Spring and fall distribution of waterfowl and other aquatic birds on the mainland of the Inuvialuit Settlement Region, Western Canadian Arctic, 1990-98

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ABSTRACT

This report summarizes, in a series of maps, aerial transect surveys of waterfowl and other birds carried out on the mainland of the Inuvialuit Settlement Region of the Western Canadian Arctic, 1990-98. The region is one of the most important habitat sites for migratory birds in the Canadian Arctic and faces the possibility of the large scale development of a natural gas pipeline and gathering system in the near future. Thus, the maps are intended for both wildlife management and environmental assessment purposes. Data from spring surveys (covering a 21 700 km^2 area stretching from the Yukon North Slope to the Bathurst Peninsula) and fall surveys (covering a 6 091 km^2 area in and near the Mackenzie Delta) are summarized. Two types of maps, reflecting different levels of data summary and synthesis, are presented: (1) "point" maps showing numbers of birds sighted per 2-km transect segment, and (2) density contour maps, modeled using an Inverse Distance Weighting approach with a Geographic Information System and depicting minimum population densities of the different species. Taken together, the two map types should allow the user to assess the distribution of each species as well as any potential limitations in the data used for a particular map. Among the most common types of waterfowl and other birds considered are Greater White-fronted Goose, Canada Goose, Black Brant, Lesser Snow Goose, Tundra Swan, Long-tailed Duck, scoters (surf and white-winged grouped), scaup (lesser and greater grouped), Canvasback, Northern Pintail, Mallard, Northern Shoveler, American Wigeon, Pacific Loon, Red-throated Loon, Sandhill Crane, Glaucous Gull, Arctic Tern, Willow Ptarmigan, and Rock Ptarmigan. Sightings of other less common species (American Rough-legged Hawk, Northern Harrier, Bald Eagle, Golden Eagle, Short-eared Owl, and Long-tailed, Parasitic, and Pomerine Jaegers) were too sparse to map in terms of population densities. Information on these species is presented only as point data.

RÉSUMÉ

Ce rapport présente une série de cartes faisant la synthèse de relevés aériens par transects de la sauvagine et d'autres oiseaux qui ont été effectués de 1990 à 1998 dans la partie continentale de la région désignée des Inuvialuit, dans l'ouest de l'Arctique canadien. Il est question d'aménager prochainement un gazoduc et un réseau collecteur d'envergure dans cette région, qui constitue pour les oiseaux migrateurs l'une des parcelles d'habitat les plus importantes de l'Arctique canadien. Ces cartes seront donc utilisées à la fois pour la gestion de la faune et pour la réalisation d'une évaluation environnementale. Les données résumées sont tirées des relevés effectués au printemps (sur un territoire de 21 700 km^2 s'étendant du versant nord du Yukon à la péninsule de Bathurst) et à l'automne (sur un territoire de 6 091 km^2 dans le delta du Mackenzie et ses environs). Des cartes de deux types sont présentées pour refléter différents niveaux de synthèse et de résumé des données : (1) cartes d'« emplacements » montrant le nombre d'oiseaux observés par portion de transect de 2 km, et (2) cartes de contour de la densité, préparées grâce à une procédure de pondération en fonction inverse de la distance dans un système d'information géographique, et illustrant les densités de population minimum des différentes espèces. Étudiés conjointement, ces deux types de cartes devraient permettre aux utilisateurs d'évaluer la répartition géographique de chaque espèce ainsi que toute limite éventuelle des données utilisées pour une carte précise. Les espèces comptant le plus grand nombre d'individus parmi la sauvagine et les autres oiseaux étudiés sont les suivantes : oie rieuse, bernache du Canada, bernache noire, petite oie des neiges, cygne siffleur, harelde kakawi, macreuses (brunes et à front blanc), fuligules (petit et milouinan), fuligule à dos blanc, canard pilet, canard colvert, canard souchet, canard d'Amérique, plongeon du pacifique, plongeon catmarin, grue du Canada, goéland bourgmestre, sterne arctique, lagopède des saules et lagopède alpin. Certains individus d'espèces moins nombreuses (buse pattue d'Amérique, busard Saint-Martin, pygargue à tête blanche, aigle royal, hibou des marais et labbes à longue queue, parasite et pomarin) ont également été observés, mais en quantité insuffisante pour qu'il soit possible de cartographier la densité de leur population. Des renseignements sur ces espèces sont donnés uniquement sous forme d'observations ponctuelles.

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1. INTRODUCTION

The Inuvialuit Settlement Region (ISR) of the Western Canadian Arctic is one of the most important breeding areas for waterfowl and other aquatic birds in northern Canada (Barry and Barry 1982, Johnson and Herter 1989, Alexander et al. 1991, Latour et al. 2005). The migration paths of birds that spend the summer in the ISR lead to diverse parts of the North and, in some instances, South American continents. Thus, the populations of migratory birds from the ISR are of national or international significance as well as forming an important part of the subsistence diet of the local Inuvialuit (Anonymous 2003).

Our understanding of the regional distribution of some avian species in the ISR, especially those inhabiting coastal environments, has been summarized by Alexander et al. (1988). General descriptions of key terrestrial habitat sites for migratory birds have also been reported (Alexander et al. 1991, Latour et al. 2005).

Since 1990, a number of aerial transect surveys have been carried out on the mainland of the Inuvialuit Settlement Region (Hines et al. 2000, Hines and Wiebe 2005). The aerial survey data are geographically coded and suited for analysis in a Geographic Information System. If presented on maps, the summarized data should enhance our understanding of bird distribution, especially in areas inland from the coastal zone considered by Alexander et al (1988).

The purpose of this report is to summarize, in mapped form, the survey information collected during 1990-98. The resulting maps are intended for use in wildlife management and environmental impact assessments, and should be of immediate value given the potential for industrial development in the region.

2. METHODS

2.1 Spring Surveys

Methods used during the spring surveys are described in detail elsewhere (Hines et al. 2000, Hines and Wiebe 2005) and briefly reiterated here. We mapped data collected during aerial surveys of a 21 700 km^2 area of the mainland of the ISR between

June 11 and June 22, 1991-1998 (Figure 1). The primary objectives of the surveys were to determine the numbers and distribution of waterfowl (particularly Greater White-fronted Geese, Canada Geese, Black Brant, Lesser Snow Geese and Tundra Swans) and other highly visible types of migratory birds, but information on other species of waterfowl, aquatic birds, and raptors was recorded as well. Timing of the surveys corresponded to the period when most waterfowl were widely dispersed as breeding pairs.

Surveys were carried out by two observers who counted all the birds sighted within 200 m of the transect line. Transects were flown in straight lines using a Bell 206 helicopter traveling at 80-100 km/hr approximately 45 m above the ground (Figures 2-5). Most transects were oriented in a North-South direction (approximately perpendicular to the coast) and were spaced at 10-km intervals, except in a few areas of prime waterfowl habitat where transects were 5 km apart. Regular transects averaged 25 km in length (range 6-82 km) and were divided into 2-km segments, which served as a basis for recording data.

Each transect segment was 0.8 km^2 in area (i.e., 400 m wide x 2 km long). Therefore, for purposes of mapping, we computed average density estimates for each segment by dividing the average number of birds seen on the segment by 0.8. Not all of the segments were surveyed each year because of the large size of the study area and related budgetary and time constraints. The average population densities calculated for each segment were based on two to seven surveys. Most transect segments (62.5% of 1567 segments) were surveyed four or more times.

2.2 Fall Surveys

Fall migration surveys were conducted in August and September of 1990-93. The surveys were flown at 1 to 2 week intervals, with 2 to 4 surveys being carried out each year (Table 1, Figure 6). Methods for the fall surveys differed in several ways from those used in the spring surveys. The transects were all 10 km in length and were distributed to maximize coverage of the study area while taking into account the logistic and financial reality that systematic or random sampling was not feasible. Thirty-nine transects totalling 390 km in length were flown in August 1990-92 and 57 transects, totalling 570

km in length, were surveyed in September 1990-93. The surveys were representative of a total area of 6 091 km^2 in or near the Mackenzie River Delta (Figure 6).

As in spring, the fall counts were carried out using a Bell 206 helicopter flown at a ground speed of 80-100 km/hr. Flight height was increased to 115 m above ground level to provide good coverage of the highly scattered flocks of birds present in fall. All sightings of waterfowl and other identifiable species within 500 m of either side of the transect were recorded by two observers. Each fall transect was divided into 2-km long segments which served as a basis for recording the data (as was also the case for the spring surveys). The area of each segment was 2 km^2 (i.e., 1 km m wide x 2 km long). Therefore, the average population density on a segment was the average number of birds seen on the segment divided by 2.

2.3 Data Analysis and Mapping

2.3.1 Spring Surveys

For purposes of mapping, the midpoint of each transect segment was treated as the geographic coordinate for that segment. Data were then mapped in two main ways: (1) as point maps showing the average number (or, for raptors, the total number) of individuals of a species sighted on a given segment over the study period; and (2) as density maps showing average spring densities. The two types of maps will allow the user to better understand the distributions of the different species and the reliability of the maps. The data were originally recorded across several UTM zones but, for the purposes of this project, it was necessary to consolidate the survey data into one UTM zone. Thus, all mapping was completed in UTM Zone 9 NAD83.

A number of different methods could have been used to model the data as densities (Bonham-Carter 1994) and we decided to use an interpolative technique called Inverse Distance Weighting (IDW) for this purpose. The value of this technique is in its simplicity and proven usefulness. For example, IDW has been used to map large scale data collection efforts such as the North American Breeding Bird Survey (Sauer 2003) as well as other arctic waterfowl surveys (Alisauskas 1997). Using IDW, large quantities of data can be mapped in an efficient manner allowing the viewer an opportunity to visualize the distribution of birds across large areas. Although it is not the intent here to

explain all the details of IDW, it is useful to highlight a few key features. The underlying assumption with IDW and related methods, is that the attributes to be mapped, in this case the number of birds present, are more apt to be similar for nearby sample locations than they are for locations that are further apart. Thus, the use of IDW assumes that each measured point has some local influence that diminishes with distance.

IDW produces a surface of cell values based on a weighted relationship of the surrounding point values. The influence of points closest to each cell is stronger than the influence of points, which are further away. A decay relationship is used to weight the points following the general formula:

$$\hat{Z}_o = \frac{\sum_{i=1}^{n} W_i Z_i}{\sum_{i=1}^{n} W_i}$$

In the above formula, $\hat{Z}_o$ is the estimated value for the cell (in this case, the number of birds per km^2). The subscript $_i$ refers to the sample points within a user defined zone of influence (or search radius). W_i is the weight given to data point $_i$ in estimating $\hat{Z}_o$. Specifically, $W_i = 1/d_{i0}^p$, where d_{i0} is the distance from point$_i$ to point$_0$ (Bonham-Carter 1994) and ^{p} is an exponent which further influences the effect of nearby and distant data points on $\hat{Z}_o$. We used the IDW interpolator in the Spatial Analyst 1.1 extension for ArcView 3.2 (Environmental Research Systems Institute 2000) to carry out the GIS analyses. In so doing, we needed to specify three different parameters: (1) cell size; (2) a search radius around a given cell which determined which neighbouring data points were included in the analysis; and (3) the exponent (^{p}). Cell size primarily influences the general appearance or graininess of maps but has little influence on computed cell densities. The choice of an appropriate cell size was primarily a trade-off between the required map resolution and computer processing time and file size considerations. The cell size used for the spring survey analysis was an 894 m square. It was chosen because it represented a surface area the size of a transect segment and

provided adequate resolution. We opted to use a search radius of 12 km to act as our zone of influence. This distance ensured that some segments from at least one other transect on each side of the cell of interest would be included in the weighting algorithm. Typically, 15-50 data points fell within the 12-km search radius and were used in calculating the cell values. We found little guidance in the literature on choosing a value for the exponent. Thus, an exponent of 2 was chosen as a power value as this seems to be commonly used and is presented as the default value in the software (McCoy and Johnston 2001). A higher power would put more weight on the points falling near the cell resulting in a less smooth density contour (i.e., a "bull's eye" effect). A lower power value would possibly give too much influence to points further away from the cell.

After generation of the interpolated density surfaces, we converted the data format from raster to vector format. This conversion allowed us to better display the data. The generated density surfaces extended beyond the study area boundaries. Therefore, the vector layer was spatially "clipped" so that the resulting layer corresponded with the study area.

2.3.2 Fall Surveys

The approach for mapping the fall surveys differed in a few ways from that used for mapping the spring survey data. The transects were not regularly distributed so we used a search radius that included the 15 data points that were nearest to the particular cell of interest. This meant that all points within a radius of 12 to 17 km were used in computing the average density values for a cell. Given the smaller size of the fall survey area, the cell size used for the fall analysis was reduced to a 500 m square. That cell size provided adequate map resolution as well as acceptable computer processing time.

The helicopter was flown at greater heights during fall than spring surveys making identification of individual species difficult. Therefore, for the fall data, we focused on mapping species groups such as dark geese, dabbling ducks, and diving ducks as well as the readily identifiable Snow Geese and Tundra Swans.

3. RESULTS

Maps showing the general location of the study area, the area covered during spring surveys from 1991-1998, and the area covered during fall surveys from 1990-93 are presented in Figure 1, Figures 2-5, and Figure 6, respectively. The spring distributions of 27 species or species groups of migratory birds are indicated in Figures 7 to 53 and fall distributions of 16 species or species groups are depicted in Figures 54 to 95. Table 2 contains the scientific names of the different species encountered during the surveys as well as the definitions of the species groups.

To allow the reader to assess the distribution of each species, as well as the amount of supporting data, we have presented maps showing locations of observations as well as population density maps derived by the GIS modeling approach. For some birds (e.g., Red-throated Loon, jaegers, Rock Ptarmigan) there were not enough data available to effectively model spring densities and so distributions were depicted only as point data which reflected the average number of birds seen per survey segment. In addition, birds of prey (hawks, owls, and eagles) were sighted infrequently. Given the interest in birds of prey, as well as the relatively small amount of information to map, all spring sightings of these raptors are presented.

In order to make best use of the maps, the user should be aware of some known data deficiencies, which could potentially influence map accuracy. Obviously, the data will be most reliable for those parts of the Mackenzie Delta and Tuktoyaktuk Peninsula surveyed during the most years (Figures 2-6). In addition, the distributions of abundant and frequently encountered species will be determined with greater reliability than will the less commonly encountered species.

To simplify analyses and map production, we chose to represent bird abundance using a small number of density classes. Our choice of density classes is most appropriate for the more abundant species of geese and ducks, but less suitable for species that normally do not occur in high densities. The data are best suited for use in a GIS where population density classes and map size can be selected to cartographically represent the particular species and geographic area of interest.

Not all birds present on aerial transects are sighted by observers so our maps indicate minimum population densities which have not been corrected for visibility bias.

Visibility correction factors (VCFs) for spring helicopter surveys of the type we conducted have been developed for some of the waterfowl species encountered during our surveys (Hines and Wiebe 2005, Hines and Dufour, unpublished data). Consideration of these VCFs will give the reader a better sense of the absolute numbers of each species found in a given area during spring. Appropriate VCF values for some common species are: dark geese (1.5), Mallard (2.2), American Wigeon (2.4), and Lesser Scaup (1.6). Thus, the true population densities for these species should be 1.5 to 2.4 times higher than reported on the maps. In contrast, Snow Geese and Tundra Swans are considered to be highly visible in the surveys and their numbers need not be corrected for visibility.

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Table 1. Fall periods considered during migratory bird surveys in the Inuvialuit Settlement Region, 1990-1993.

Year	Period	Date	Transects Surveyed
1990	mid August	16-17 August	1-39
	early September	2-5 September	1-39
	mid September	15-16 September	1-57
1991	mid August	13-14 August	1-39
	early September	4-5 September	1-57
	mid September	13-14 September	1-57
	late September	18-22 September	1-57
1992	mid August	21 August	1-39
	early September	5-7 September	1-57
	mid September	11-12 September	1-57
	late September	18-22 September	1-57
1993	early September	2-3 September	1-57
	mid September	14-15 September	1-57

Table 2. Species and species groups referred to in the text or figures.

Species	Scientific Name	Comment
Greater White-fronted Goose	*Anser albifrons*	
Lesser Snow Goose	*Chen caerulescens caerulescens*	
Black Brant	*Branta bernicla nigricans*	
Canada Goose	*Branta canadensis*	
Tundra Swan	*Cygnus columbianus*	
Dark Goose		includes Greater White-fronted Goose, Black Brant, Canada Goose, and unidentified dark geese
American Wigeon	*Anas americana*	
Mallard	*Anas platyrhynchos*	
Northern Shoveler	*Anas clypeata*	
Northern Pintail	*Anas acuta*	
Dabblers		includes American Wigeon, Mallard, Northern Pintail, Northern Shoveler, and other dabbling ducks
Canvasback	*Aythya valisineria*	
Scaup		includes Lesser Scaup (*Aythya affinis*), Greater Scaup (*Aythya marila*), and scaup unidentified to species.
Scoters		includes White-winged Scoters (*Melanitta fusca*), Surf Scoters (*Melanitta perspicillata*), and scoters unidentified to species.
Long-tailed Duck	*Clangula hyemalis*	
Divers		includes Canvasback, Scaup, Long-tailed Ducks, Scoters, and other diving ducks
Red-throated Loon	*Gavia stellata*	
Pacific Loon	*Gavia pacifica*	
Loons		includes Red-Throated Loon, Pacific Loon, and small numbers of Yellow-billed *(Gavia adamsii)* and Common (*Gavia immer)* Loons
Sandhill Crane	*Grus canadensis*	
Jaegers		includes Parasitic Jaeger (*Stercorarius parasiticus*), Pomerine Jaeger (*Stercorarius pomarinus*), and Long-tailed Jaeger (*Stercorarius longicaudatus)*
Glaucous Gull	*Larus hyperboreus*	
Arctic Tern	*Sterna paradisea*	
American Rough-legged Hawk	*Buteo lagopus*	
Northern Harrier	*Circus cyaneus*	
Short-eared Owl	*Asio flammeus*	
Eagles		includes Bald Eagle (*Haliaeetus leucocephalus*) and Golden Eagle (*Aquila chrysaetos*)
Willow Ptarmigan	*Lagopus lagopus*	
Rock Ptarmigan	*Lagopus mutus*	

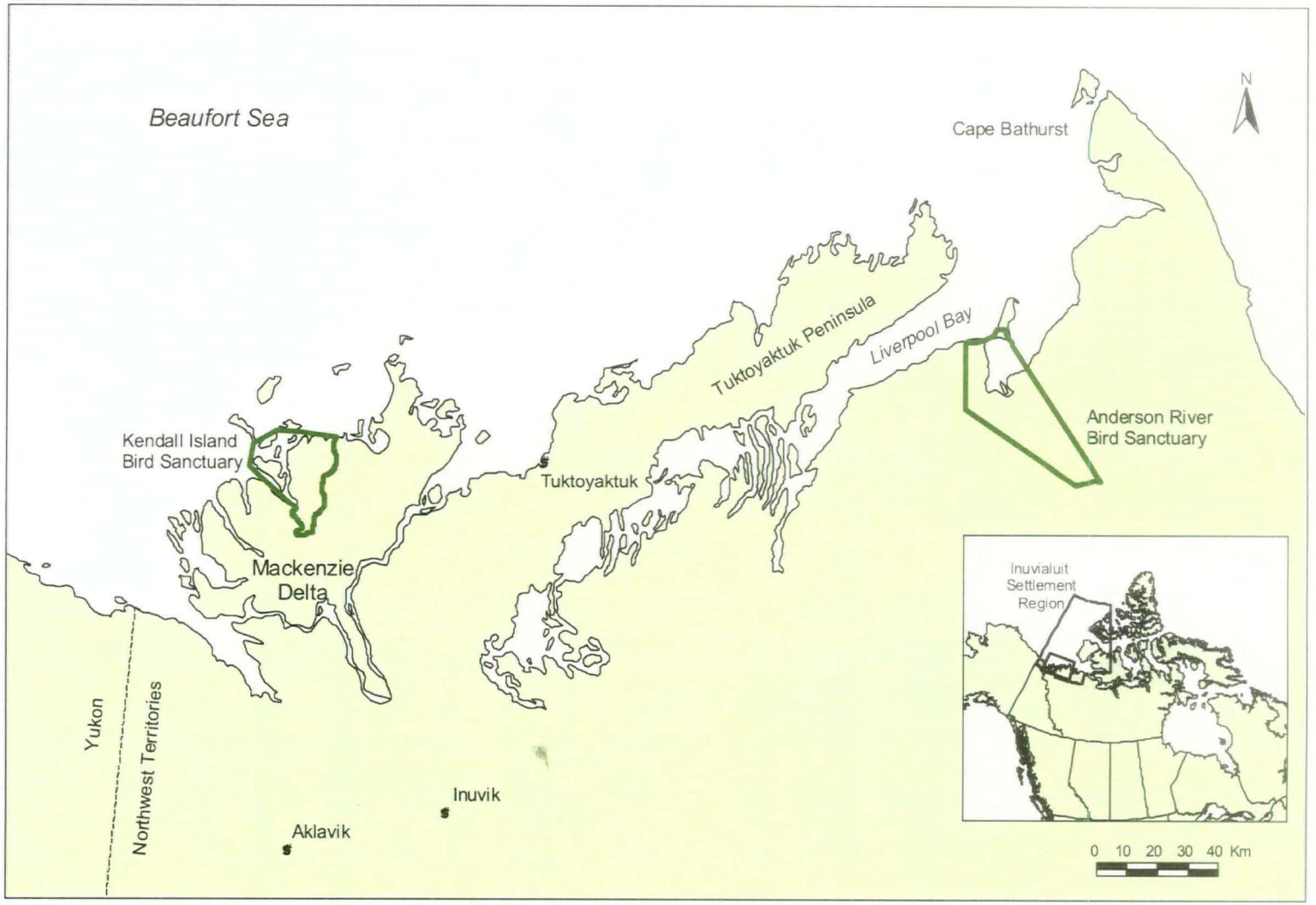

Figure 1. Location of the study area for aerial surveys of migratory birds in the Western Canadian Arctic, 1990-1998.

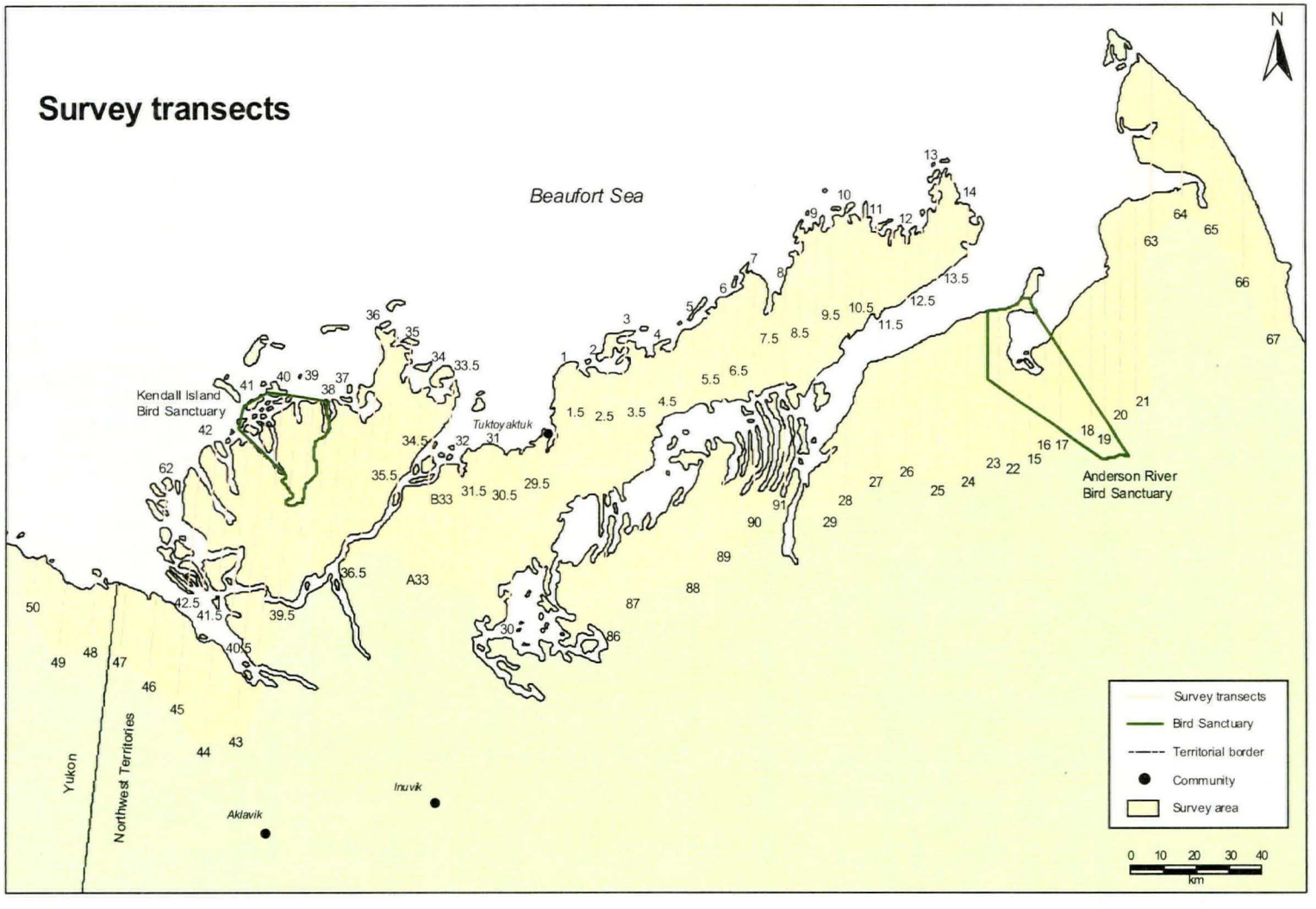

Figure 2. Locations of transects where aerial surveys of migratory birds were carried out on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1993-98.

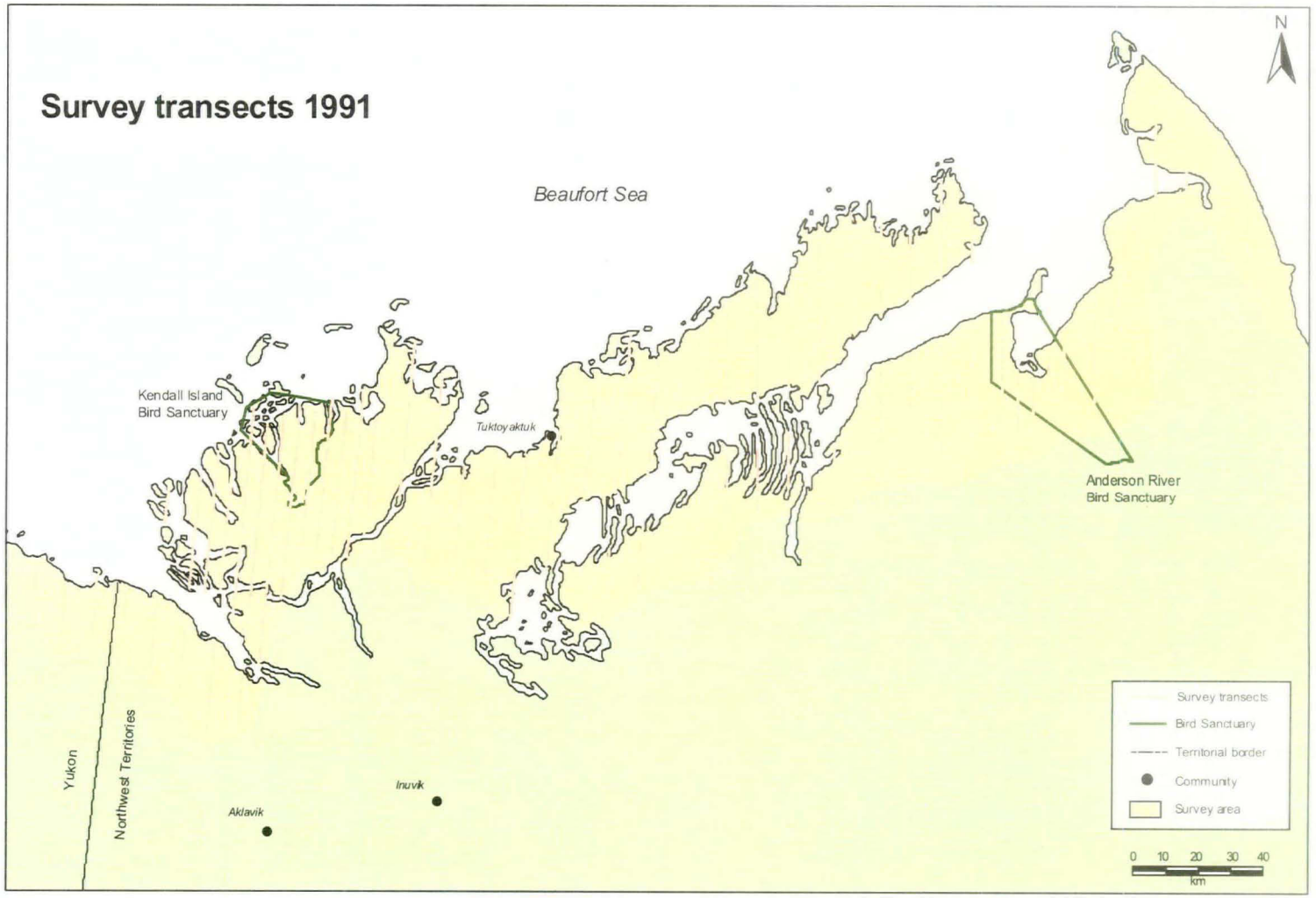

Figure 3. Locations of transects where aerial surveys of migratory birds were carried out on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991.

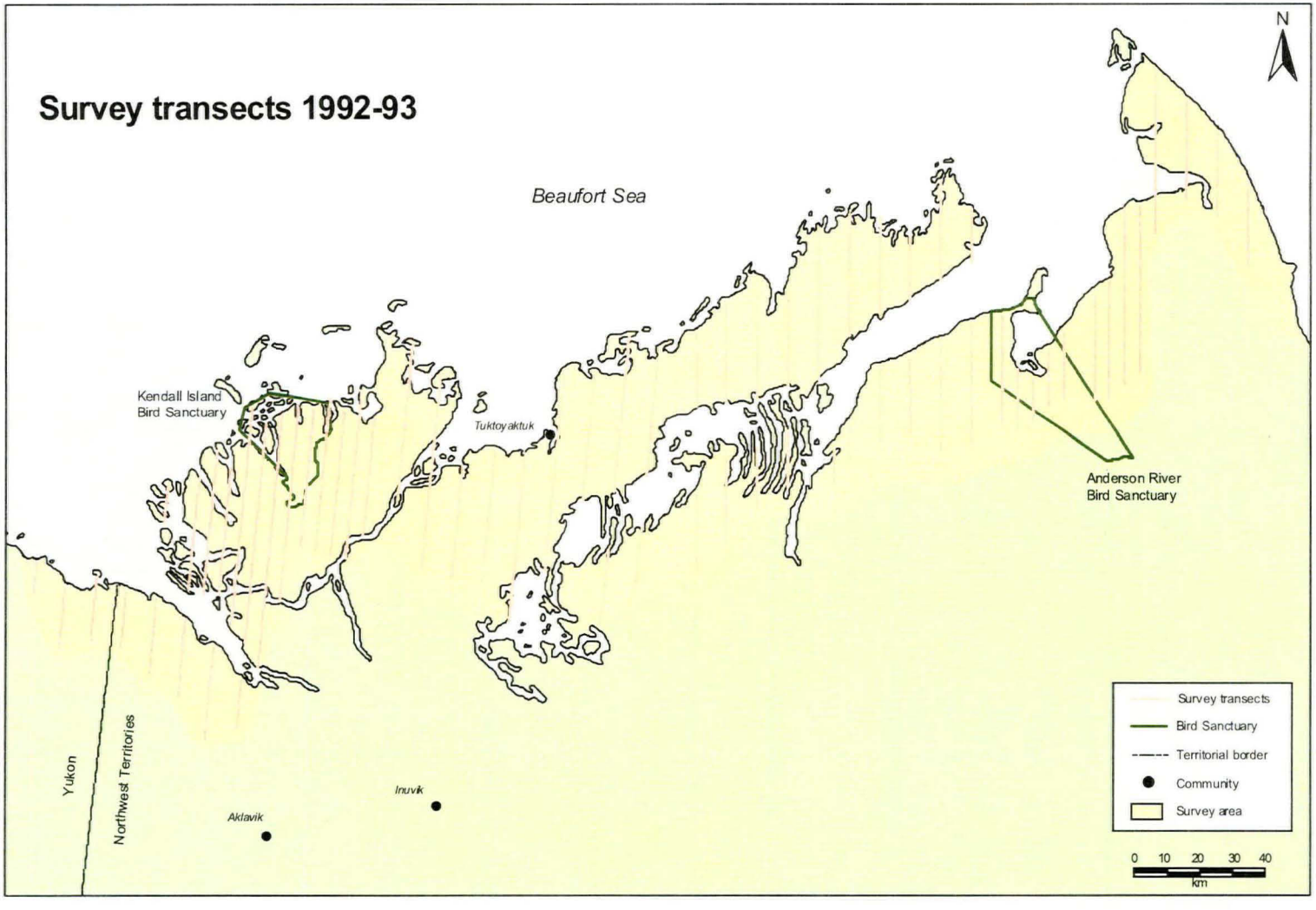

Figure 4. Locations of transects where aerial surveys of migratory birds were carried out on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1992-93.

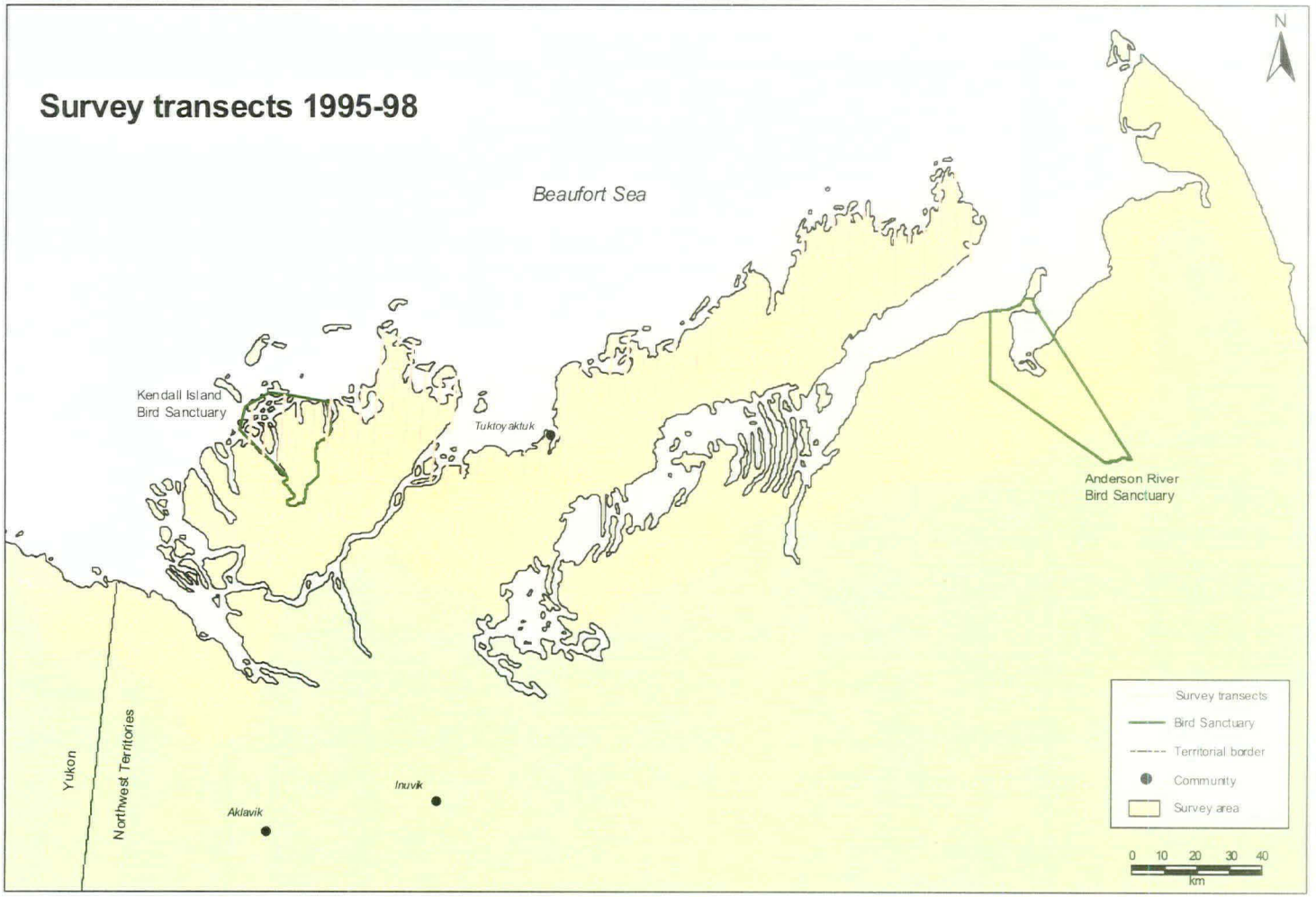

Figure 5. Locations of transects where aerial surveys of migratory birds were carried out on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1995-98.

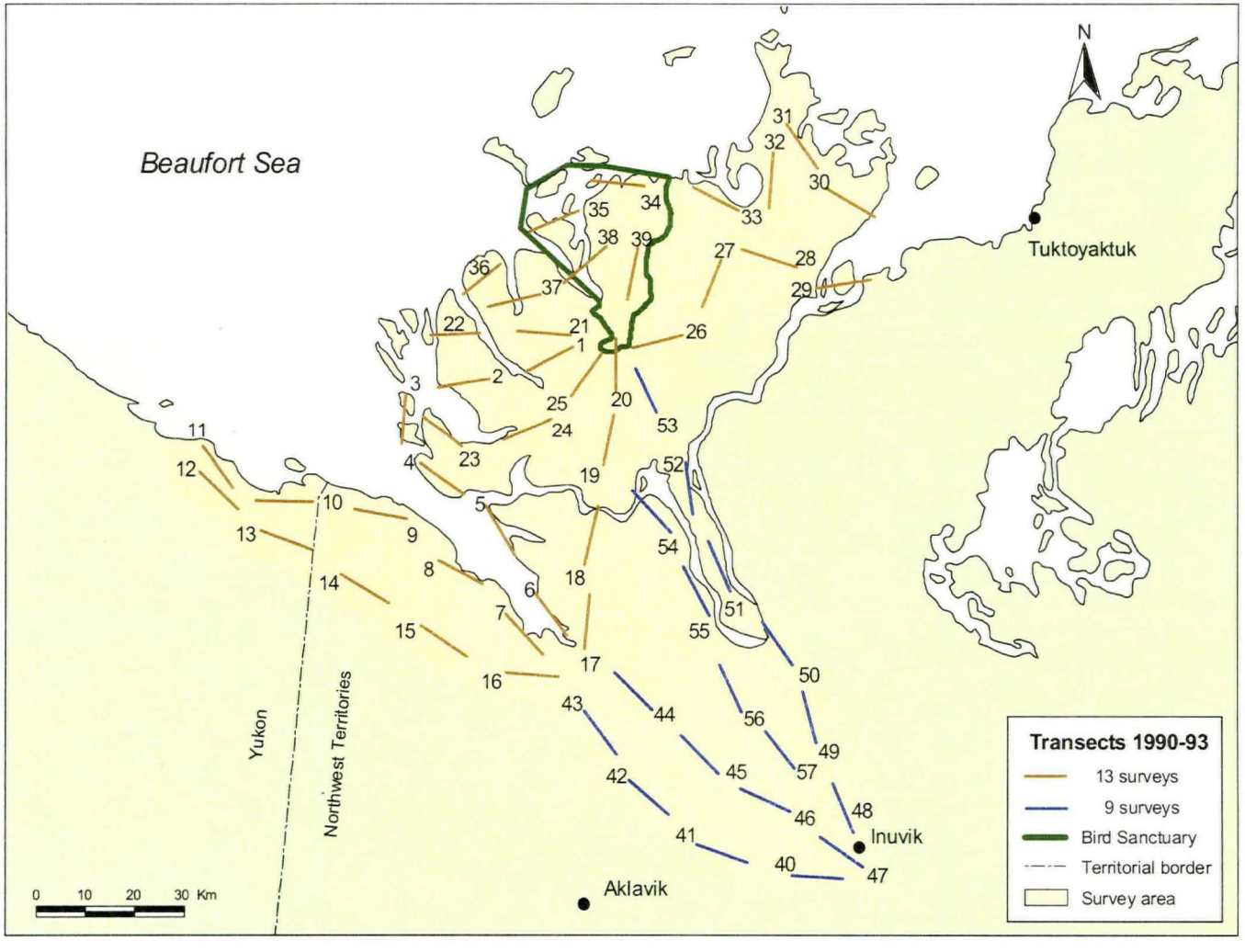

Figure 6. Locations of transects where aerial surveys of migratory birds were carried out on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-93.

