Research Notes from NERI No.: 91

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Arktisk Miljø/Arctic Environment

Ministry of Environment and Energy, National Environmental Research Institute

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Ministry of Environment and Energy
National Environmental Research Institute
1998

Data sheet

Title:	Satellite tracking of spring migrating and summering Greenland White-fronted Geese, 1998
Subtitle:	Arktisk Miljø/Arctic Environment
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Department:	Department of Arctic Environment
Serial title and no.:	Research Notes from NERI No. 91
Publisher:	Ministry of Environment and Energy National Environmental Research Institute ©
URL:	http://www.dmu.dk
Date of publication:	October 1998
Please quote: and sum	Glahder, C. M., Fox, A. D. & Walsh, A. J. (1998): Satellite tracking of spring migrating mering Greenland White-fronted Geese, 1998. Arktisk Miljø/Arctic Environment. National Environmental Research Institute, Denmark. 21 pp Research Notes from NERI No. 91.

Abstract:

In the middle of March 1998 six Greenland White-fronted Geese were fitted with satellite transmitters (30 g) in Wexford, SE Ireland. Throughout the period March-September, positions of the geese were obtained every 1½ day. Three of the geese were tracked from the wintering grounds in Ireland, via Iceland to the summering grounds in West Greenland, and one was tracked back to Iceland. The objectives of the study, to increase the knowledge of the spring migration complex to protect the geese during this period from different disturbances, were in many ways fulfilled through the obtained information. The staging period in West Iceland was on aver age 18.3 days (SD=1.5), and in West Greenland on average 9.3 days (SD=1.2). The Greenland staging areas were situated between 67° and 69°N. Two of the geese were summering in the Disko Bugt area (68°-69°N), and one at Svartenhuk (72°N).

Keywords:	Greenland White-fronted Geese, satellite transmitter, migration, spring staging.
ISSN:	1395-5675
Number of pages:	23
Circulation:	40

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Preface

This study is a joint project between two departments of NERI, Arctic Environment and Coastal Zone Ecology, and Dùchas - The Heritage Service (the Irish National Parks and Wildlife). The project was initiated in 1996 and is planned to run until 2000.

The project was in 1998 funded by the Commission for Scientific Research in Greenland, National Environmental Research Institute and Irish National Parks and Wildlife.

We wish to thank the following for their valuable support:

Paddy O'Sullivan and Chris Wilson, both members of the cannon-netting team, Oran Walsh, for help with the goose catching, Alice Walsh, for accommodation, Oscar Merne, David Norriss, Paddy Keane, and Padraig Comerford, National Parks and Wildlife, for approval and support, Kendrew Colhoun and Graham McElwaine, for standing by in case of goose staging in Northern Ireland, Arnor Sigfuson, Hugh Boyd, David Stroud, Jens Nyeland Kristiansen, Bjorn Thorsteinsson, Oli Einarsson, Johann-Oli Hilmarsson and Einar Thorliefsson, who helped with goose work in Iceland and searching for satellite geese there, and Poul Howey, Microwave Telemetry, Inc., for supplying us with replacement transmitters.

Summary

Six adult male Greenland White-fronted Geese were fitted with 30 g satellite transmitters (Microwave Telemetry, Inc.) on the wintering grounds at Wexford Slobs in Southeast Ireland in the middle of March 1998. During the period from March to September three of the geese were tracked to the summering areas in West Greenland, and one was tracked back to Iceland.

The purpose of the project "Satellite tracking of the migration of Greenland White-fronted Geese" was to determine spring migration strategies of the geese and to identify spring staging areas in both Greenland and Iceland in order to protect the Greenland White-fronted Geese from the impacts of mineral exploration, hunting, tourism etc.

Signals from three of the satellite transmitters stopped during a period from late March to mid April. One of the transmitters had probably technical problems, the other two were probably damaged by the geese.

The three transmitters that did function during the entire period, transmitted for more than three months longer than calculated initially. Thereby, parts of the autumn migration were included in the project.

The geese migrated north from Wexford in the middle of April and followed, as had one satellite goose in 1997, a direct route from Northern Ireland to Southwest Iceland. Based on obtained fixes, the ground speed of one goose exceeded 100 km/h. Unlike in 1997, the geese fitted with transmitters did not stage in Northern Ireland. All three geese staged in West Iceland for an average of 18.3 days, and migrated west across Danmark Strædet on 7 and 8 May. On the 10 May the geese arrived in West Greenland after a short stop of one to two days in the Ammassalik area, East Greenland. The geese staged at three different staging areas in West Greenland (67° to 69°N) for on average 9.3 days, before they continued to their summering areas. Two of the summering areas were situated about 50 km to the Northwest of the staging areas, one about 600 km to the north at Svartenhuk (72°N).

The geese remained within a restricted area during the summer, which they left during 11-20 September. One goose staged in Iceland from at least 22-28 September, and two geese were resighted in Wexford during 21-27 October. Four of the six geese fitted with a satellite transmitter were resighted in Wexford during 21 October and 5 November, and none of these carried a transmitter. None of the geese attached with a transmitter returned to the wintering grounds with yearlings.

1 Introduction

Objective

The primary purpose of the project "Satellite tracking of the migration of Greenland White-fronted Geese" is to determine spring migration strategies of the geese and to identify spring staging areas in both Greenland and Iceland in order to protect the Greenland White-fronted Geese from the impacts of mineral exploration, hunting, tourism etc.

Satellite tracking

In order to achieve this objective we planned to attach satellite transmitters to the geese on the wintering grounds prior to spring migration. Because previous studies have shown that the use of radio and satellite transmitters can affect bird behaviour, we wished to test the use of different transmitter weights and different harness types (Glahder et al. 1997).

