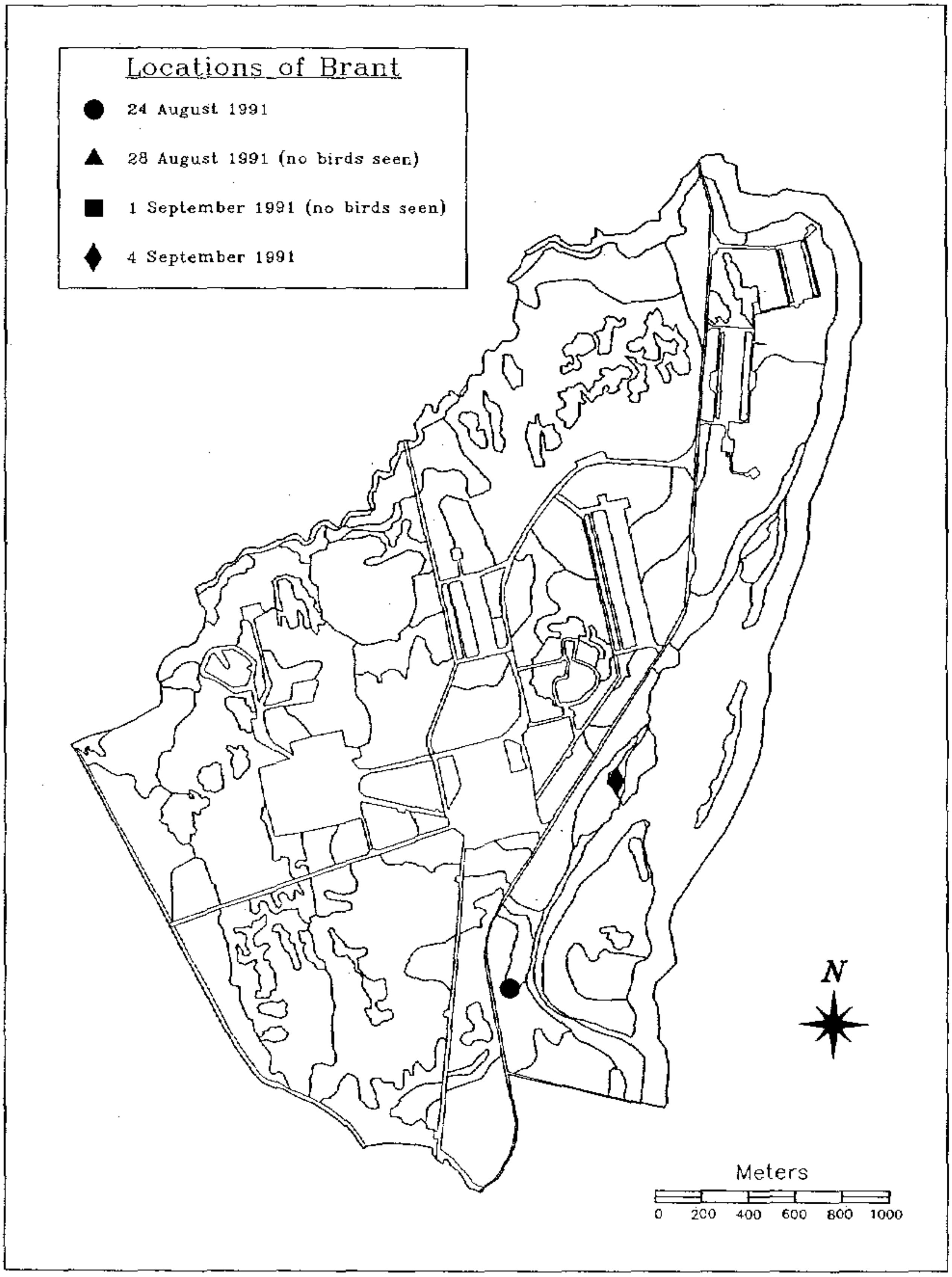
Date	Putuligayuk River CCP area		Unnamed Stream N of DS-L1/LGI		West Beach State No. 1		West Dock Causeway	
	Adults	Young	Adults	Young	Adults	Young	Adults	Young
2 July	114	0	4	0	1	0		
6 July	46	13	6	0	4	0		
10 July	213	11			17	0		
15 July	189	29			9	3		
19 July	206	14			16	3		
23 July	312	67	6	8	24	17		
27 July	138	13	18	16	24	22	2	2
31 July	159	20			38	20	2	4
5 August	217	45			58	33		
9 August	93	30			71	56		
14 August	89	15			34	13	13	12
16 August	54	23			34	22		
20 August	4	1	18	20	4	6	6	6
24 August	14	12	10	8	4	3	12	14
28 August					9	5		
1 September					6	0		
4 September	6	0			1	0		