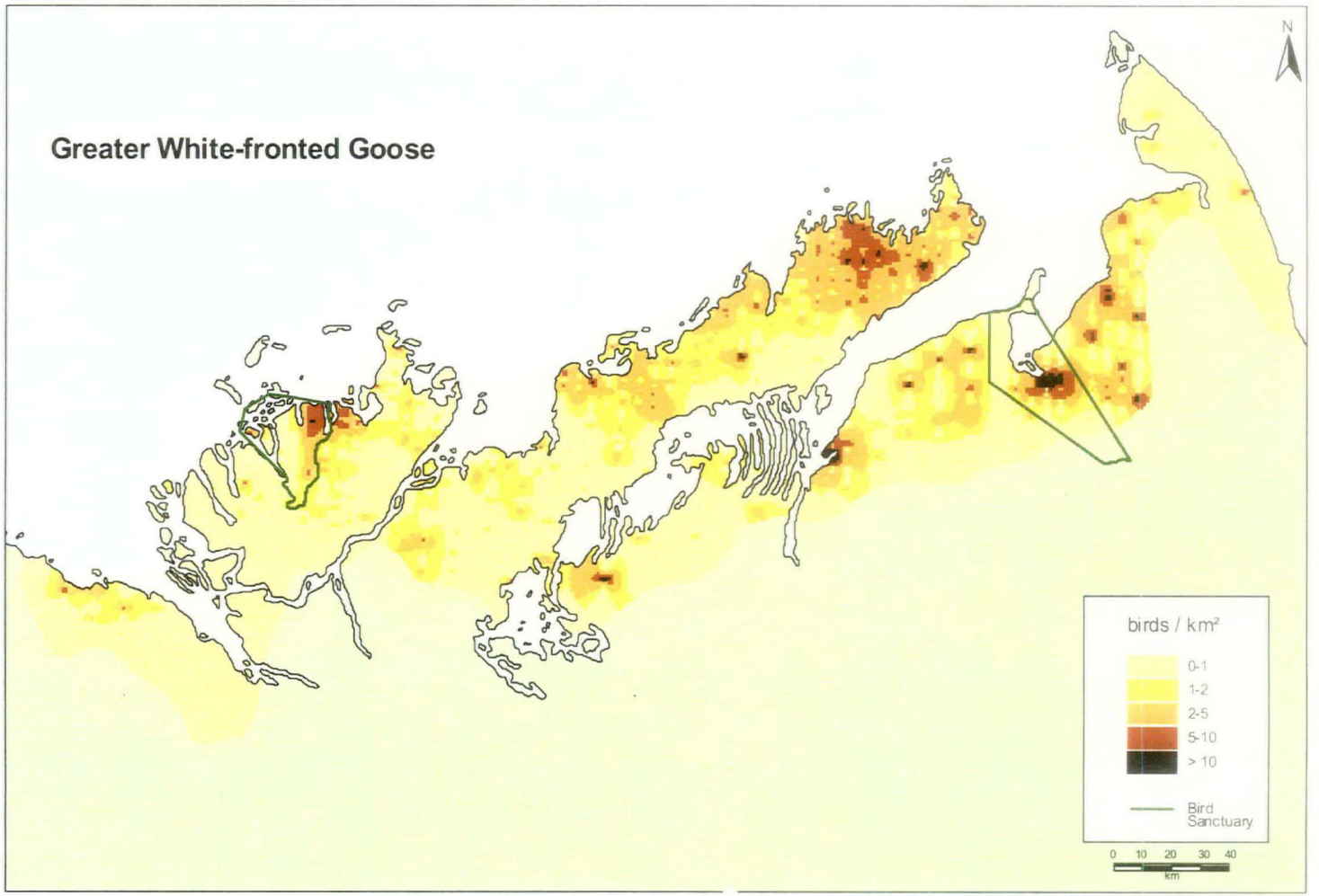

Figure 7. The distribution of Greater White-fronted Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

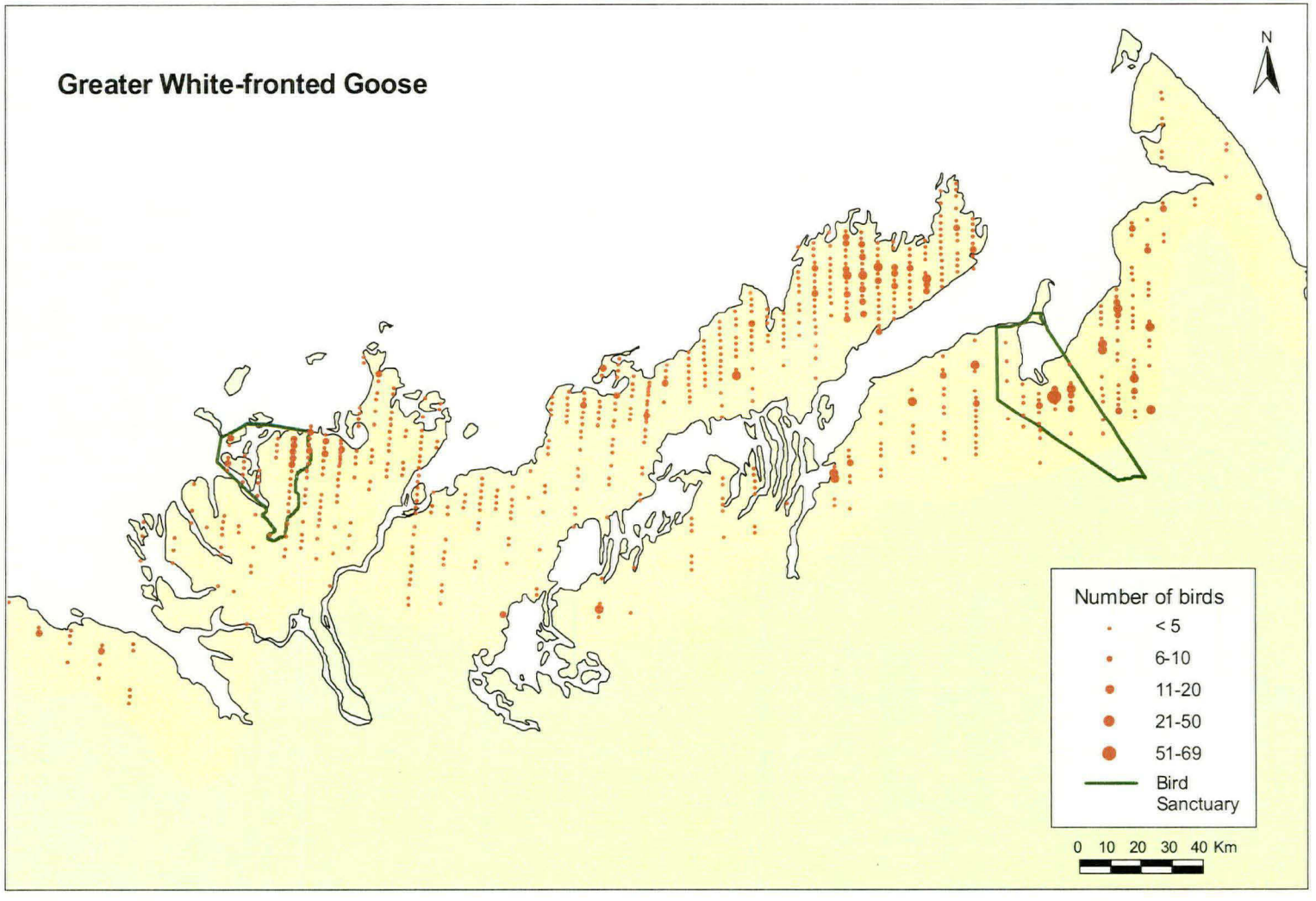

Figure 8. Mean annual numbers of Greater White-fronted Geese observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

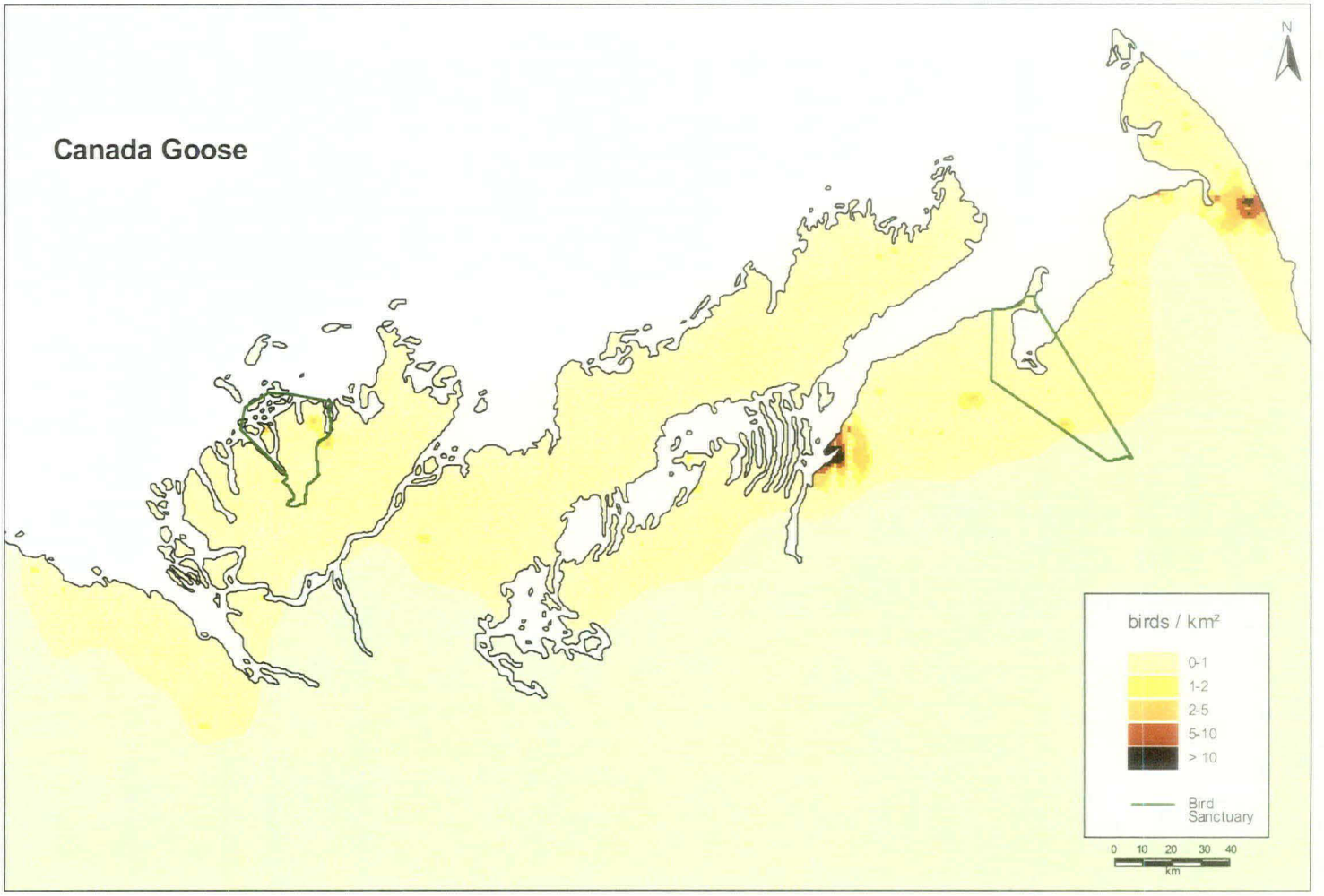

Figure 9. The distribution of Canada Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

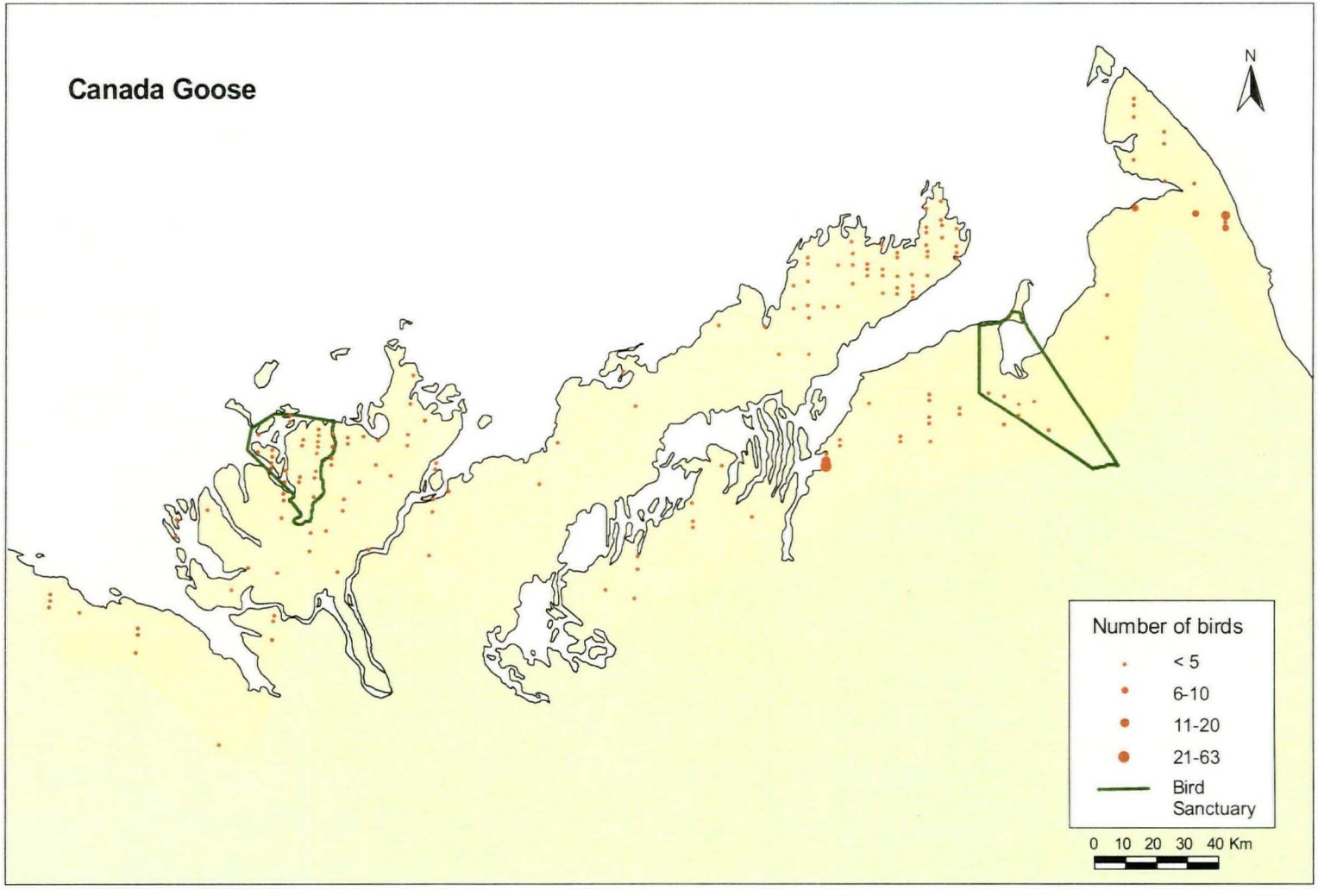

Figure 10. Mean annual numbers of Canada Geese observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

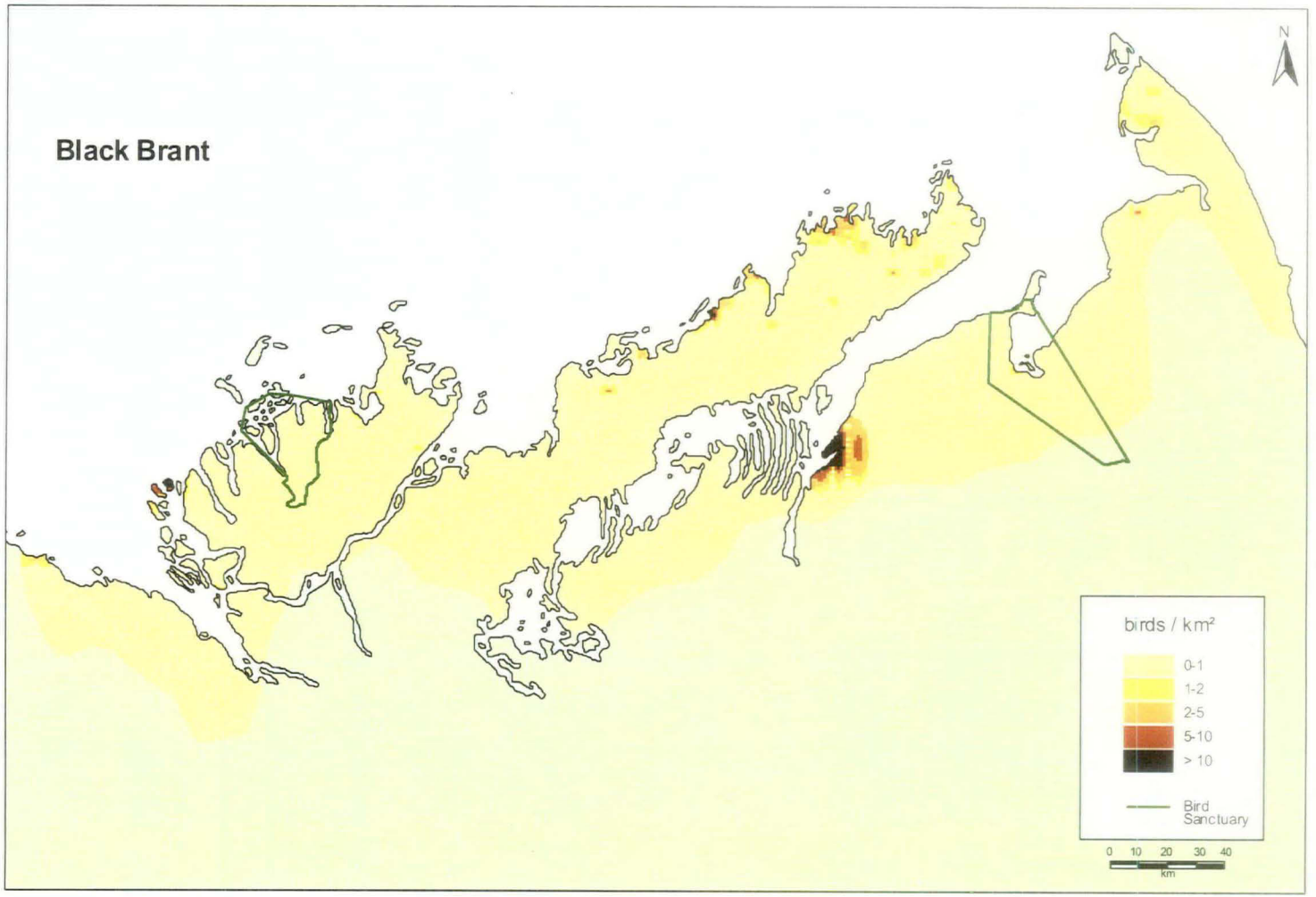

Figure 11. The distribution of Black Brant on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

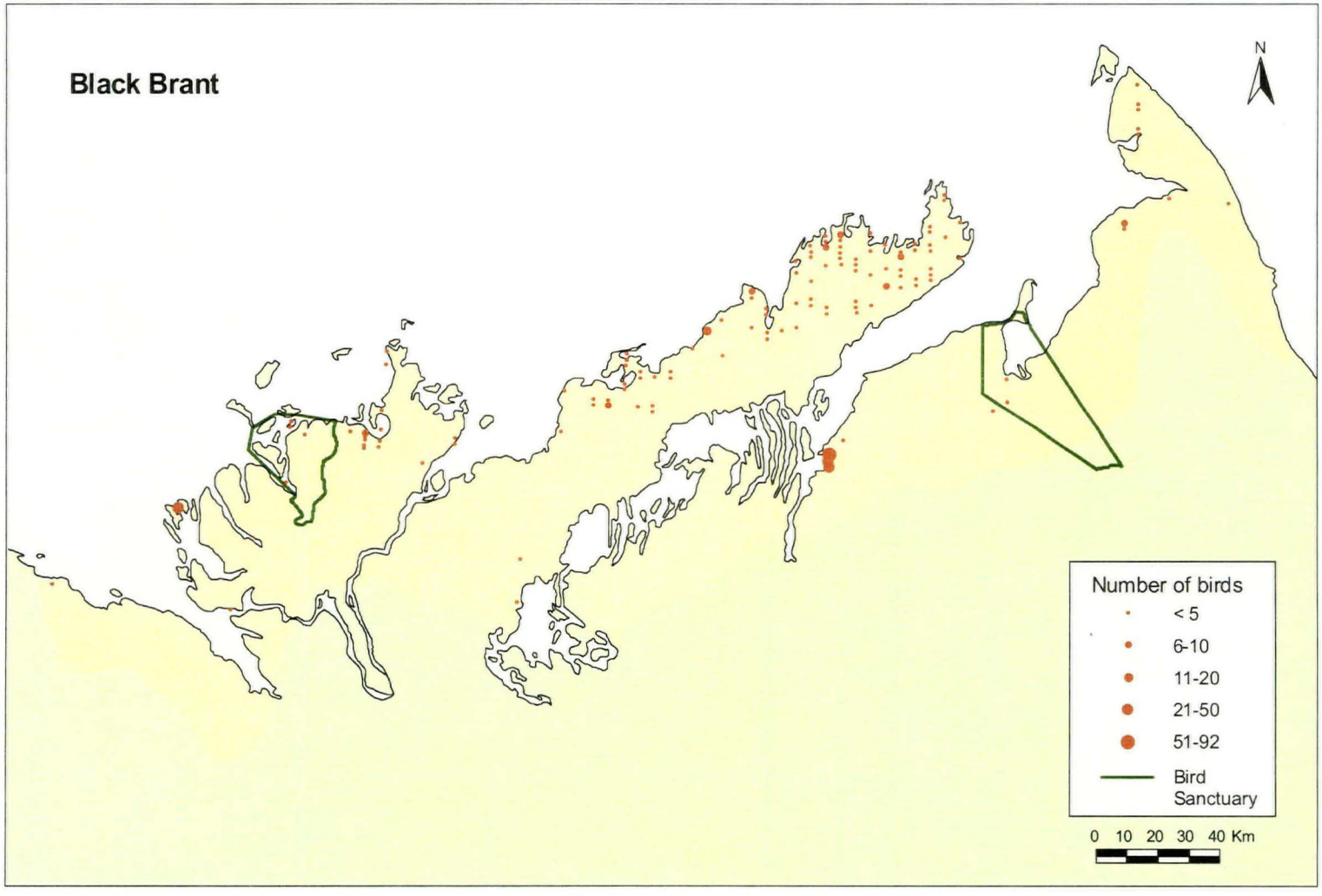

Figure 12. Mean annual numbers of Black Brant observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

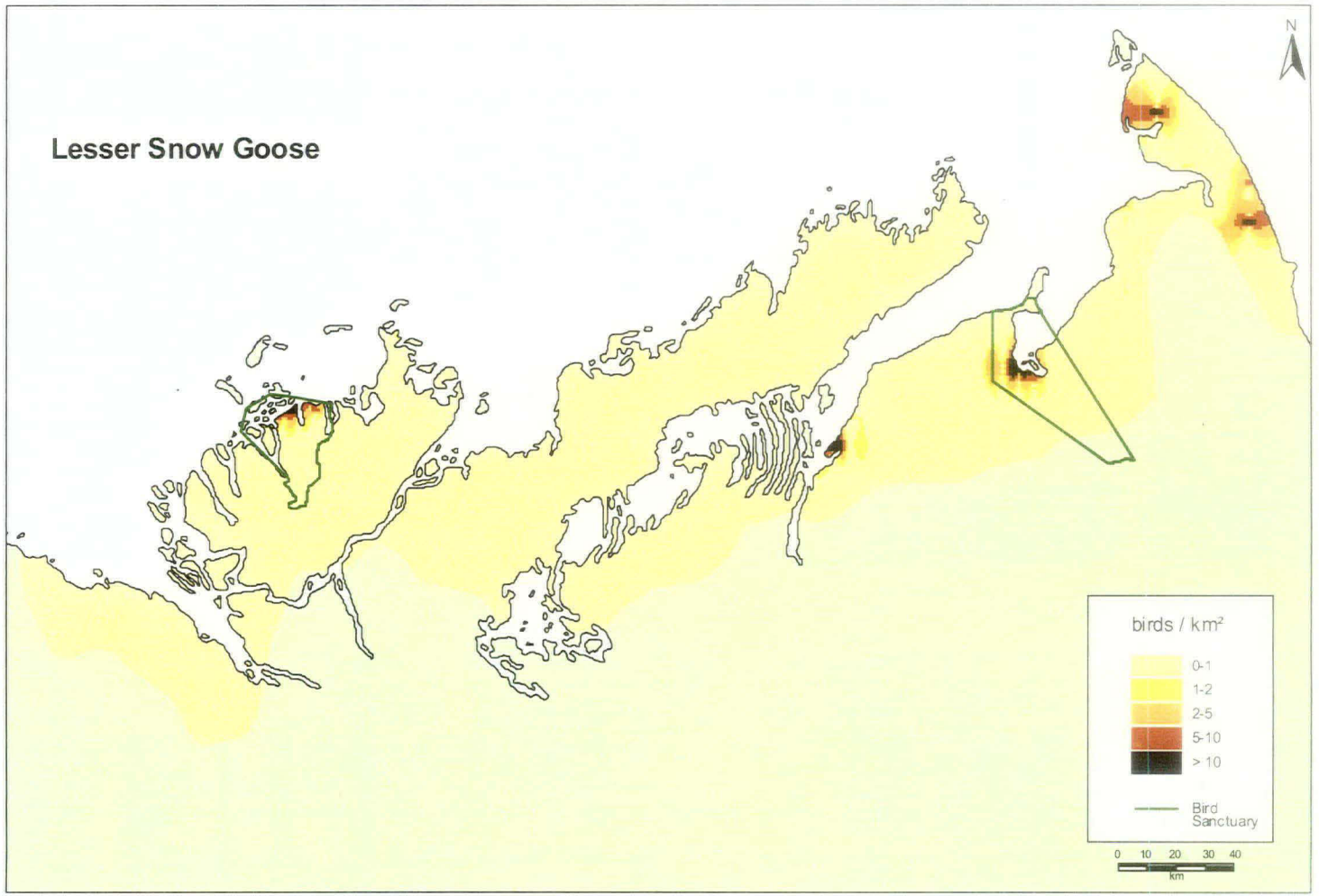

Figure 13. The distribution of Lesser Snow Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

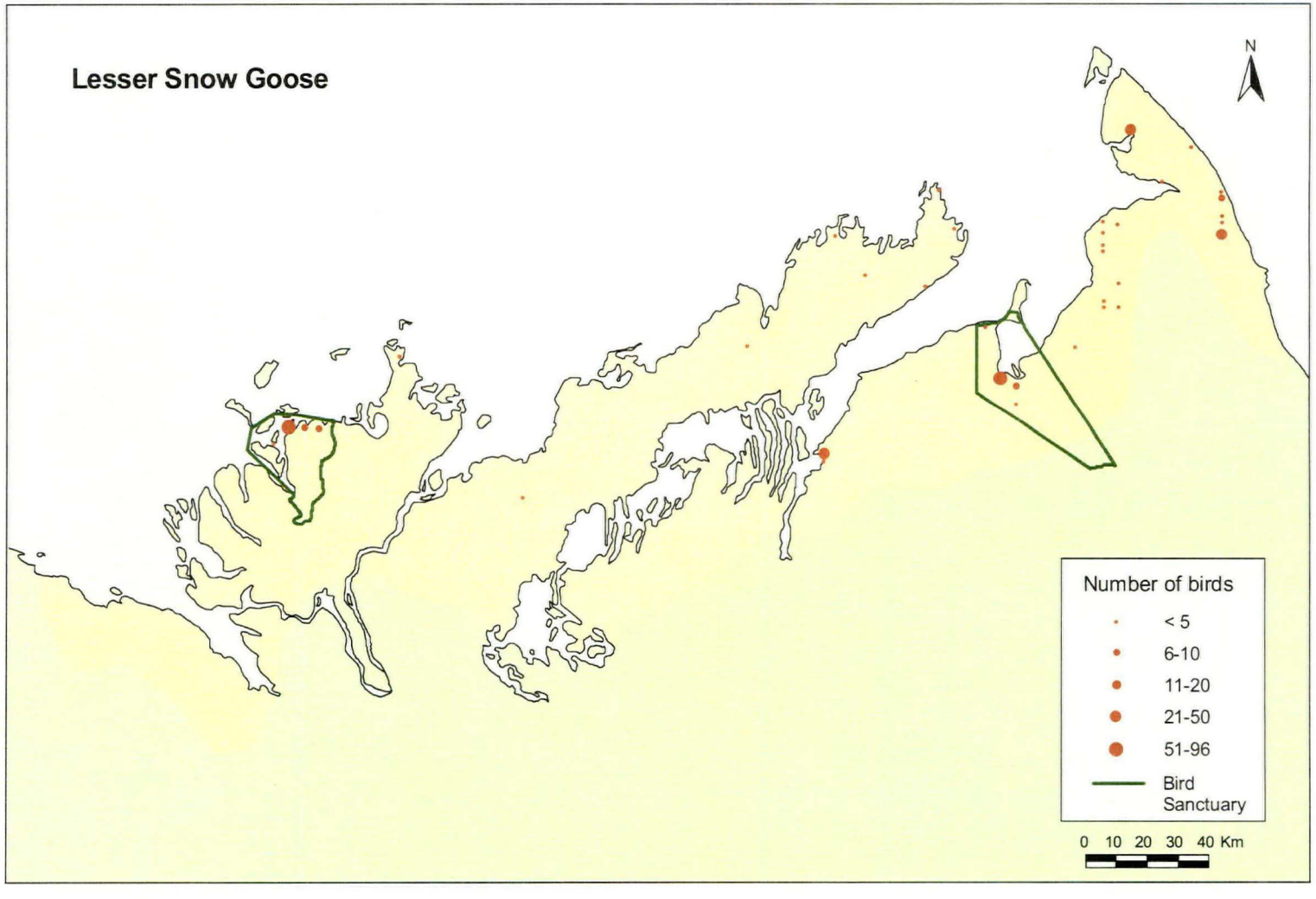

Figure 14. Mean annual numbers of Lesser Snow Geese observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

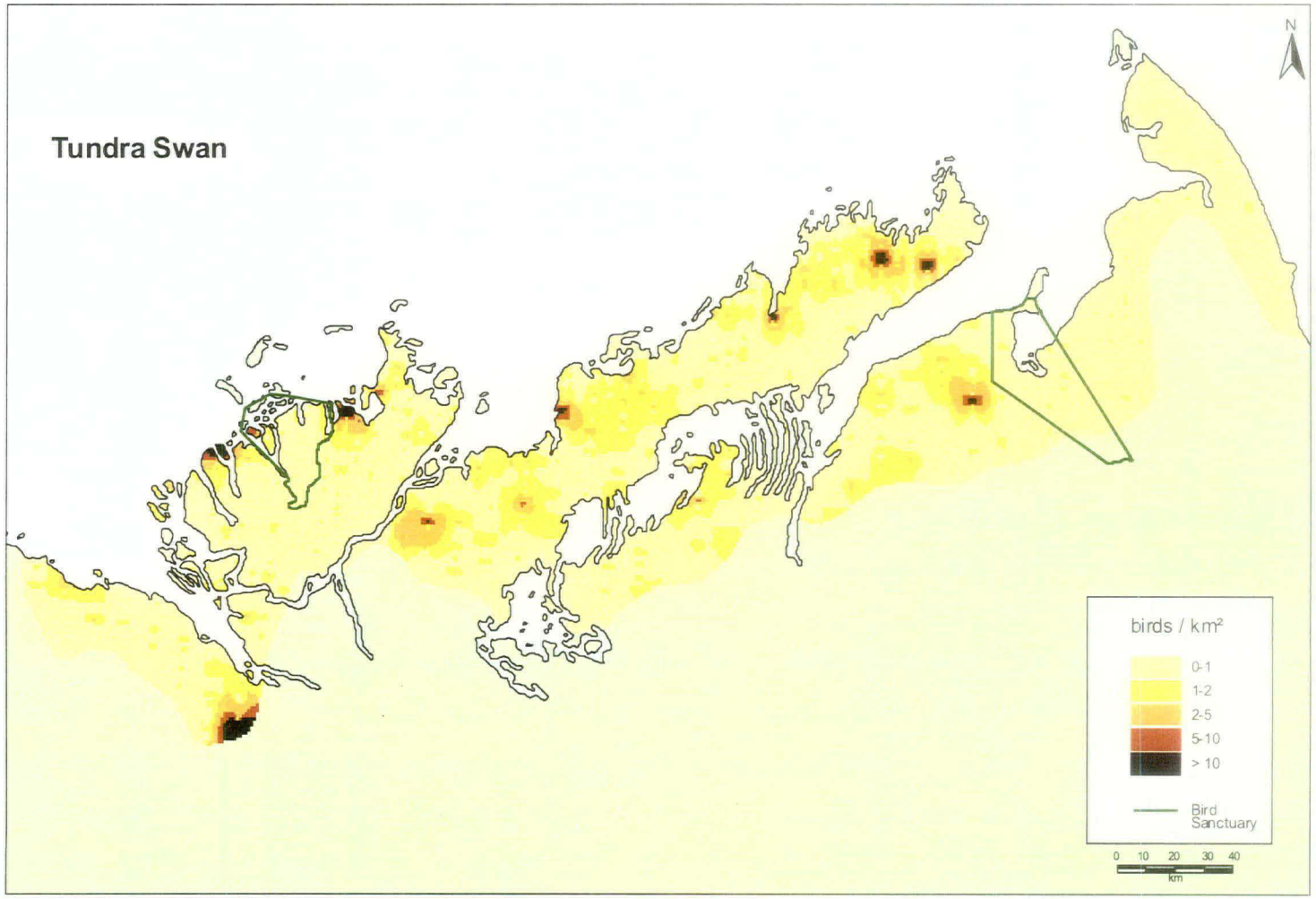

Figure 15. The distribution of Tundra Swans on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

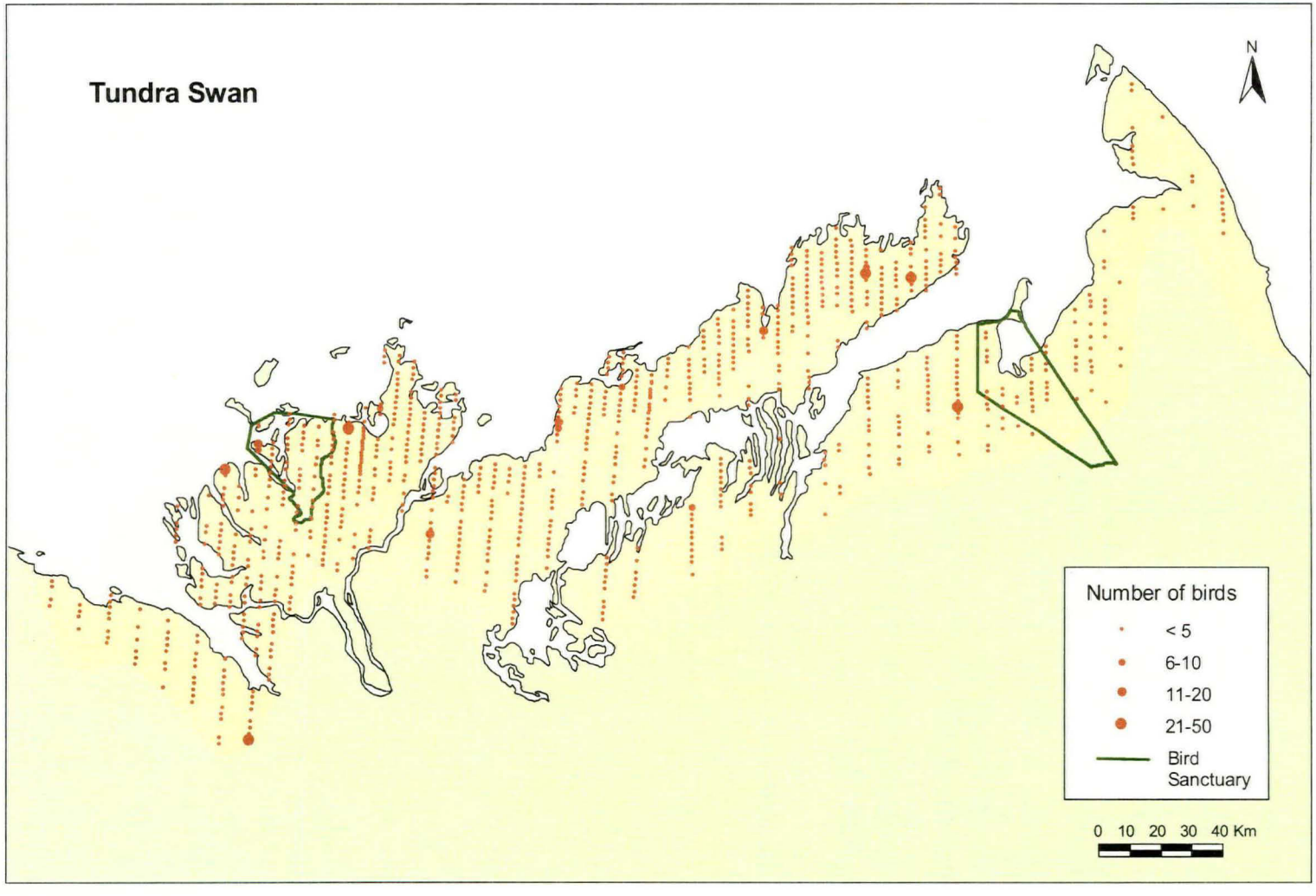

Figure 16. Mean annual numbers of Tundra Swans observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

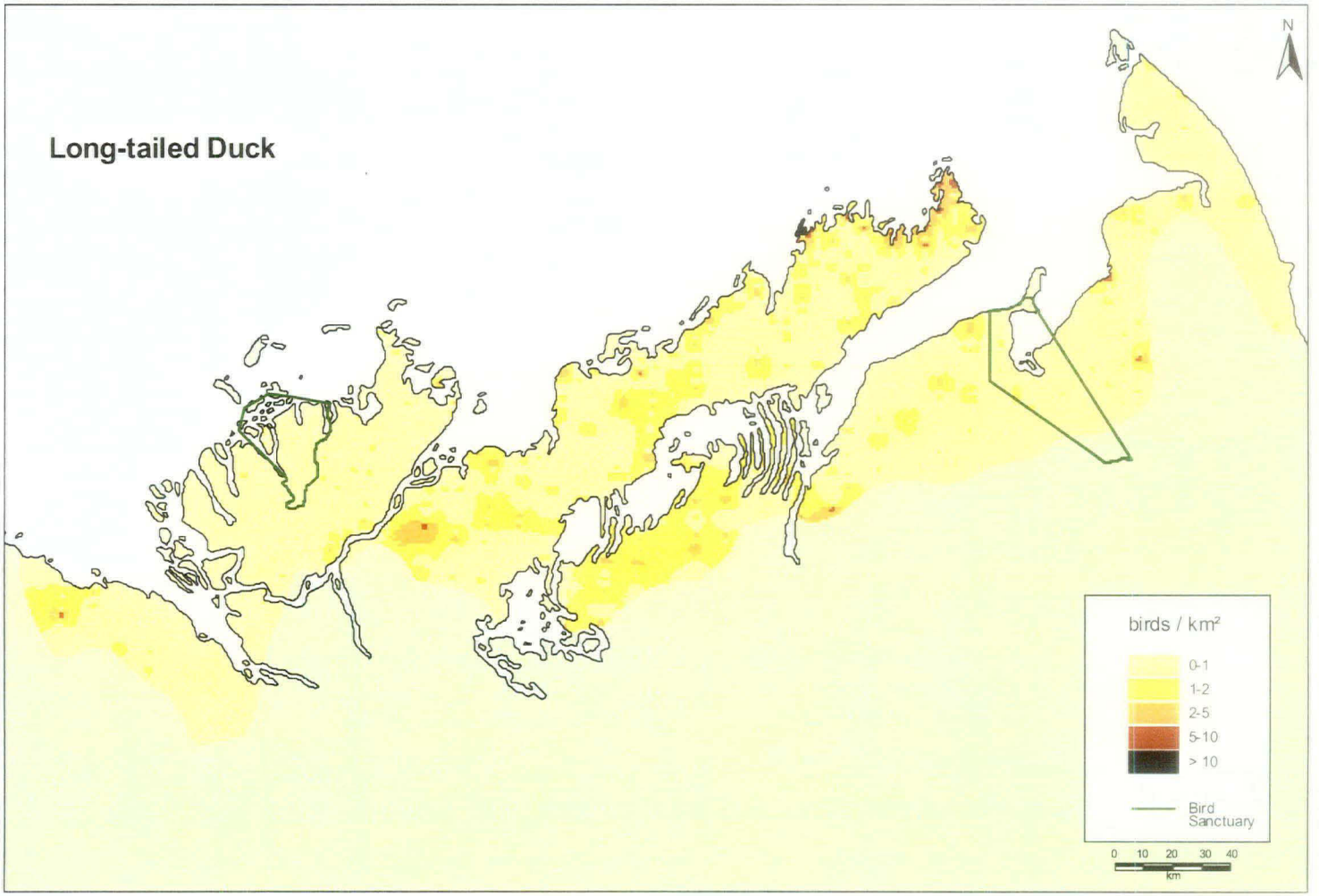

Figure 17. The distribution of Long-tailed Ducks on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

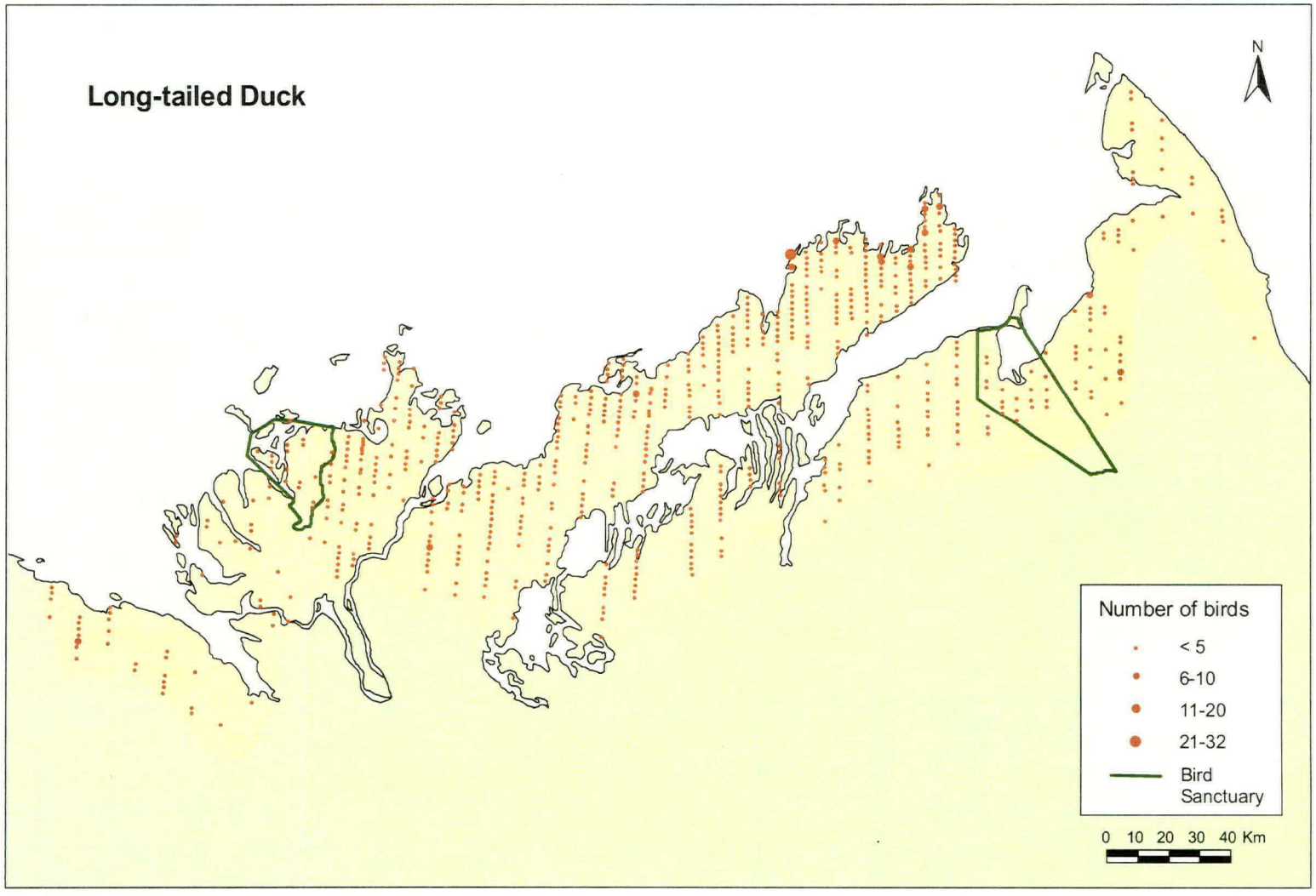

Figure 18. Mean annual numbers of Long-tailed Ducks observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

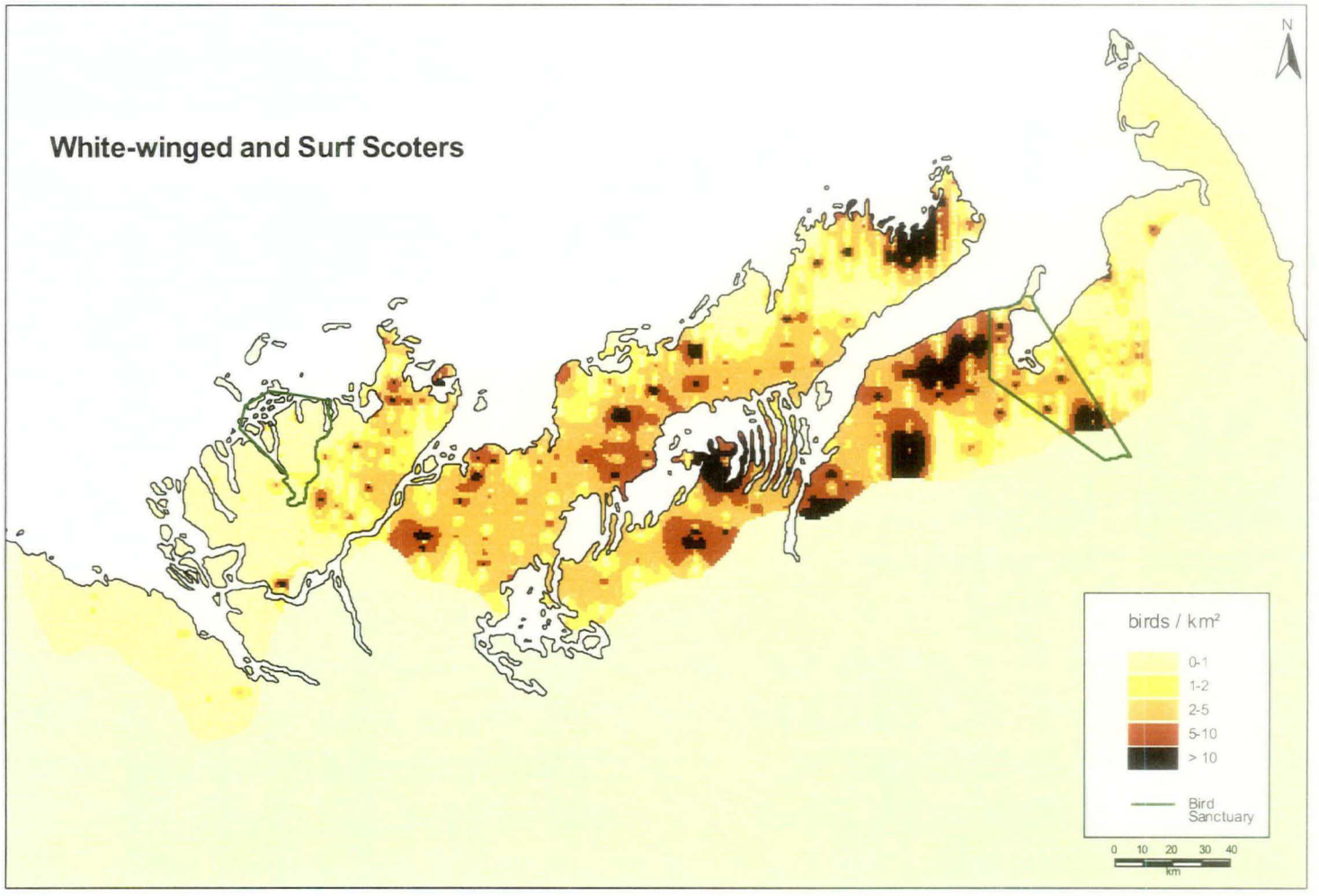

Figure 19. The distribution of White-winged and Surf Scoters on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

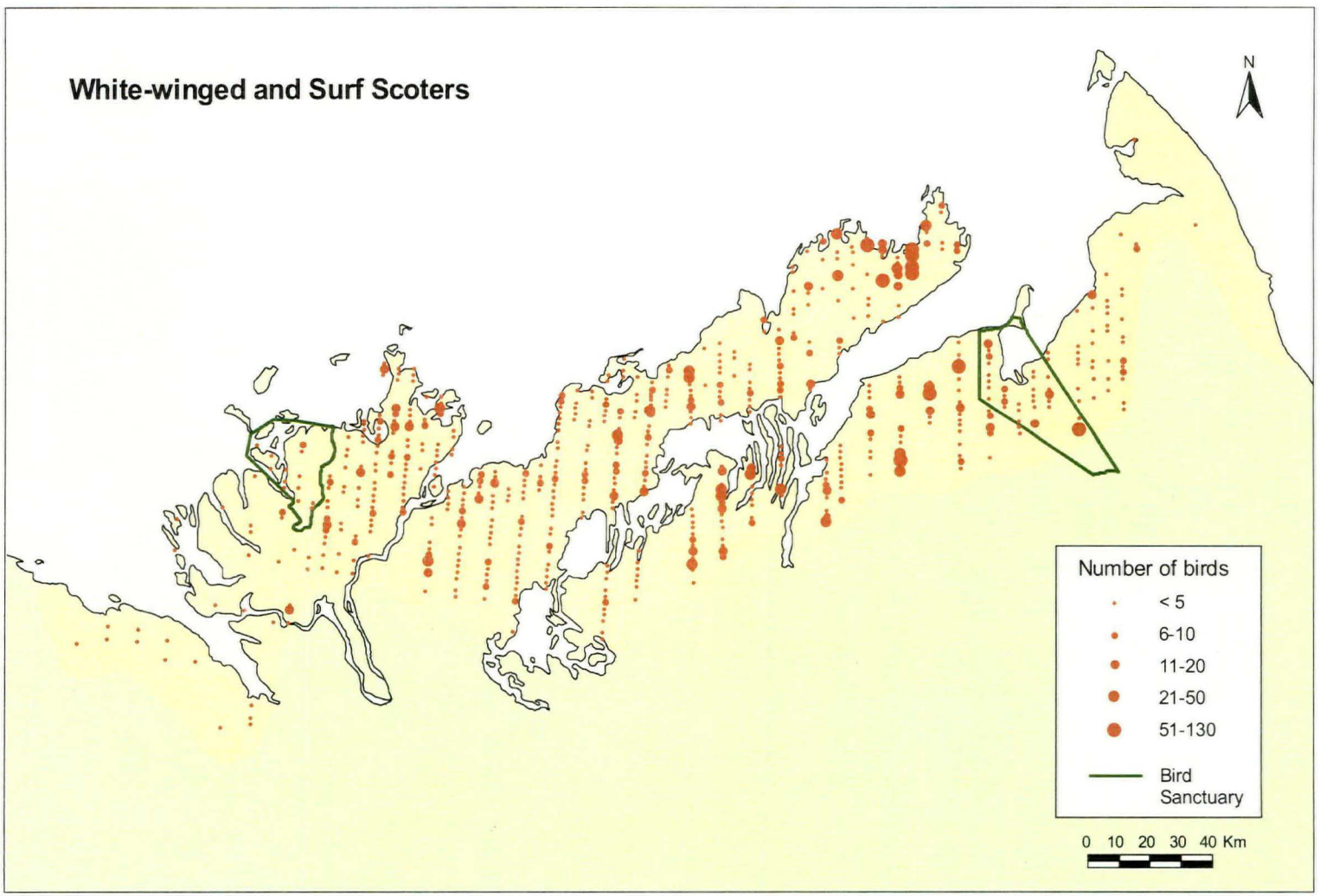

Figure 20. Mean annual numbers of White-winged and Surf Scoters observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