The pilot project

The pilot study was performed on the wintering grounds at Wexford Slobs, Ireland, from 13 January to 22 April 1996. Twelve Greenland White-fronted Geese were fitted with dummy packs containing radio transmitters. Two different transmitter weights (38.0 g (SD=2.3, n=6) and 54.1 g (SD=2.2, n=6)) and two harness types (knicker elastic and neoprene tape) were tested. The pilot study was reported in Glahder et al. (1996 and 1997).

Pilot study, conclusions and recommendations

After release, the observed dummy-fitted geese preened significantly more than control geese two to three days after the attachment, but one week after handling their behaviour seemed normal. There were indications that dummy-fitted geese increased their abdominal profile index less than controls during a one month period. Other behaviour such as site fidelity, flying to roost and family group cohesion all appeared normal. The knicker elastic harness proved more effective than the neoprene harness. It was recommended that (i) satellite transmitters are attached to the geese at least two weeks prior to spring migration, i.e. in late March, (ii) transmitters are as light as possible, (iii) transmitters are fixed to the harness to prevent sideways slippage and (iv) a less robust harness design be developed to ensure packages fall off within a year.

Attachment of satellite transmitters in 1997

Considering the results of the pilot study, seven satellite transmitters were attached to adult male Greenland White-fronted Geese on 28 and 30 March 1997. The transmitters weighed c. 20 g or about 0.6% of the body weight of each of the geese. The harness was made of knicker elastic. Six of the transmitters ceased to function one to three days after attachment, probably because of the weakness of the antenna. The seventh transmitter functioned for 35 days, enabling the goose to be tracked to Iceland, where it stopped transmitting on 4 May (Glahder & Fox 1997, Glahder et al. 1998).

Attachment of satellite transmitters in 1998

The six satellite transmitters which experienced technical problems in 1997 were replaced with 30 g transmitters by Microwave Telemetry, Inc., and attached to adult male Greenland White-fronted Geese in Wexford, Ireland in the middle of March 1998.

2 Materials and methods

Satellite transmitters of 30 g

Because of the poor results obtained from the 20 g PTT-100 satellite transmitters in 1997, we changed the transmitters to a 30 g PTT-100 version. The antenna was made of 2 mm of braided wire instead of the 1 mm wire of the 20 g version. The base of the antenna was protected by a 4 cm long spring to protect the antenna from goose biting and the base was also protected by an epoxy cover. Finally the knicker elastic harness was fixed to the transmitter in such a way as to ensure that there was no contact with the antenna to prevent moisture, absorbed by the harness material, interfering with signal propagation.

Specifications

The 30 g version of PTT-100 has the dimensions 63x18x17 mm. The average weight of the six transmitters was 35.60 g (SD=0.39, n=6). The epoxy glass housing incorporates three harness mounting loops. A 216 mm antenna protrudes from the back edge of the transmitter at 45° to the bottom face. Geographic positions and altitude above sea level can be calculated from the signals transmitted, and the signals contain information on transmitter temperature, battery voltage and goose activity. The six transmitters were programmed to transmit for 8 hours and "sleep" for 29 hours, extending the effective battery life time from 25 days (was it to run continuously) to 92 days for this study. Transmitters attached to geese in the middle of March could then theoretically transmit until the middle of June, and thereby cover the entire spring migration period until the start of the breeding period.

Down-loading signals

The transmissions from the satellite transmitters were down-loaded by ARGOS, CLS, in France, and were both received on-line real time and, retrospectively, on floppy disks.

Catch

The geese were caught on Wexford North Slobs, South-east Ireland, during the period 16-26 March 1998, in co-operation with Alyn Walsh, National Parks & Wildlife Service. Three different catching sites were chosen because the known site fidelity on the wintering grounds could reflect site fidelity to different staging and breeding areas. The geese were caught on 18, 21 and 22 March. On 18 March, 13 geese were caught, and three adult males were fitted with satellite transmitters, on 21 March nine geese were caught and two adult males had transmitters attached, and on 22 March seven geese were caught and one adult male was equipped with a transmitter (Appendix 1). Adult males were chosen as transmitter birds because our primary interest is to discover the migration behaviour of breeding birds, and because males exhibit greater body weight which reduces the relative weight of the transmitter (to about 1.2 %).

Testing the transmitters

Prior to attachment the satellite transmitters were tested with a Telonics up-link receiver, and all transmitters functioned well. After handling, all geese were released in one group and afterwards tracked on the Slobs. The up-link receiver was unable to pick up signals from the transmitters in the field if distances to the transmitter

geese exceeded 50-150 m. During this period, ARGOS submitted data on fixes received from the deployed transmitters by e-mail every day. In the field, the family relations and behaviour of the satellite birds were studied, as well as the position of the transmitter and condition of the antenna (refer to Appendix 1).

Spring migration

The majority of the Greenland White-fronted Geese left Wexford Slobs during 14-18 April 1998, most on 16 April; during that period the wind was fresh from Southeast to south (Alyn Walsh, pers. comm.). The geese went directly to Iceland without staging in Northern Ireland, the Loch Foyle area, as the transmitter bird had in 1997 (Graham McElwaine, pers comm.). In 1997, the geese left Wexford as early as on 7 April, but despite this difference in departure date the geese arrived in Iceland both years around 18 April. The explanation is that many of the departing geese in 1997 had an intermediate staging period of some 7 days in Northern Ireland.

3 Results

Transmitter life-span

Of the six satellite transmitters attached during 18-22 March, three were still transmitting in late September after 182 (20.09.1998, K3F), 194 (28.09.1998, K3A) and 187 (21.09.1998, K2A) days. Two transmitters stopped in the middle of April after 20 (K3C) and 25 (K2C) days, and one stopped on the day the goose was released (K4A). Positions for each of the six geese attached with a satellite transmitter are shown in appendices 2-7. The expected life span of a transmitter coded with an 8/29 duty cycle ratio was 92 days, and by September 28, the average life span was 102 days (SD=94.8, n=6).