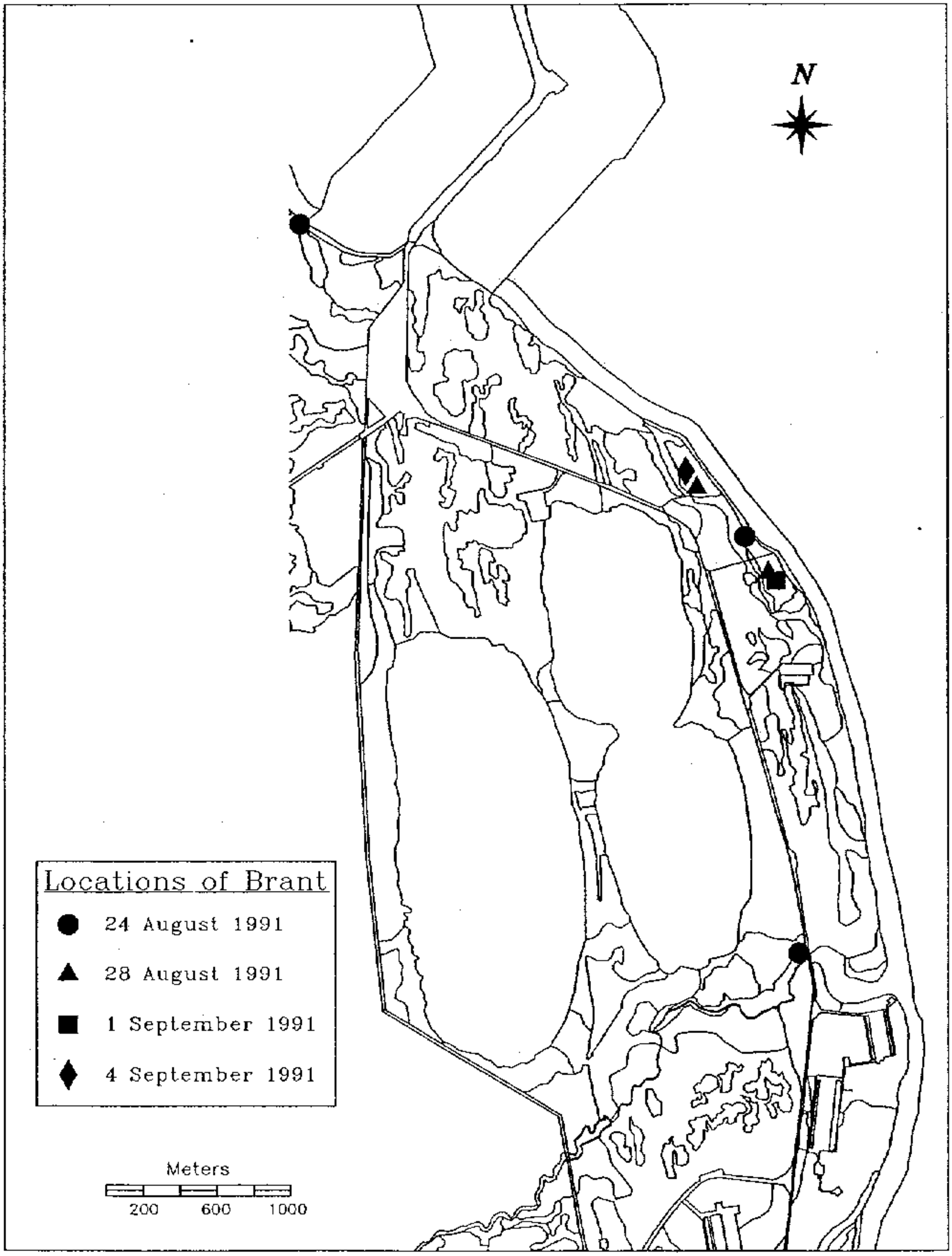
Appendix 2. Locations of Brant during road surveys from 31 July - 4 September 1991. Locations are mapped for Brant in the GHX-1 study area and for Brant along the western shore of Prudhoe Bay north of the GHX-1 area to the base of the West Dock causeway. For names of oilfield facilities refer to Figures 1 and 2.


Locations of Brant
31 July 1991
5 August 1991
9 August 1991
N
Meters
0 200 400 600 800 1000


Locations of Brant
14 August 1991
16 August 1991
20 August 1991
N
Meters
0 200 400 600 800 1000


N
Locations of Brant
14 August 1991
16 August 1991
20 August 1991
Meters
200
600
1000


Locations of Brant
24 August 1991
28 August 1991 (no birds seen)
1 September 1991 (no birds seen)
4 September 1991
N
Meters
0
200
400
600
800
1000


N
Locations of Brant
24 August 1991
28 August 1991
1 September 1991
4 September 1991
Meters
200
600
1000