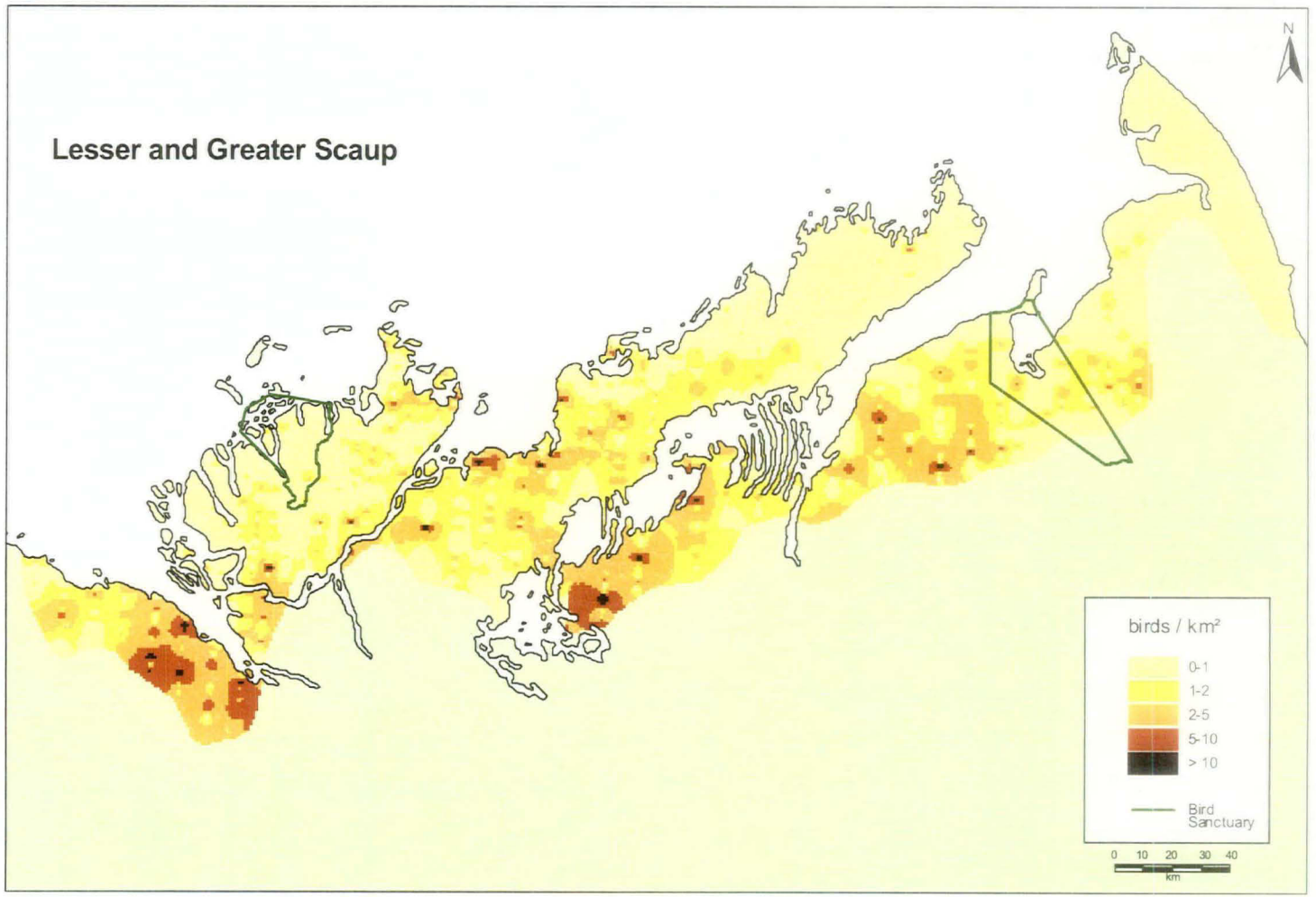

Figure 21. The distribution of Lesser and Greater Scaups on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

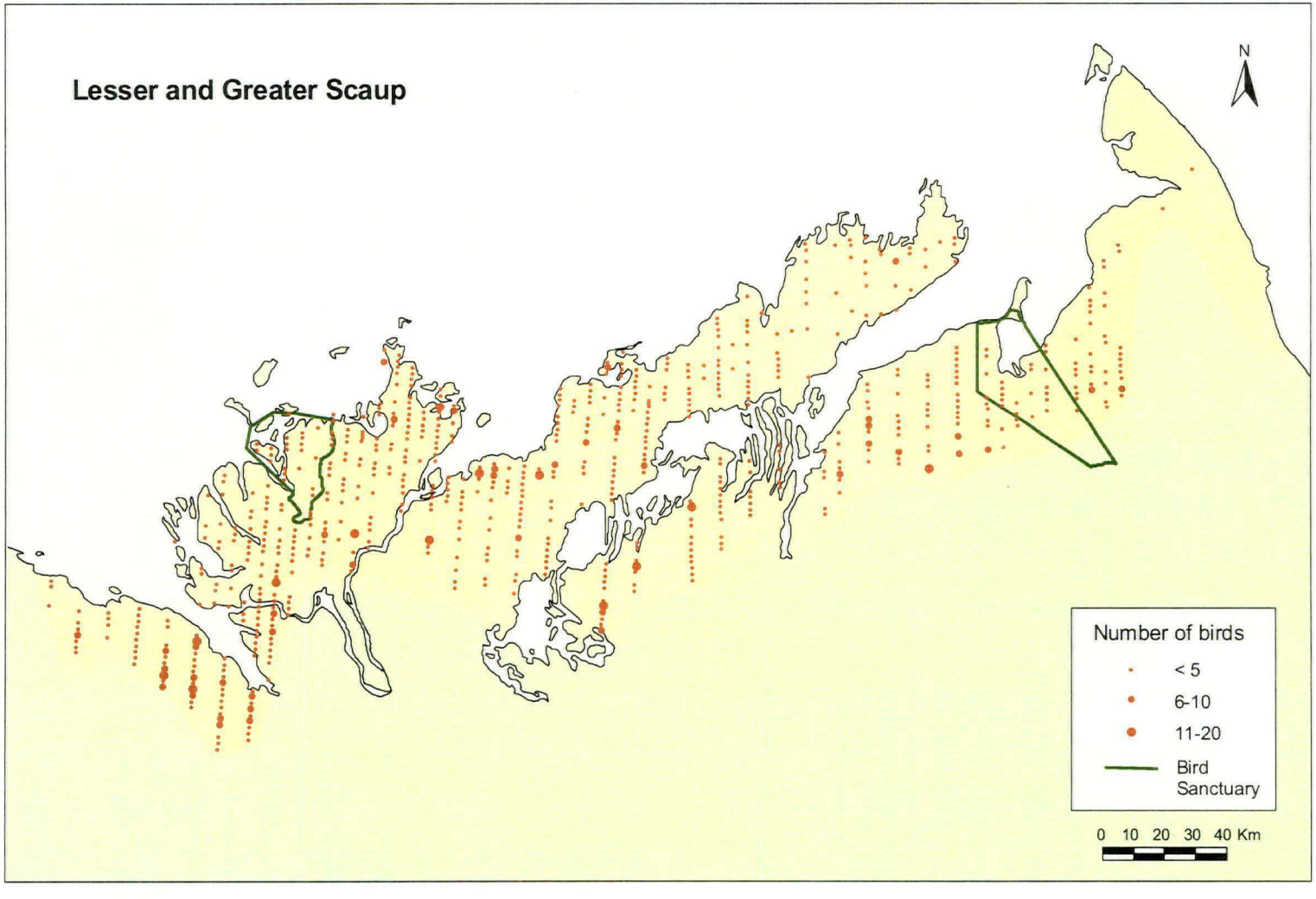

Figure 22. Mean annual numbers of Lesser and Greater Scaups observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

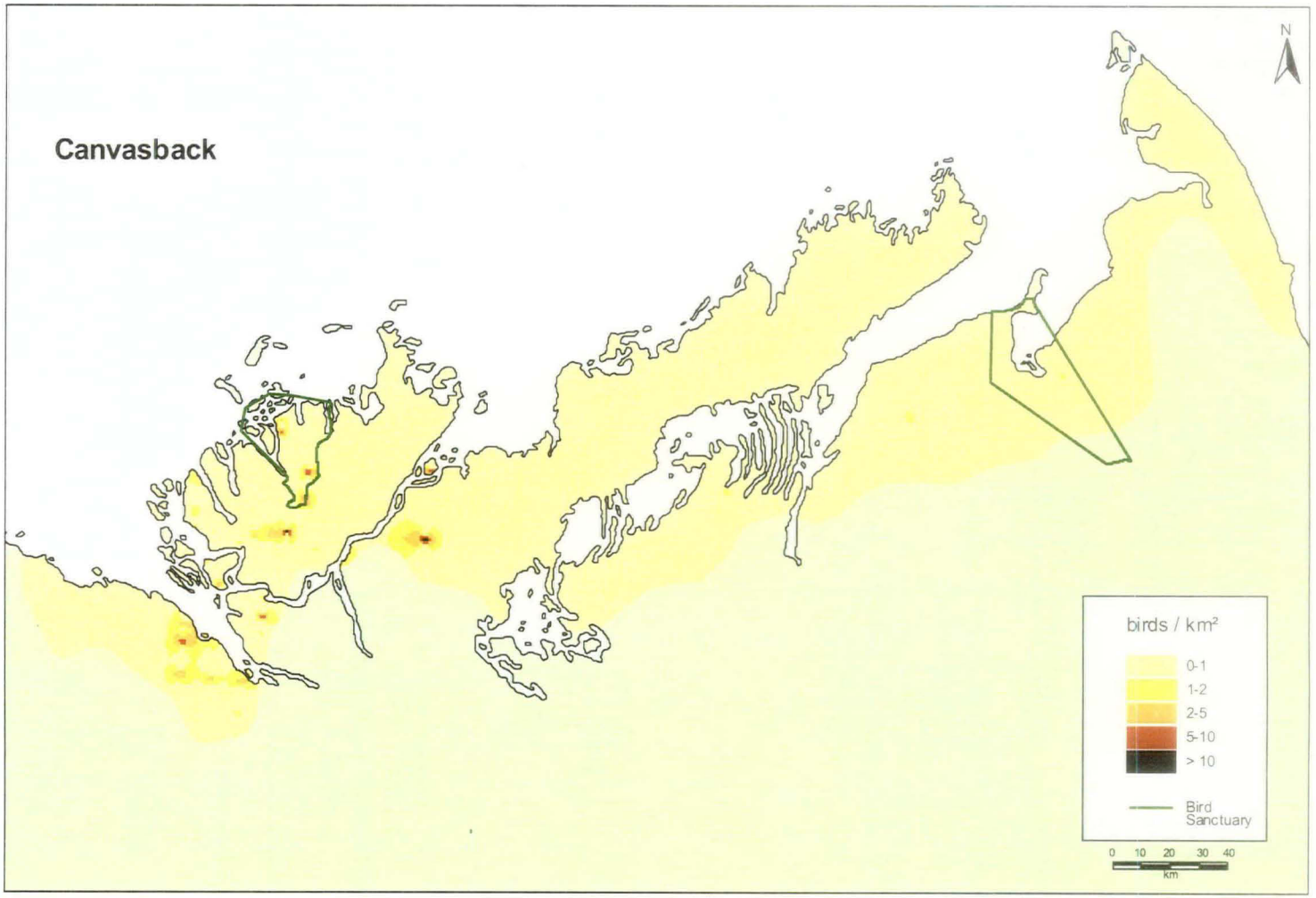

Figure 23. The distribution of Canvasbacks on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

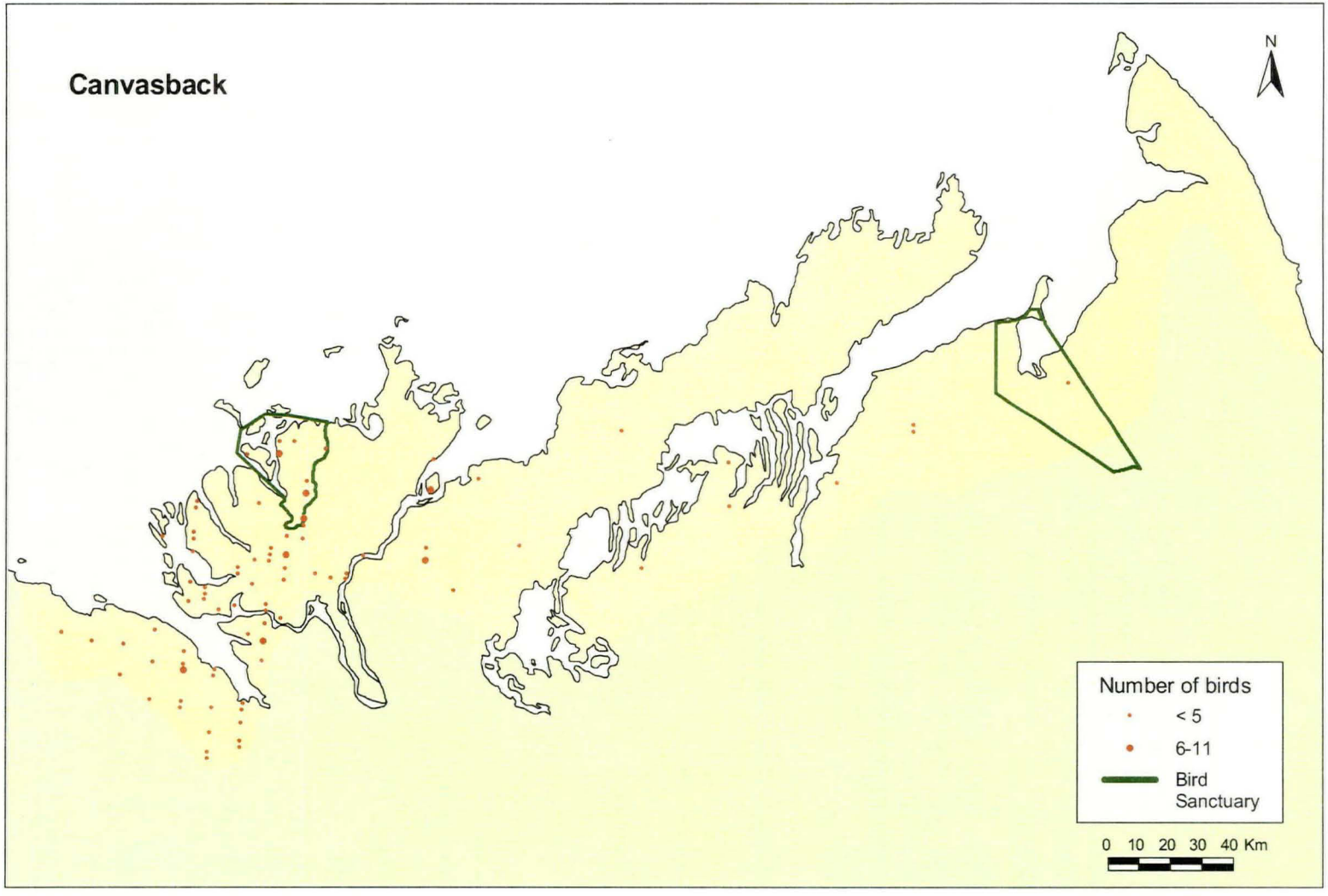

Figure 24. Mean annual numbers of Canvasbacks observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

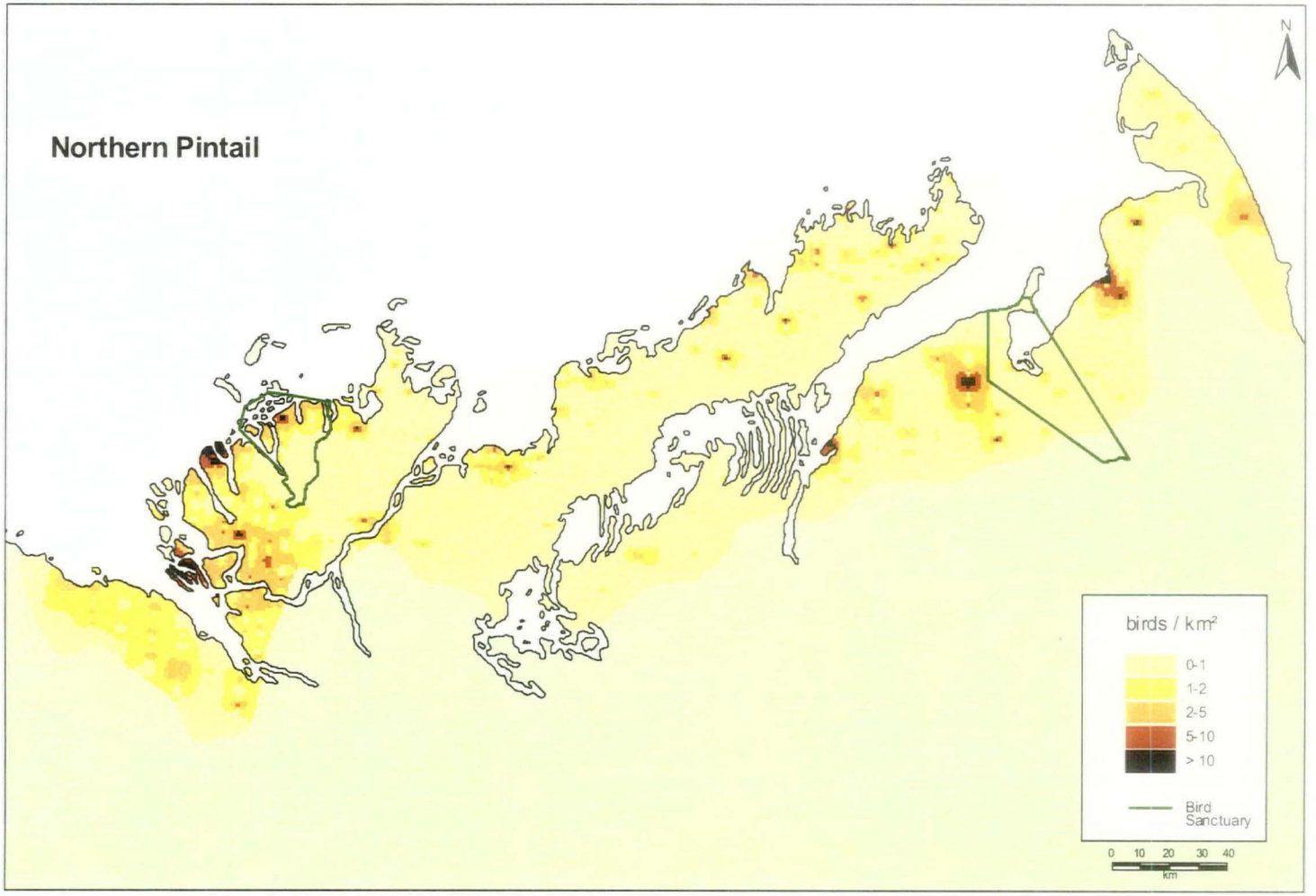

Figure 25. The distribution of Northern Pintails on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

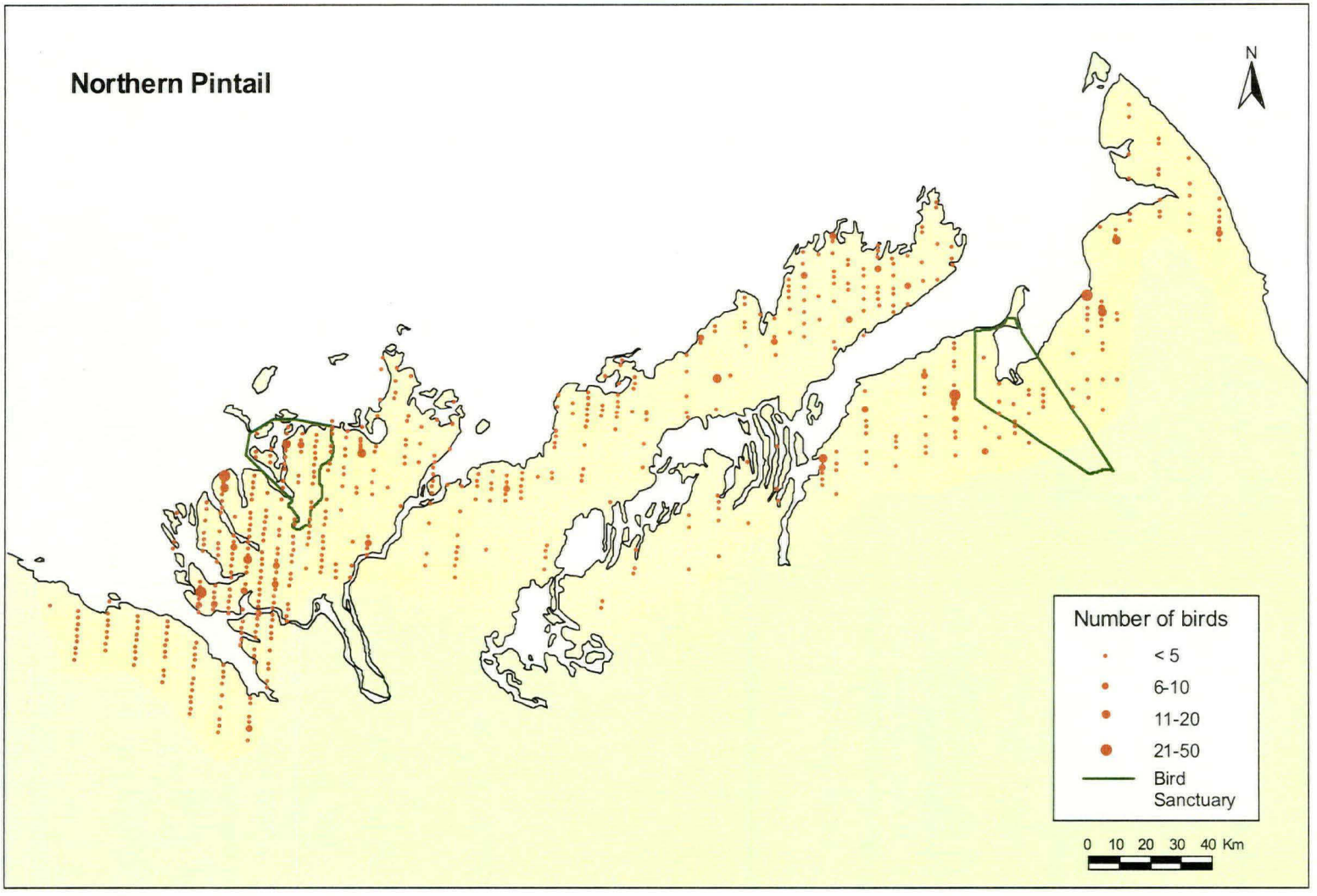

Figure 26. Mean annual numbers of Northern Pintails observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

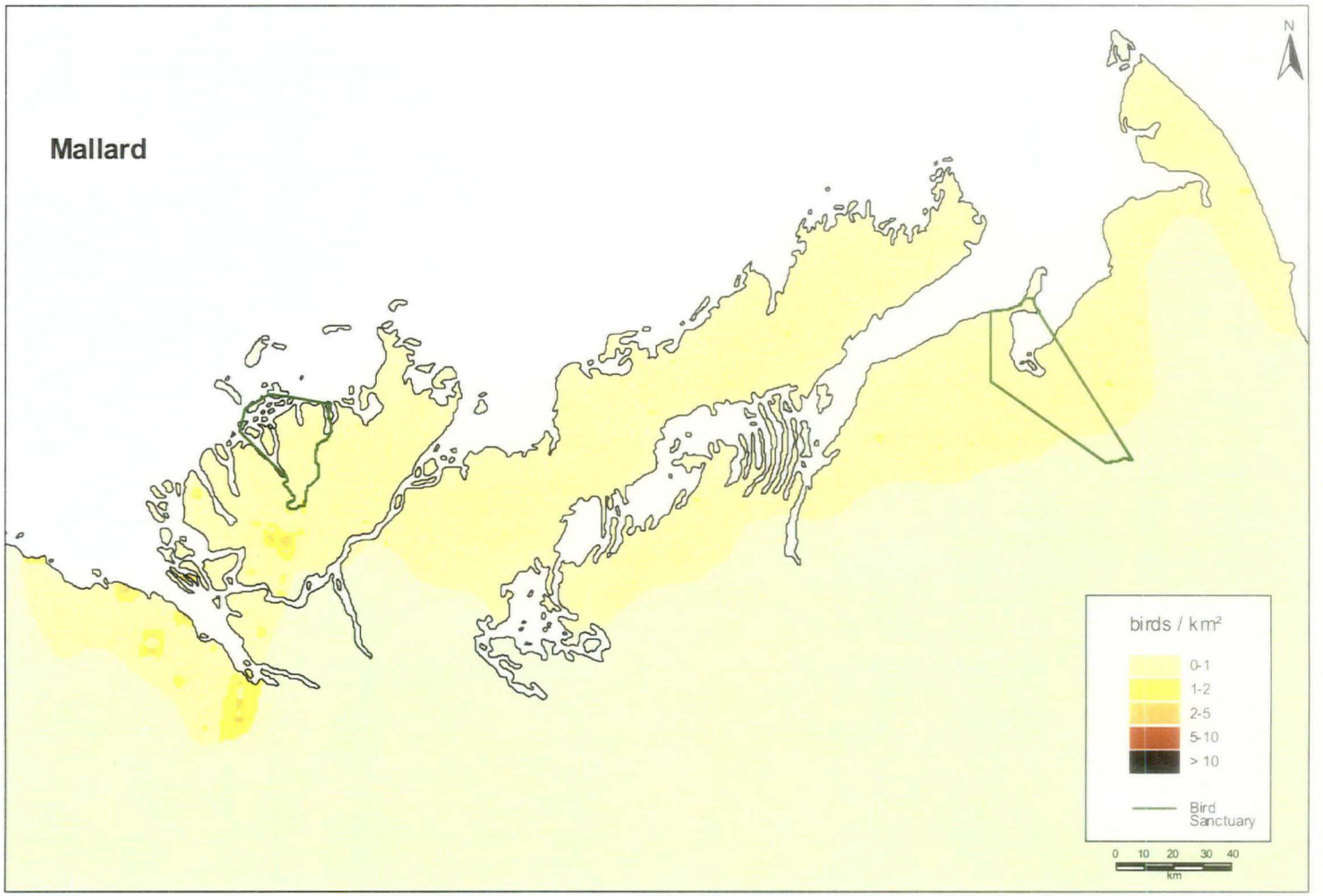

Figure 27. The distribution of Mallards on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

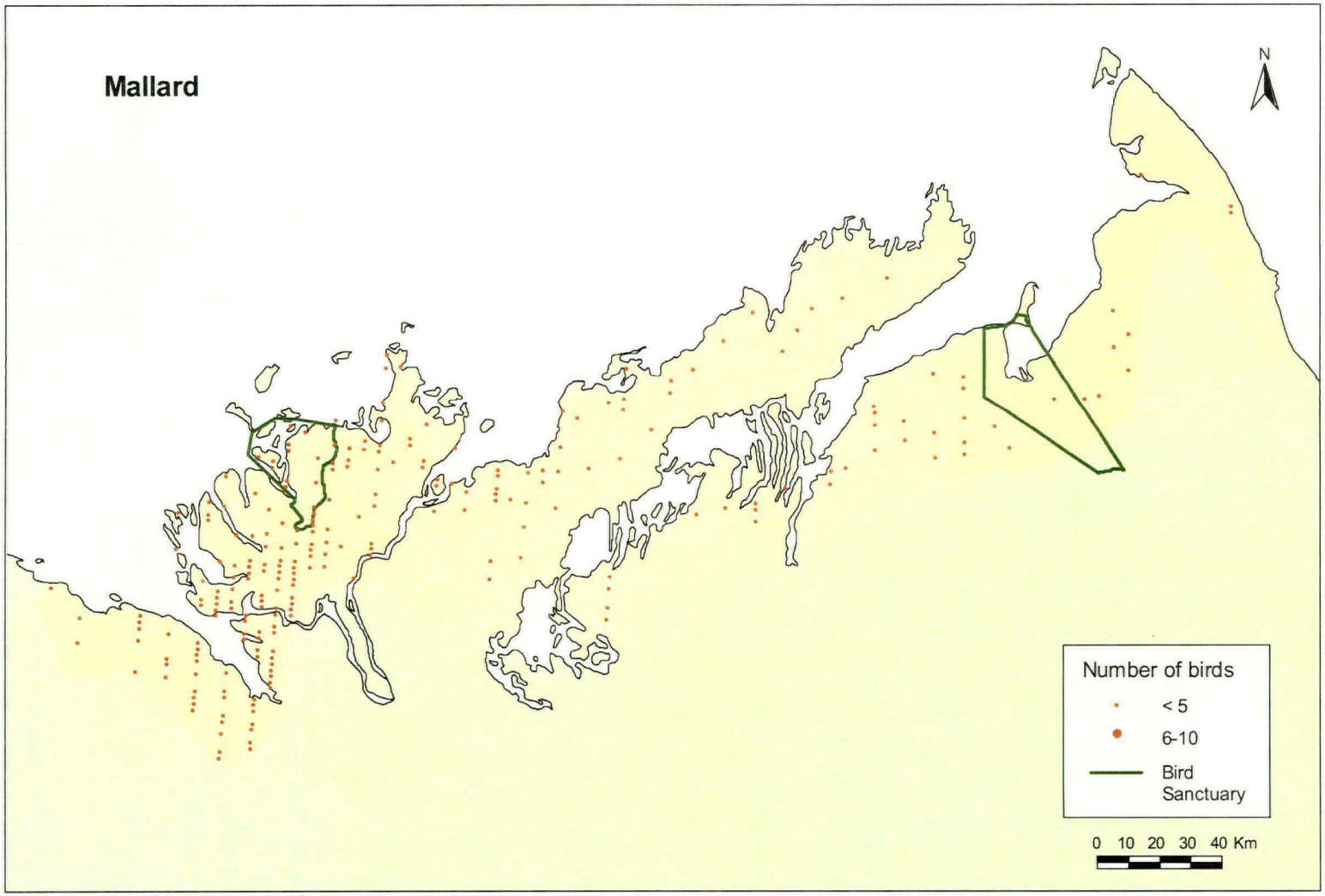

Figure 28. Mean annual numbers of Mallards observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

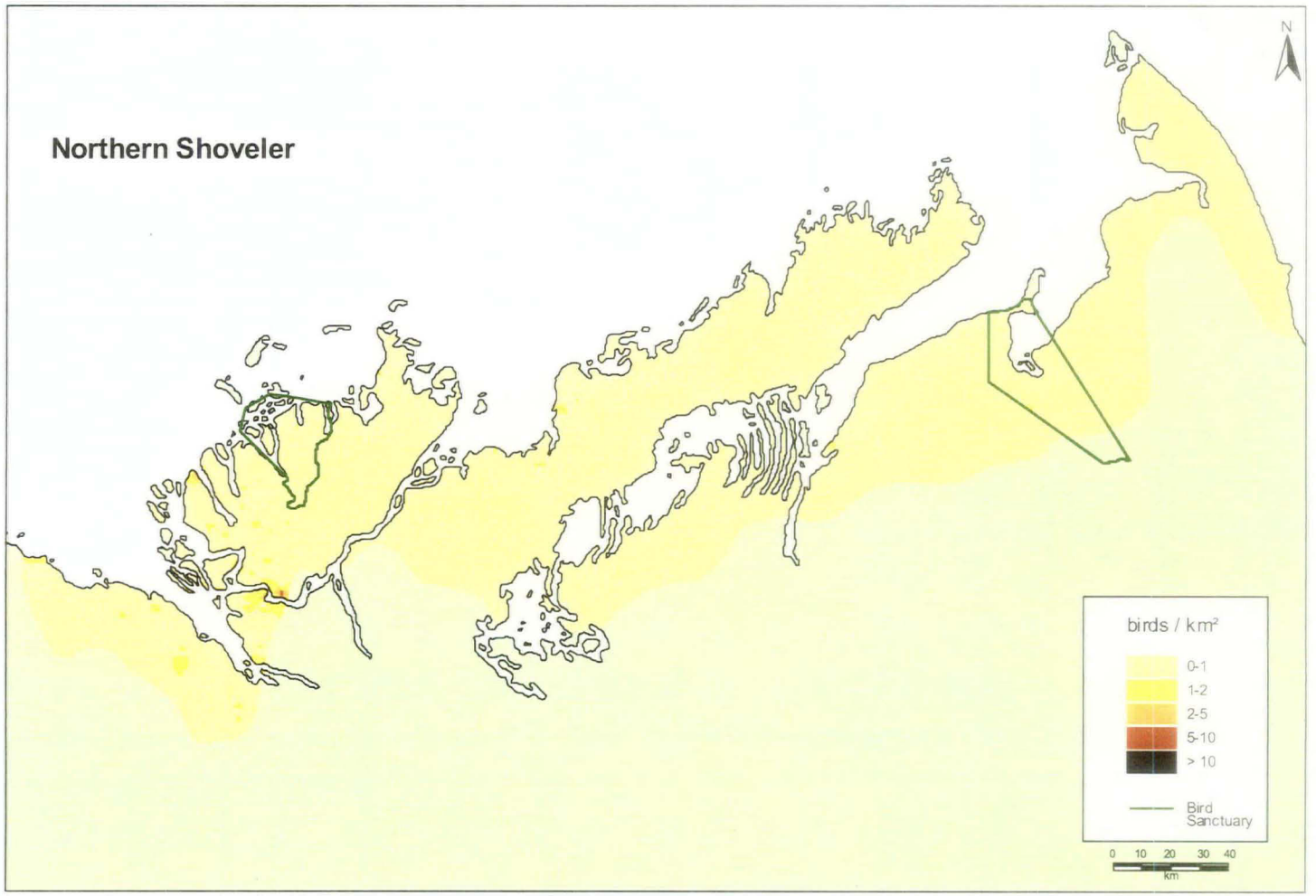

Figure 29. The distribution of Northern Shovelers on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

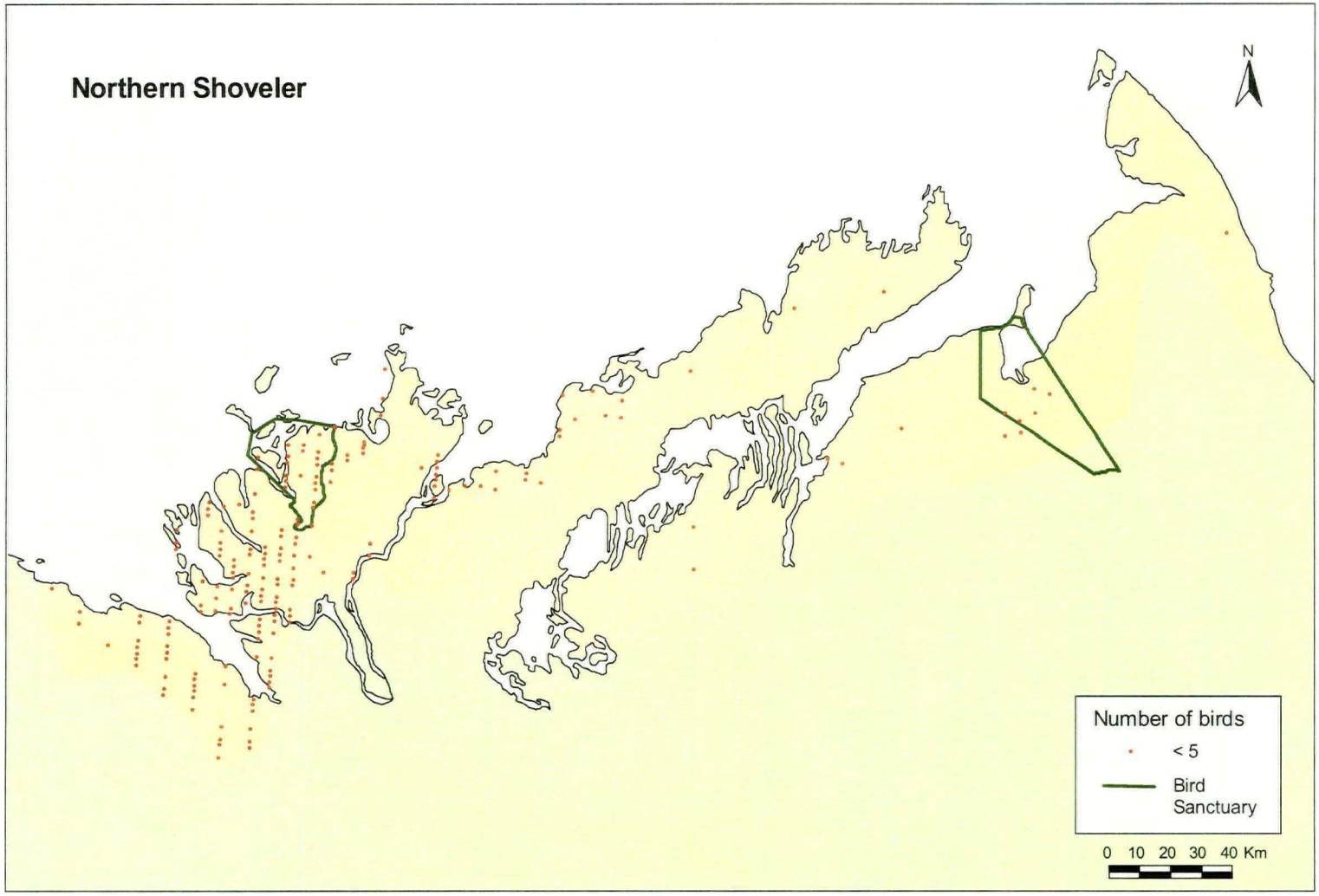

Figure 30. Mean annual numbers of Northern Shovelers observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

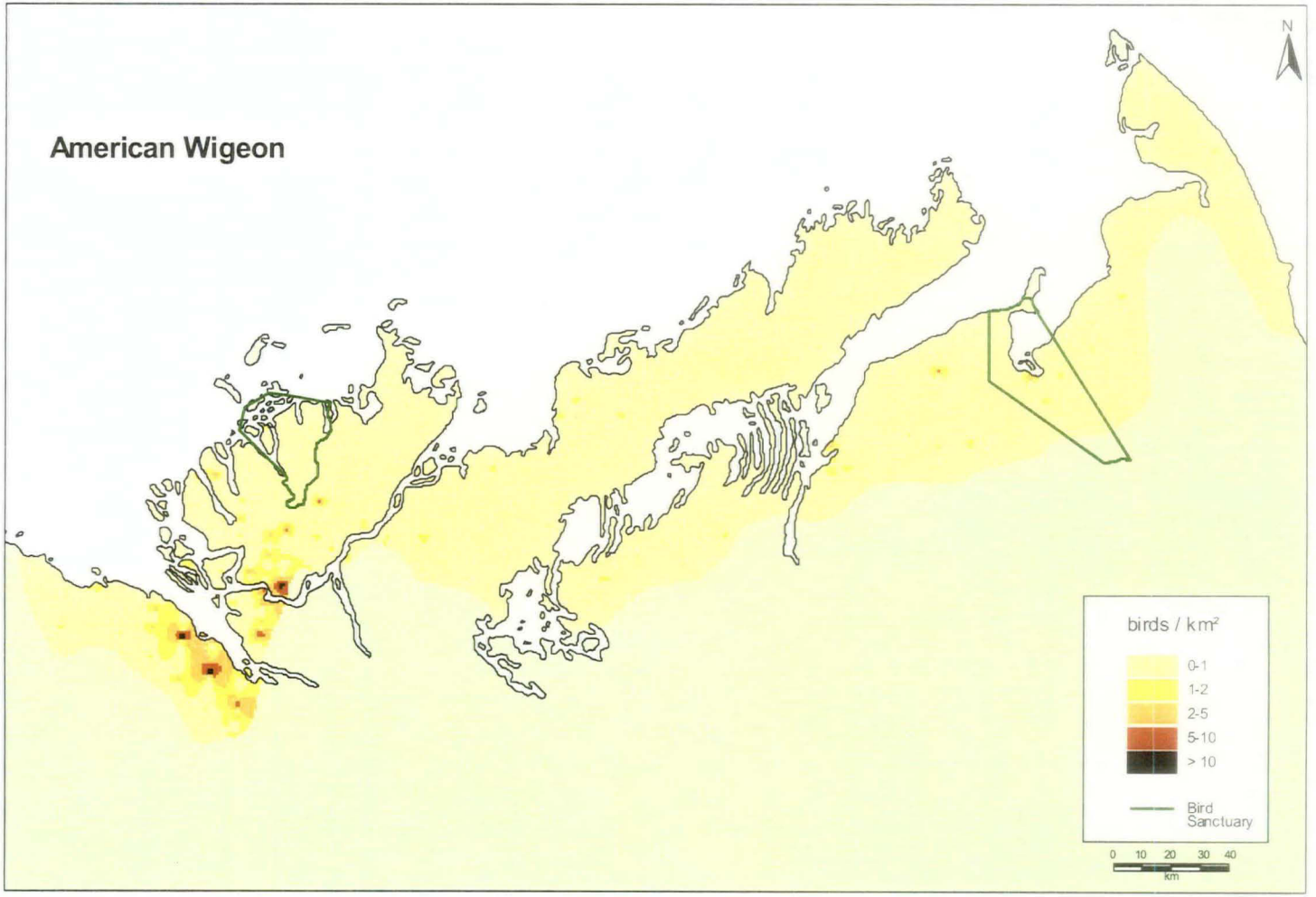

Figure 31. The distribution of American Wigeons on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

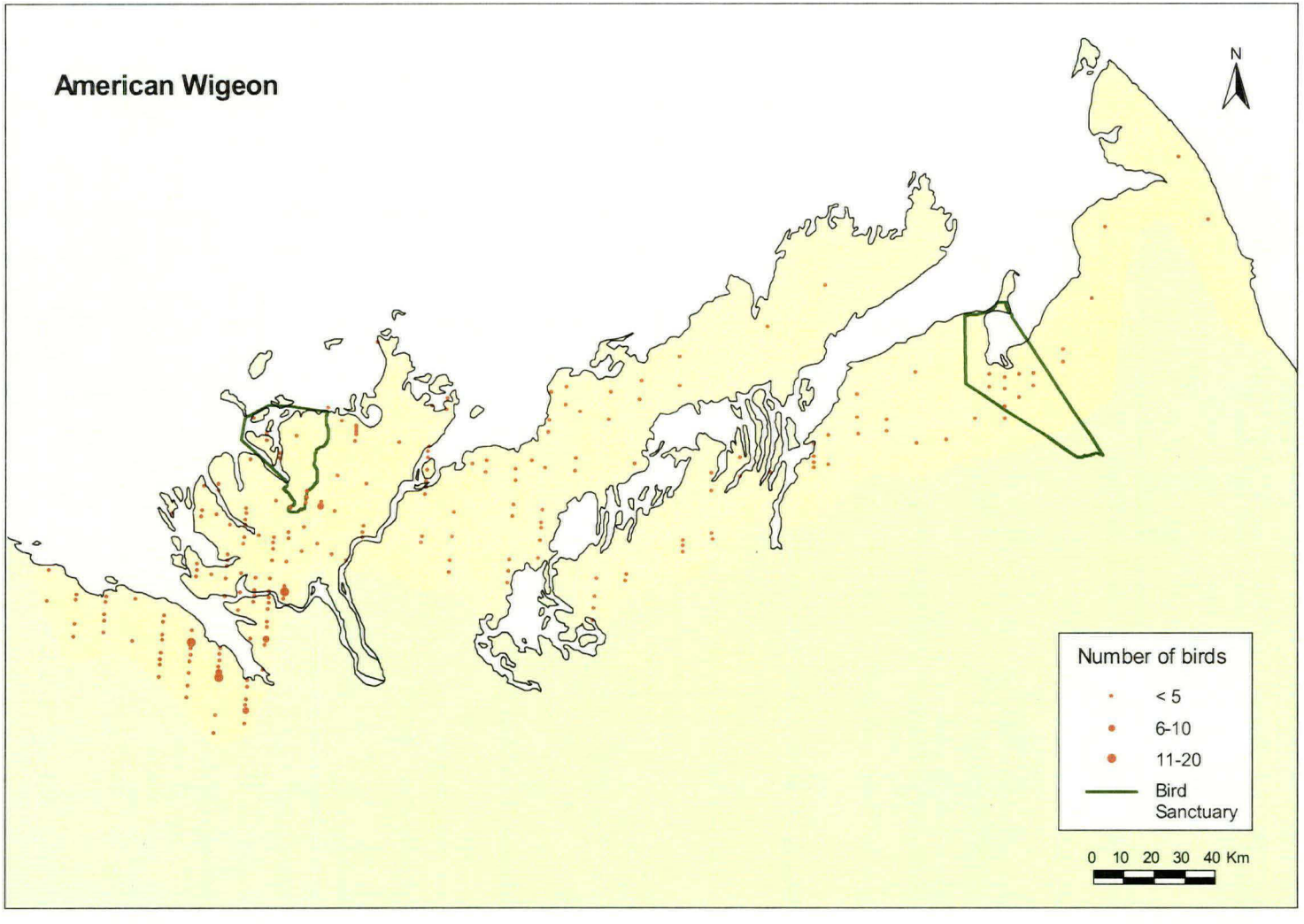

Figure 32. Mean annual numbers of American Wigeons observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

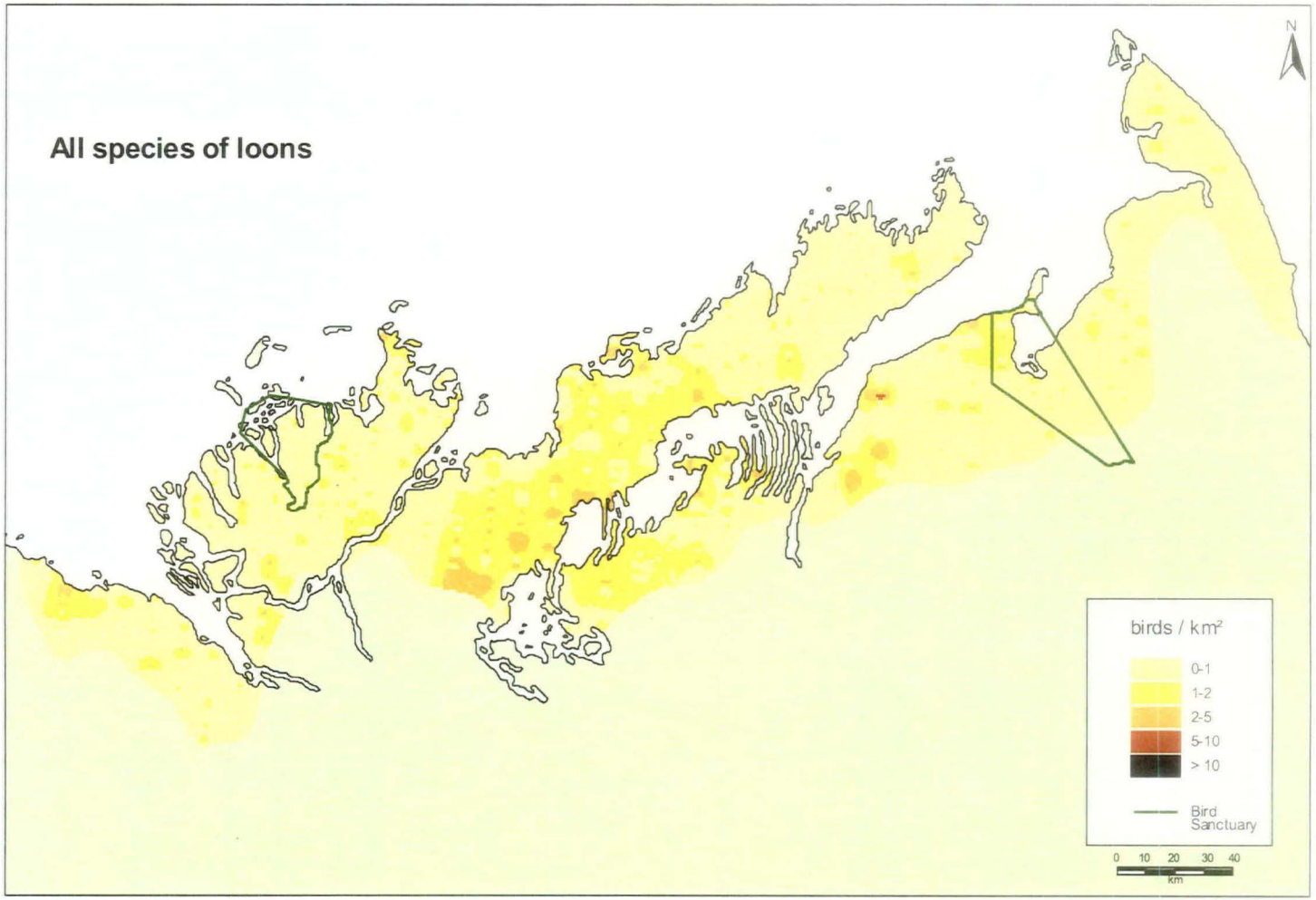

Figure 33. The distribution of loons of all species on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