Location classes

Locations or positions are assigned to seven different ARGOS location classes, based on quality and strength of signal. Classes 3, 2 and 1 gives the position to an estimated accuracy of <150 m, between 150 and 350 m, and between 350 and 1000 m, respectively. Class 0 is >1000 m, and the classes A and B have no accuracy estimate. The table below shows that positions of the Greenland White-fronted Geese in 1998 (18 March-31 August) have a much higher accuracy than positions had in 1997, and that accuracy in 1998 is higher than obtained in the studies of Barnacle Goose *Branta leucopsis* (Tony Woakes, pers. comm.) and Light-bellied Brent Goose *Branta bernicla hrota* (Preben Clausen, pers. comm., preliminary data).

Table 1 Percent of locations in different ARGOS location classes for three goose species.
The geese were fitted with Microwave Telemetry PTT-100 transmitters; the 30 g version was used in the Greenland White-fronted and the Barnacle Goose study, the 20 g version in the Brent Goose study.

Species/classes	3	2	1	0	A	B
Gr. White-fr. 1998	1.2	4.4	12.6	44.7	18.4	18.8
Gr. White-fr. 1997	0	0	1.8	16.4	34.5	47.3
Barnacle G. 1994	0.7	0.9	5.8	50.6	22.1	21.1
Brent Goose 1997	1.0	3.0	3.0	23.2	25.3	44.4

Resightings in Ireland

All six geese were resighted on the Wexford North Slobs during the period from their catch to their migration (Appendix 1). Three of the geese (K3F, K2C, K3C) preened the transmitter and antenna, especially the base of the antenna, rather much during the first one to three days. After that period no or little preening was observed. These observations correspond with the pilot study (Glahder et al. 1997). In the field, it could be seen that the antenna on K2A leant to one side 8 days after release and that on K3C after 5 days. The antenna on K2C was not visible in the field after 28 days.

Observations on Iceland

Three of the geese attached with a satellite transmitter were observed on Iceland during 17 April-10 May by Tony Fox and others. K3F was observed during 2-5 May 10 km north of Hvanneyri, West Iceland. Both transmitter and antenna were observed and seemed OK. Some preening of the housing was observed. K2A and K4A were both ob-

served on 28 April (Hugh Boyd) at Hvanneyri. The antenna on the K2A-transmitter leant to the one side, whereas transmitter and antenna on K4A (which had stopped transmitting on 18 March) looked in good condition. It was not possible to pick up signals from the functioning transmitters by the use of a ground-based receiver. The three geese that were tracked all the way to West Greenland staged on average 18.3 days on Iceland (SD=1.5, n=3, range=17-20 days).

Staging in West Greenland

The three geese attached with functioning satellite transmitters arrived in West Greenland around 10 May after a short stop of one or two days in East Greenland. In West Greenland, all three geese staged at three different staging areas for on average 9.3 days (SD=1.2, n=3, range=8-10) before they continued to their summering areas; these were reached on 18 May (Ilulissat, K3F), on 20 May (Naternaq, K3A) and on 31 May (Svartenhuk, K2A).

Summering period and arrival on Iceland

During the summering period all geese remained within a very restricted area. K3F was still in its summering area near Ilulissat on 20 September, the latest position received. On 17 October an up-link was received with no information of position. The transmitter's temperature was only 5°C which indicates that the transmitter was either dropped or the goose had died. K3A stayed in the same area in Naternaq throughout the summer until 11 September, was either crossing the ice-cap or had arrived in West Iceland on 19 September, and had been staging in West Iceland from 22 September until the latest up-link on 28 September. This bird was staging in the same area as it used in spring, i.e., Mýrar in central West Iceland. K2A remained on the breeding areas on Svartenhuk until at least 15 September, but had moved southward, staging near to the ice-cap a little north-east of the Nuussuaq peninsula on 18 and 19 September. The last up-link was received on 21 September on a position on the ice-cap c. 100 km east of Ilulissat ice fjord (Appendix 1).

Arrival in Ireland

The first group of 9 geese arrived in Ireland on 13 September after a period of winds from NW. Yet, the majority of geese arrived on the Wexford Slobs during 18-20 October, with more than 6,000 geese on 22 October. Among these were the two transmitter birds, K2A and K4A. No transmitters or antennae were observed on the geese. Relative to the newly finished migration the geese were in good condition with APIs of 1.5 and 2.0 (Alyn Walsh, pers. comm.).

Popular information

Information on the geese attached with satellite transmitters has been published in a news-letter from the National Environmental Research Institute (DMU Nyt 3 1998), and was referred to in a Greenland newspaper (Atuagagdliutit AG 1998). Information on the satellite tracking study was also given on an exhibition at the National Environmental Research Institute, Roskilde, on two posters and through a mounted museum specimen Greenland White-fronted Goose attached with a dummy satellite transmitter (DMU 1998). A presentation was also given at the Wetlands International Specialist Group Meeting held in Bulgaria in February 1998 (Glahder et al. 1998).

4 Discussion

Transmitter damages

There seems to be a connection between heavy preening, impact on the antenna and early transmission failure; the transmitter attached to K2C stopped transmissions after 25 days, and the transmitter attached to K3C stopped after 20 days. Both geese were observed to preen their transmitters heavily, and the antennae were seen to be either damaged or removed by the geese. K3F preened the transmitter and antenna to some extent during the first two days after attachment, but the orientation of the antenna was observed not to have been affected. K2A was not observed preening the transmitter or antenna, but the orientation of the antenna had changed after just over a week. K4A was atypical, in that no preening of the transmitter or antenna was observed, nor was the antenna visibly affected, yet transmissions stopped the very same day the transmitter was attached. This suggests technical failure not related to antenna damage resulting from goose biting.

Transmitters in 1997 and 1998

There were indications that all but one antennae in 1997 were removed by the geese during the first few days of heavy preening. The only antenna observed in the field was attached to the one remaining functional transmitter. The transmitters used in 1998 had a thicker antenna and a basal protection in the form of a spring, with the result this year that only one antenna was lost. All antennae were observed in the field this year. Two of the antennae were bent to one side, but only one of the these stopped transmitting. Two transmitters showing some evidence of damage in the field (one which lost its antenna, the other visibly bent) transmitted for 20 and 25 days, suggesting that some geese may persist in preening and pulling at their transmitter and antenna for three weeks to one month before sustaining sufficient damage to cease transmission. The three transmitters that "survived" the early preening continued to transmit for approximately double the time expected. The reason for this is unclear, but could be an effect of optimal weather conditions with regard to battery life.

Migration from Ireland to Iceland

A total of six positions of two migrating geese (K3A and K2A) in 1998 together with five positions from 1997 (H3Z) indicates that the migration route between northern Ireland and south-western Iceland follows a direct straight route. Whereas signals from the goose in 1997 were mainly from the last part of the journey up to arrival in Iceland, positions received in 1998 were all from the first part of the journey. For K2A, only one position was obtained on 16 April, west of the Outer Hebrides. Five positions were obtained for K3A on 19 April covering a route of about 600 km, with a calculated ground speed exceeding 100 km/h. We have not so far obtained detailed weather data for that period, but conditions north of Britain and Ireland changed dramatically after 16 April, with rapidly rising pressure leading to the most stable conditions of the month on 18 April (based on data from Fair Isle Meteorological Station, http://www.zetnet.co.uk/sigs/weather/dly0498.htm). On 18 April 1998, the average wind speed was the lowest of the month, with a

light breeze from south and Southeast. In 1997 ground speed of the tracked goose was about 45 km/h with no or little wind from the west.

Staging in Iceland

The average length of stay of 18.3 days is similar to the one goose in 1997 that staged in Iceland for at least 16 days. The three geese in 1998 staged in West Iceland (Hvanneyri and Mýrar), whereas the goose in 1997 staged in Southwest Iceland (Olfusa-Landeyjar). All four geese seemed to remain in same staging area throughout the entire period.

Verification of position accuracy in Iceland

A preliminary analysis of the accuracy of the locations provided from the satellite PTTs whilst geese staged in Iceland indicated a much poorer accuracy than claimed by ARGOS. During the spring staging period, where K3A and K3F were located by the ground team working in Iceland, it was possible to be present on site for a series of up-links when the geese were known to be at a definite position on the ground. These could be compared with the location and the level of accuracy of each of the up-links provided from ARGOS. For location classes 1 and 2, the accuracy varied by 7 km (for K3F) and between 6 and 12 km (for K3A), and for location class 0 the accuracy was within 20-55 km (K3A) and 22-40 km (K2A) of the known positions. The accuracy was best in the north-south orientation than east-west. From field observations it seems that the centre of gravity of all the locations derived during the staging period corresponds closely to the actual located ground position of the goose in each case. However, we intend to carry out a full analysis of the accuracy of the positions in due course.

Migration to West Greenland

All three geese probably left Iceland on 7 May (when the ground team witnessed major departures in the Icelandic staging areas generally) and for two of the geese (K3F and K2A) there are indications that these staged in East Greenland for one to two days. K3F stopped for at least two hours apparently on the sea ice about 30 km off the coast 150 km north of Ammassalik, and the next position was at the centre of the ice-cap, 28 hours later. K2A was c. 300 km east of East Greenland on the afternoon of 7 May, and its next position was 150 km Southwest of Ammassalik on 9 May about 1½ day later. The ground speed of K3F off East Greenland was about 45 km/h calculated on the basis of five class 0 positions. No weather data from this part of the journey are available yet.

Staging and summering in West Greenland

During the 9 days staging within Greenland, it seems that the two southern-most summering geese (K3F and K3A) briefly explored their summering area during the middle of the staging period, before settling in the same area for the remainder of the summer. Assuming the birds return to the wintering areas, we shall be able to see whether the tagged birds were successful breeders or not during 1998. Until then, it is not clear whether these movements relate to breeding attempts or moult migration. We lack data from the autumn migration flight from West Greenland to Iceland, probably because the power levels in the batteries were to low to sustain up-links in the low temperatures experienced during the ice-cap crossing.

5 Conclusion and further studies

Catching of geese

The capture of geese at three different sites in five days and the attachment of satellite transmitters was well planned and well executed. Because of the very early migration in 1997 on 7 April, it was decided that geese should be caught 10 days earlier in 1998. In the event, the start of migration in 1998 was normal, such that the transmitter geese remained in Ireland for almost one month, during which period three transmitters were lost. An attachment in late March 1999 would increase the possibility of getting more migration data.

Improvement of transmitters

Compared to the satellite transmitters attached to the geese in 1997 the transmitters in 1998 were much more successful in terms of life span and efficacy. Nevertheless, a 50% loss of contact after about three weeks is unacceptably high. Most of the problems seem still to be associated with the combination of heavy preening undertaken by this race of geese and the fact that the antennae are too weak to withstand such preening. The antennae should be protected at the base with a longer (7-10 cm) and stronger spring, and the antenna must be firmly fixed inside the housing, e.g., with a double crimp. We attempted to keep the geese from interfering with the antennae by applying a bitter oil (manufactured to stop children biting their fingernails) to the antennae, but the oil had no effect. There seem to be no problems with the harness. No transmitters were observed on two of the geese in Ireland in October 1998, indicating that the harnesses were shed after about half a year.