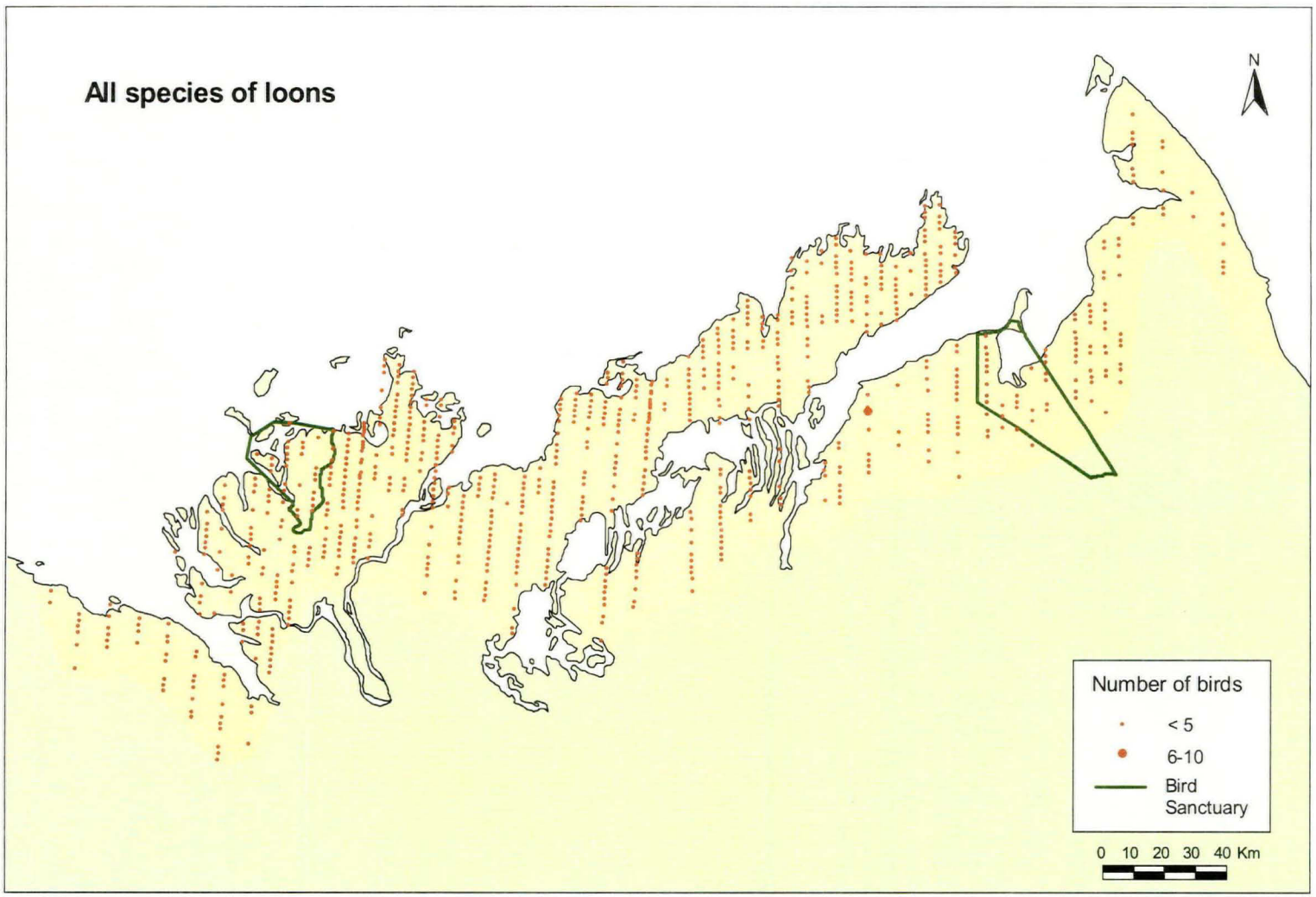

Figure 34. Mean annual numbers of loons of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

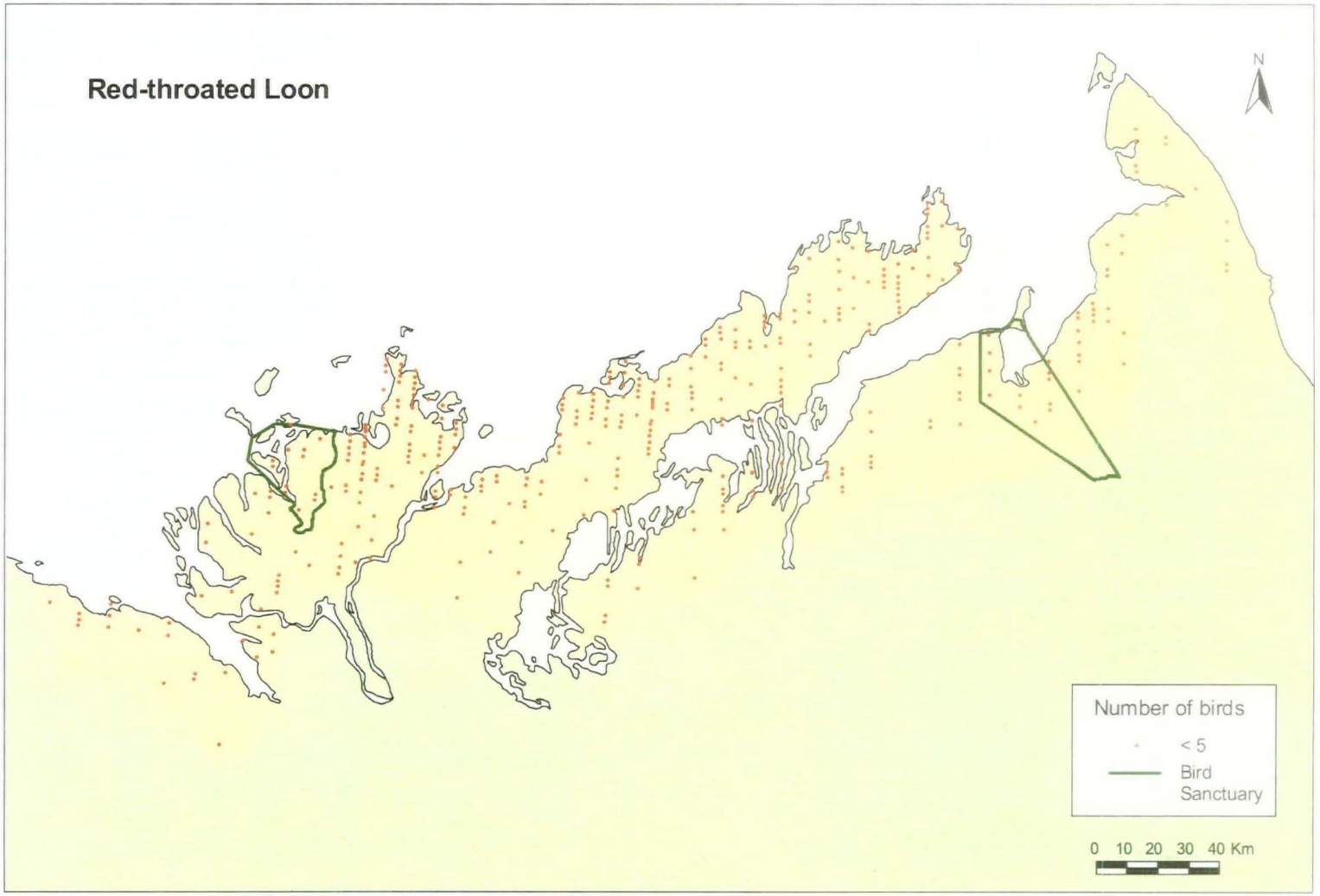

Figure 35. Mean annual numbers of Red-throated Loons observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

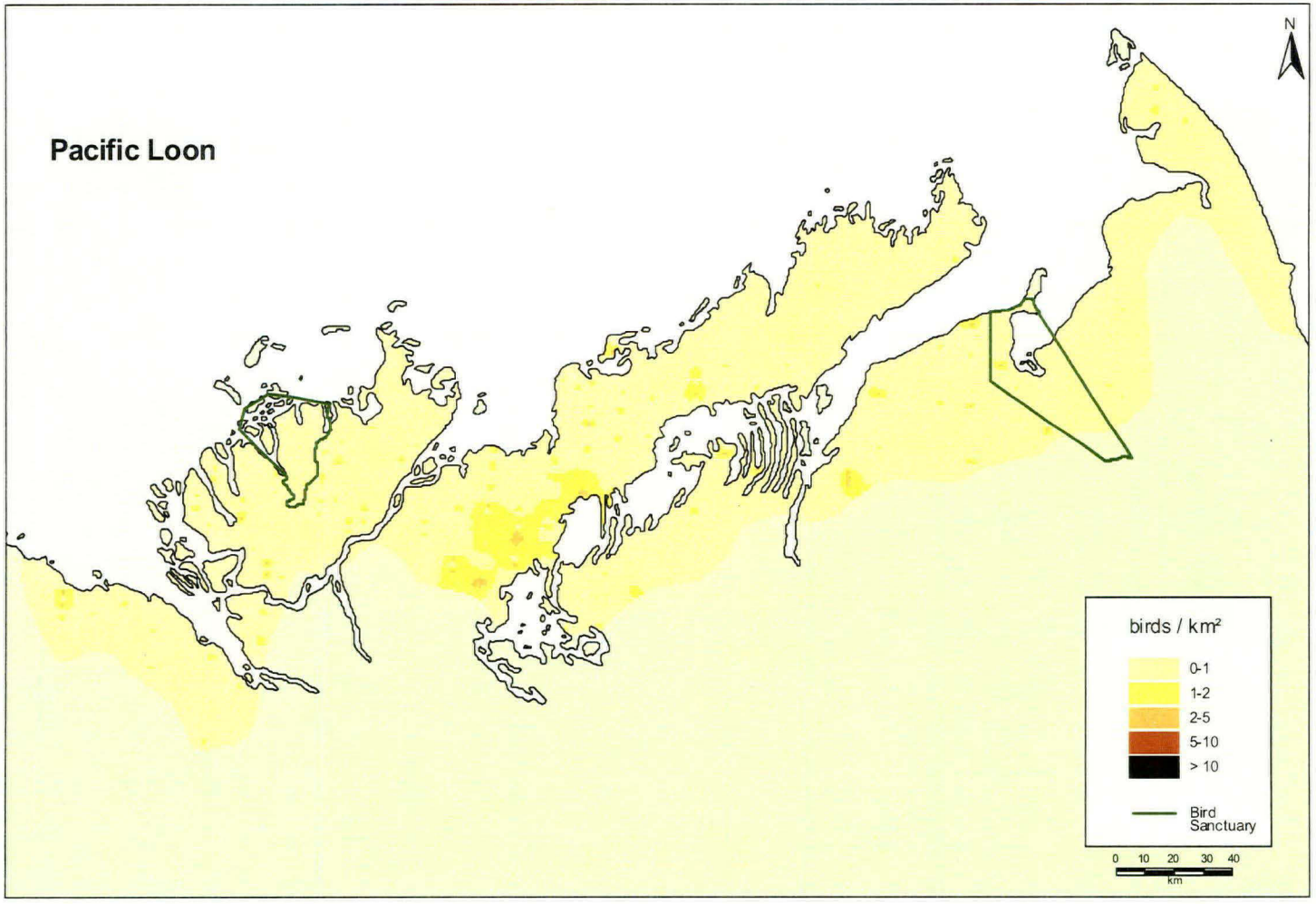

Figure 36. The distribution of Pacific Loons on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

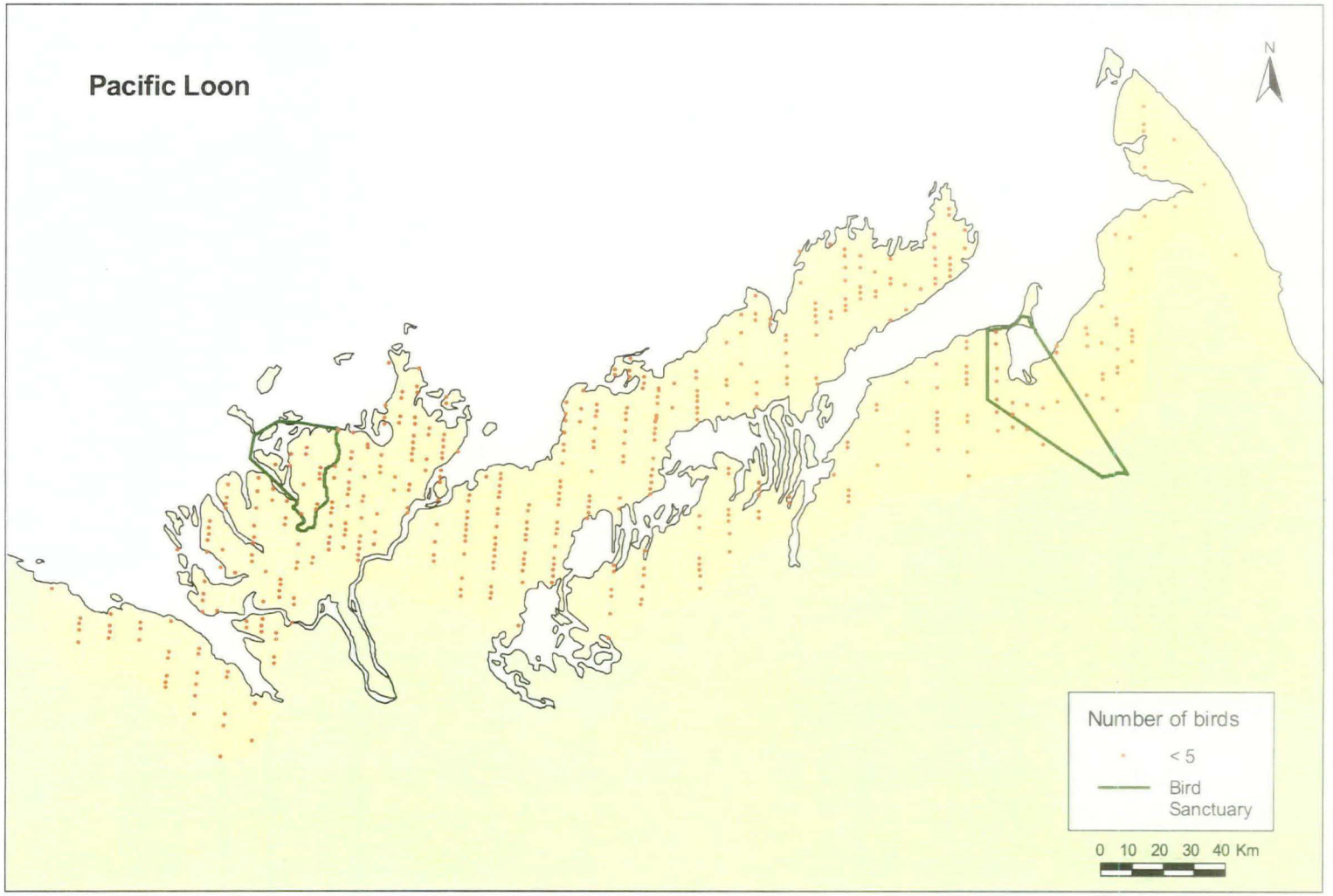

Figure 37. Mean annual numbers of Pacific Loons observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

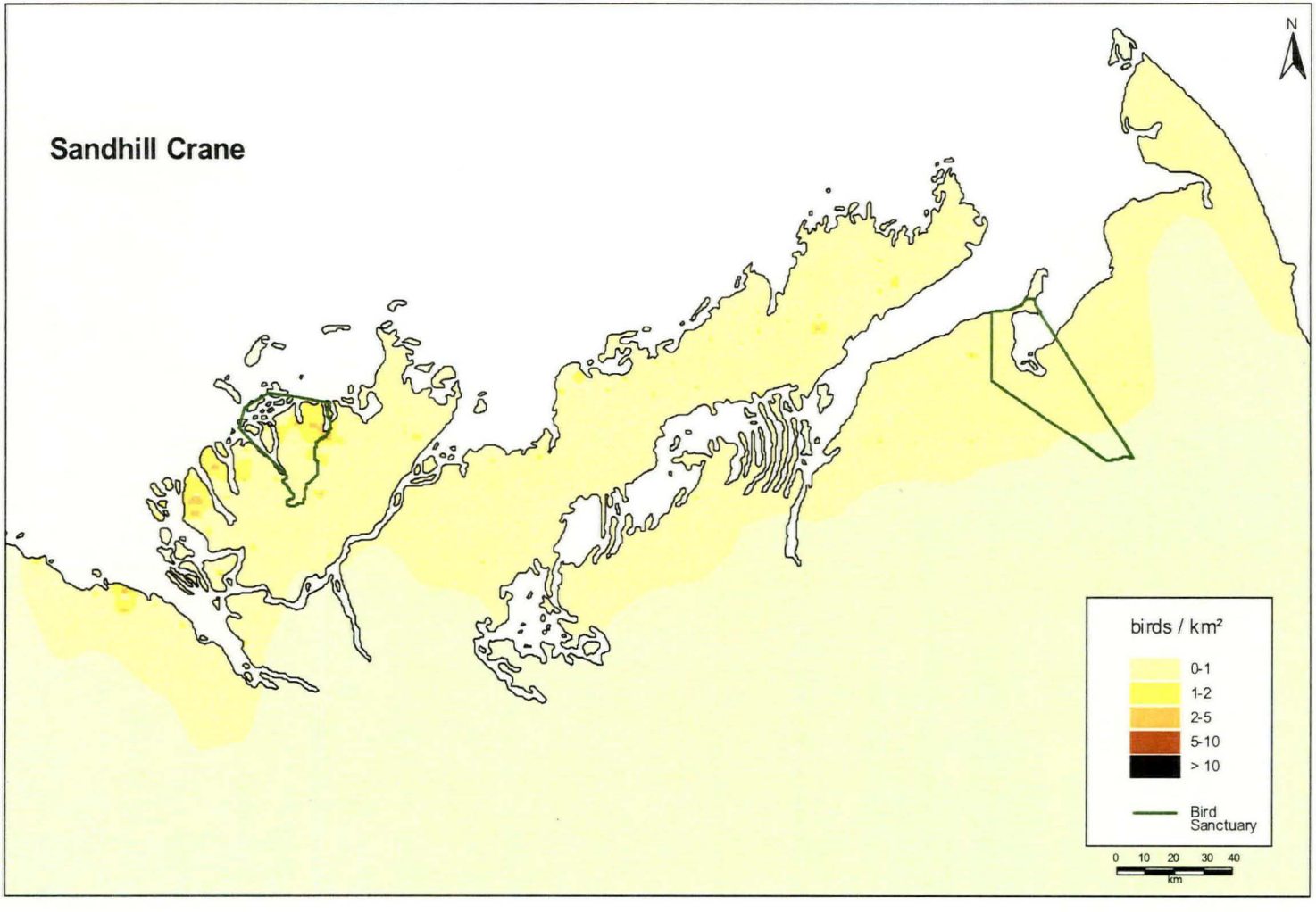

Figure 38. The distribution of Sandhill Cranes on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

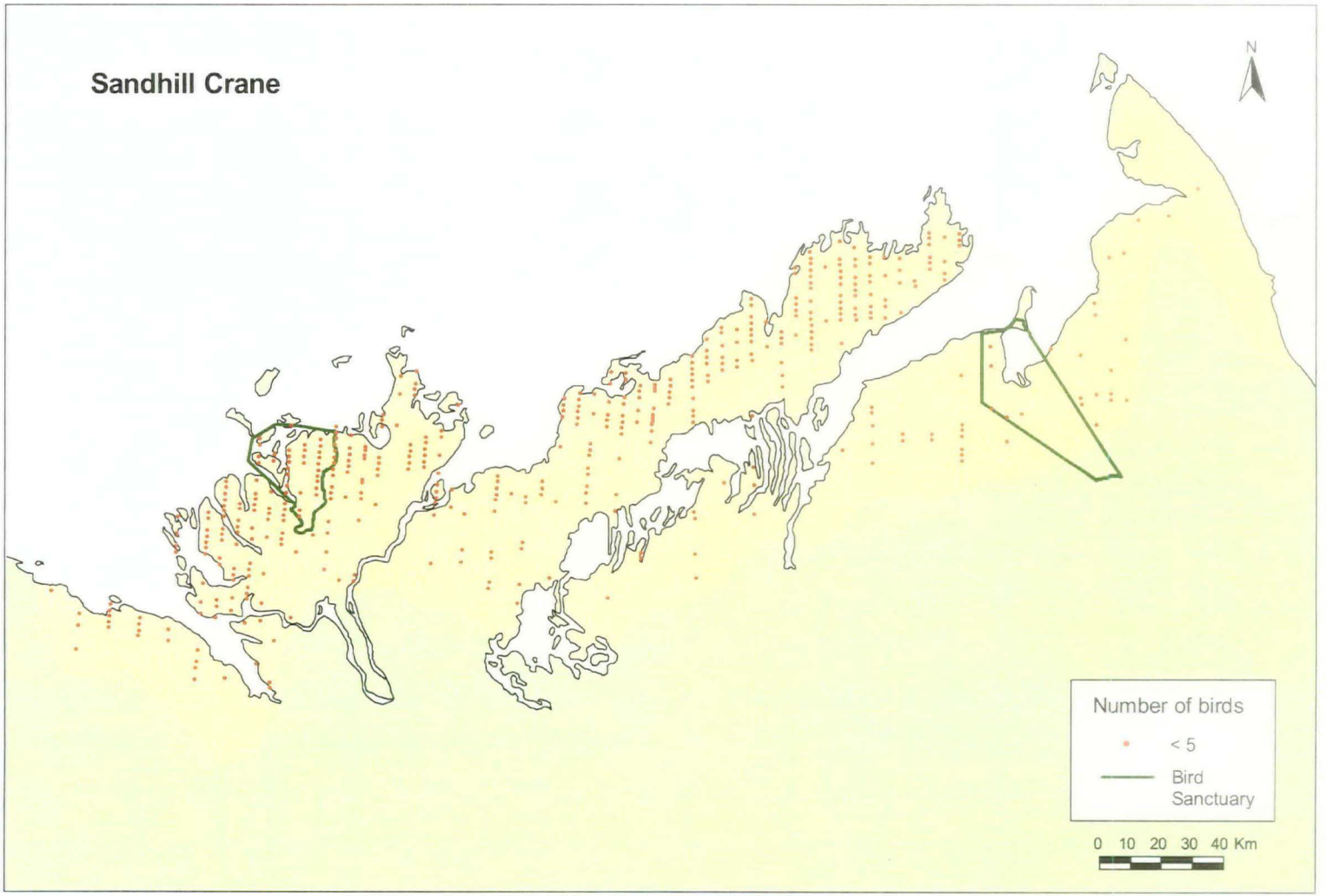

Figure 39. Mean annual numbers of Sandhill Cranes observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

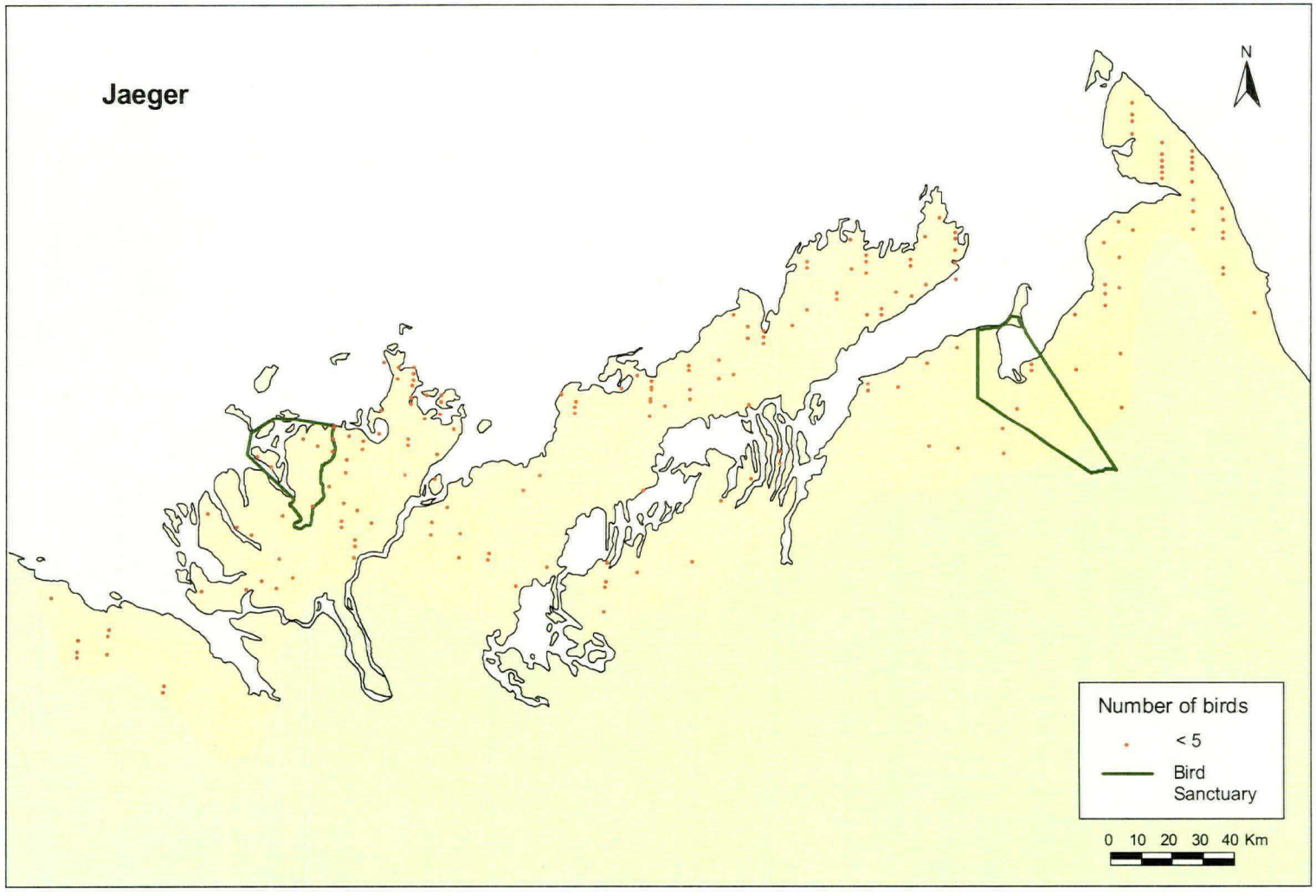

Figure 40. Mean annual numbers of jaegers of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

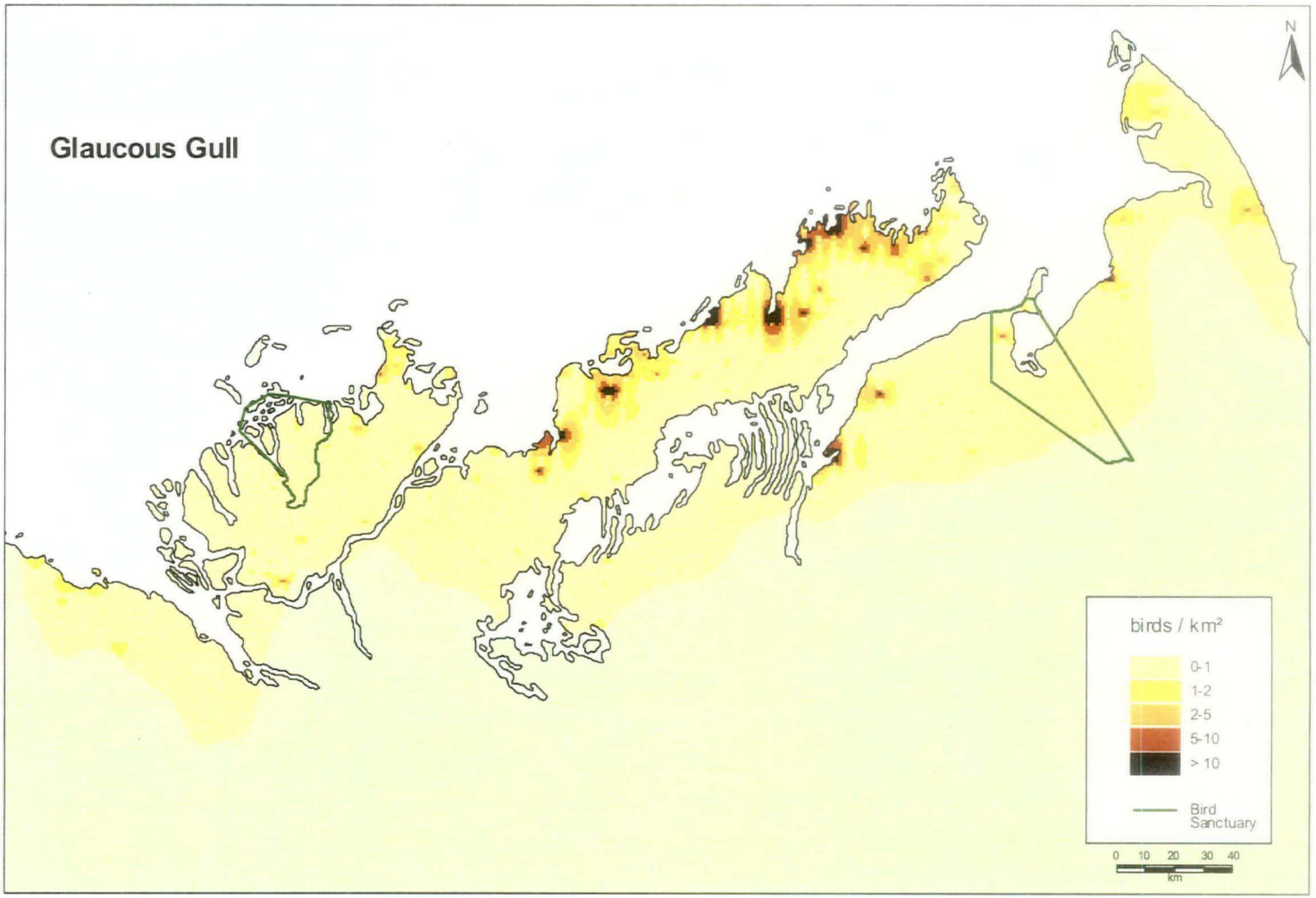

Figure 41. The distribution of Glaucous Gulls on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

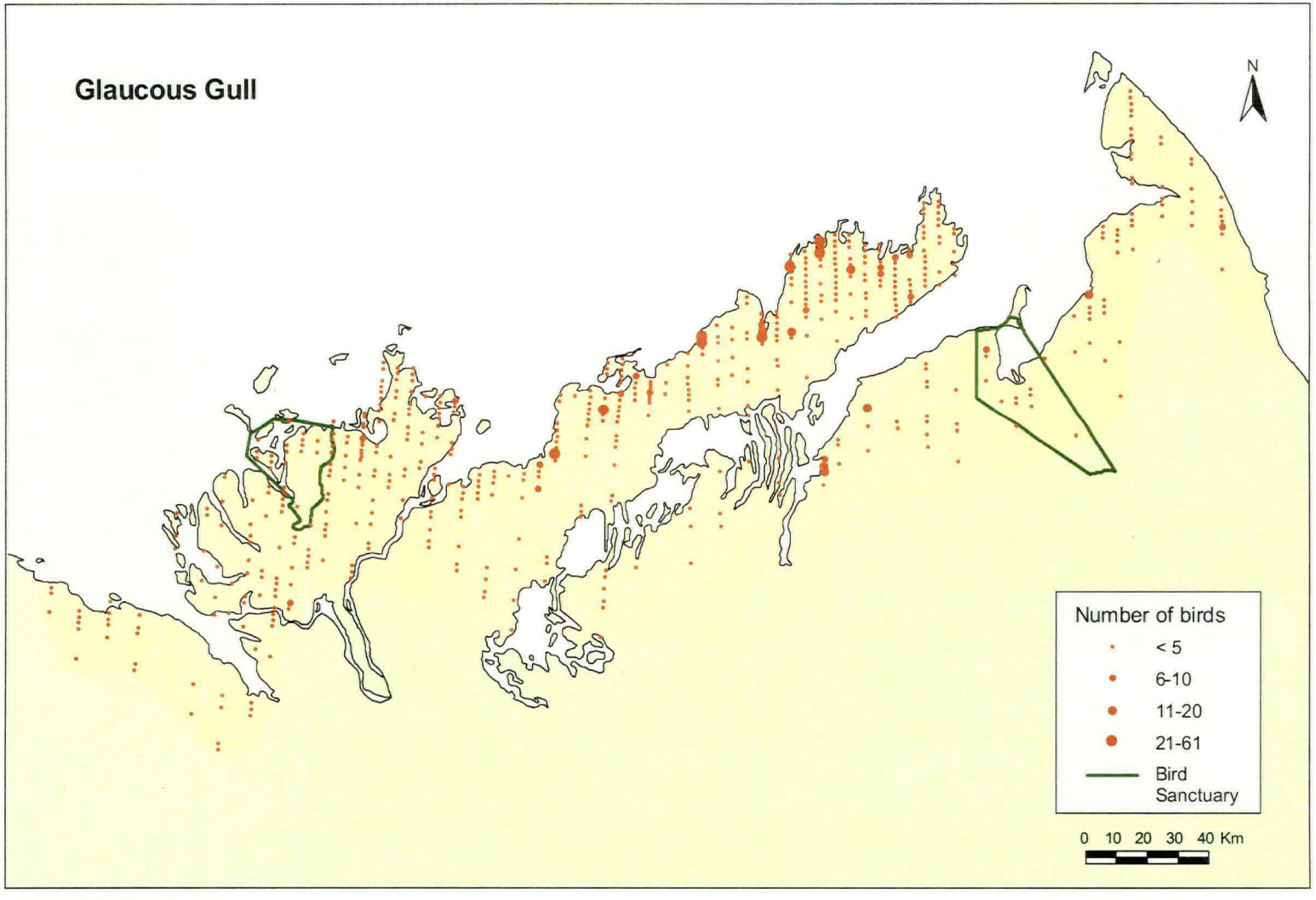

Figure 42. Mean annual numbers of Glaucous Gulls observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

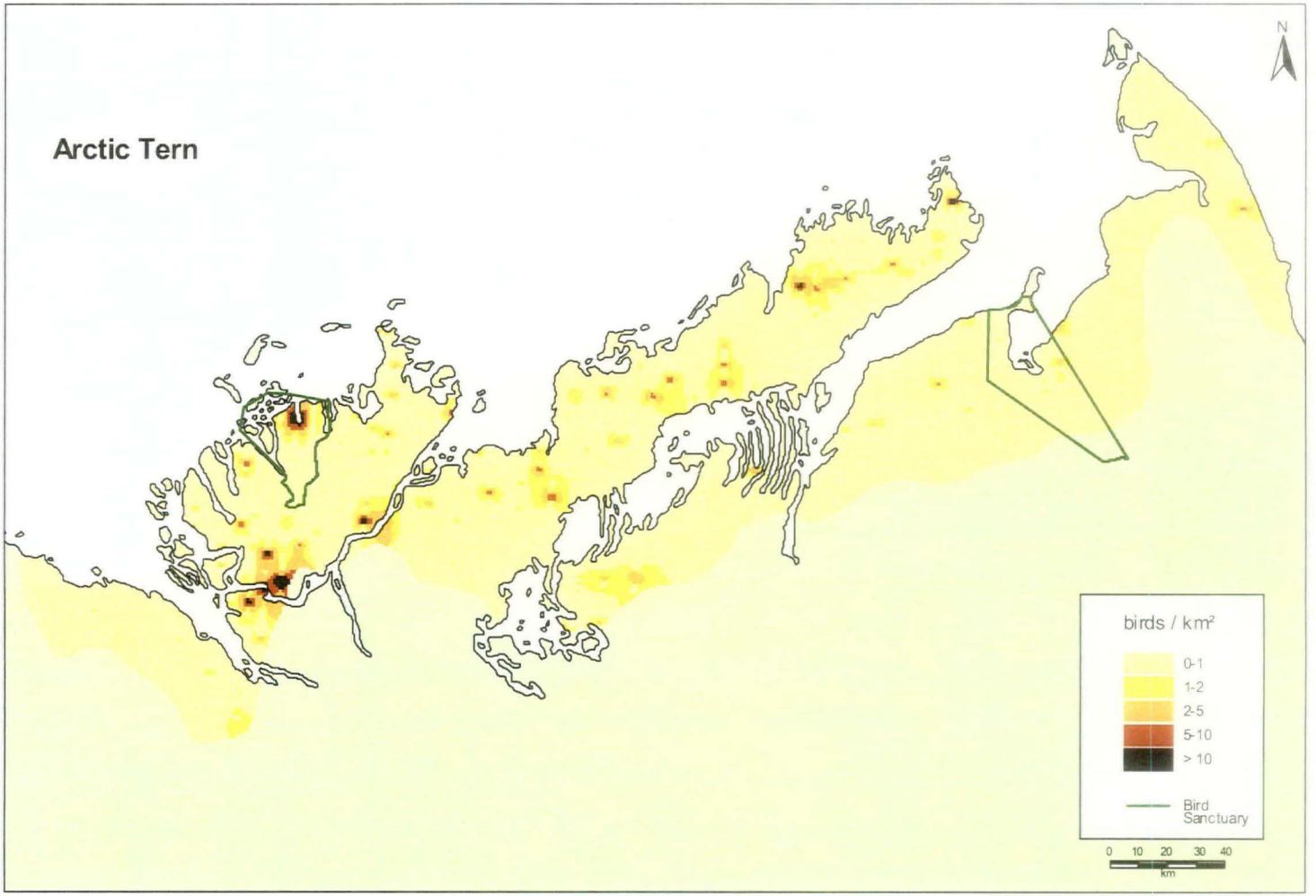

Figure 43. The distribution of Arctic Terns on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

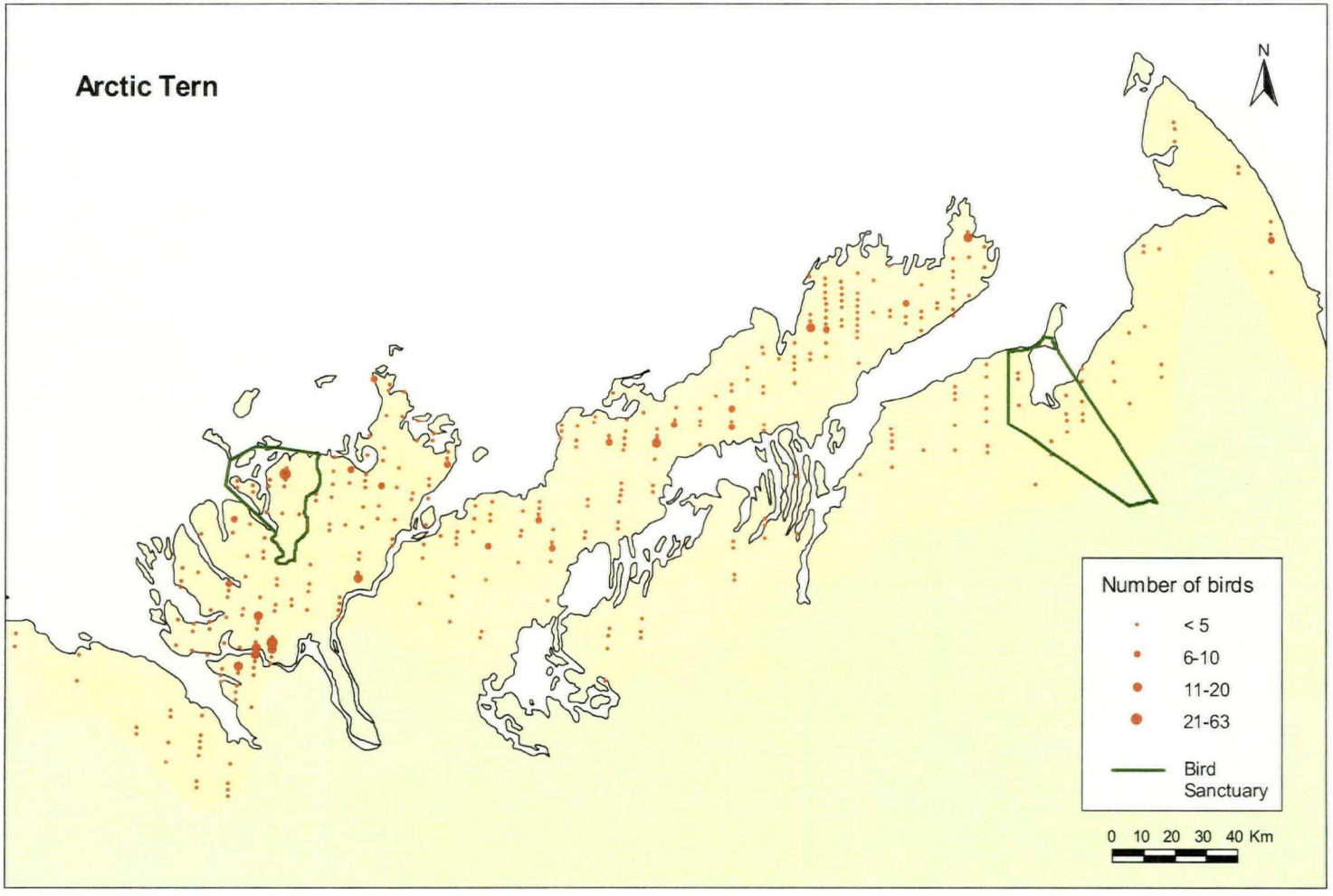

Figure 44. Mean annual numbers of Arctic Terns observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

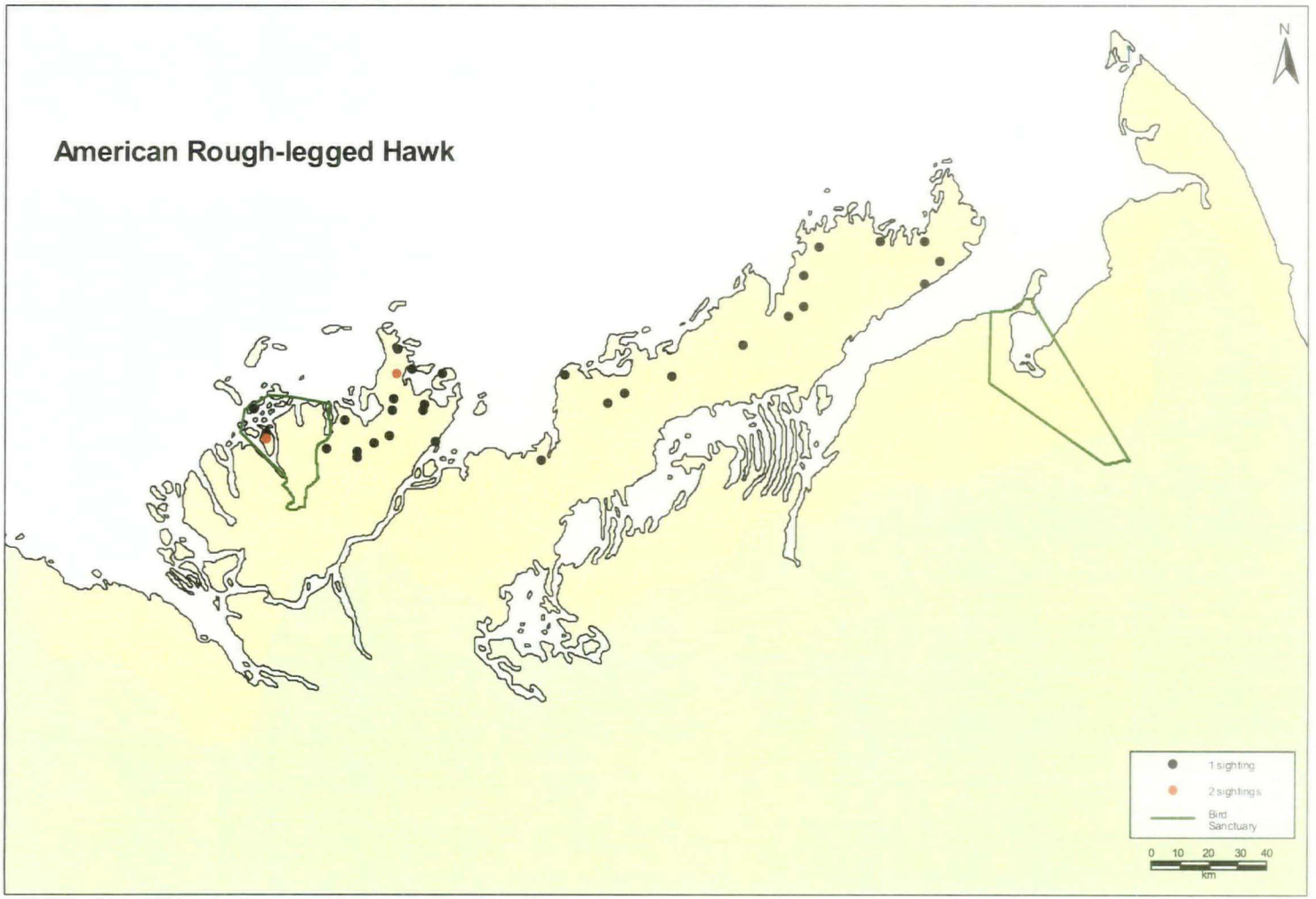

Figure 45. Locations where American Rough-legged Hawks were sighted during aerial surveys on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. All sightings over the study period are plotted.