ARGOS data

The delivery of data on floppy disks, e-mail and on-line from ARGOS, CLS, has functioned without any problems.

New knowledge

The three geese bearing satellite transmitters which have provided regular transmissions for about half a year, have given us new and exciting insights into, e.g., staging areas and periods in Iceland and Greenland, site fidelity, migration routes and ground speeds. From weather data obtained from the Danish Meteorological Institute we will be able to analyse the influence of weather conditions on migration start, direction of migration routes and ground speed, as well as attempting to assess the energetic costs of such flights.

Continuation of the project in 1999

Even though we this year have obtained considerable information over a prolonged period, including the entire period spent in Greenland, data from just three individual geese in a single year represents very limited material. Therefore, we intend to repeat the study in 1999, with the purpose of obtaining more data to replicate, confirm and extend the information gathered during 1997 and 1998, and to provide data on migration strategies in different years under different weather conditions, using different migration routes, staging areas, summering areas, etc. The year of 1999 is planned to be the last study year of the project. We have applied the Commission for Scientific Research in Greenland for financial support for the 1999 study.

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Appendix 1: Data for Greenland White-fronted Geese attached with satellite transmitters

K3F, 6932, adult male, weight 3,050 g, wing span 131 cm, caught 22.03.1998 on the western part of the North Slobs.
Family group: K5F (ad. female), K9C, K1F (juv.), D9N (ad), unringed (1 juv.).
Abdominal profile index, API: 1.5 (24.03); 1.5. (27.10)
Ireland: 22.03: Preening antenna (ant.) base: 11x, house/sides: 9x (observation period of 15 min.); 23.03: Satellite transmitter (PTT)/ant. seen, little preening; 24.03: Ant. OK, preening ant. base: 1x, ant.: 0x, house/sides: 18x (58 min.); 25.03: PTT/ant. seen, no preening (40 min.); 26.03: PTT/ant. seen, no preening (40 min.); 18.04: Migrates from Wexford.
West Iceland: 21.04: Hvanneyri; 2.05-5.05: obs. Hvanneyri; 7.05: Migrates from Hvanneyri.
East Greenland: 8.05: Danmark Strædet, Kangertitsivaq.
West Greenland: 9.05: Ice-cap; 10.05: Staging area, SE Ilulissat; 18.05: Summering area, Rodebay-Ilulissat; 20.09: Mouth of Ilulissat ice fjord.
Ireland: 27.10: Wexford, PTT / ant. not. observed, with K5F, K9C, K1F, K9N, one unringed (juv.).

K3A, 6933, adult male, weight 3,000 g, wing span 134 cm, caught 18.03.1998 in the middle of the North Slobs.
Family group: H9Z (ad. female), H8Z, H0Z, K7A, K8A, K9A (juv.).
API: 1.5 (23.03).
Ireland: 18.03: Preening PTT in catching tent, ant. OK, signal from flying K3A; 23.03: Ant. OK; 24.03: Ant. OK, no preening (13 and 32 min.); 17.04: Migrates from Wexford; 19.04: Donegal, west of Wexford; mid Atlantic Ocean (5 up-links).
West Iceland: 20.04: Mýrar; 7.05: Migrates from Mýrar.
West Greenland: 8.05: Mid ice-cap (2 up-links); 10.05: Staging area, Nordenskjölds Fjord; 20.05: Summering area, Naternaq; 11.09: Naternaq; 19.09: Crossing the ice-cap or on West Iceland (1 up-link, class A, gives both possibilities).
West Iceland: 22.09-28.09: Mýrar.

K2A, 6934, adult male, weight 2,850 g, wing span 130 cm, caught 18.03.1998 in the middle of the North Slobs.
Family group: K4A (ad. male), K5A, K6A (juv.).
API: 1.5 (26.03), 1.5 (21.10).
Ireland: 18.03: PTT/ant. OK, signal picked up; 23.03: PTT/ant. OK, no preening (28 min.); 26.03: Ant. slightly bent to the right and lying rather flat along the back, no preening; 30.03: Ant. to the right; 15.04: Migrates from Wexford; 16.04: Atlantic Ocean, west of the Outer Hebrides.
West Iceland: 18.04: Mýrar and Hvanneyri; 28.04: Obs. Hvanneyri, ant. to one side; 6.05: Migrates from Mýrar/Hvanneyri; 7.05: Mid Danmarks Stræde.