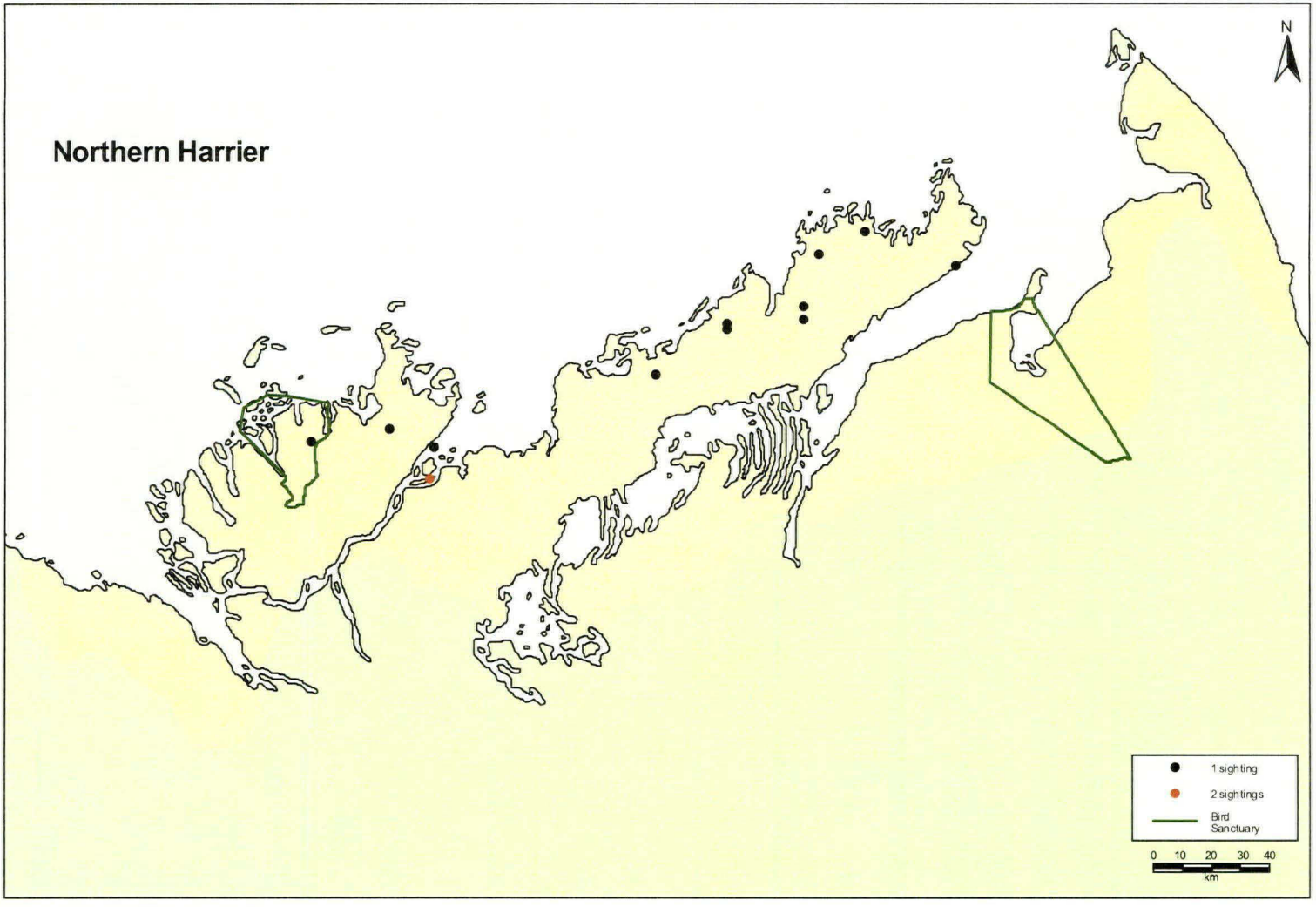

Figure 46. Locations where Northern Harriers were sighted during aerial surveys on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. All sightings over the study period are plotted.

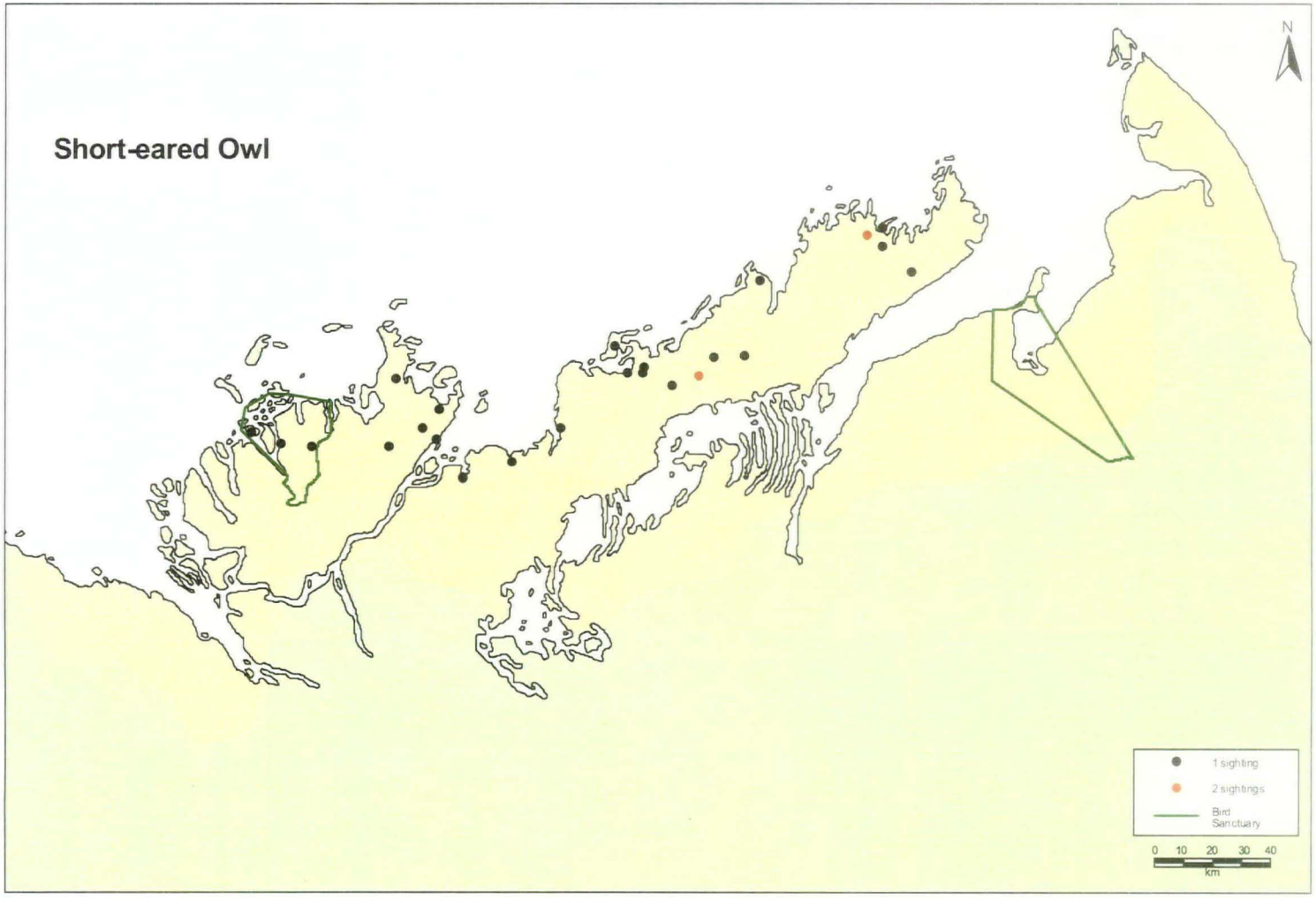

Figure 47. Locations where Short-eared Owls were sighted during aerial surveys on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. All sightings over the study period are plotted.

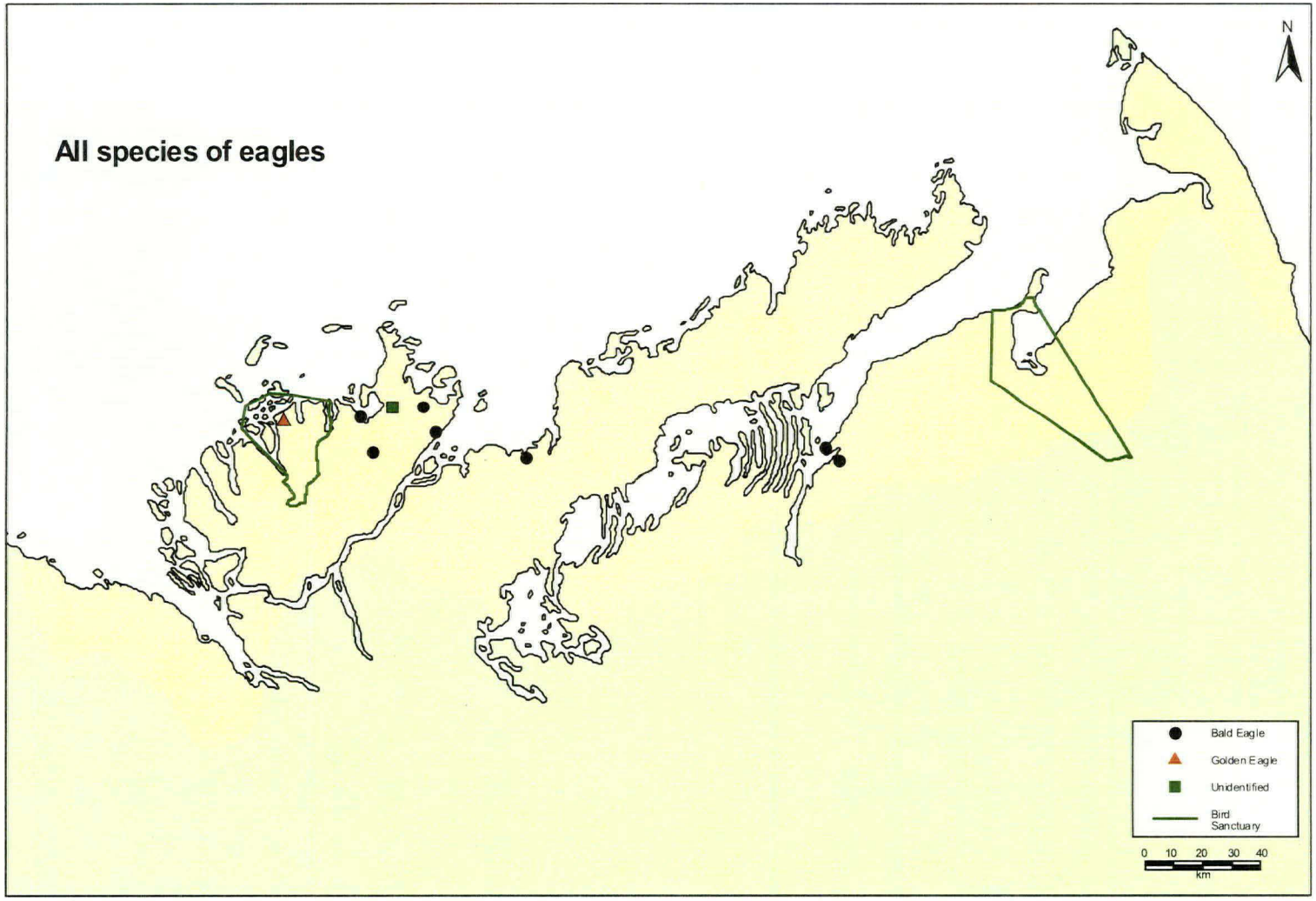

Figure 48. Locations where eagles were sighted during aerial surveys on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. All sightings over the study period are plotted.

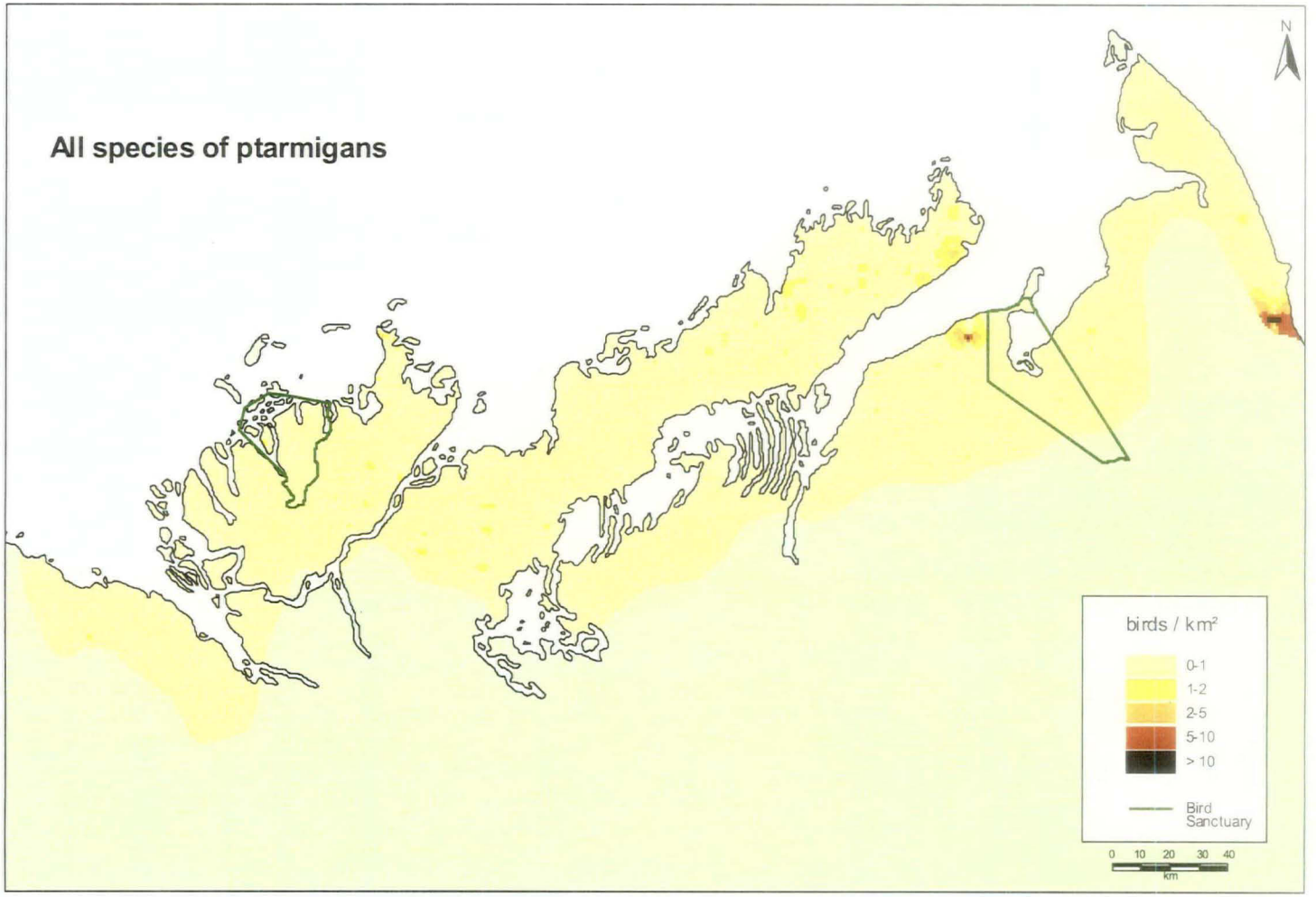

Figure 49. The distribution of Willow and Rock Ptarmigan on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

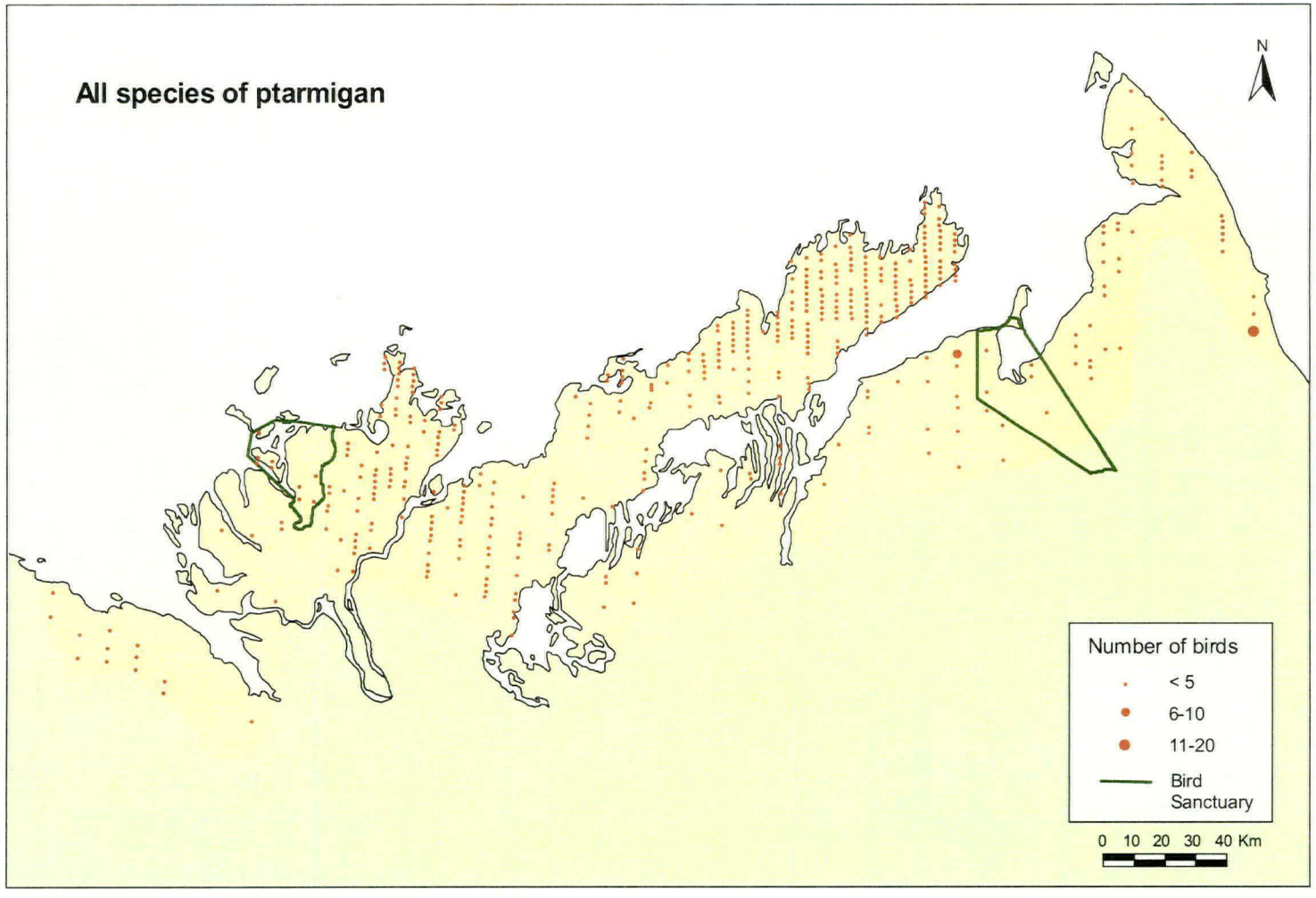

Figure 50. Mean annual numbers of Willow and Rock Ptarmigan observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

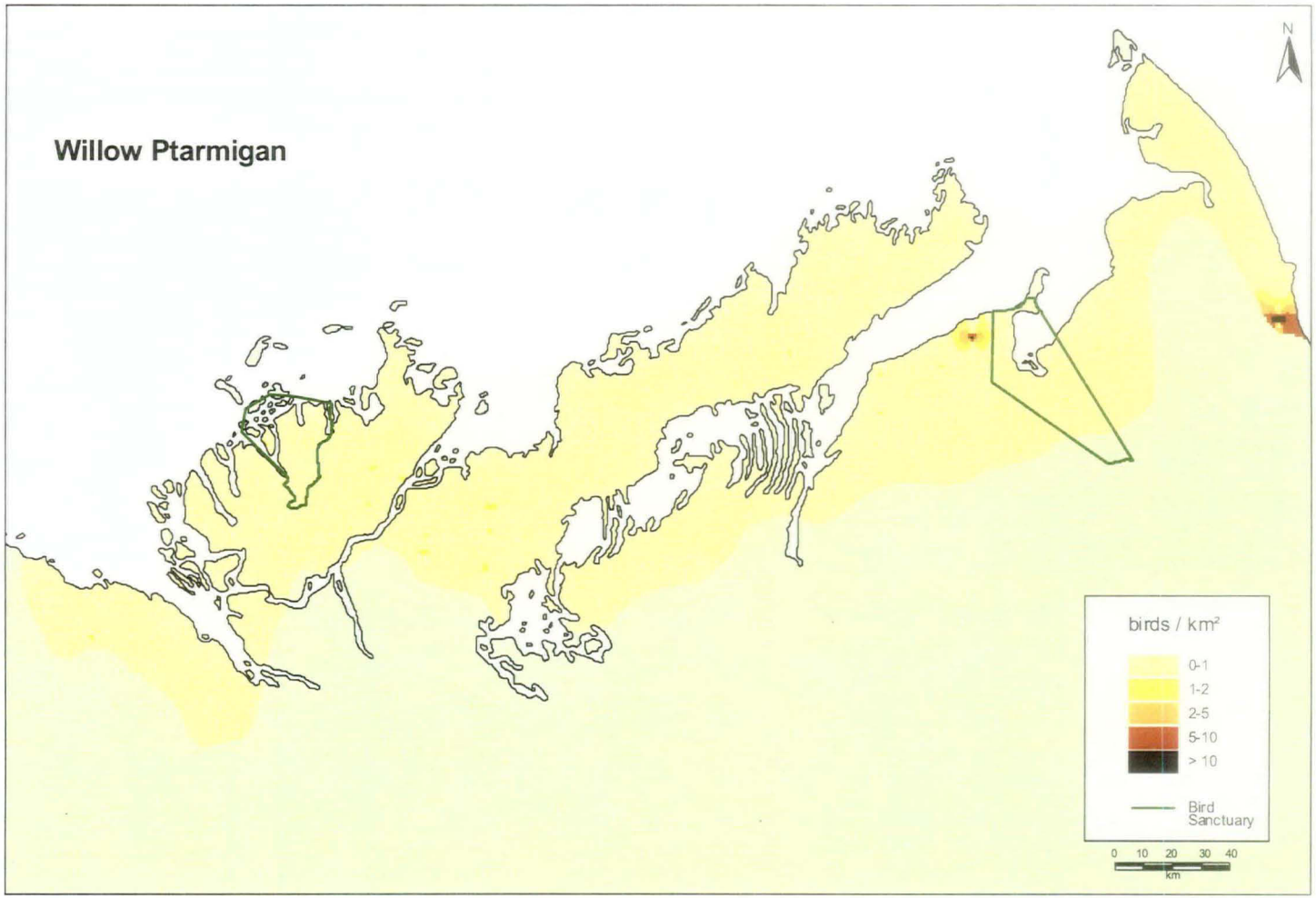

Figure 51. The distribution of Willow Ptarmigan on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998. Population densities are averages for the period and are not corrected for visibility bias.

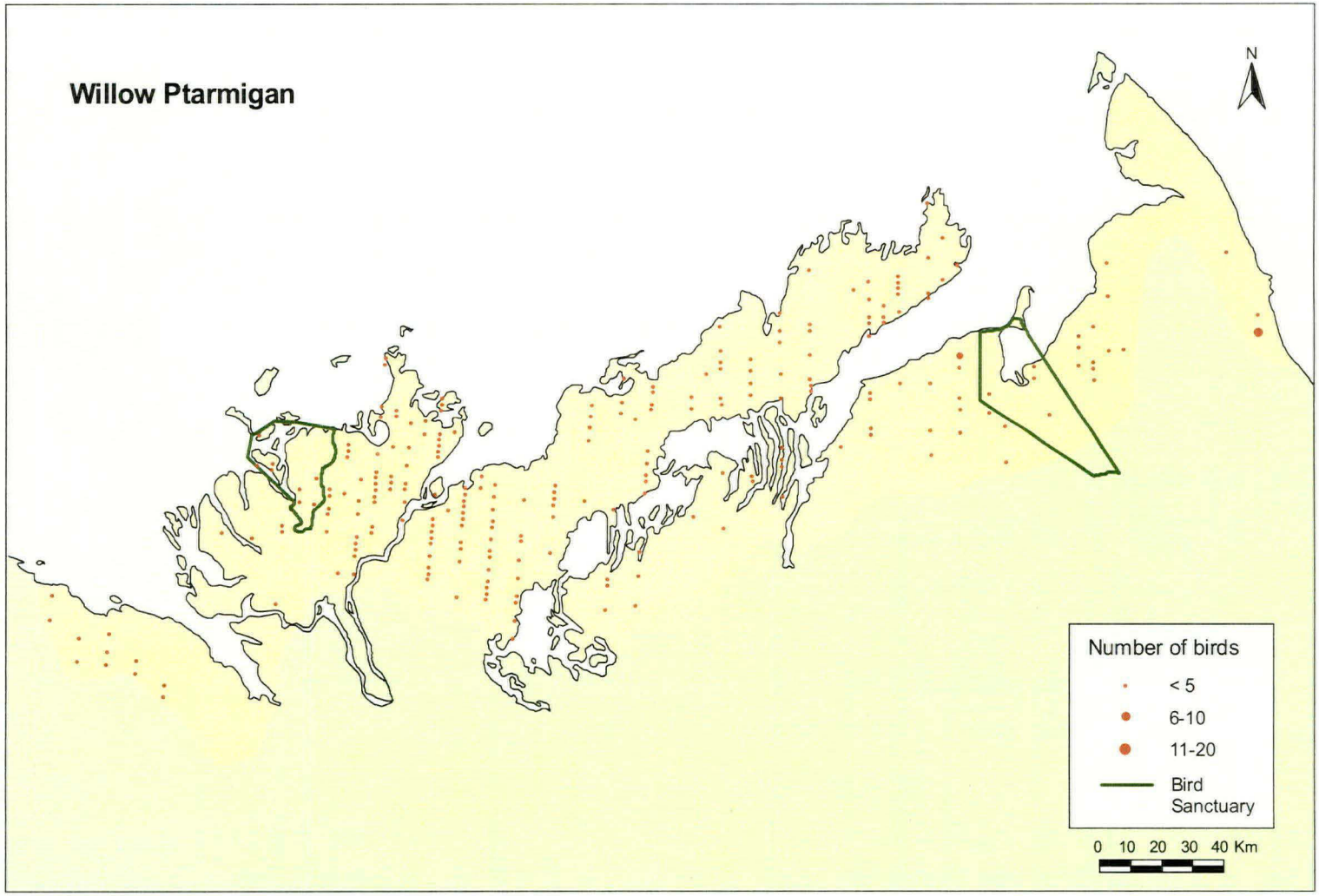

Figure 52. Mean annual numbers of Willow Ptarmigan observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

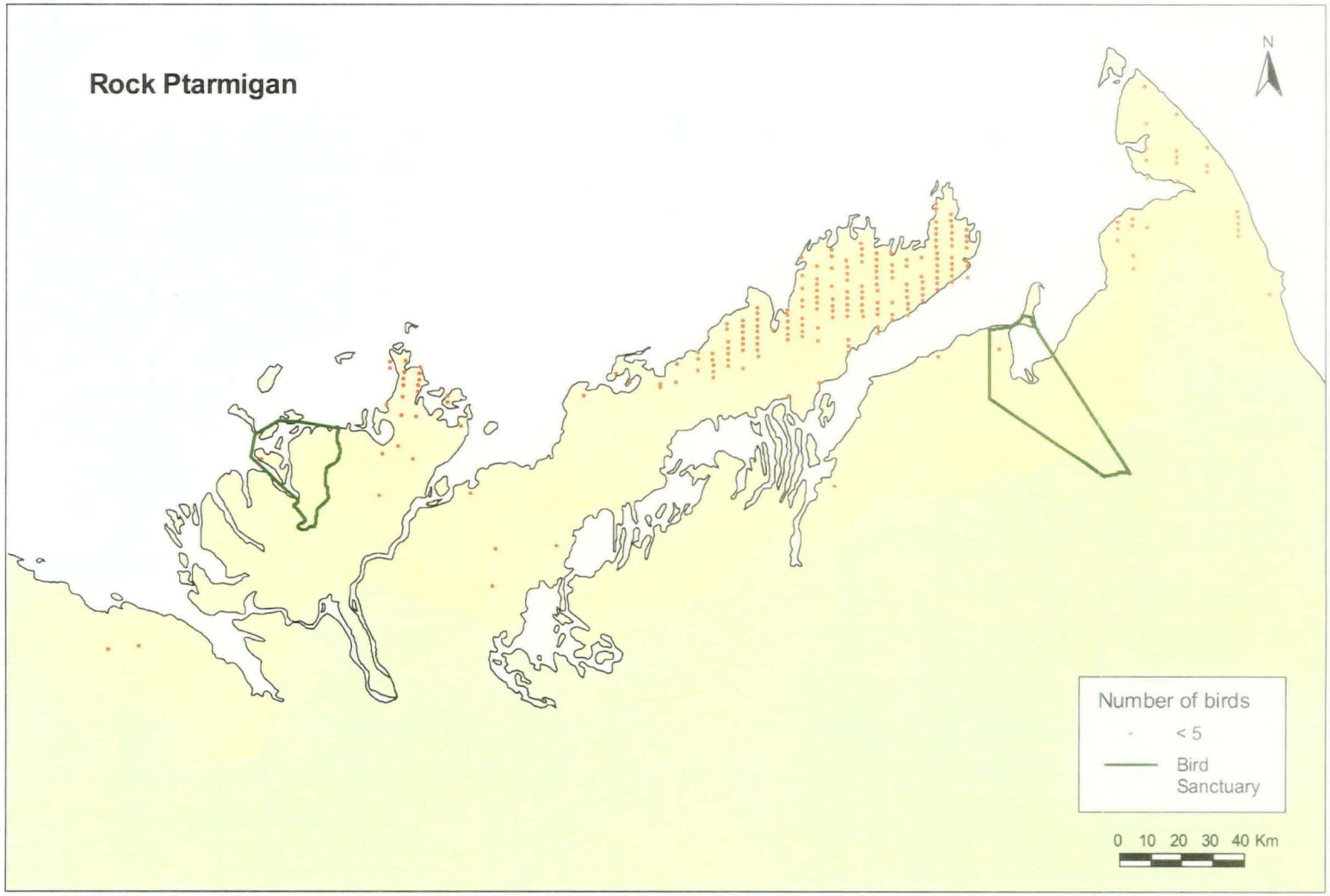

Figure 53. Mean annual numbers of Rock Ptarmigan observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in June, 1991-1998.

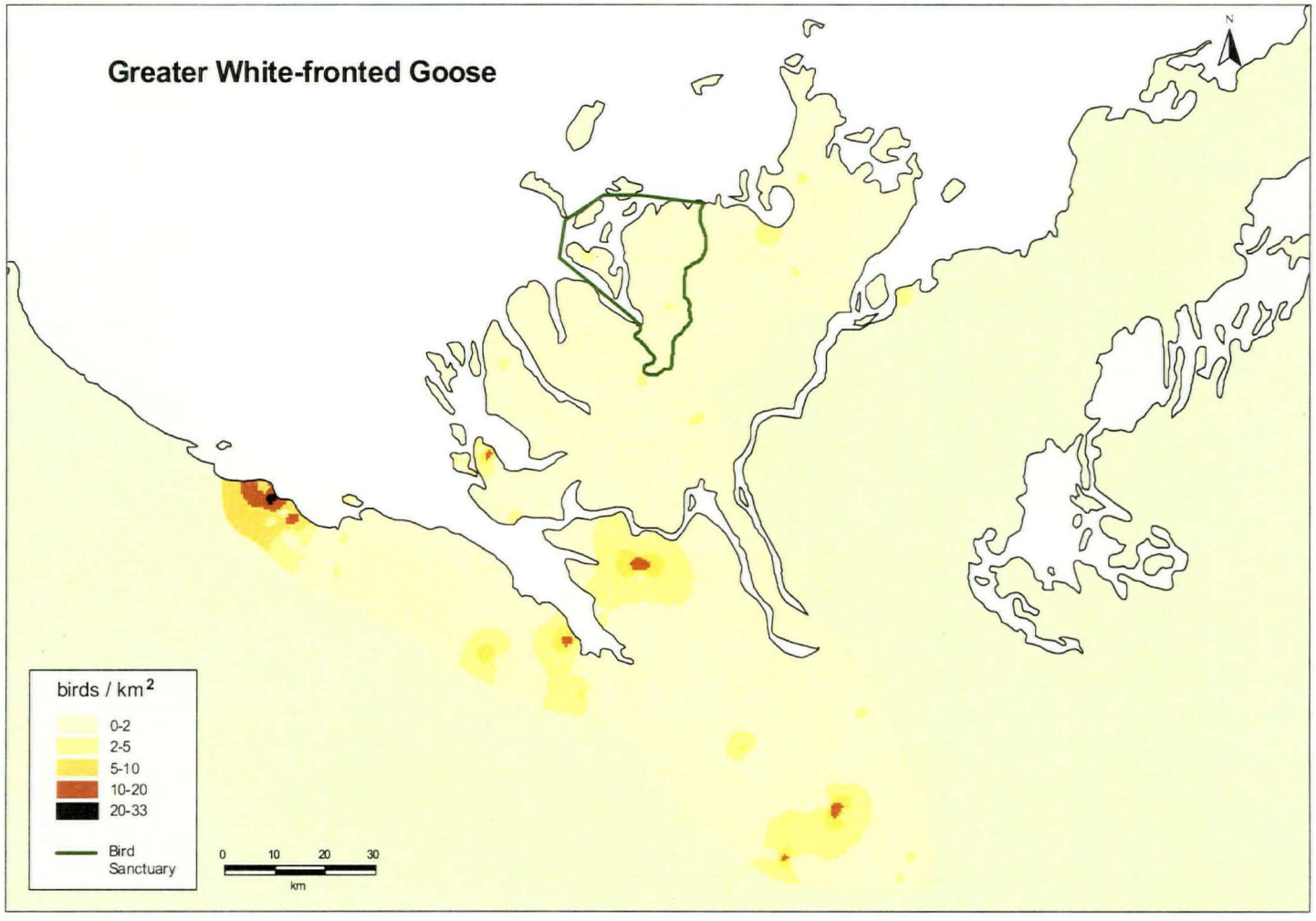

Figure 54. Fall distribution of Greater White-fronted Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

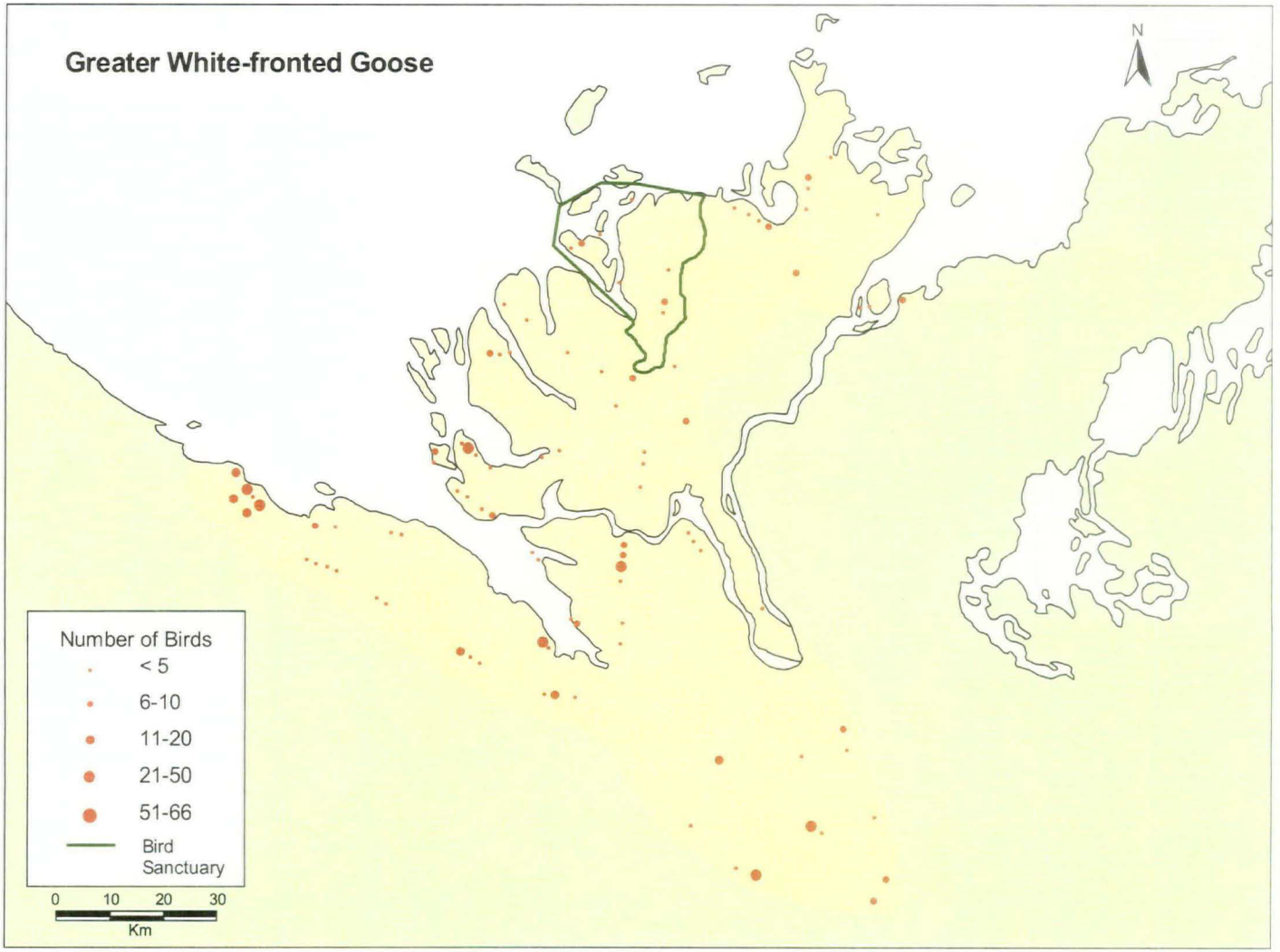

Figure 55. Mean numbers of Greater White-fronted Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

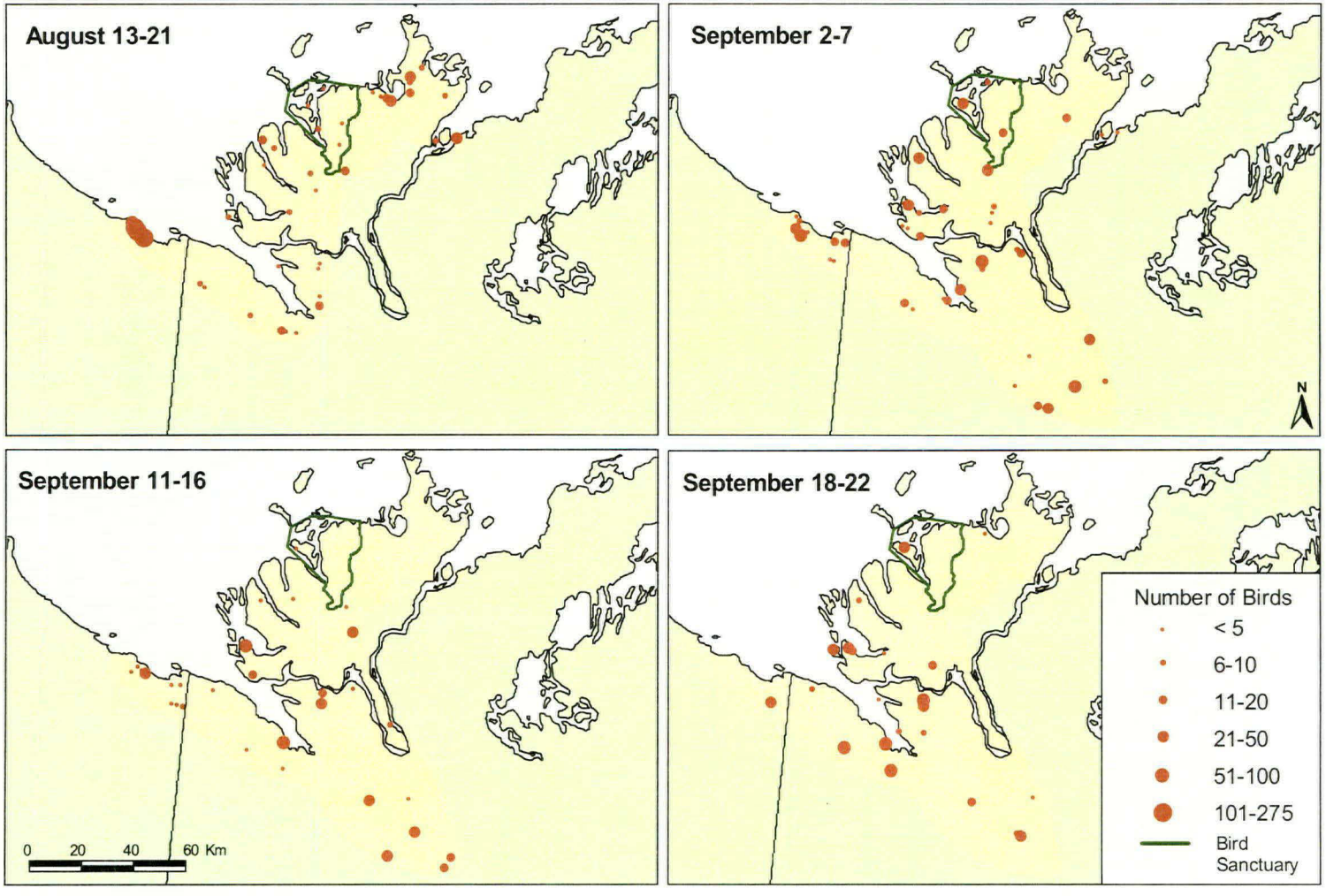

Figure 56. Mean numbers of Greater White-fronted Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

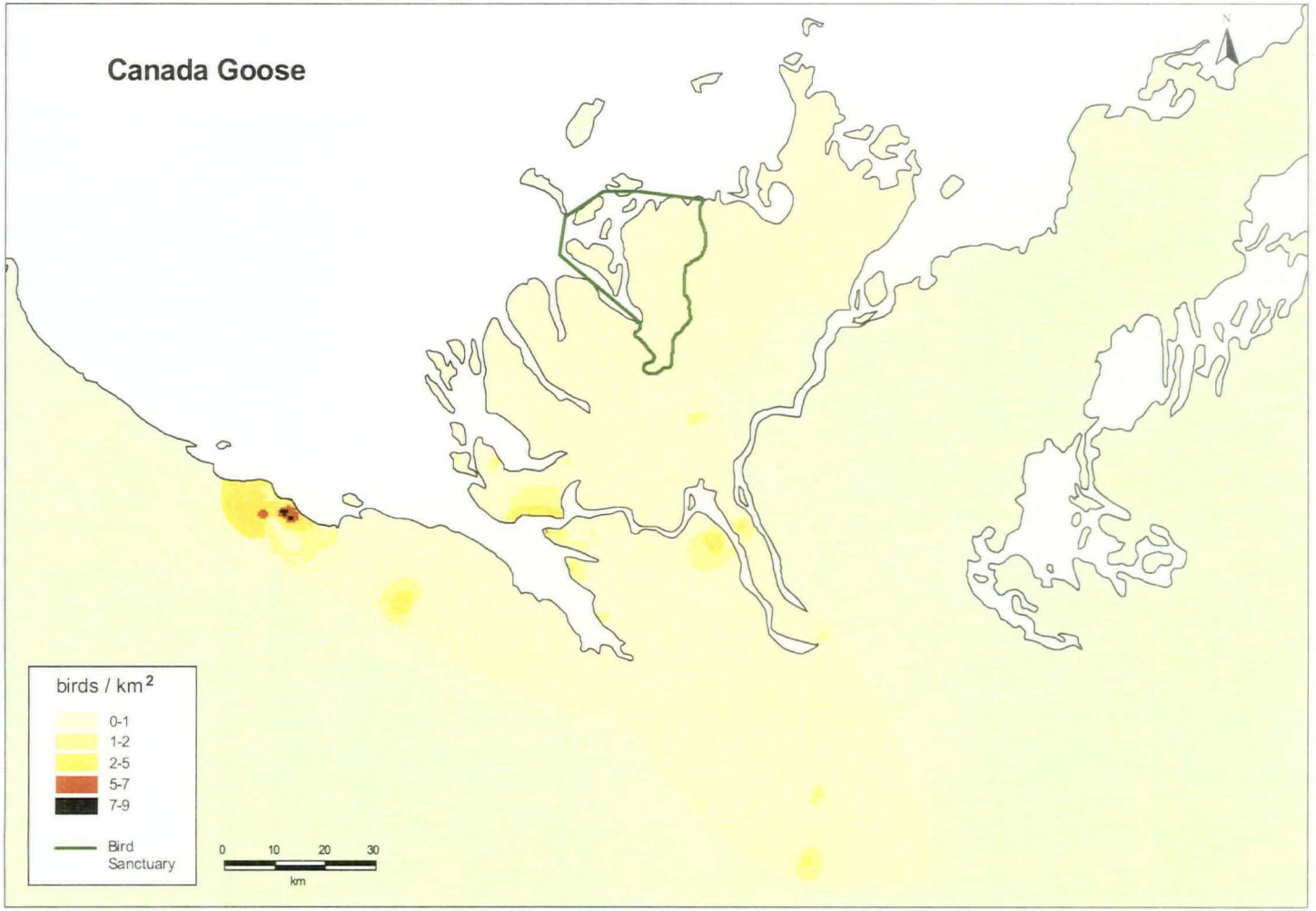

Figure 57. Fall distribution of Canada Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

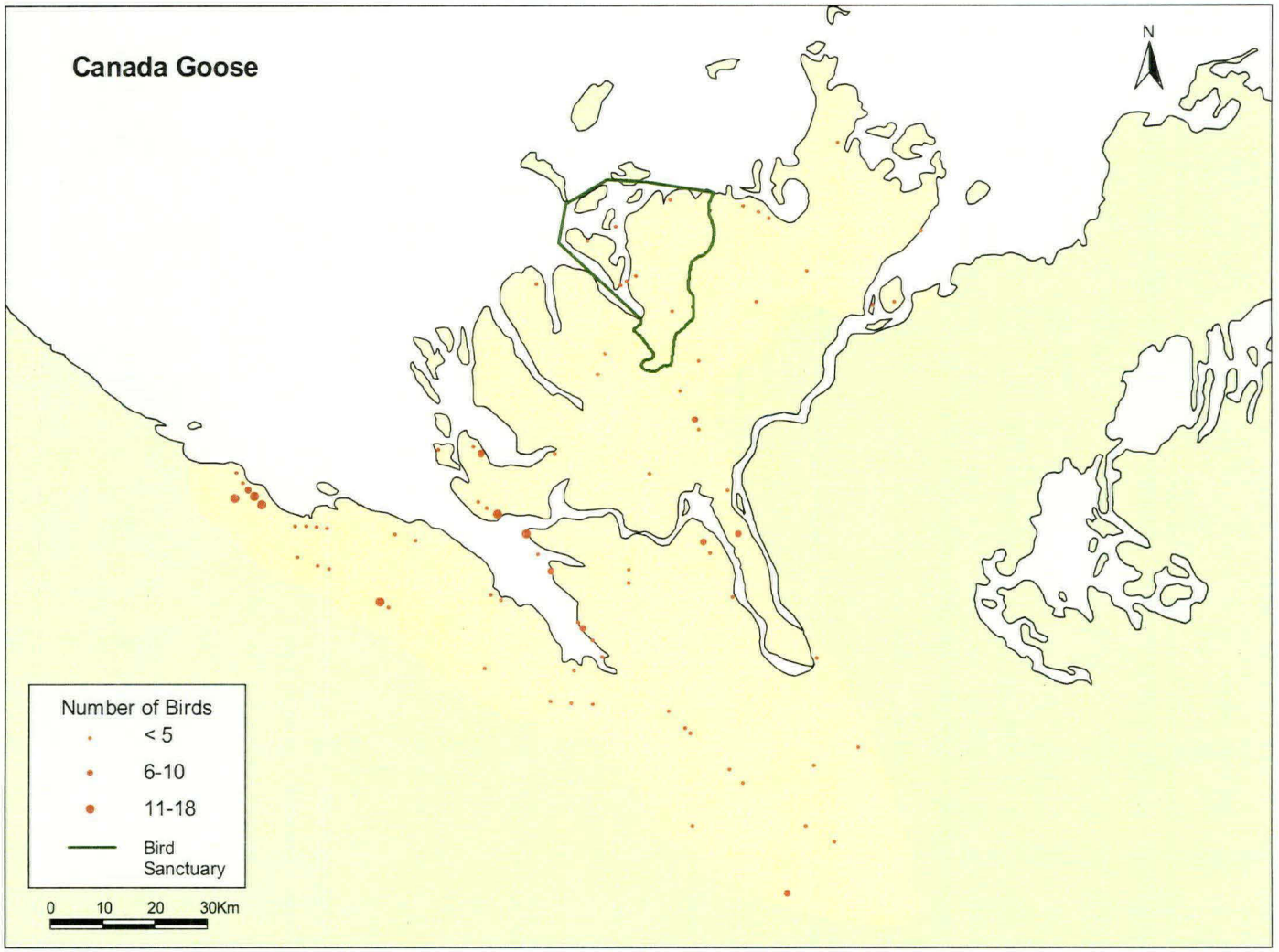

Figure 58. Mean numbers of Canada Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

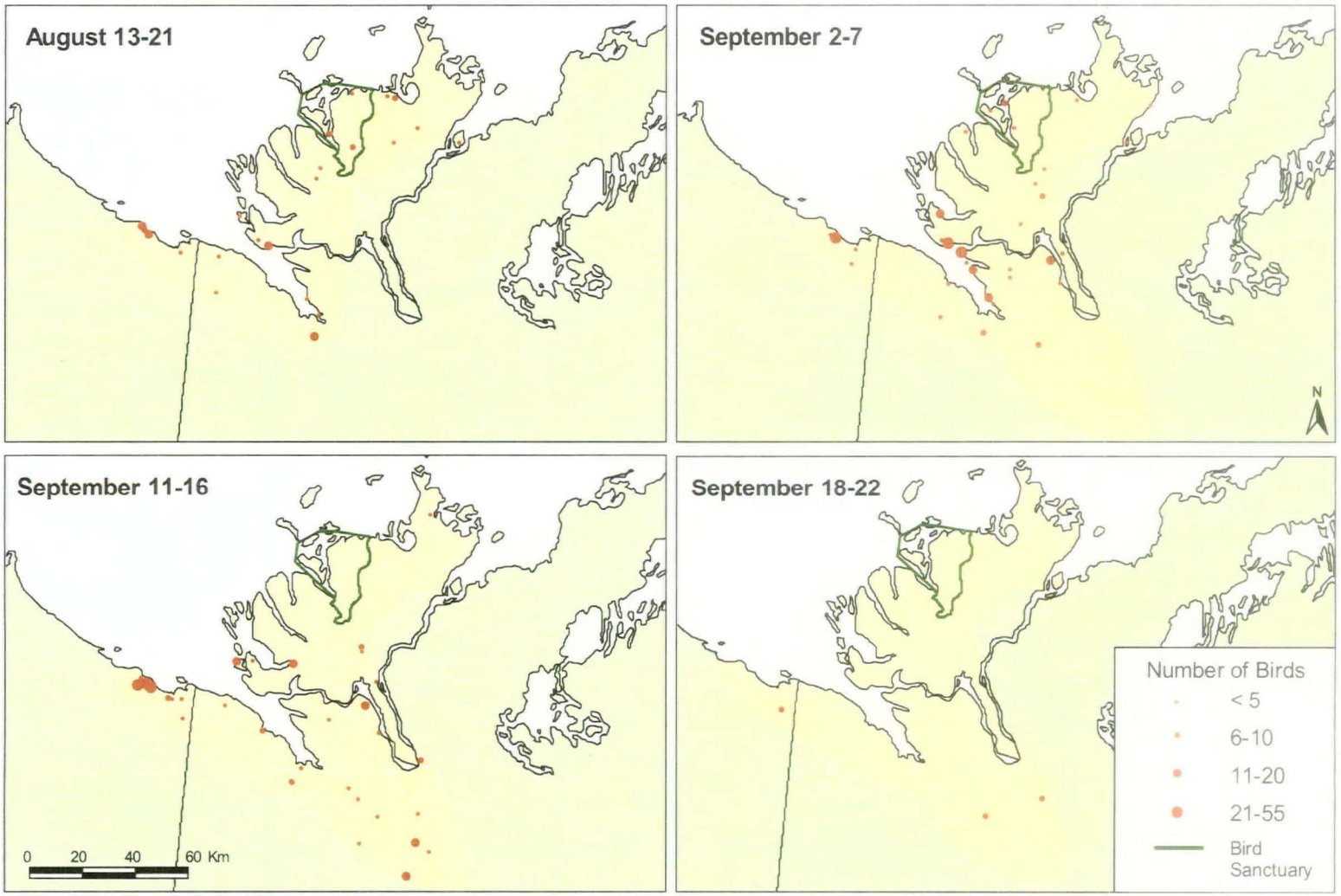

Figure 59. Mean numbers of Canada Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

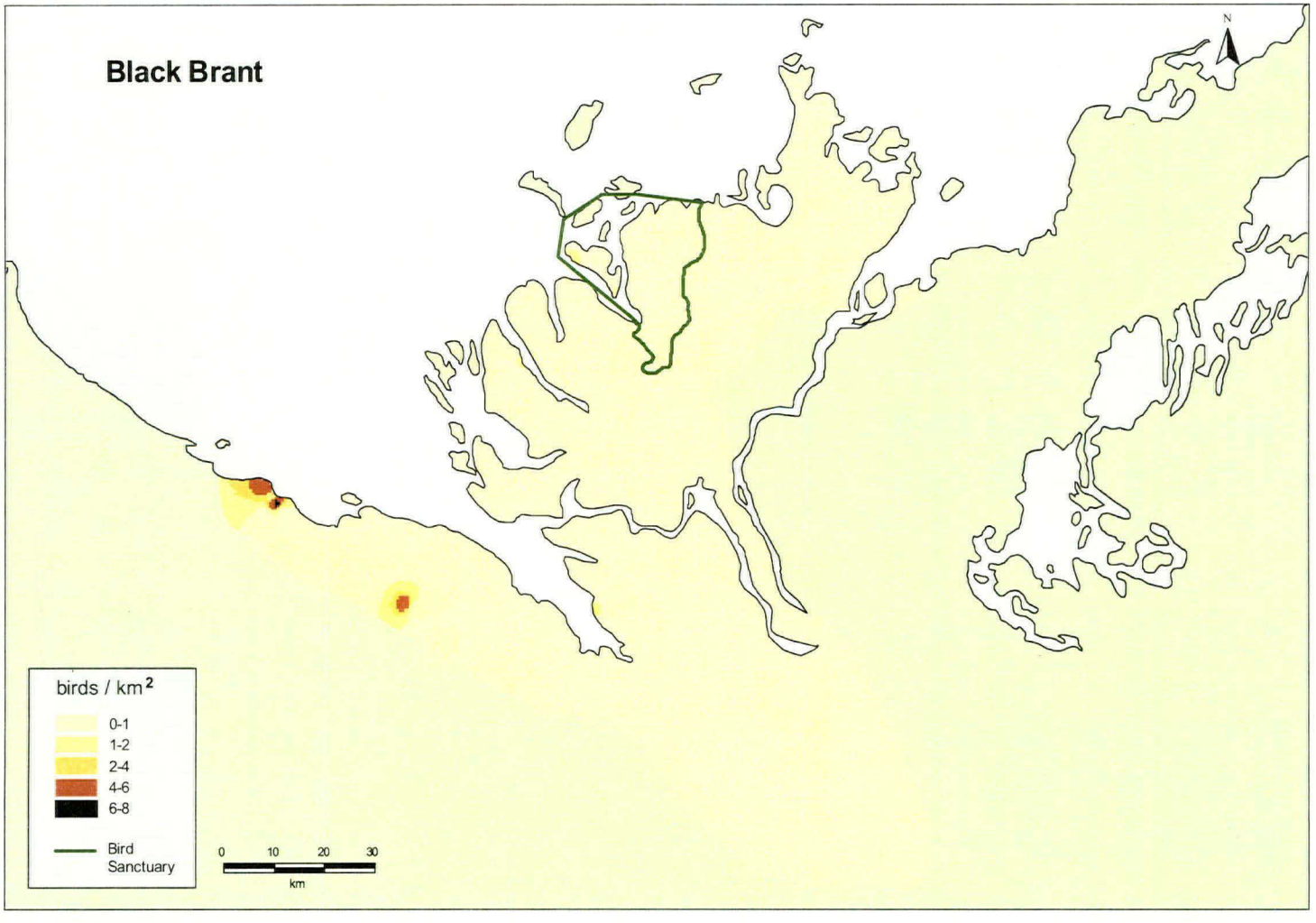

Figure 60. Fall distribution of Black Brant on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

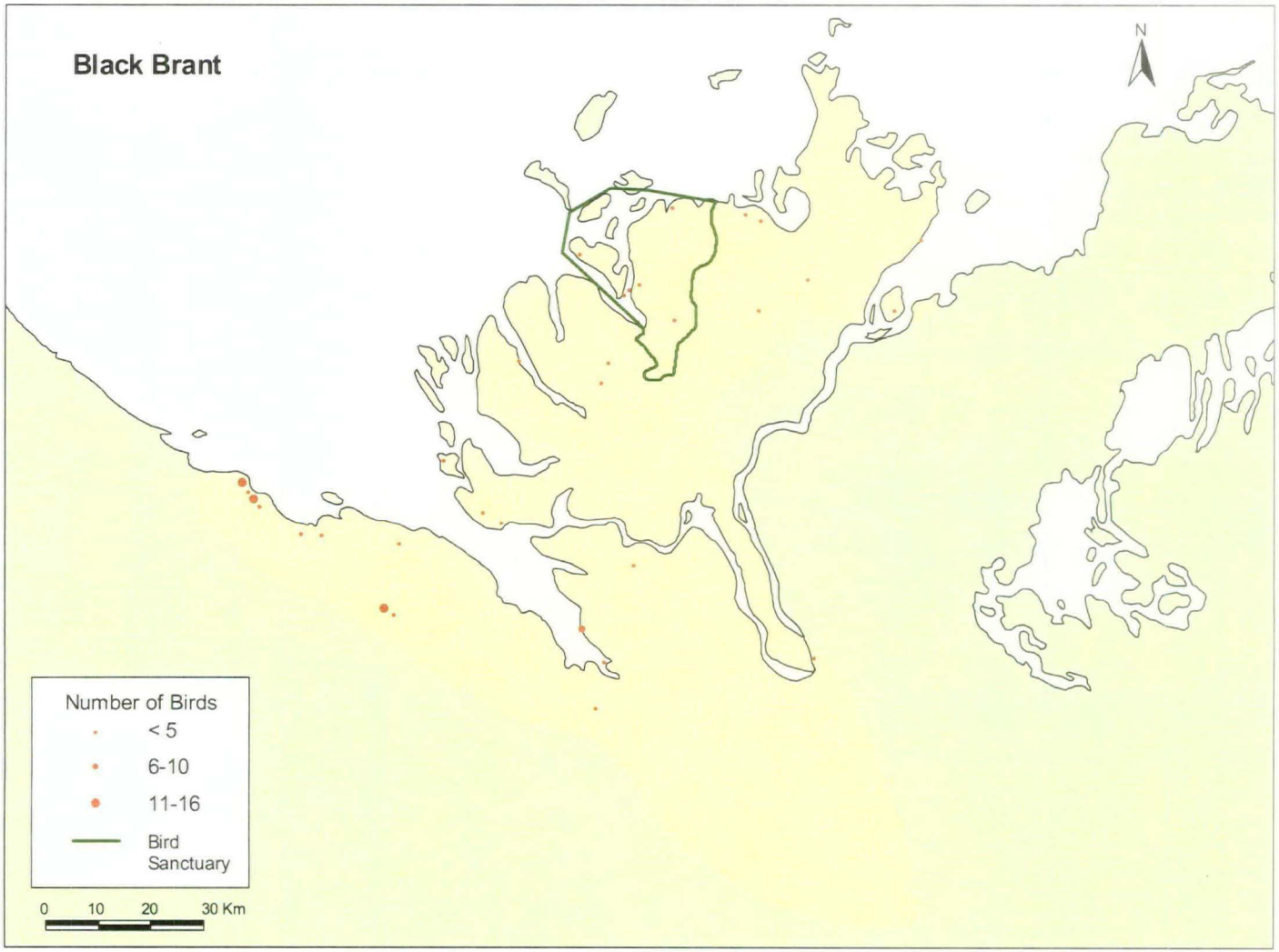

Figure 61. Mean numbers of Black Brant observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

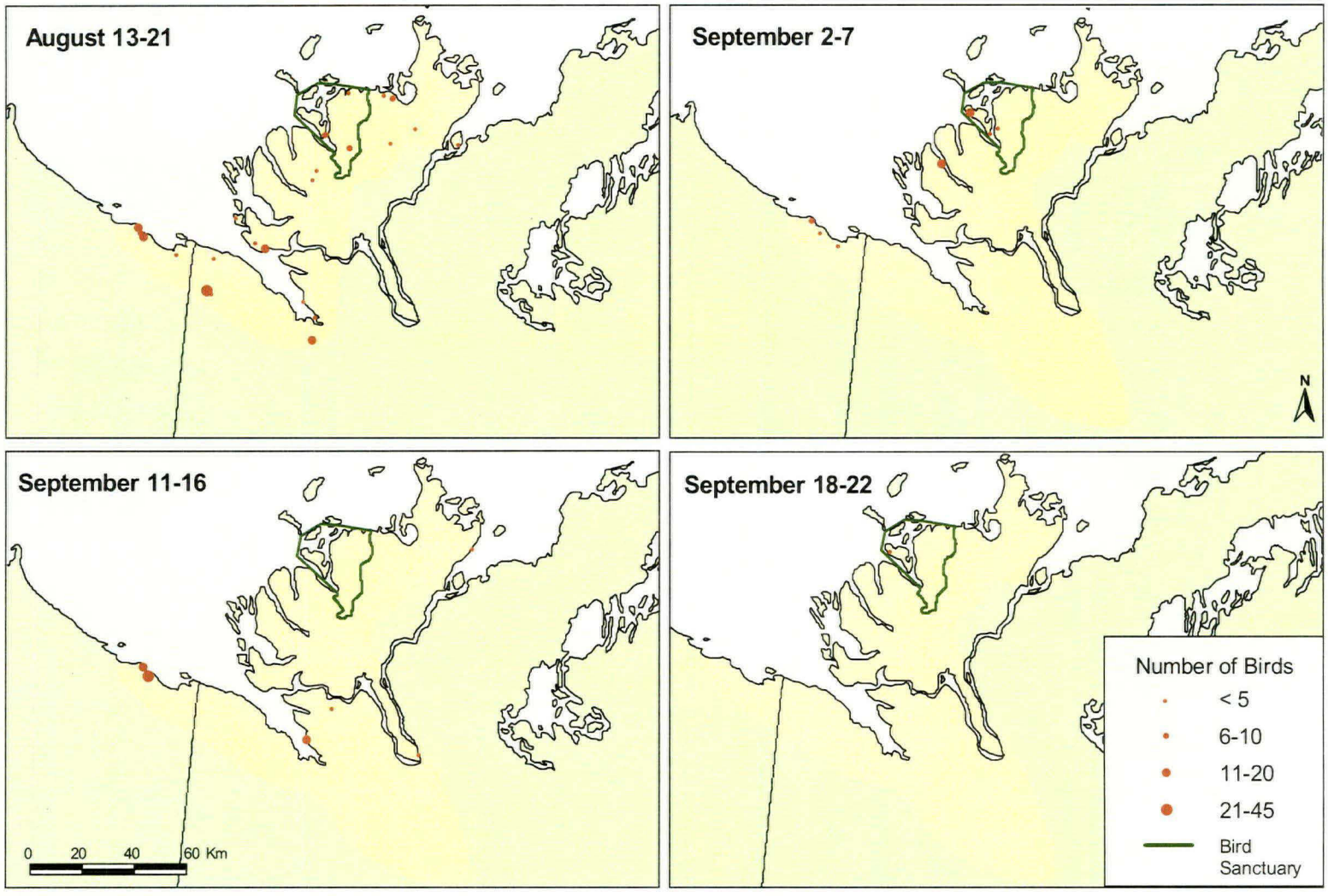

Figure 62. Mean numbers of Black Brant observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

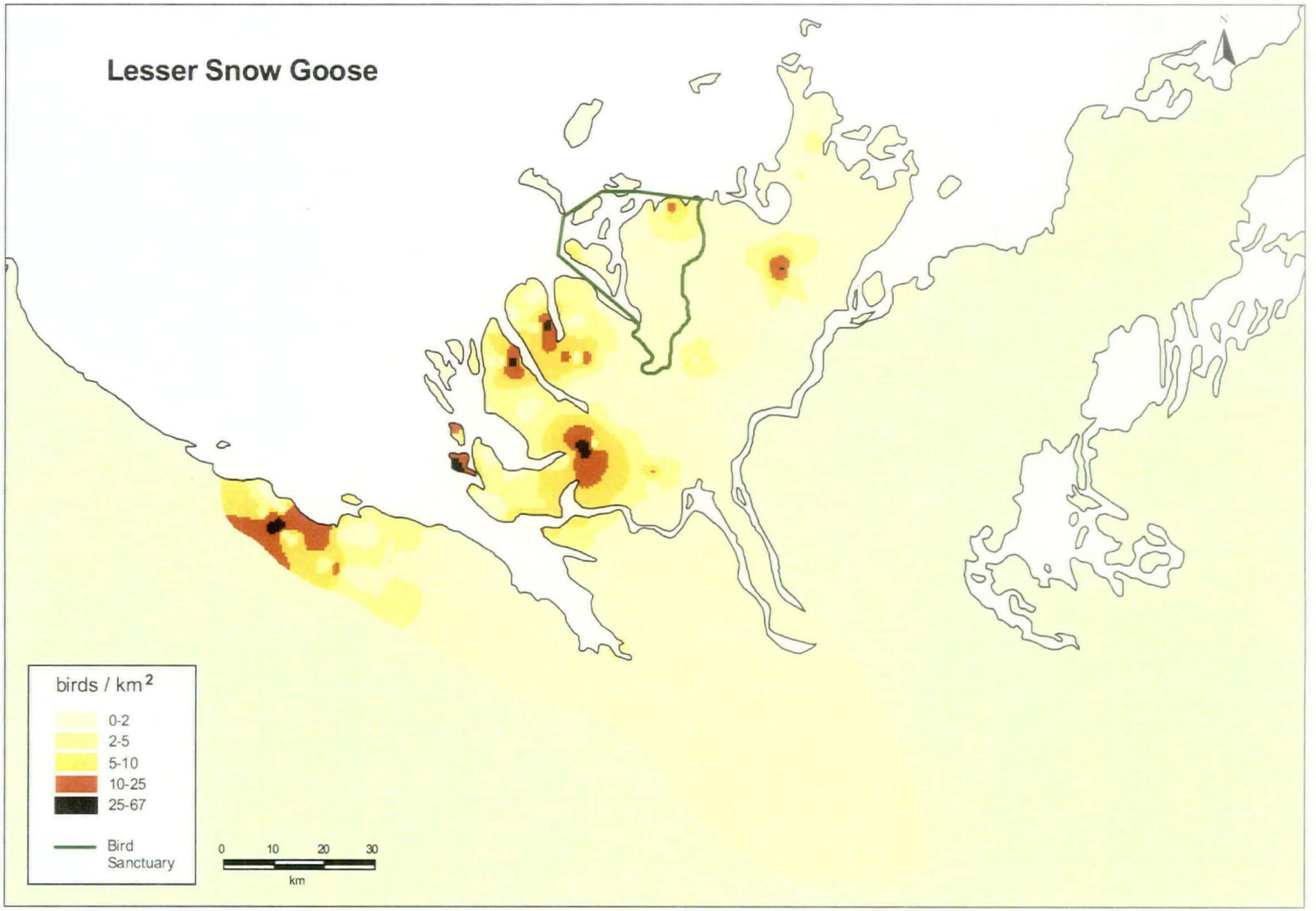

Figure 63. Fall distribution of Lesser Snow Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

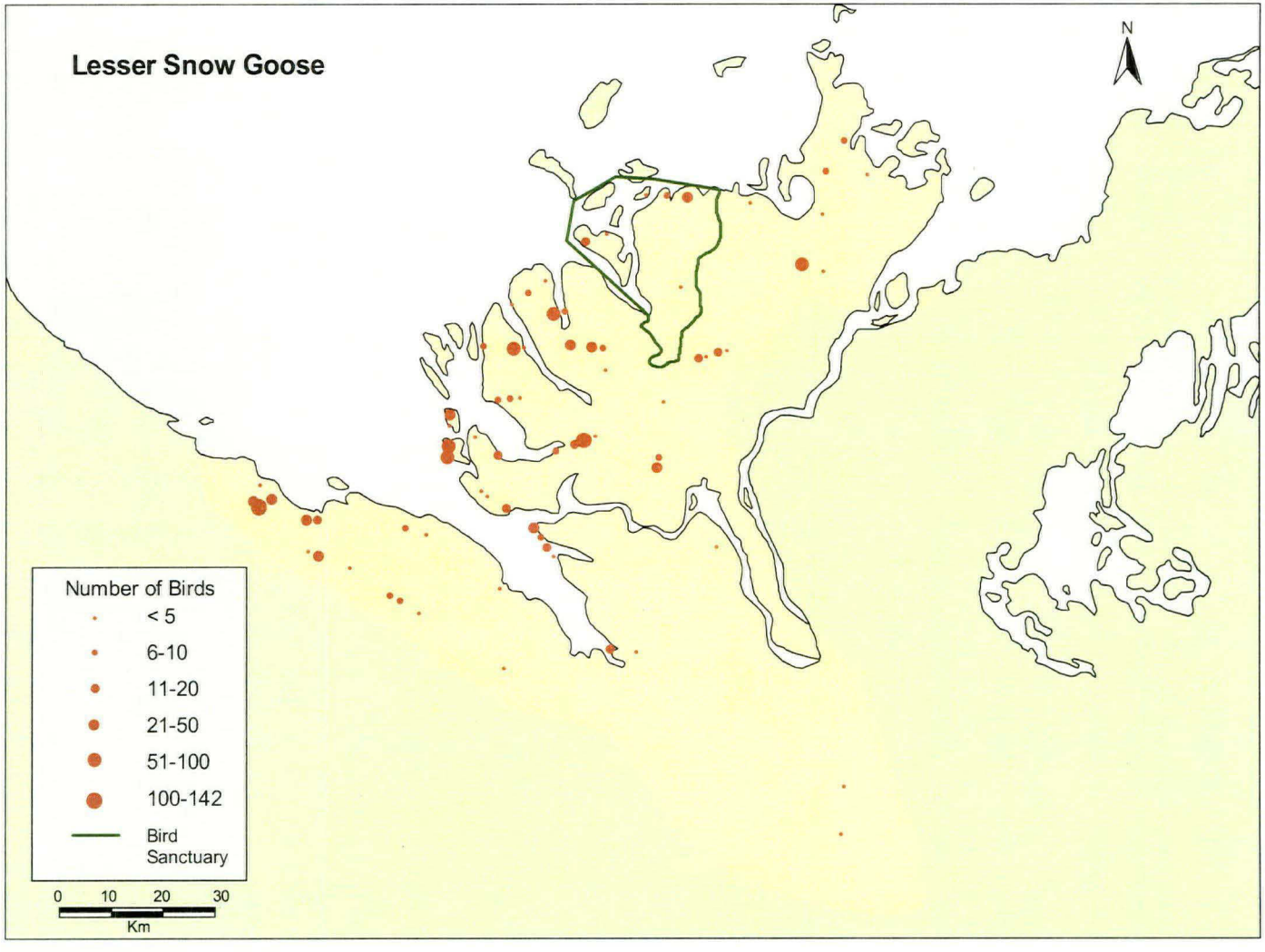

Figure 64. Mean numbers of Lesser Snow Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

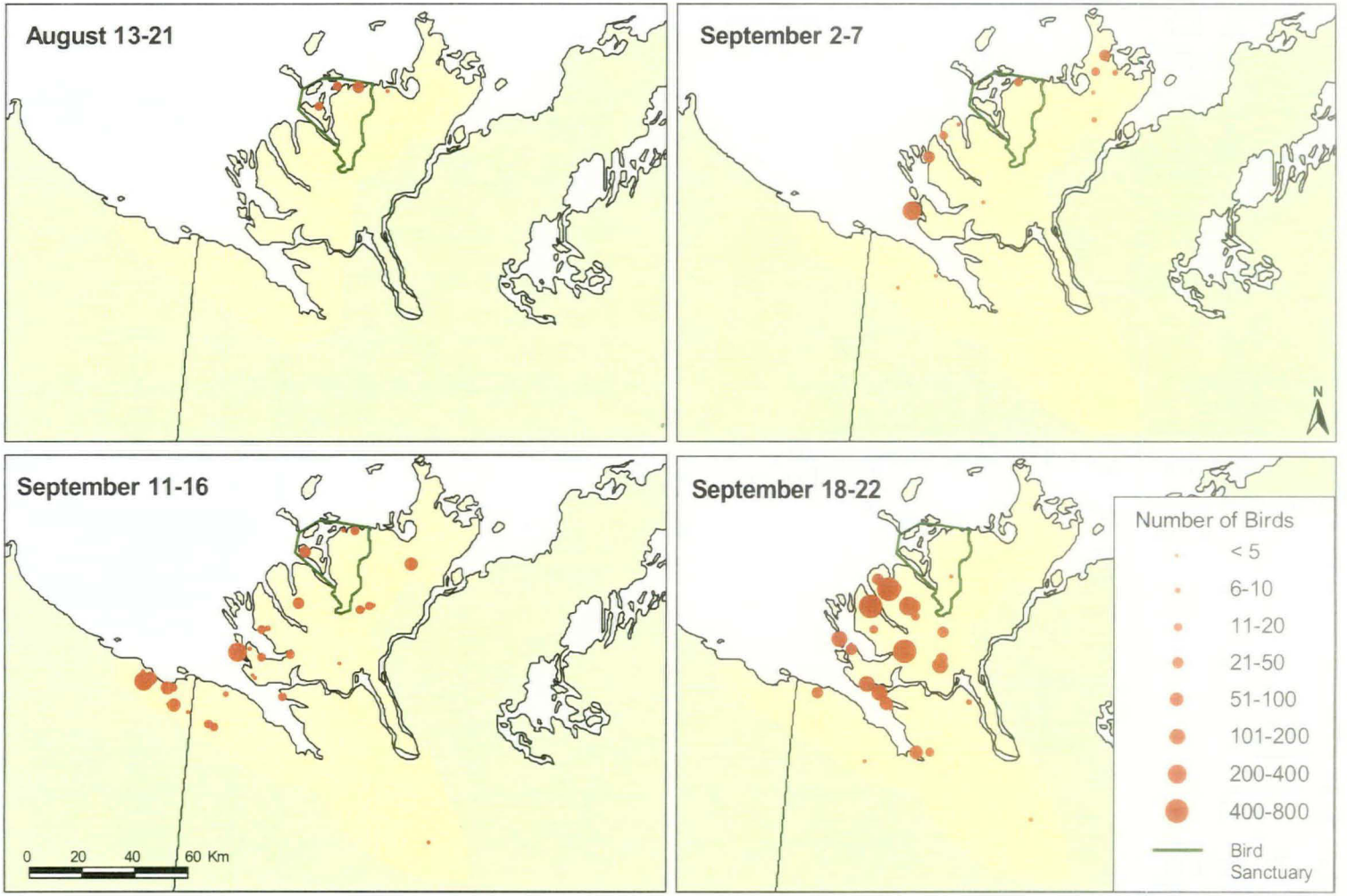

Figure 65. Mean numbers of Lesser Snow Geese observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

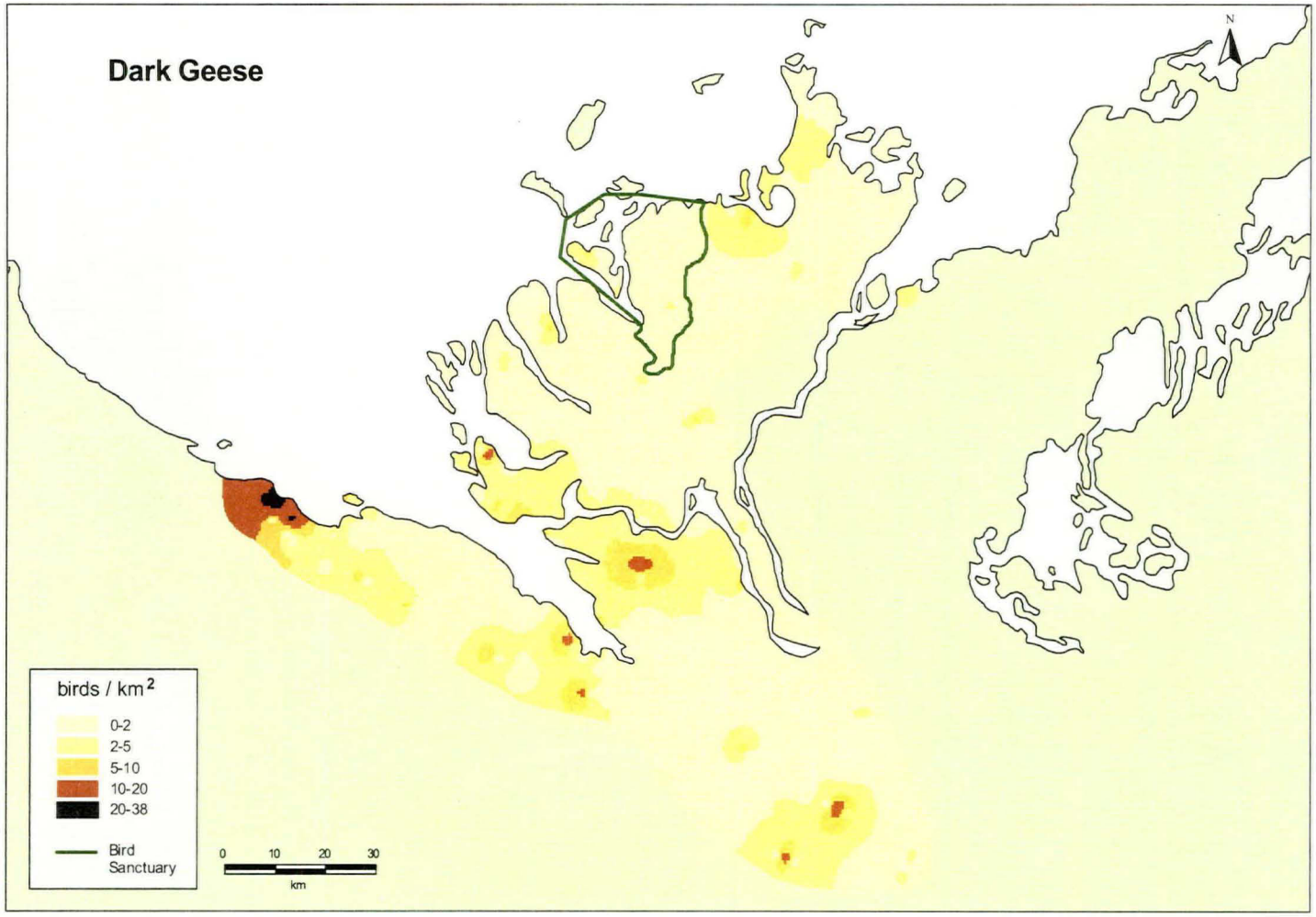

Figure 66. Fall distribution of "dark geese" (White-fronted, Brant and Canada Geese) on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

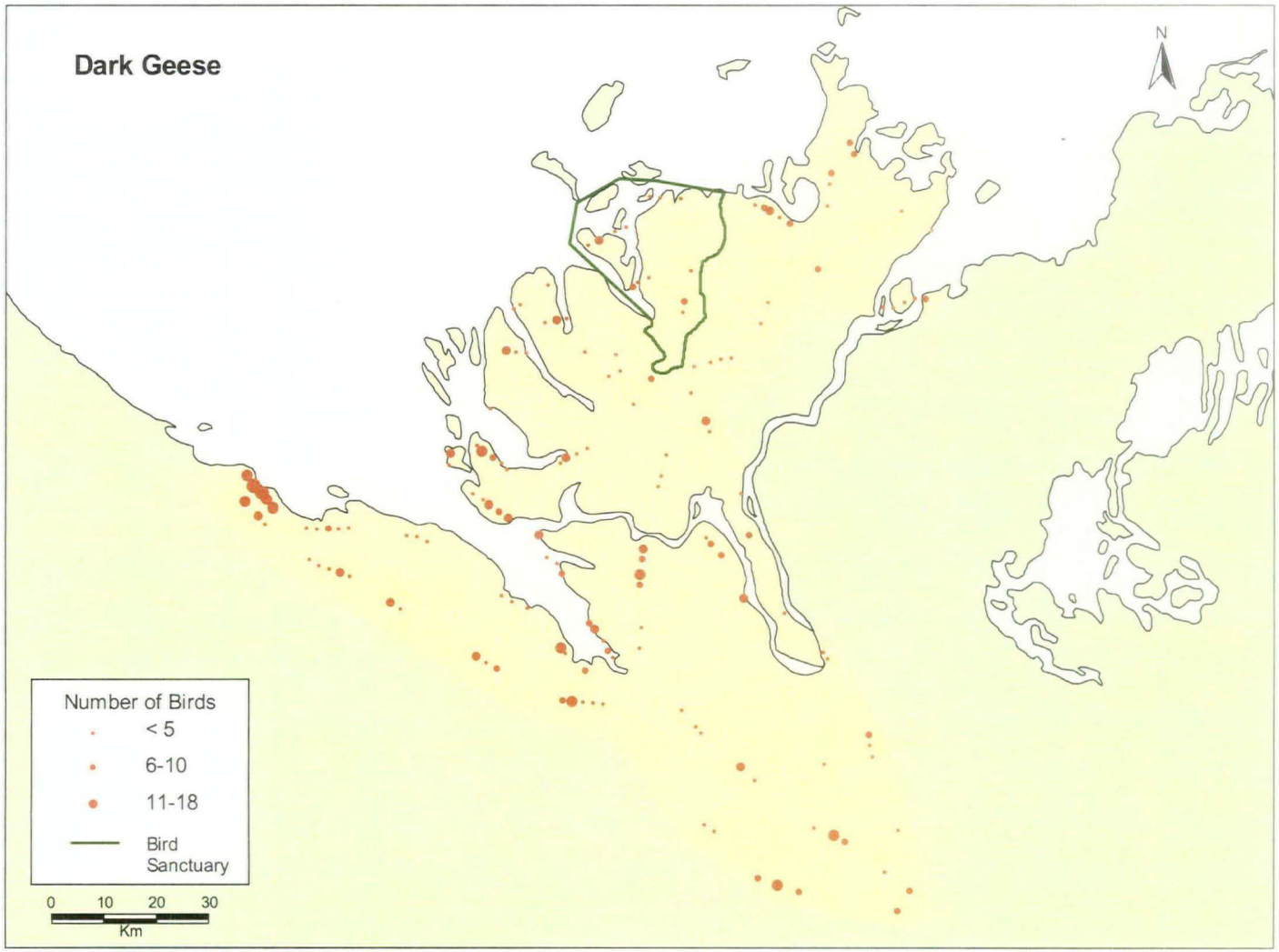

Figure 67. Mean numbers of "dark geese" observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

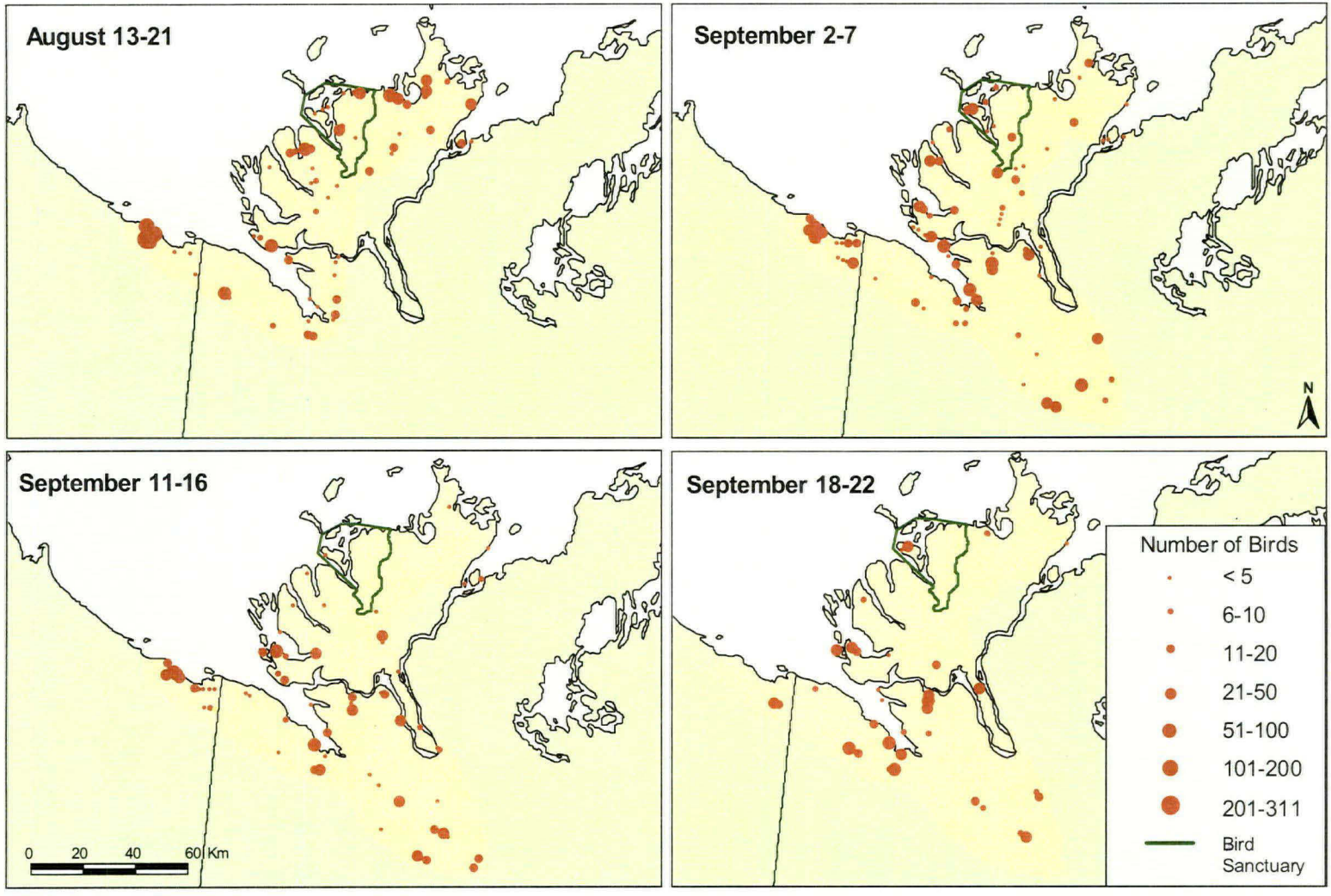

Figure 68. Mean annual numbers of "dark geese" observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

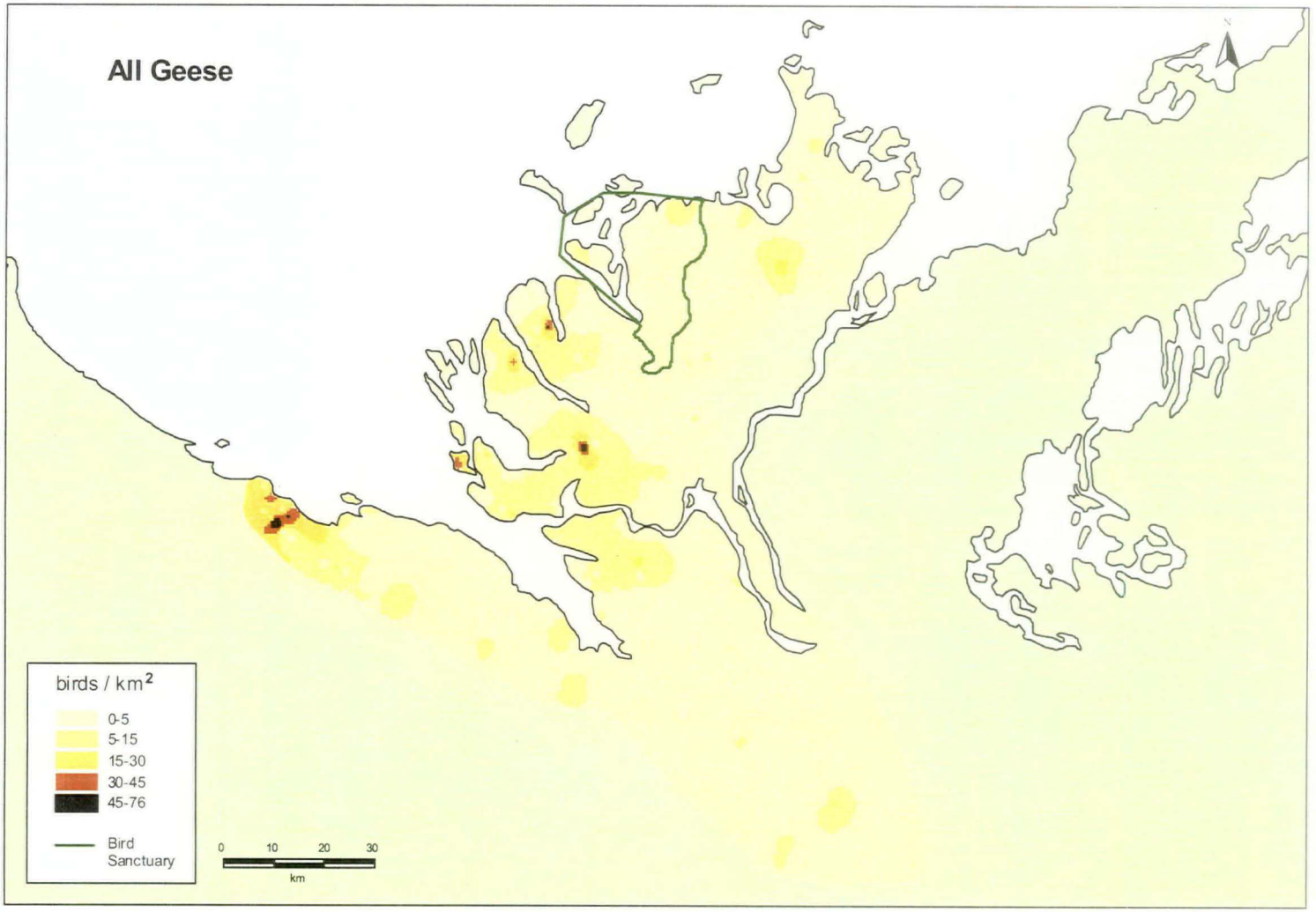

Figure 69. Fall distribution of all Geese on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

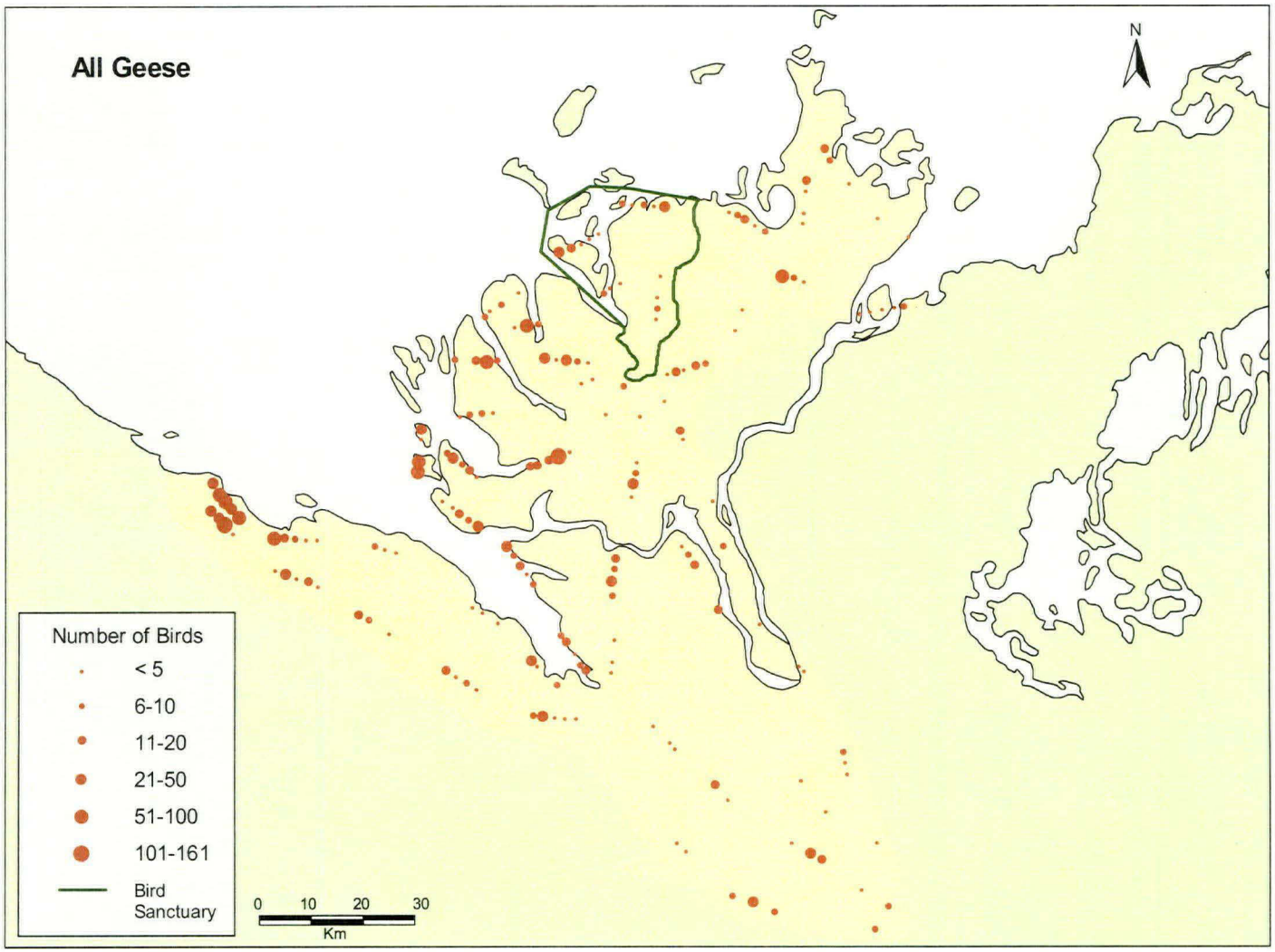

Figure 70. Mean numbers of geese of all species observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