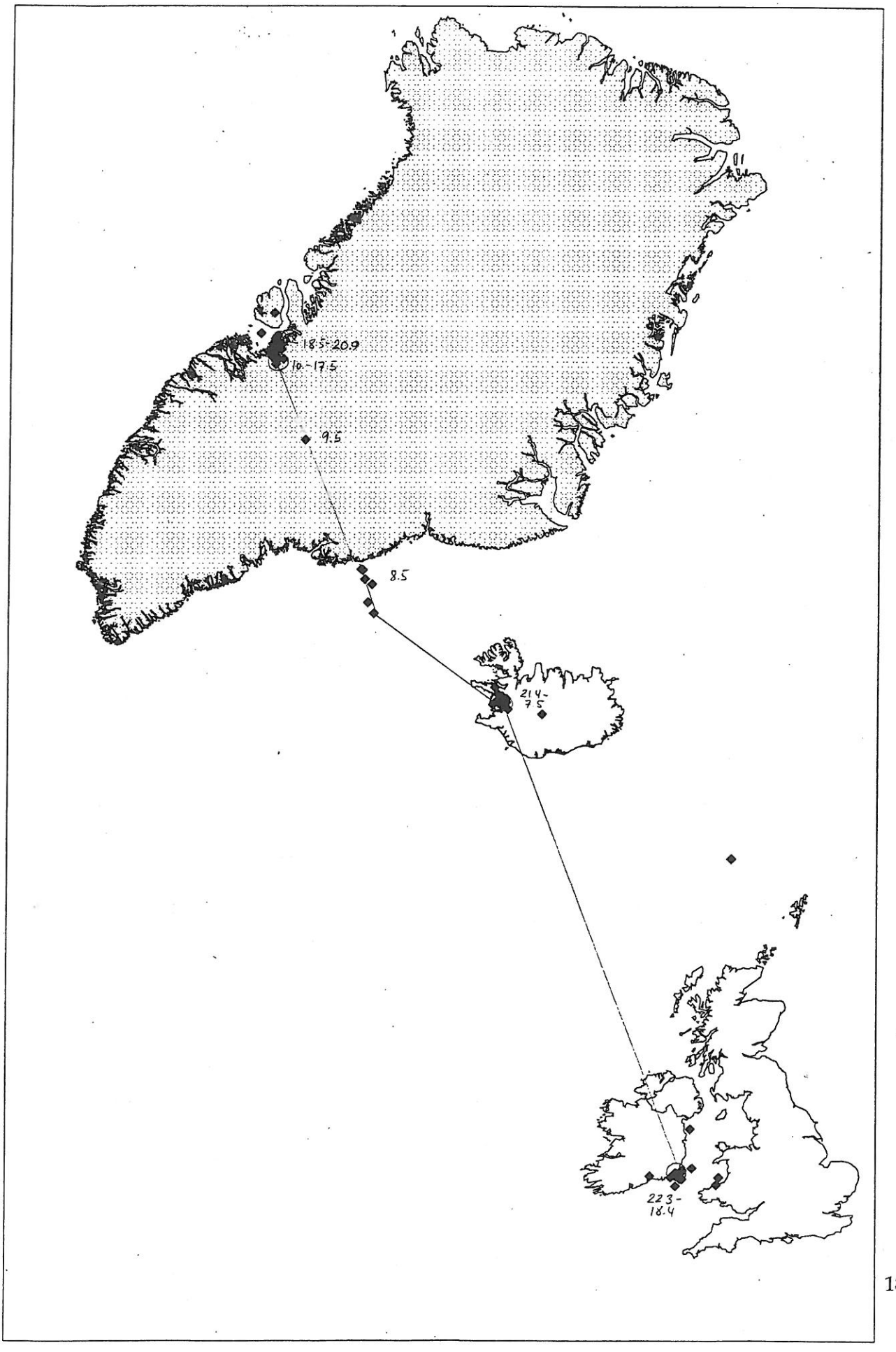
East Greenland: 9.05: Pikiulleq.
West Greenland: 10.05: Staging area, S of Kangerlussuaq; 20.05: Ilulissat; 21.05: Nuussuaq; 27.05: Ubekendt Ejland; 31.05: Summering area, Itsako, Svartenhuk; 15.09: Svartenhuk; 18.09-21.09: NE of Nuussuaq close to ice-cap.
Ireland: 21.10: Wexford Slobs, PTT/ant. not observed.

K4A, 6935, adult male, weight 3,000 g, wing span 134 cm, caught 18.03.1998 in the middle of the North Slobs.
Family group: Unringed (ad. female), K2A (ad. male), K5A, K6A (juv.).
API: 1.5 (23.03), 2.0 (21.10).
Ireland: 18.03: PTT/ant. OK, 1 ARGOS up-link, class: Z, first and last; 20.03: PTT)/ant. OK, preening house: 1x (44 min.), ant.base: 7x, ant.: 3x (68 min.); 21.03: PTT/ant. OK; 23.03: PTT/ant. OK; 25.03: Ant. OK, plastic coating intact, no preening; 26.03: PTT: OK, some preening; 1.04: PTT OK.
West Iceland: 28.04: Obs. at Hvanneyri, ant. OK and undamaged.
Ireland: 21.10: Wexford Slobs, PTT/ant. not observed.