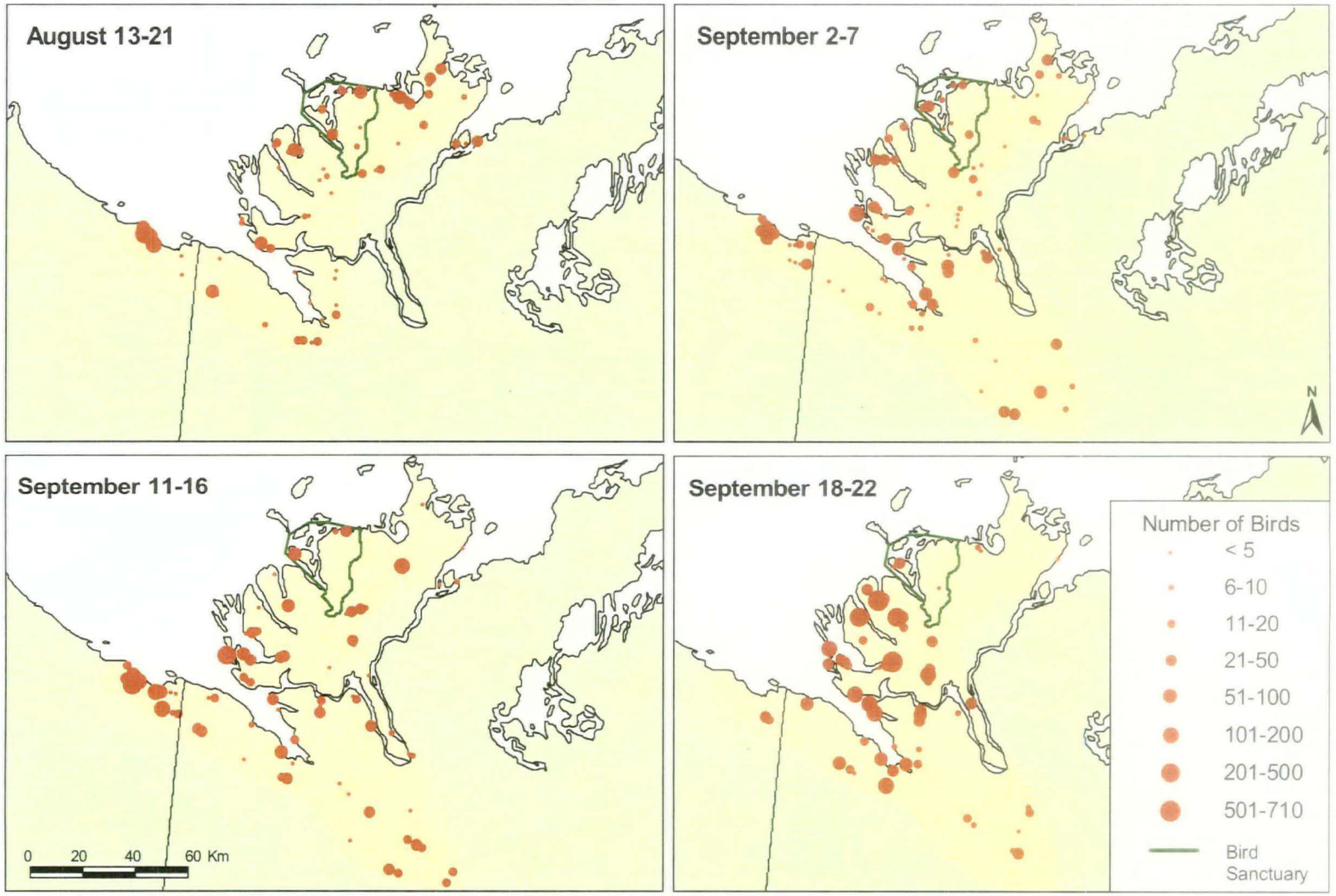

Figure 71. Mean annual numbers of geese of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

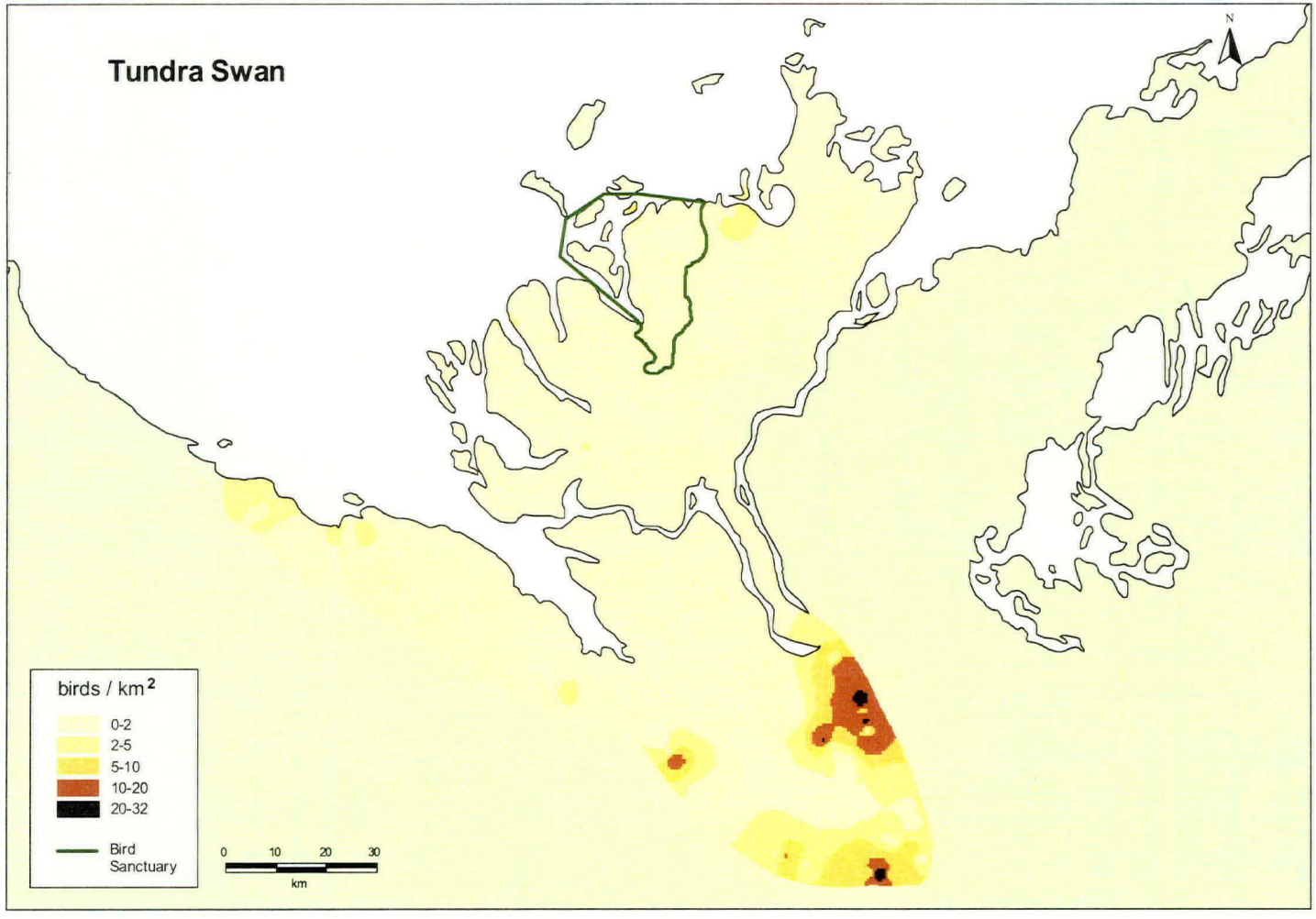

Figure 72. Fall distribution of Tundra Swans on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

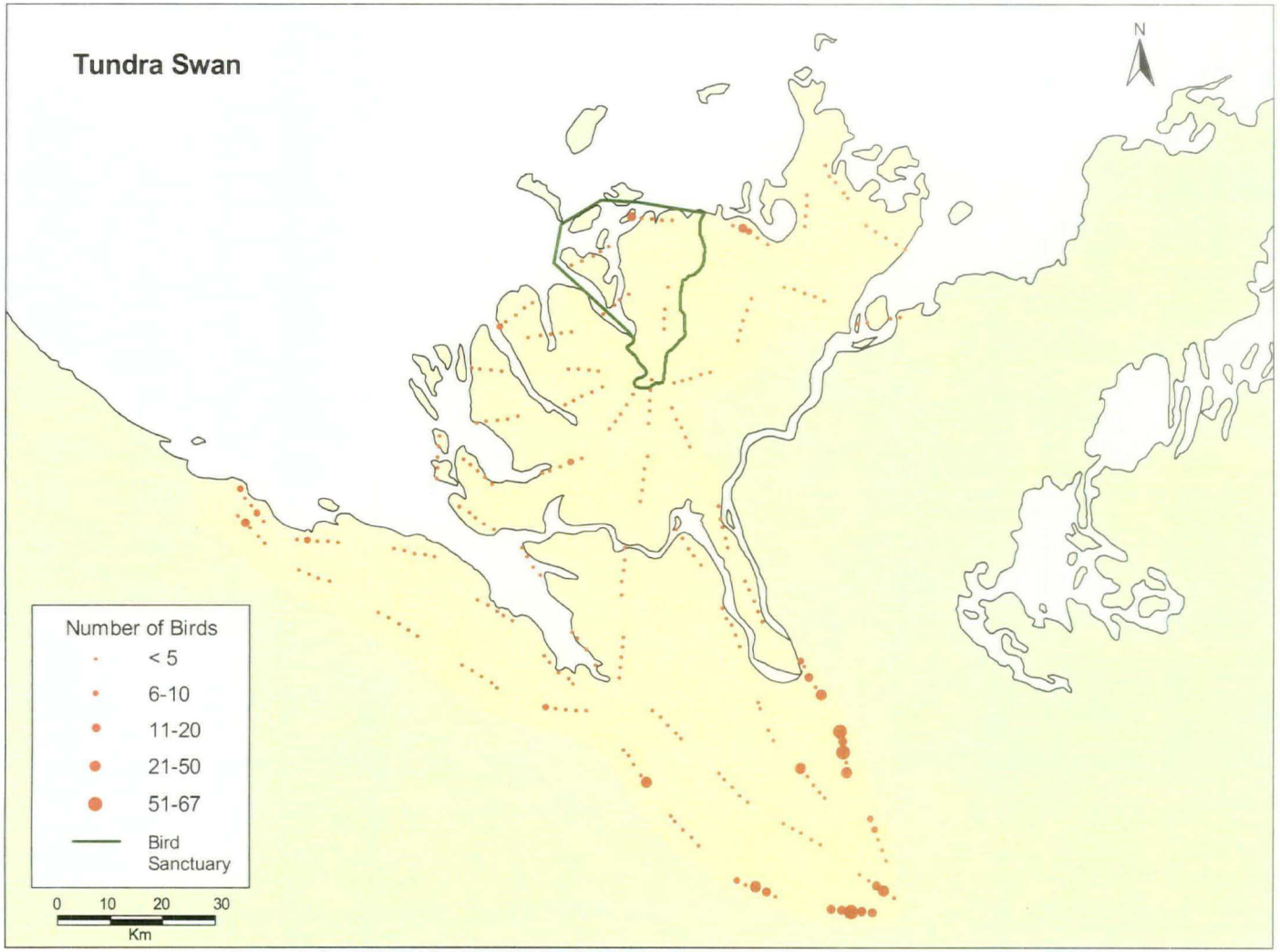

Figure 73. Mean numbers of Tundra Swans observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

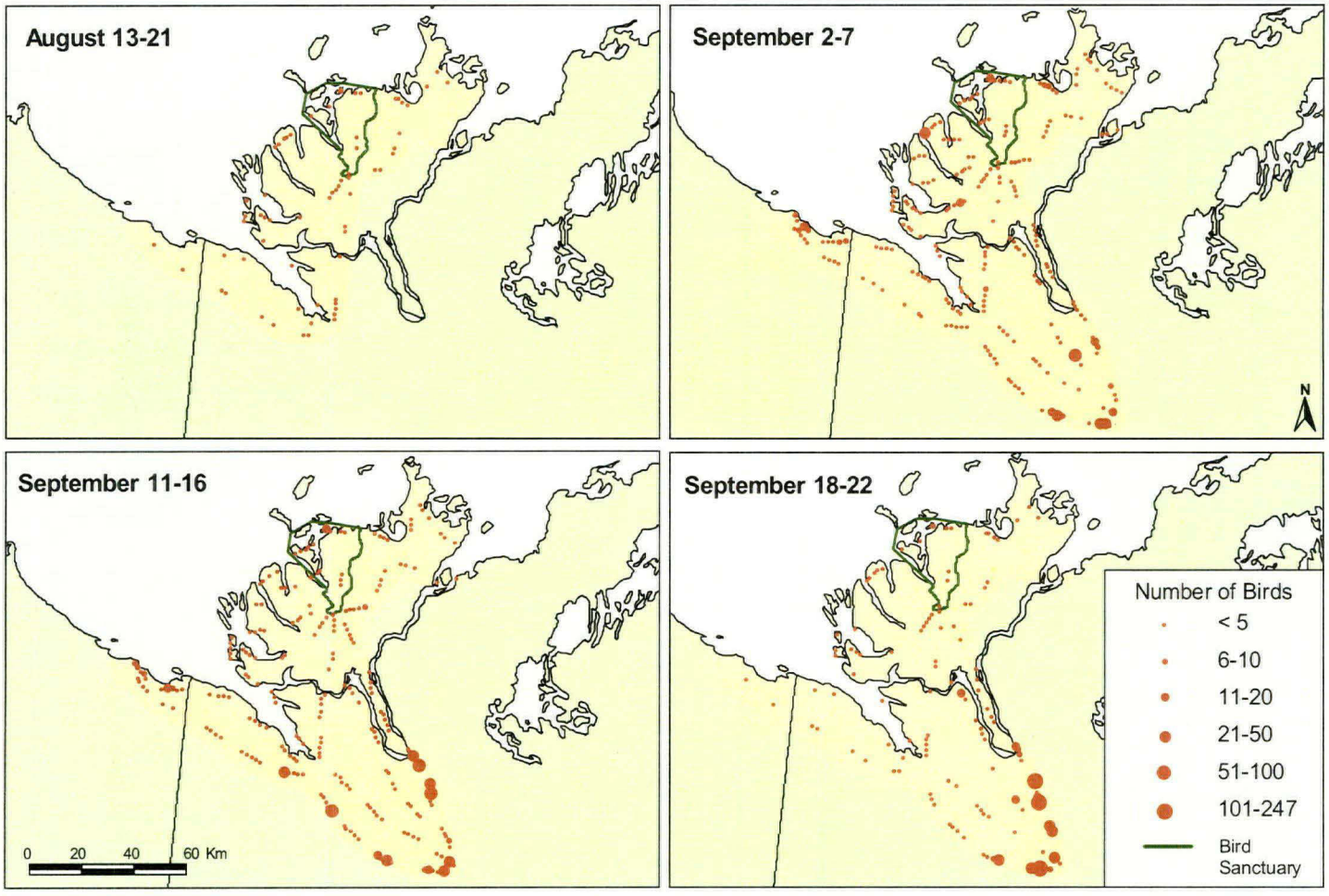

Figure 74. Mean annual numbers of Tundra Swans observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

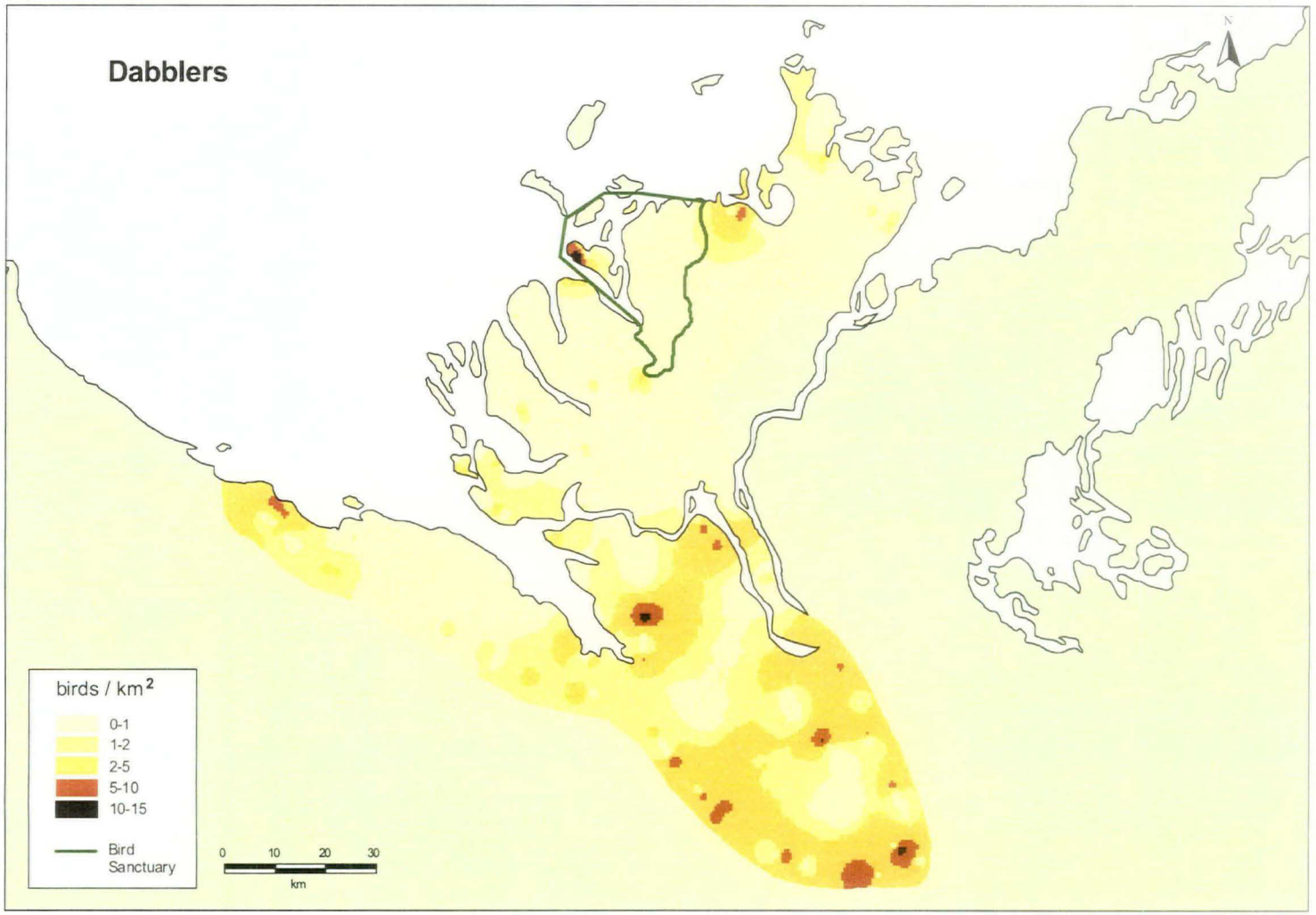

Figure 75. Fall distribution of "dabbling ducks" of all species on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

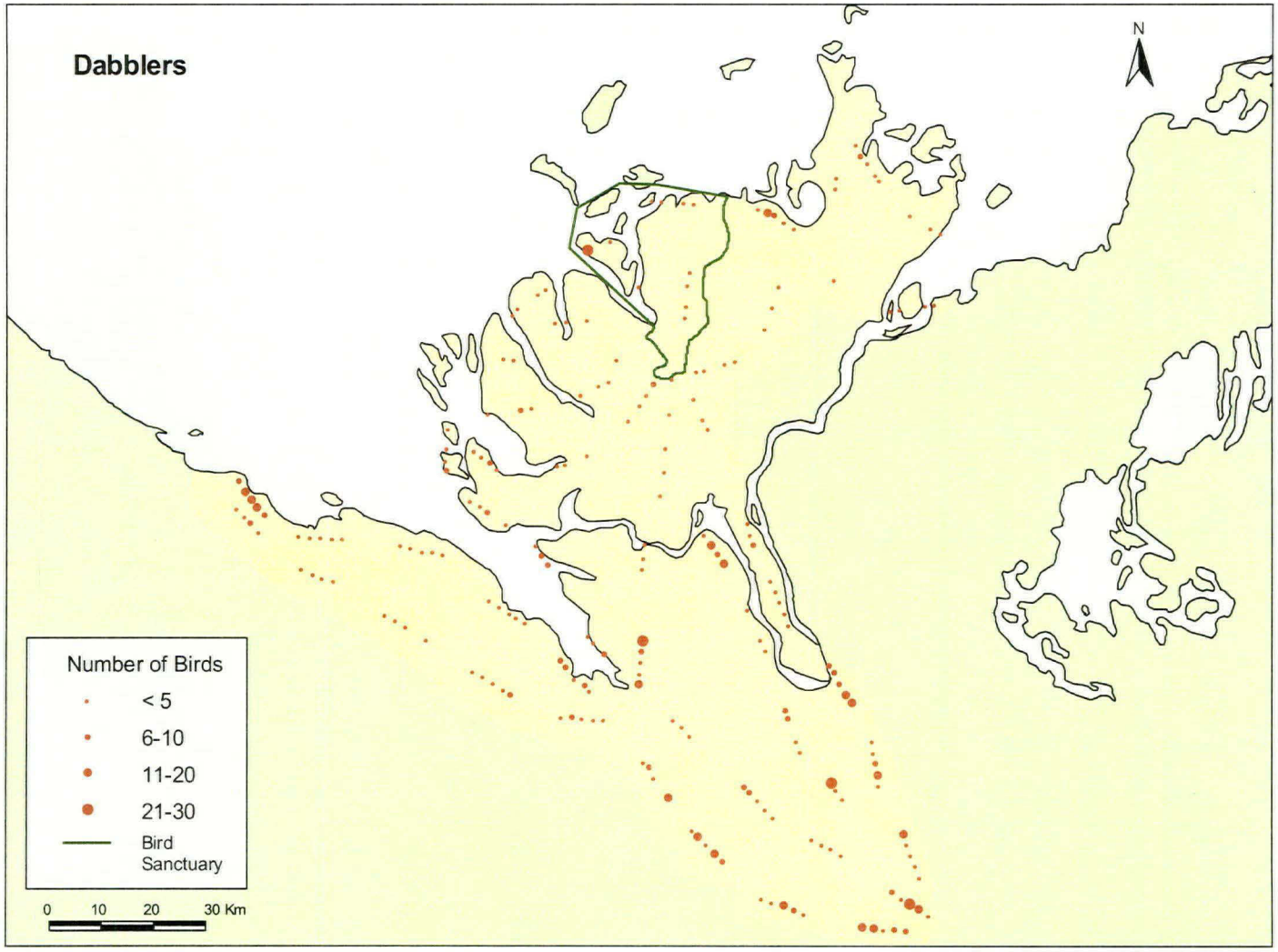

Figure 76. Mean numbers of "dabbling ducks" of all species observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

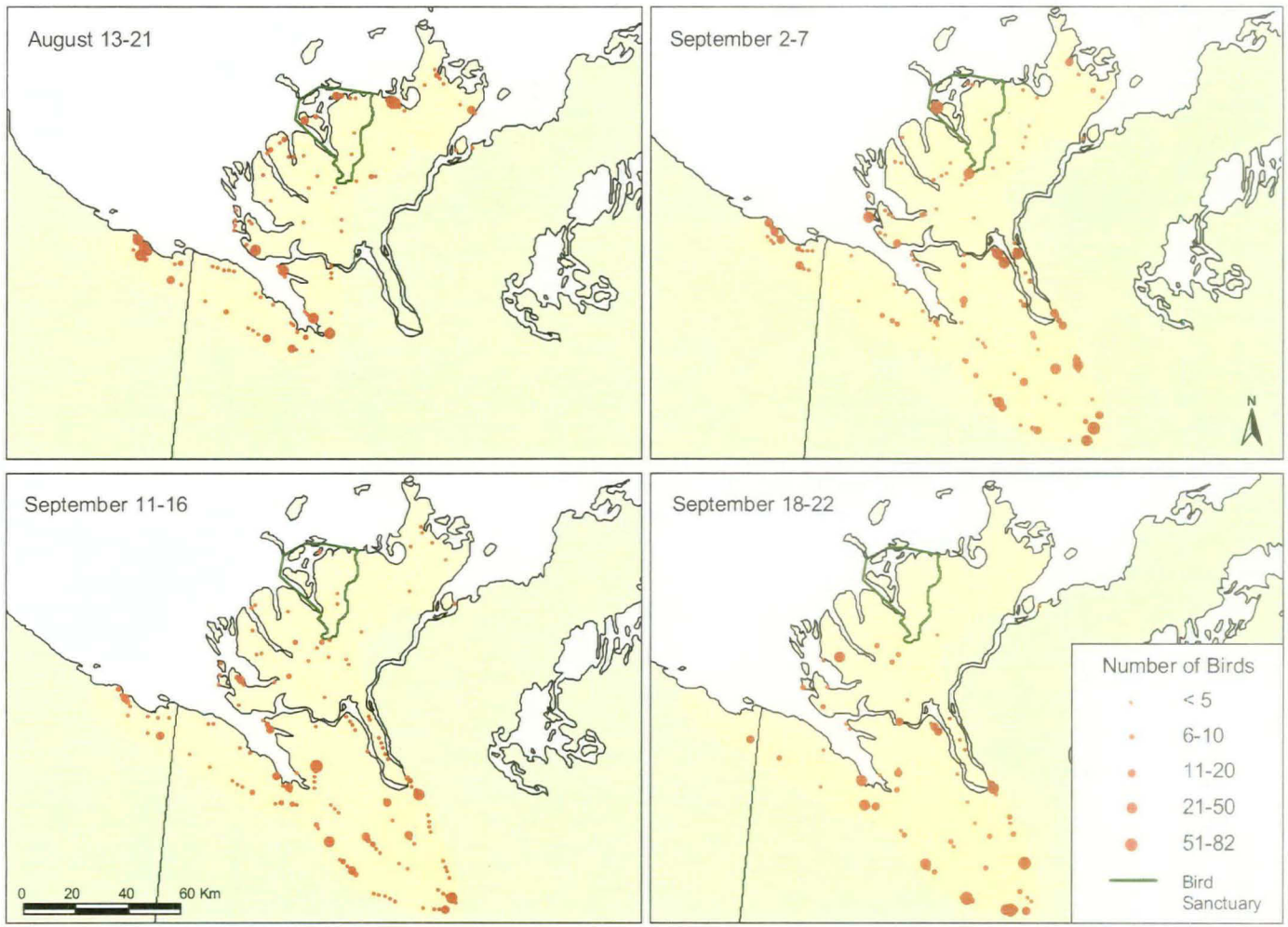

Figure 77. Mean annual numbers of "dabbling ducks" of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

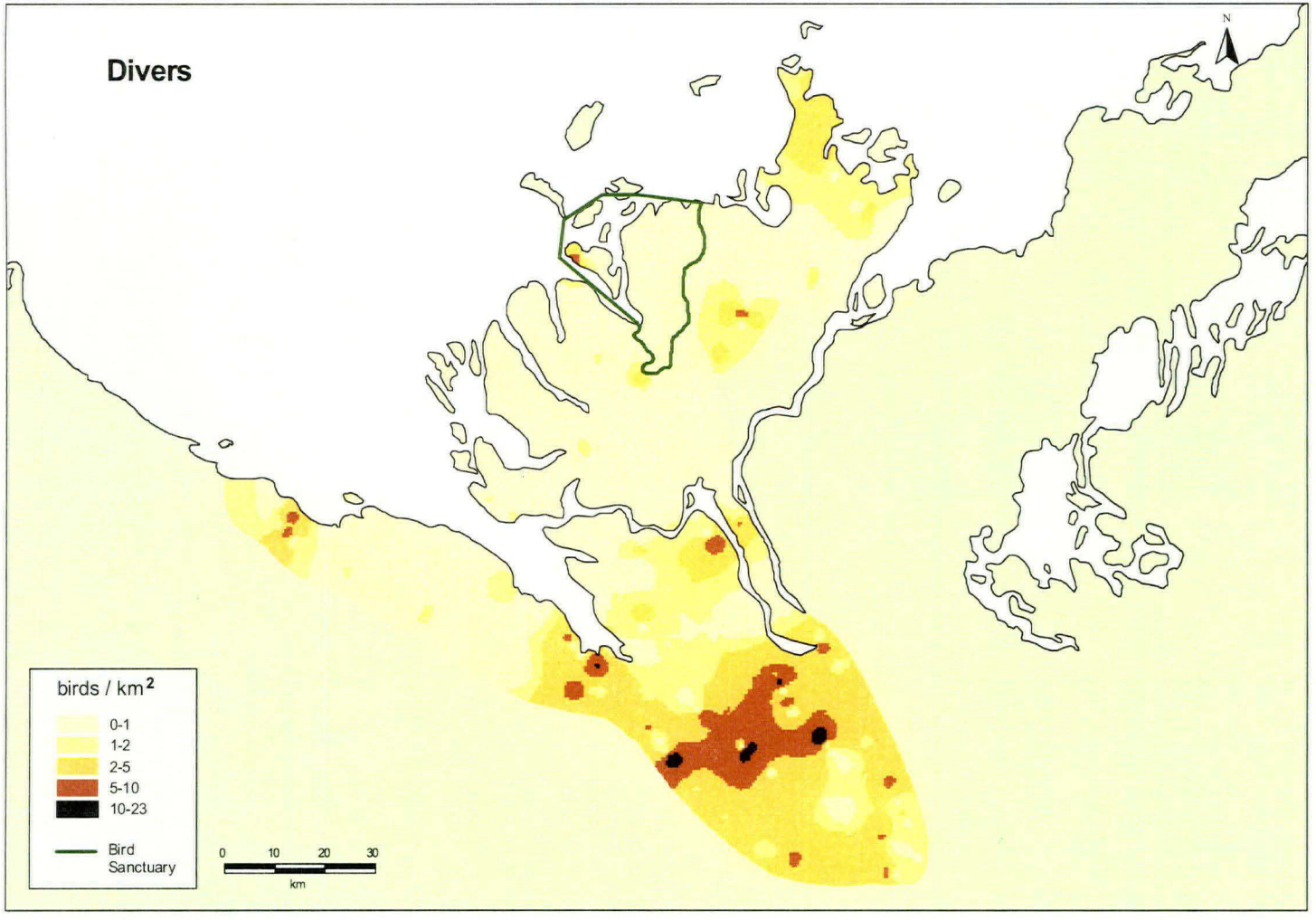

Figure 78. Fall distribution of "diving ducks" of all species on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

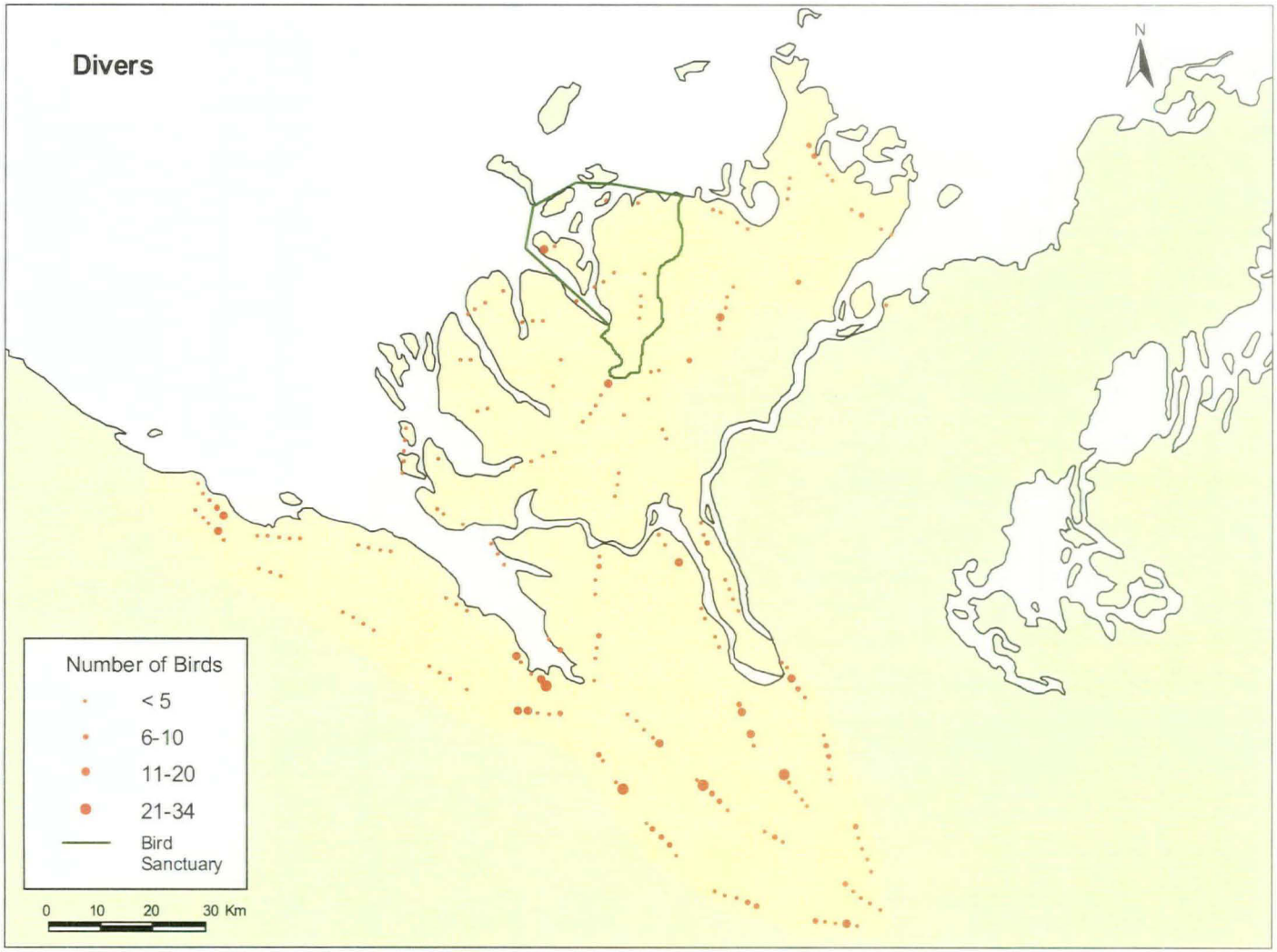

Figure 79. Mean numbers of "diving ducks" of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

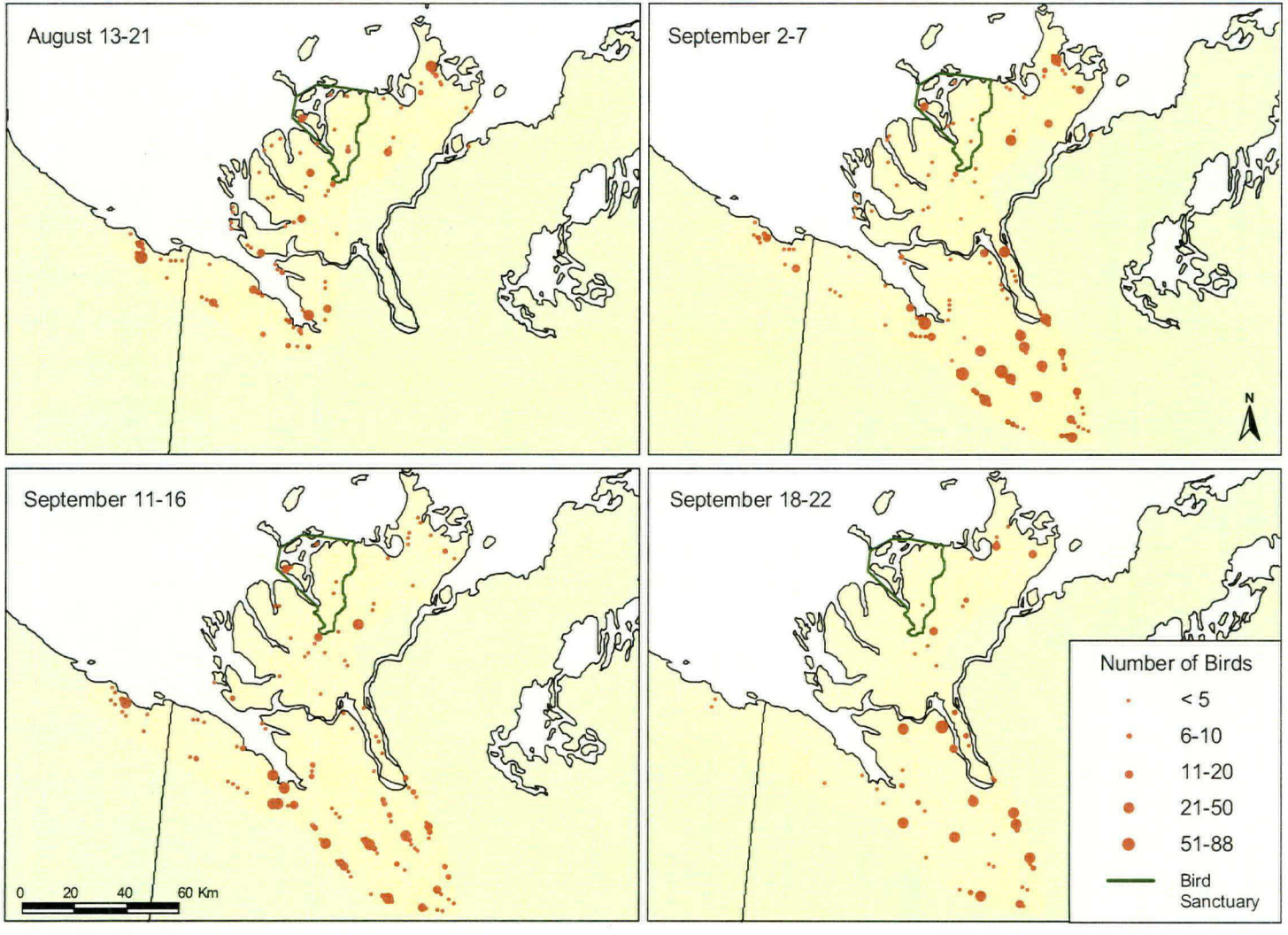

Figure 80. Mean annual numbers of "diving ducks" of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

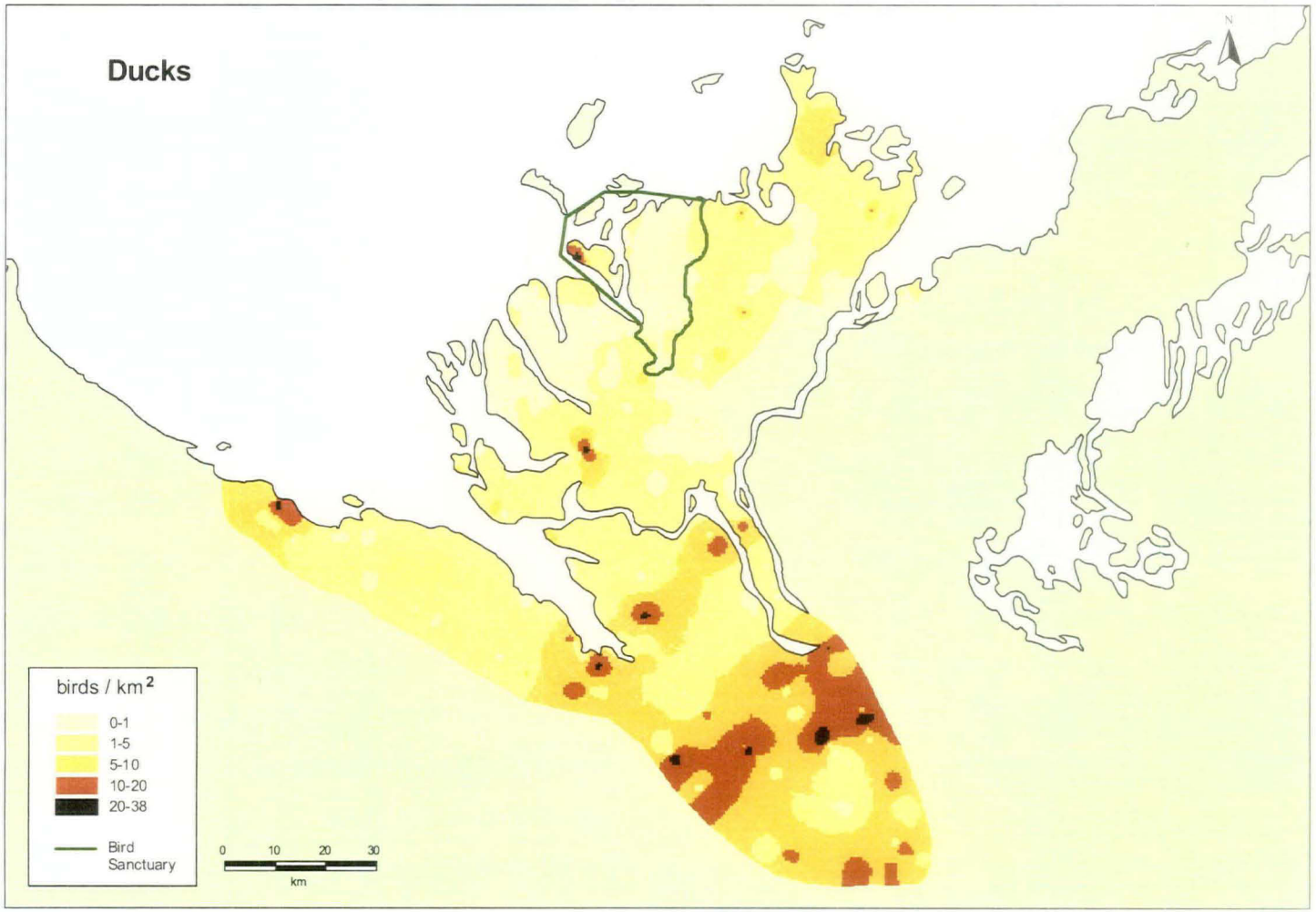

Figure 81. Fall distribution of ducks of all species on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in 1990-1993. Population densities are averages for the period and are not corrected for visibility bias.

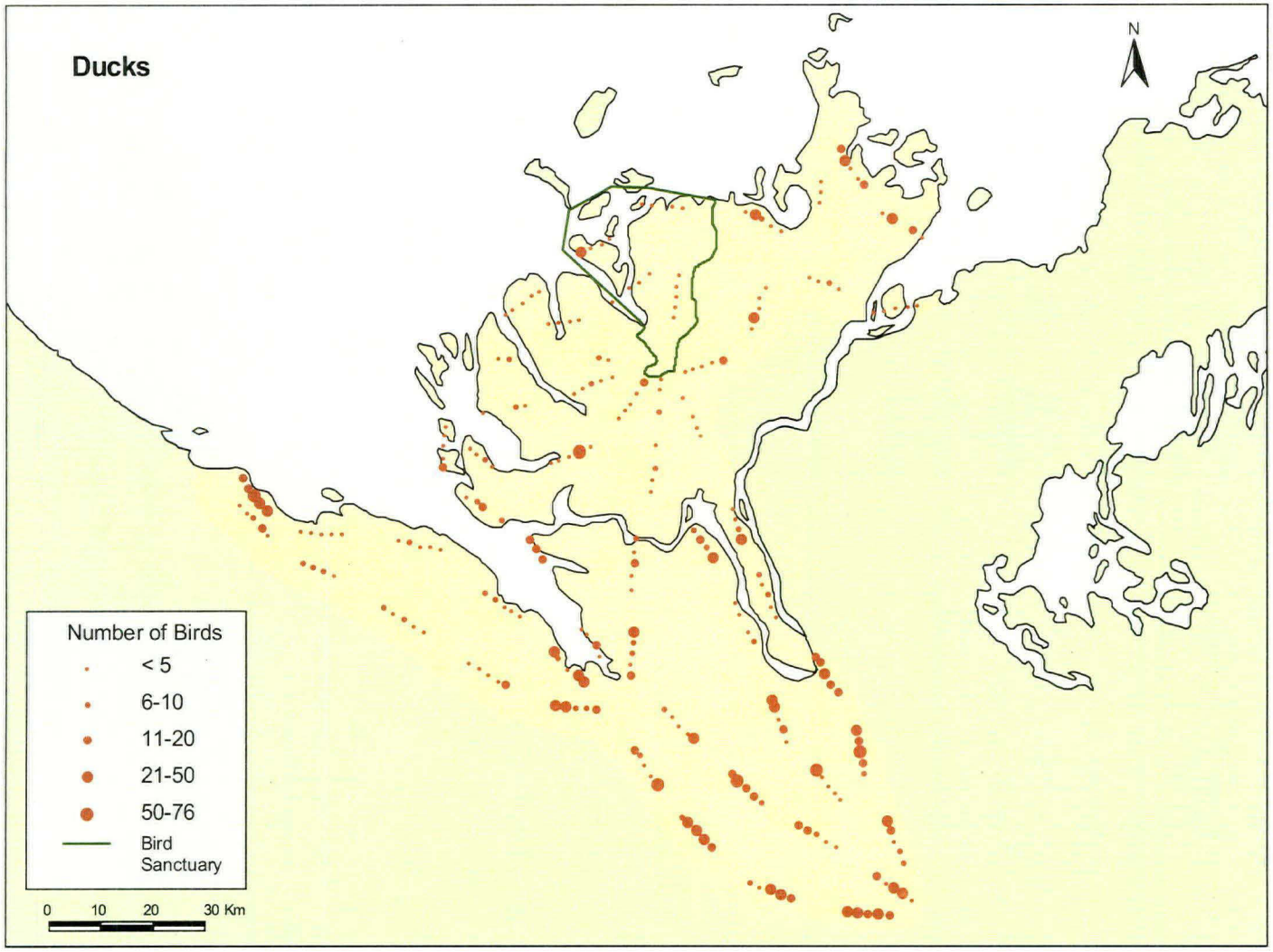

Figure 82. Mean numbers of ducks of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

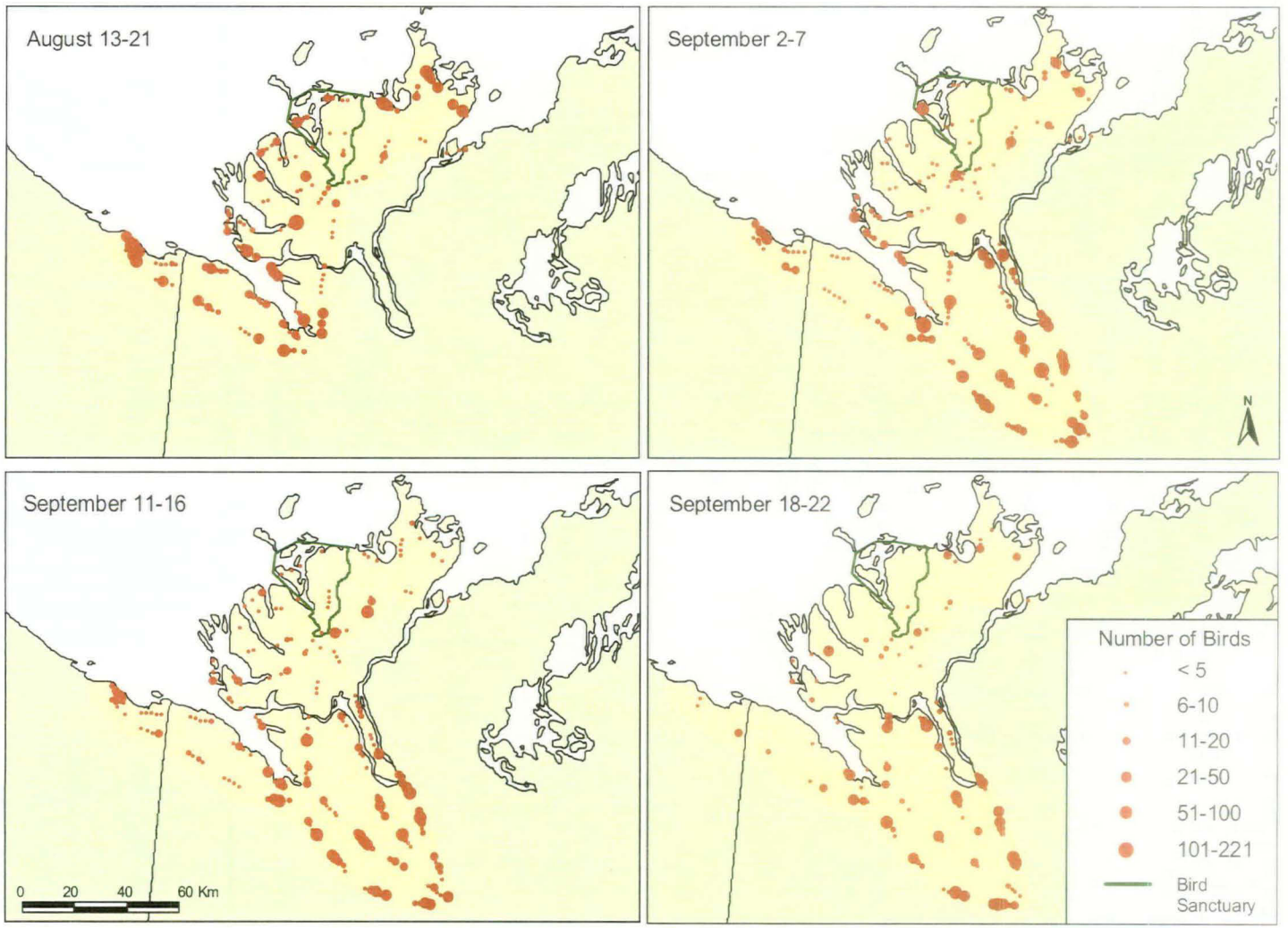

Figure 83. Mean annual numbers of ducks of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

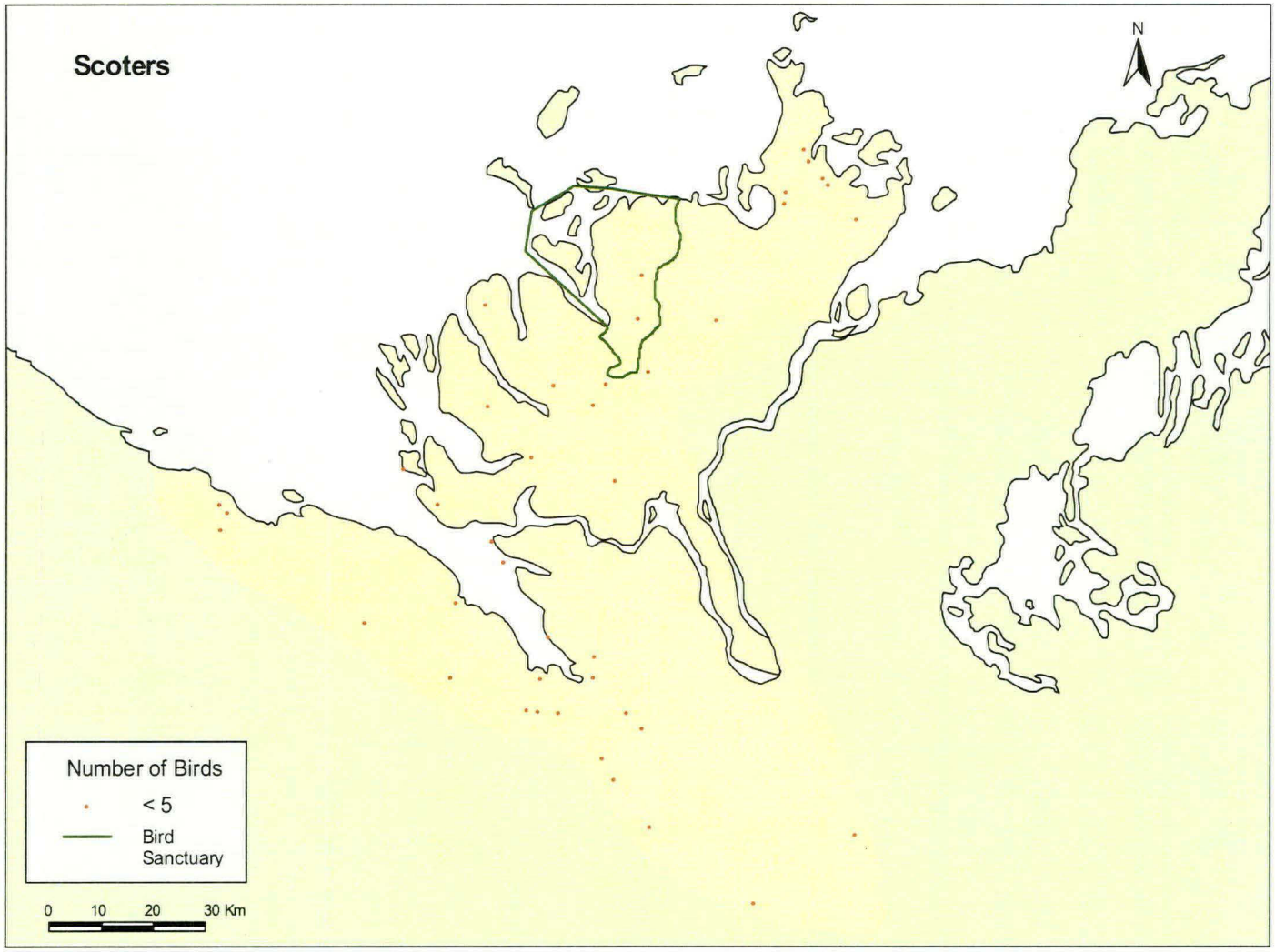

Figure 84. Mean numbers of scoters observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

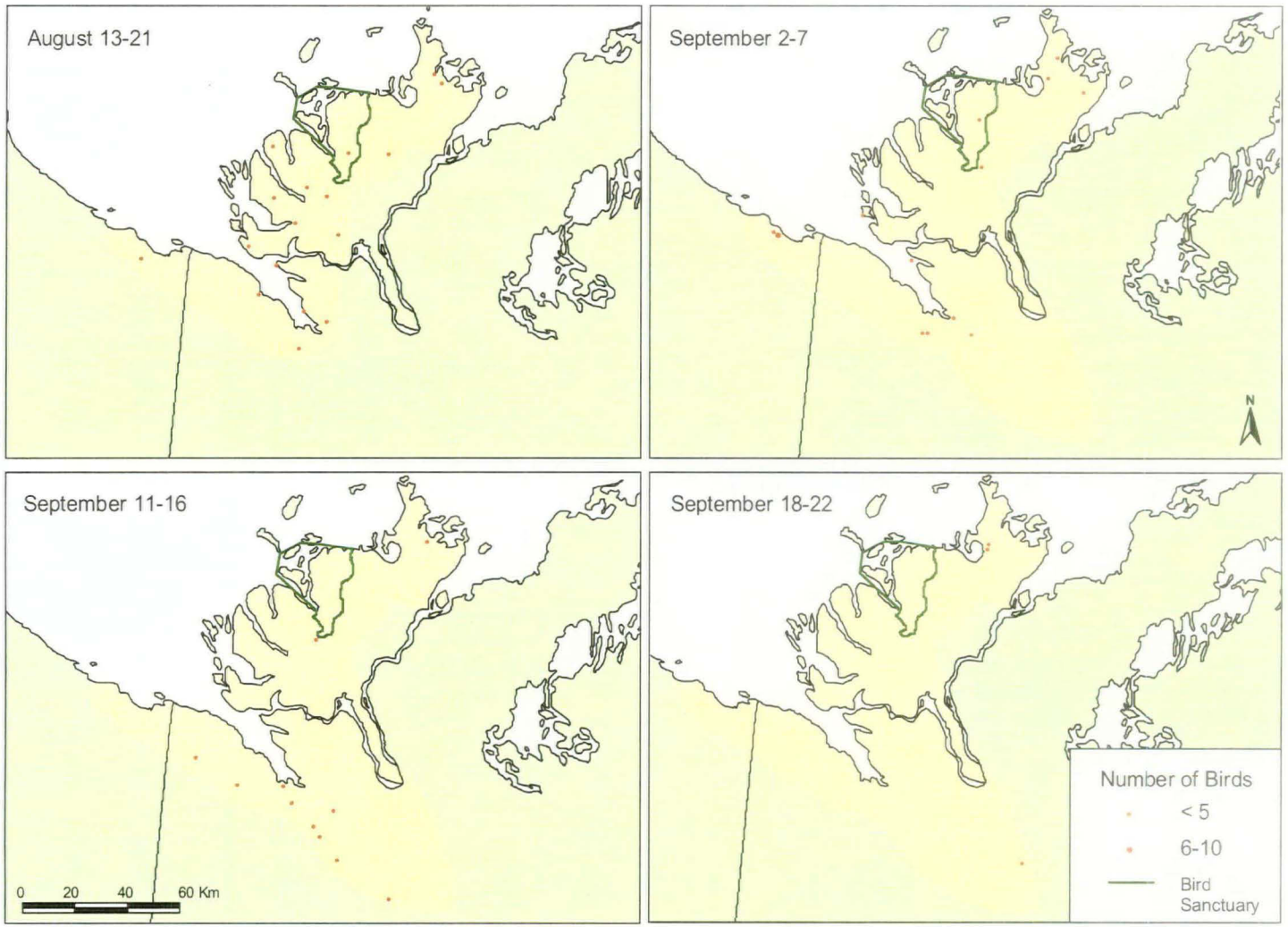

Figure 85. Mean annual numbers of scoters observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

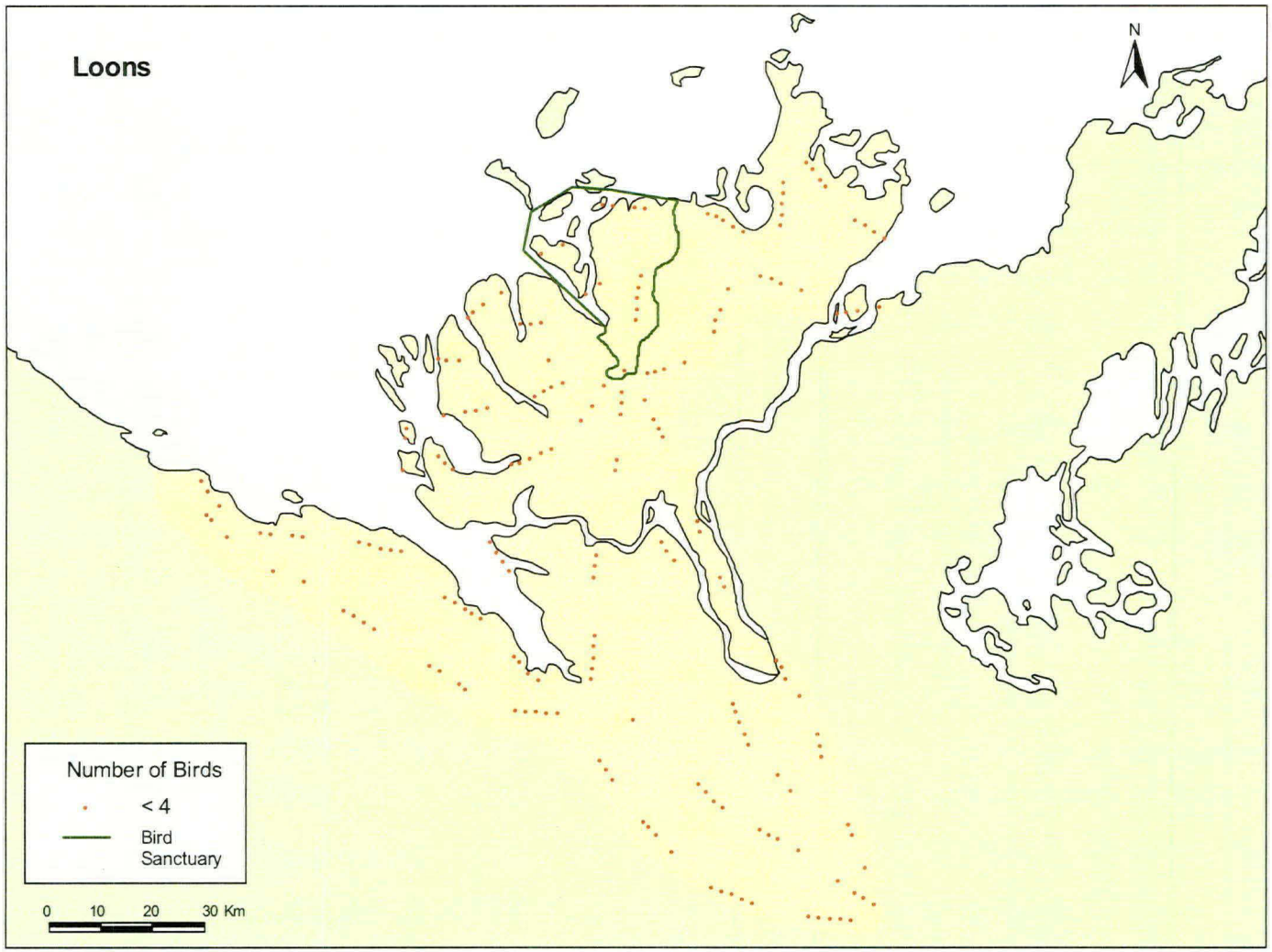

Figure 86. Mean numbers of loons of all species observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

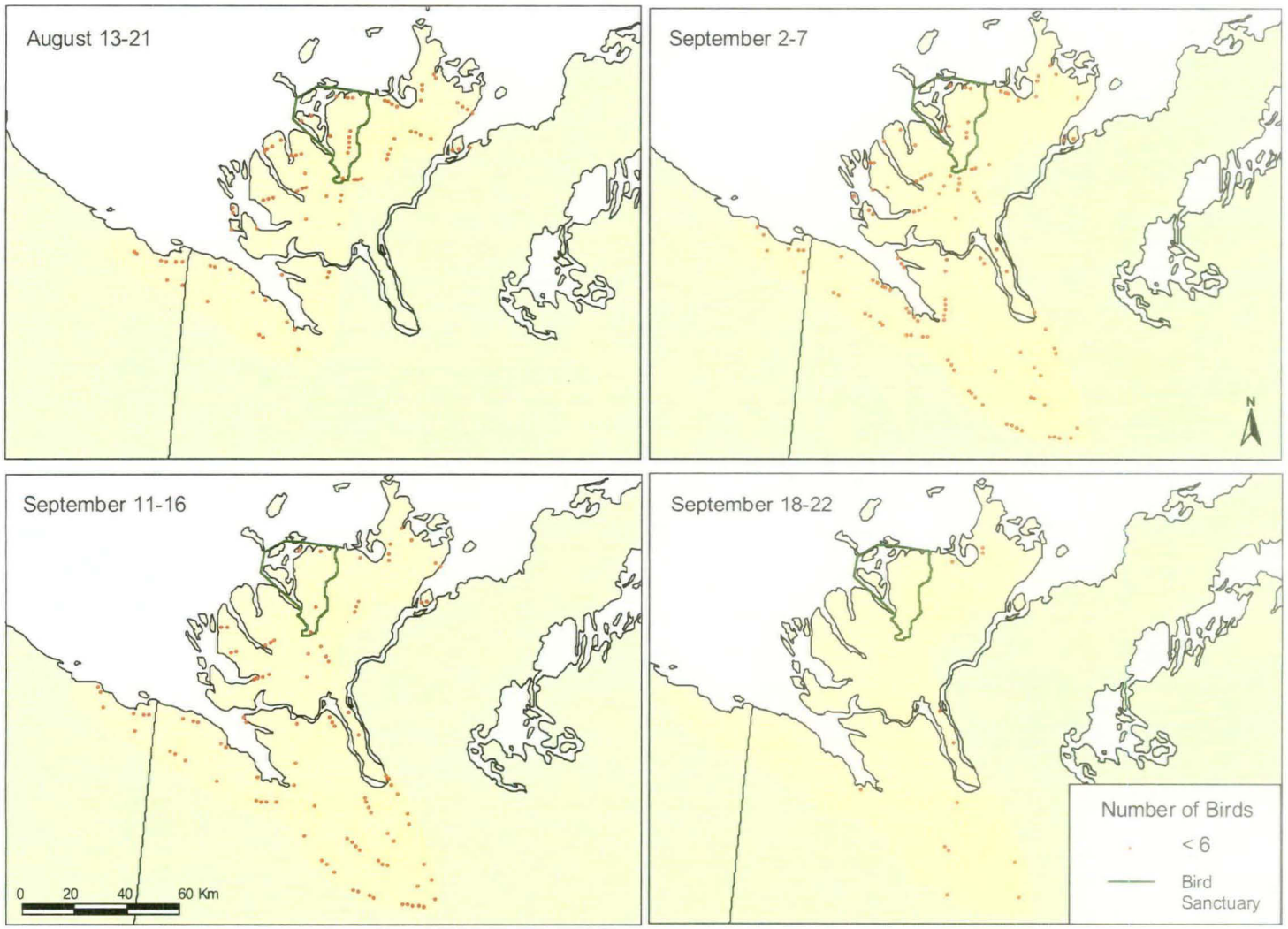

Figure 87. Mean annual numbers of loons of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

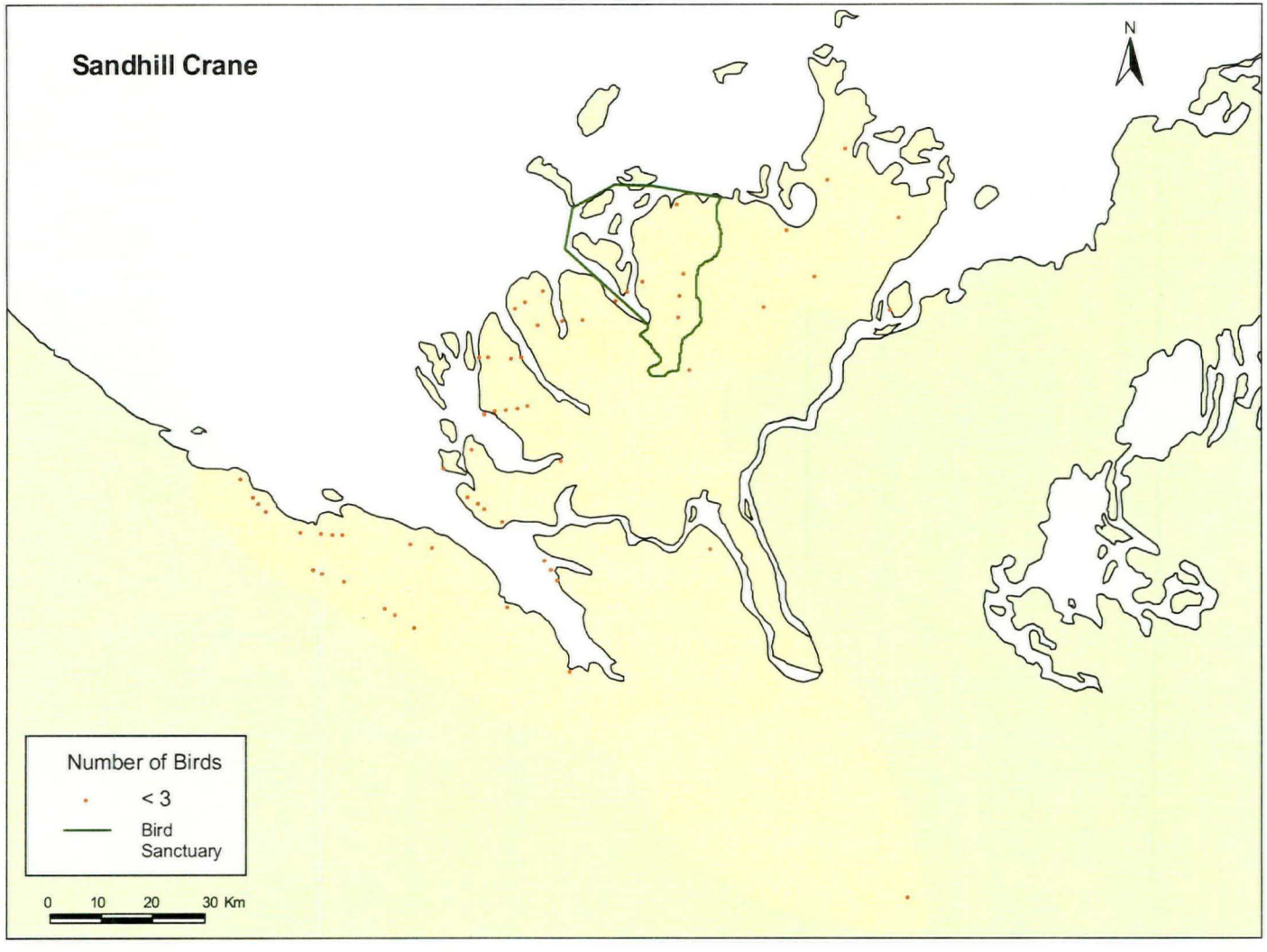

Figure 88. Mean numbers of Sandhill Cranes observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

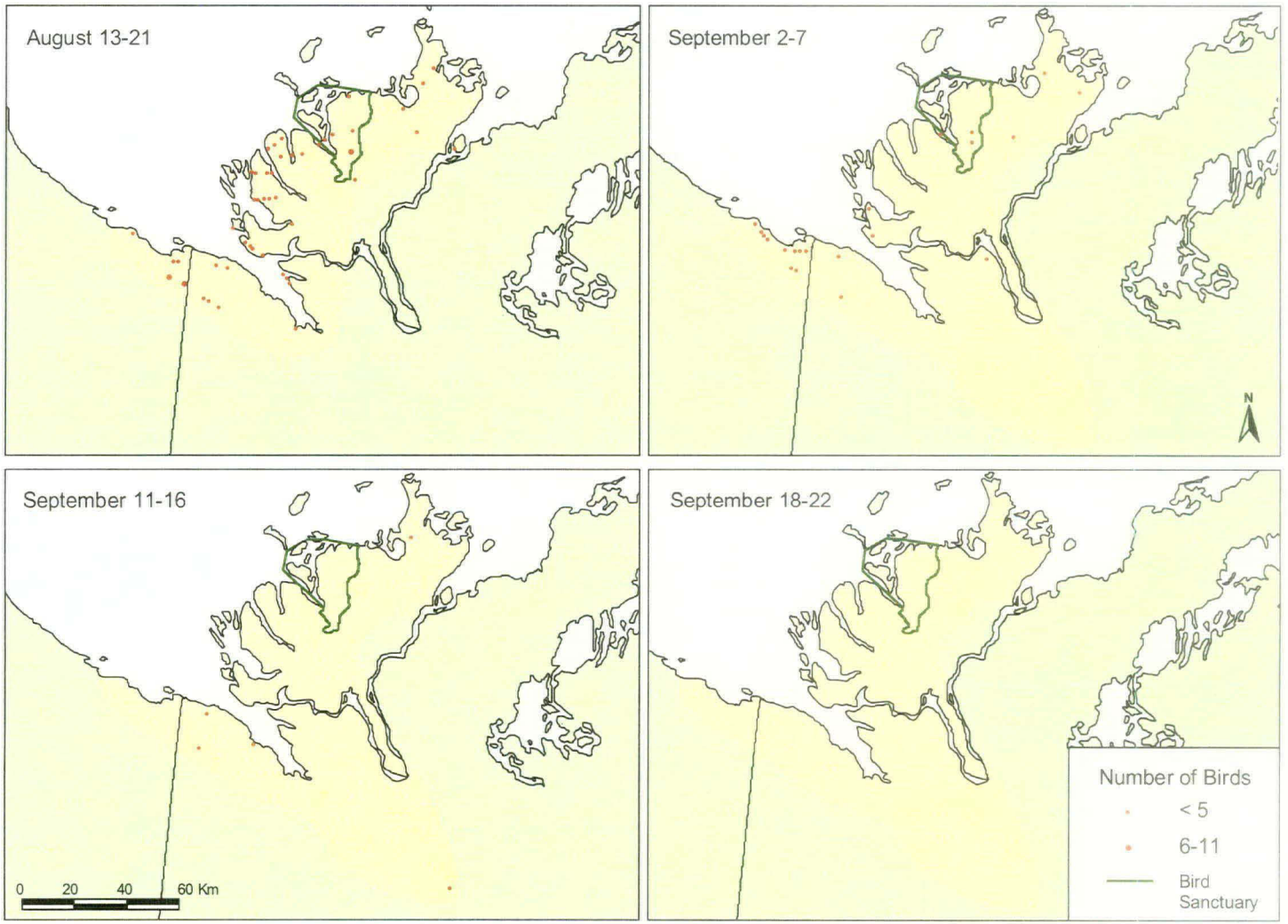

Figure 89. Mean annual numbers of Sandhill Cranes observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

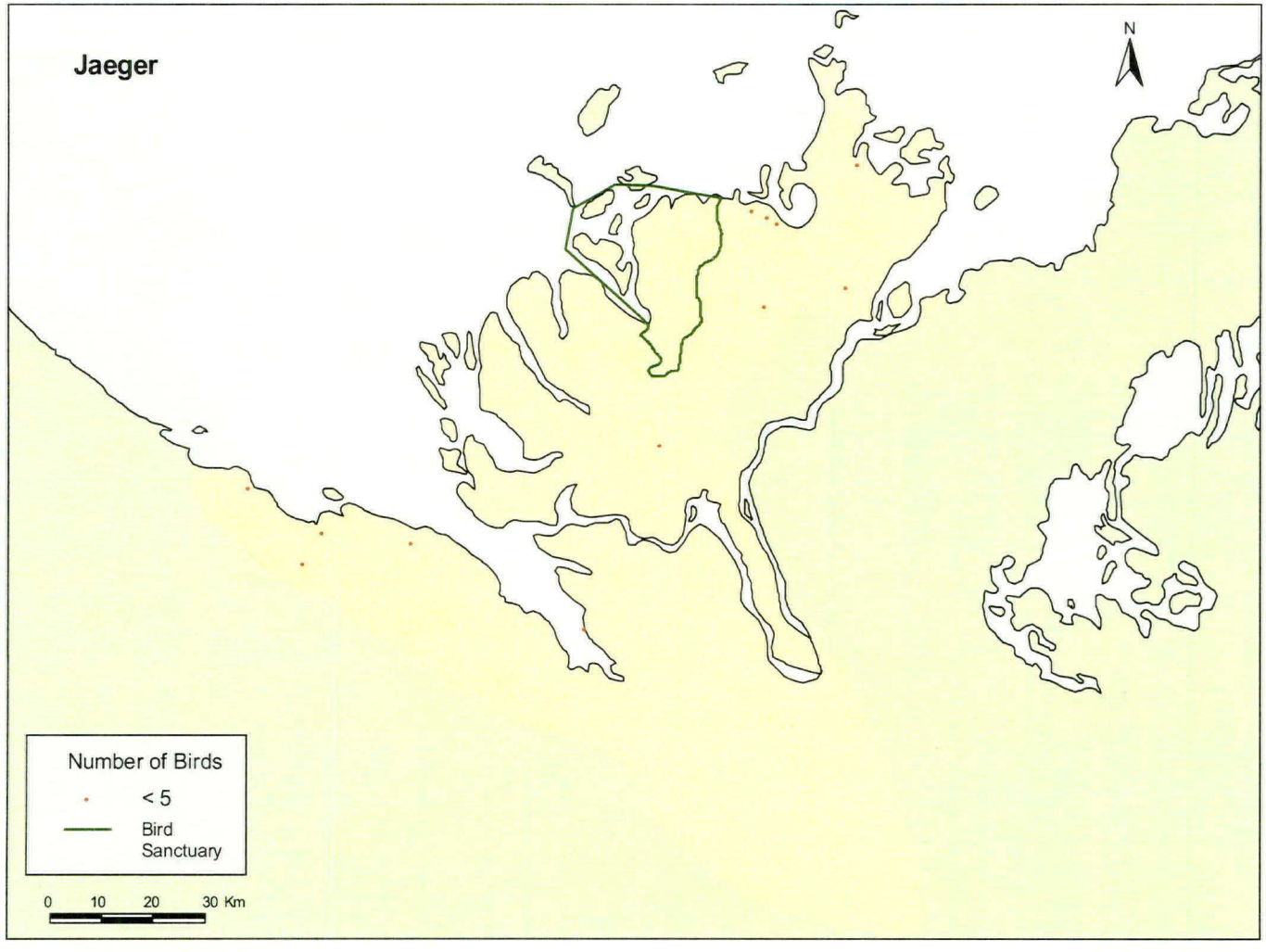

Figure 90. Mean numbers of jaegers of all species observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

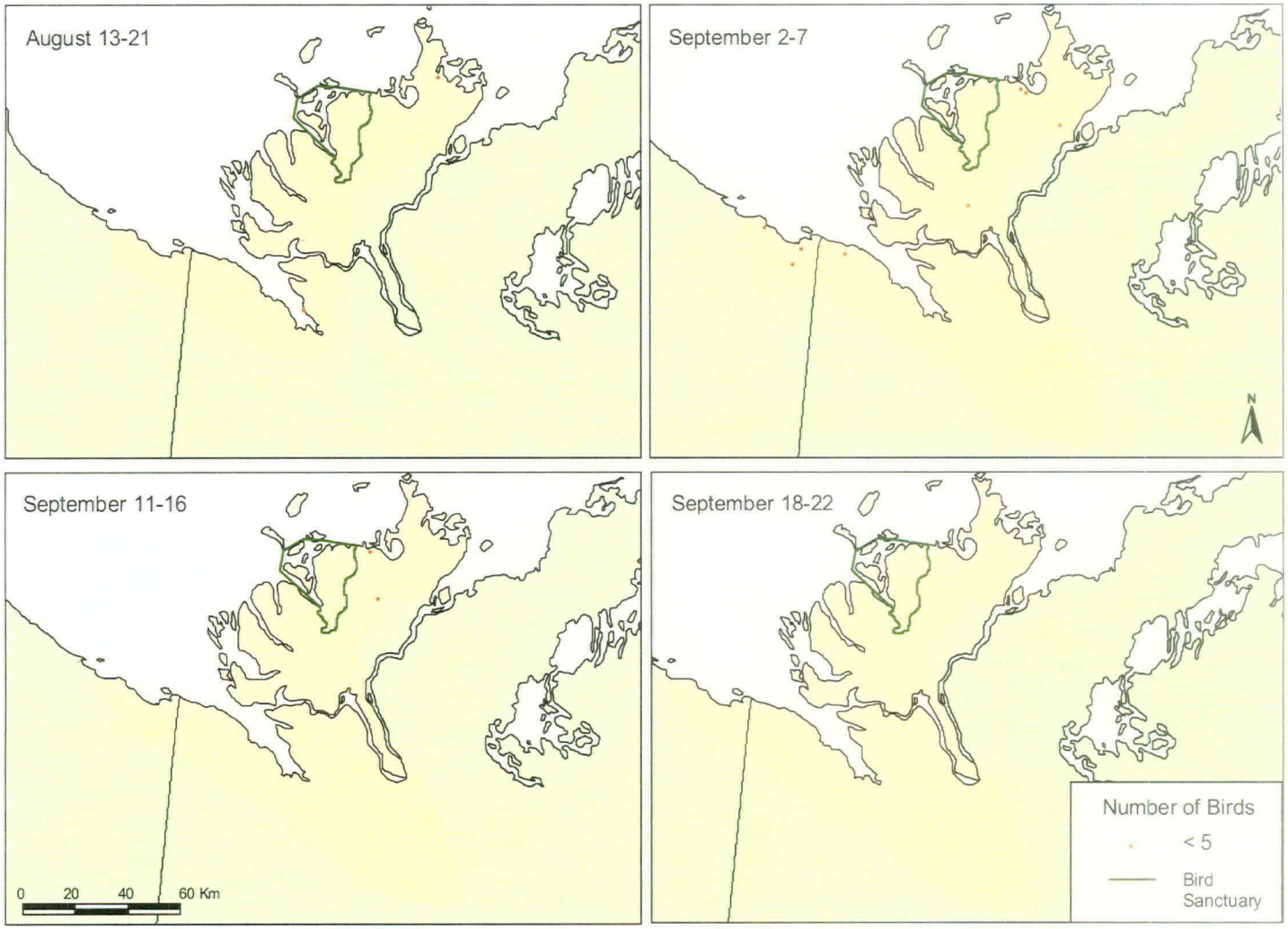

Figure 91. Mean annual numbers of jaegers of all species observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

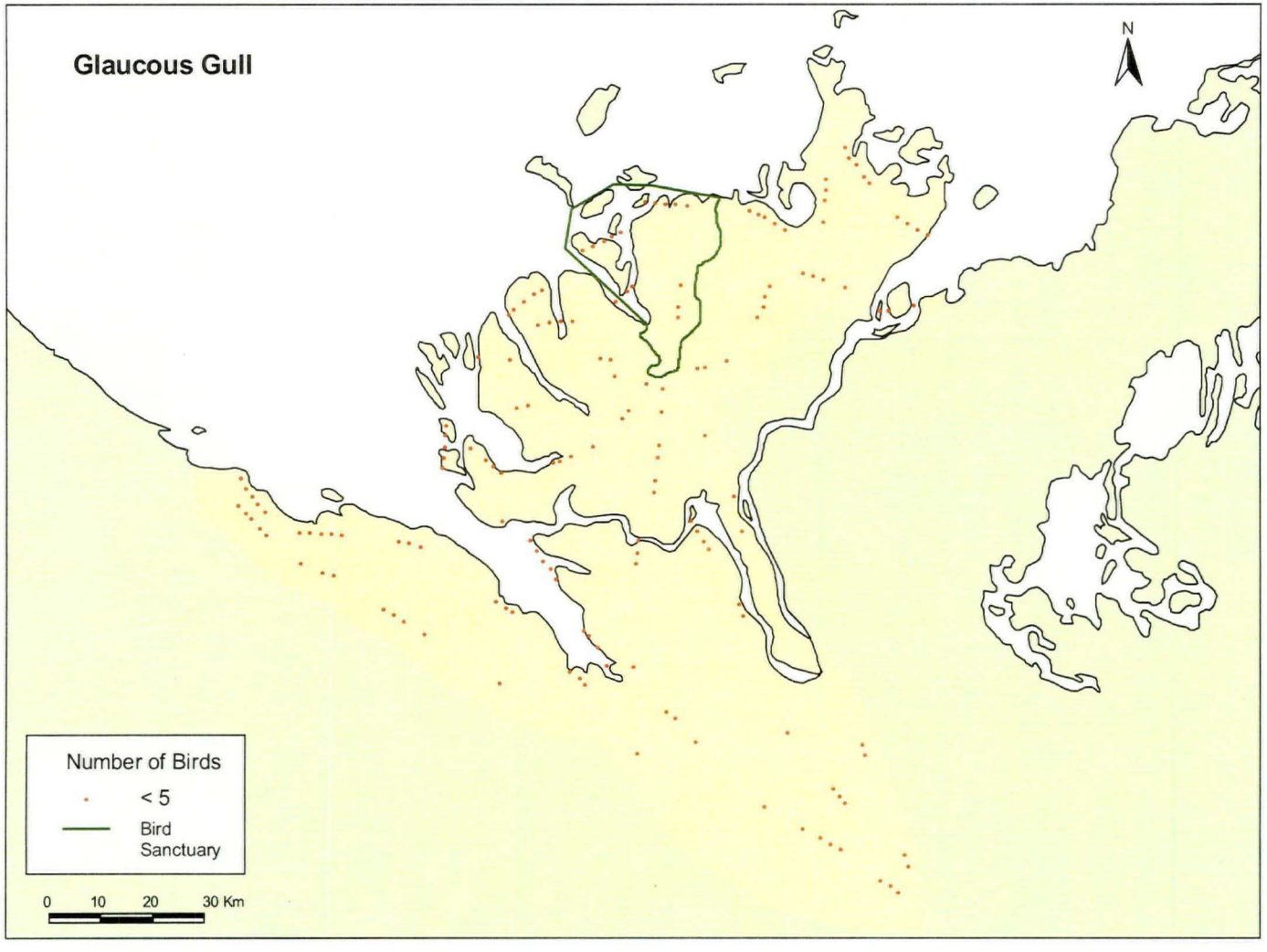

Figure 92. Mean numbers of Glaucous Gulls observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

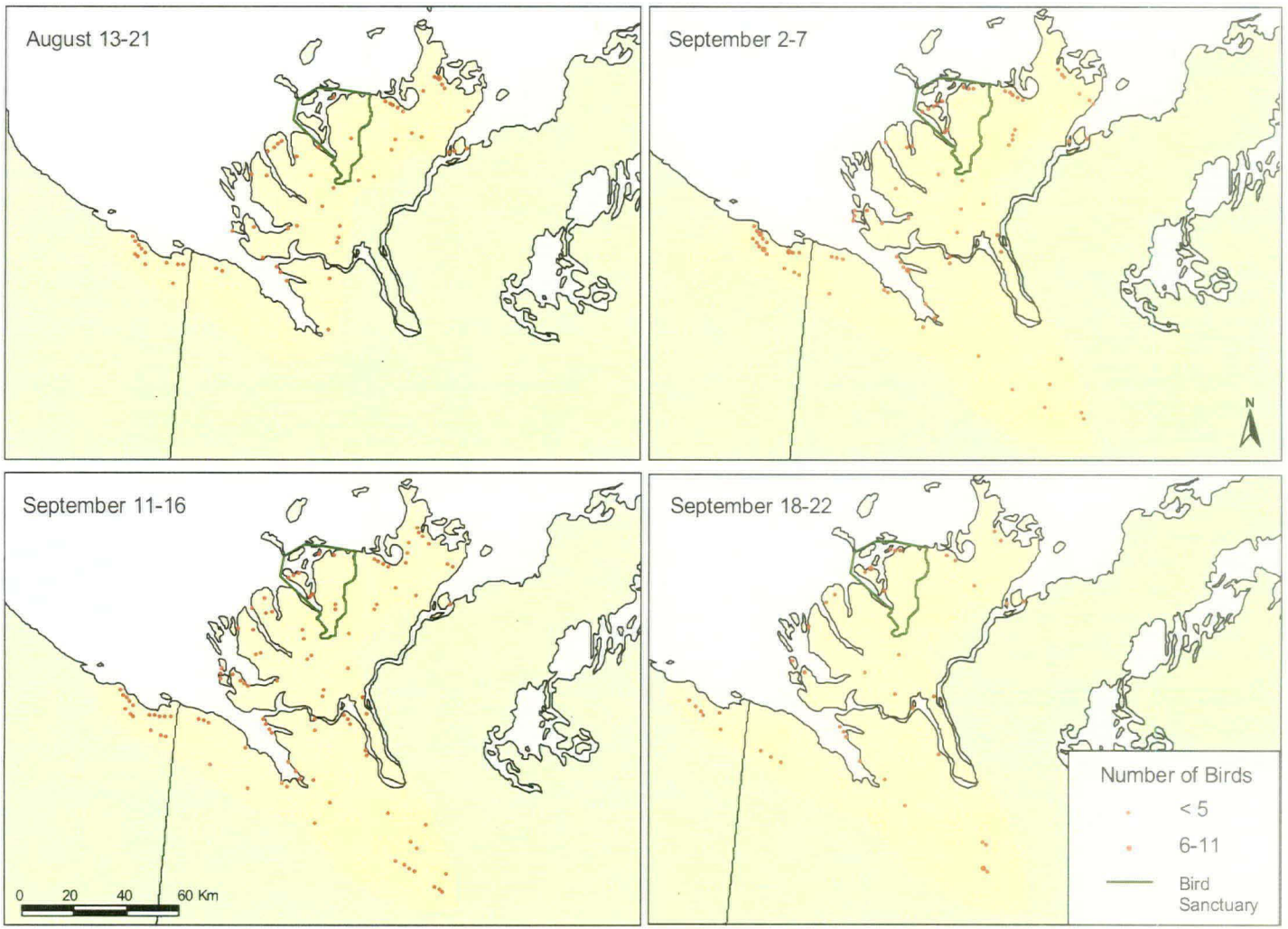

Figure 93. Mean annual numbers of Glaucous Gulls observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.

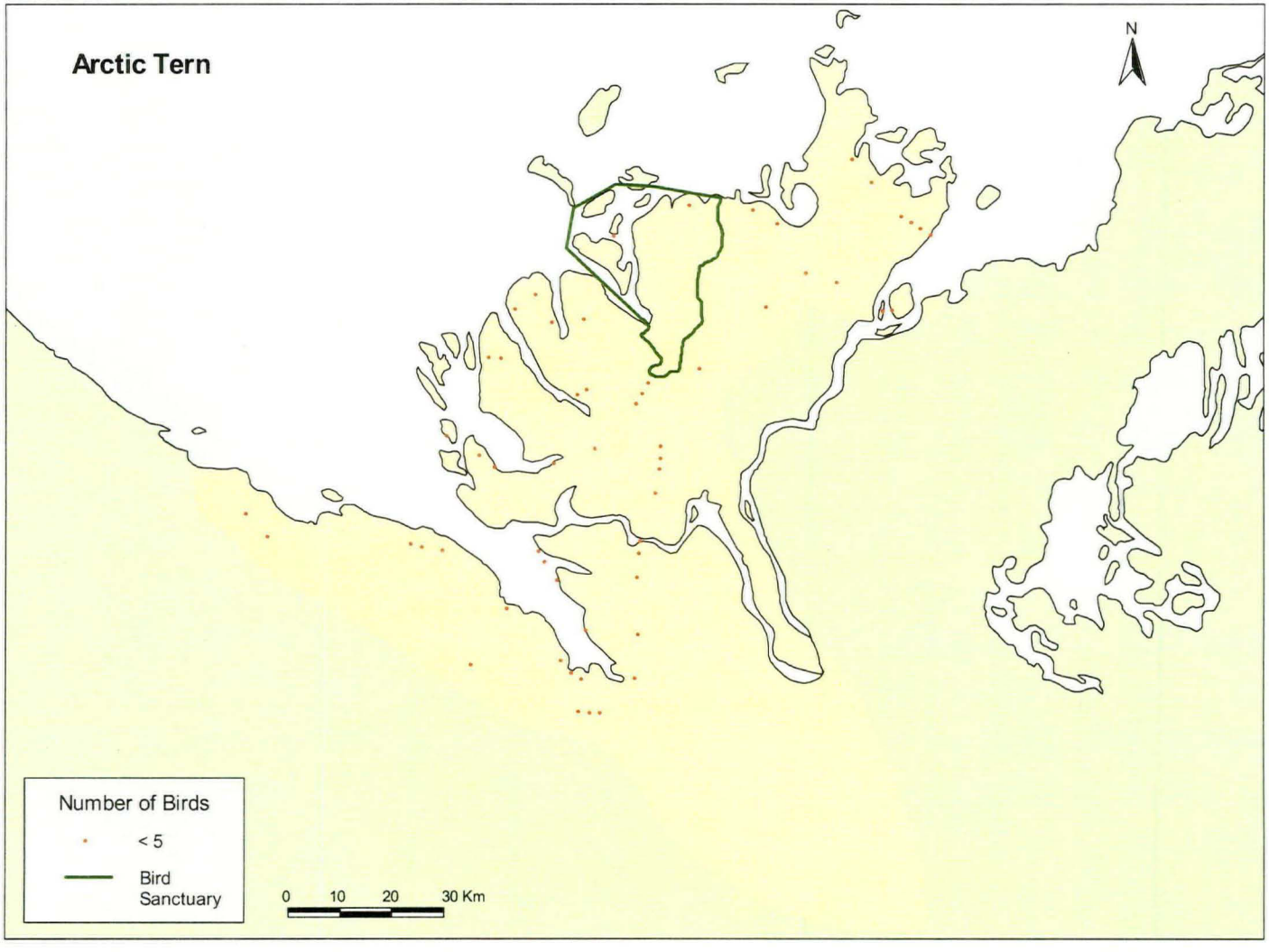

Figure 94. Mean numbers of Arctic Terns observed per transect segment on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) in August and September, 1990-1993.

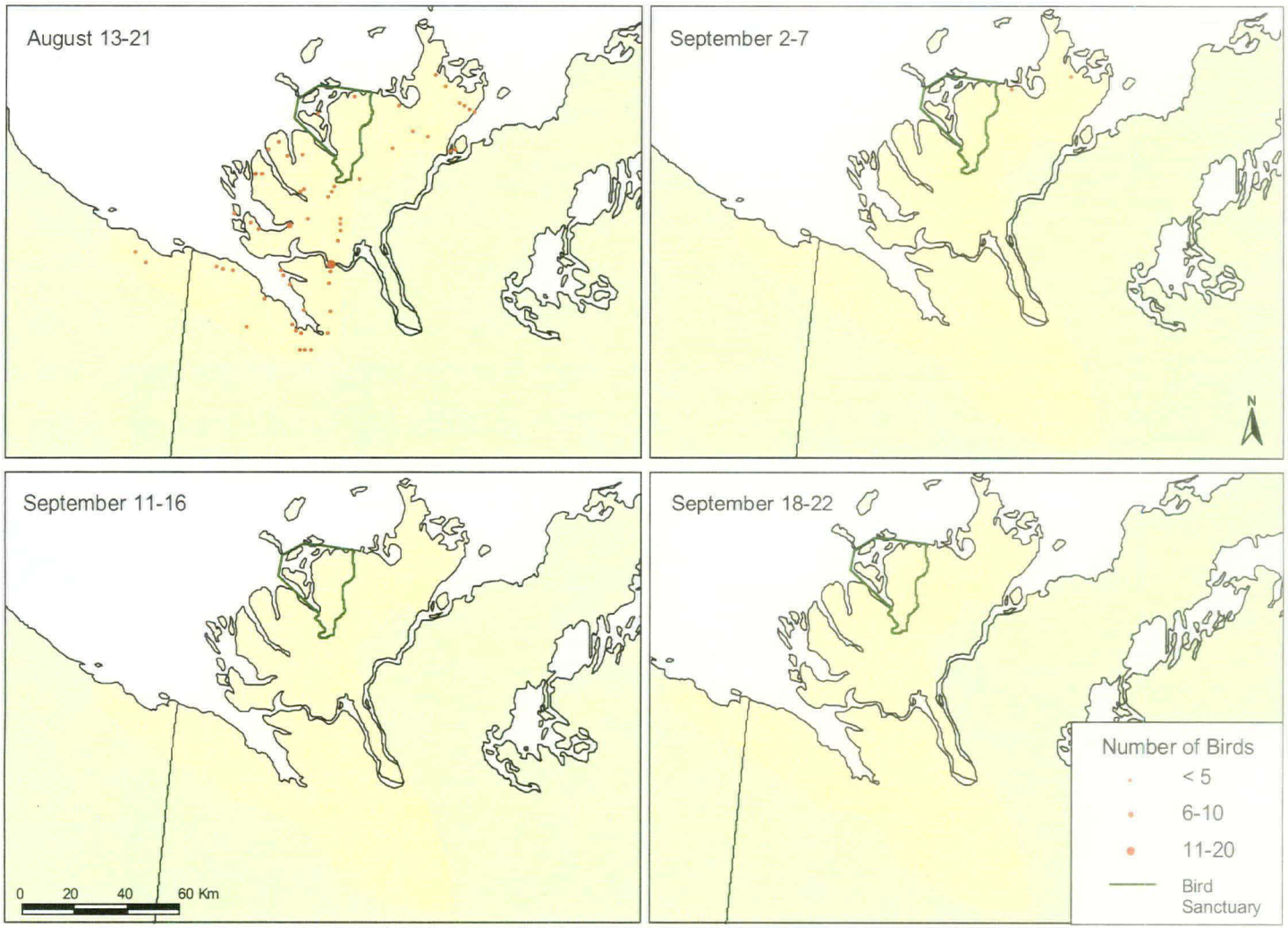

Figure 95. Mean annual numbers of Arctic Terns observed on the mainland of the Inuvialuit Settlement Region (Western Canadian Arctic) during different periods in August and September, 1990-1993.