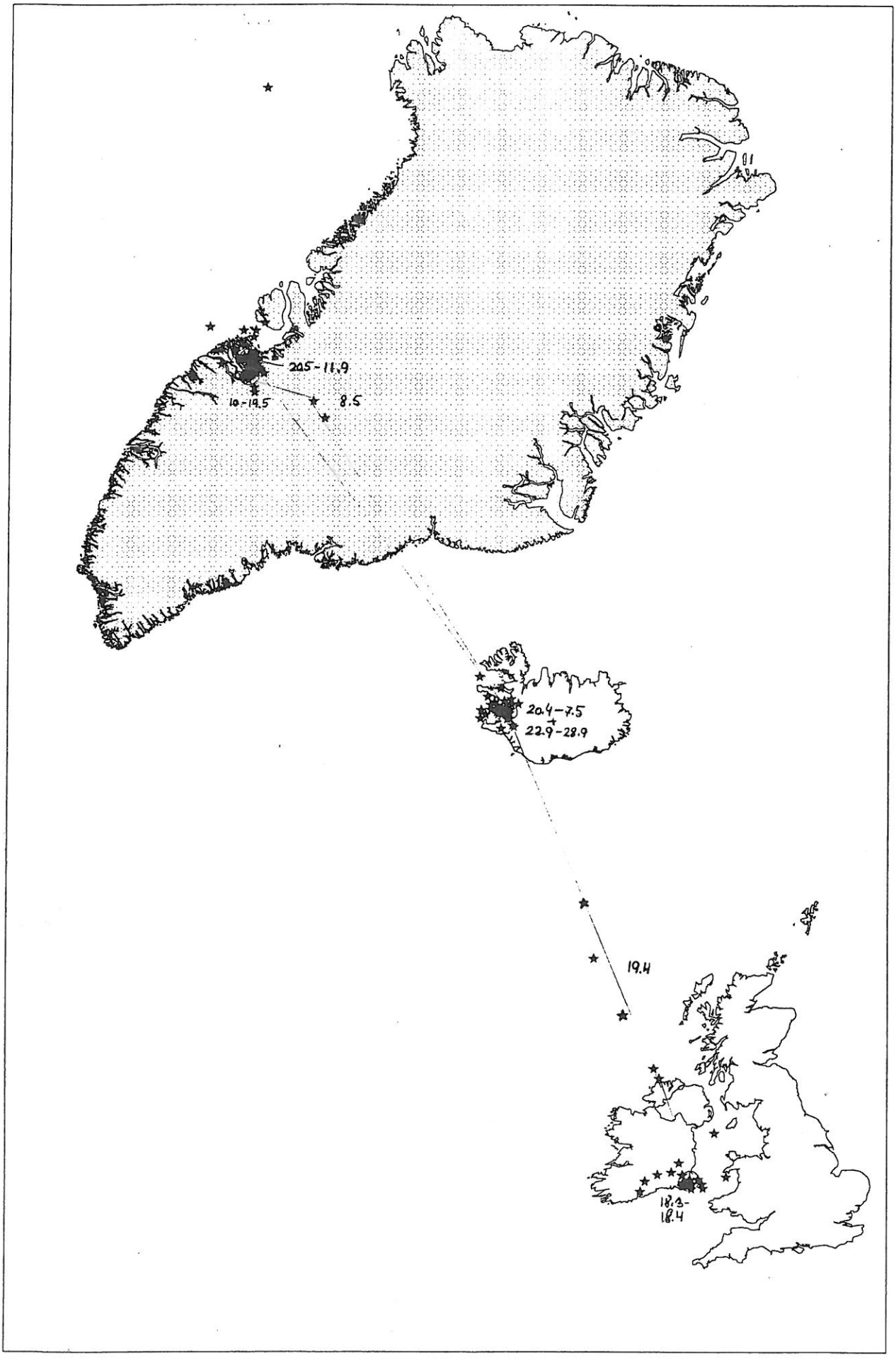
K2C, 6936, adult male, weight 2,900 g, wing span 133 cm, caught 21.03.1998 on the eastern part of the North Slobs.
Family group: K0A (ad. female), K4C, K5C, K6C, K7C, K8C (juv.).
API: 2.5 (5.04).
Ireland: 21.03: A lot of preening of PTT and ant.; 22.03: Ant. OK, no preening; 24.03: PTT OK; 25.03: PTT/ant. OK, preening ant: 9x, sides: 3x (35 min.), no preening (10 min.); 1.04: PTT OK; 5.04: PTT OK; 15.04: Last ARGOS up-link; 19.04: No antenna on the PTT.
Ireland: 5.11: Wexford, PTT not observed, with: K0A, K4C, K5C, K6C, K7C, one unringed (juv.).

K3C, 6937, adult male, weight 3,250 g, wing span 140 cm, caught 21.03.1998 on the eastern part of the North Slobs.
Family group: K1C (ad. female)
API: 1.5 (24.03), 2.5 (30.03), 2.5 (1.04).
Ireland: 21.03: Preening ant. base: 168 x, ant: 41x, sides: 6x (40 min.); 22.03: Preening ant. base: 11x, ant. 14x, sides: 0x (8 min.); 23.03: Ant. OK; 24.03: Ant. OK, no preening (10 min.), ant. 1x (35 min.); 25.03: PTT/ant. OK, some preening; 26.03: PTT/ant. OK, ant. slightly to the left; 30.03: Ant. slightly to the left; 1.04: K3C seen; 10.04: Last ARGOS up-link.

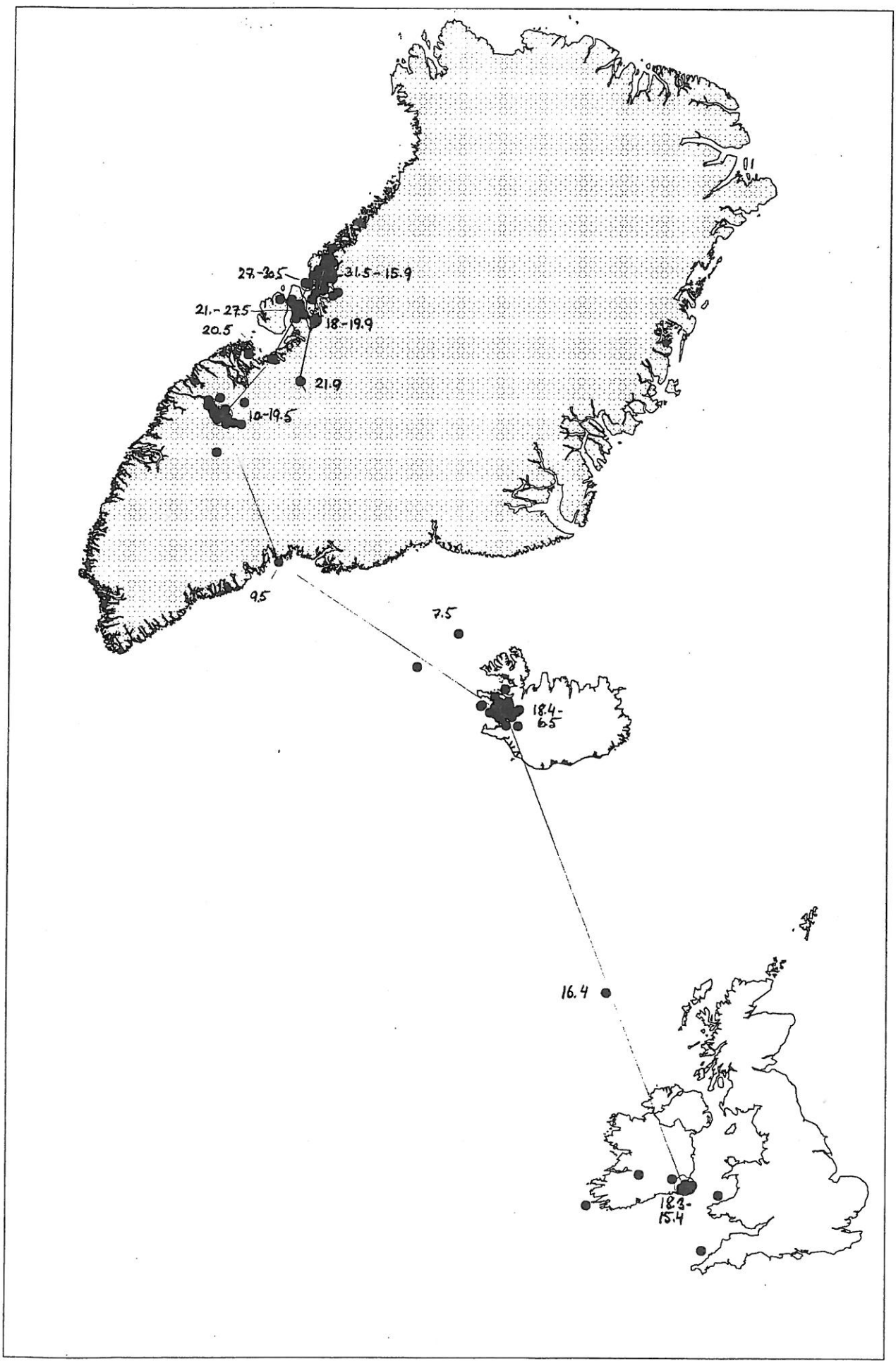
Appendix 2: Positions for K3F, 6932



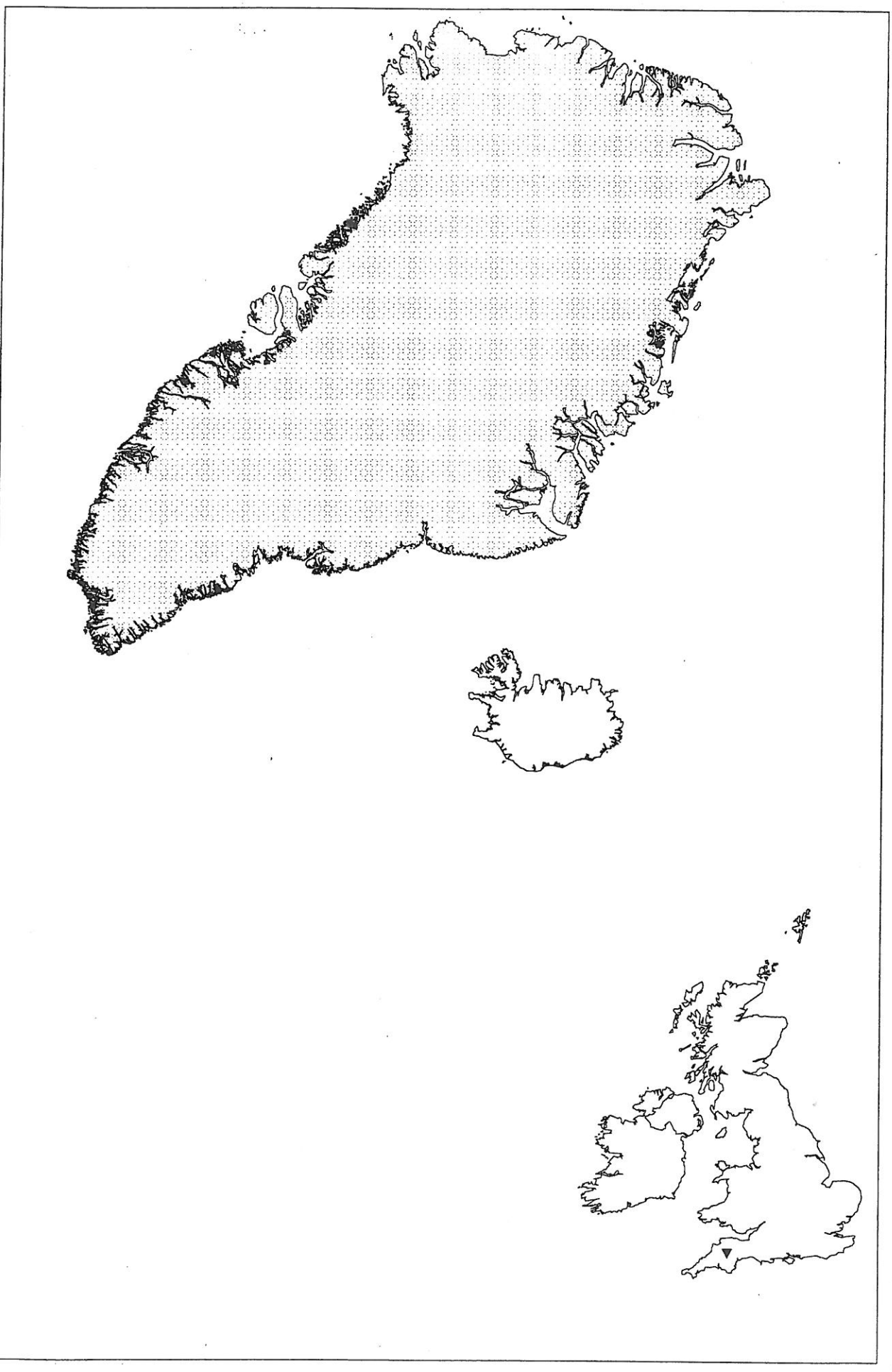
Appendix 3: Positions for K3A, 6933



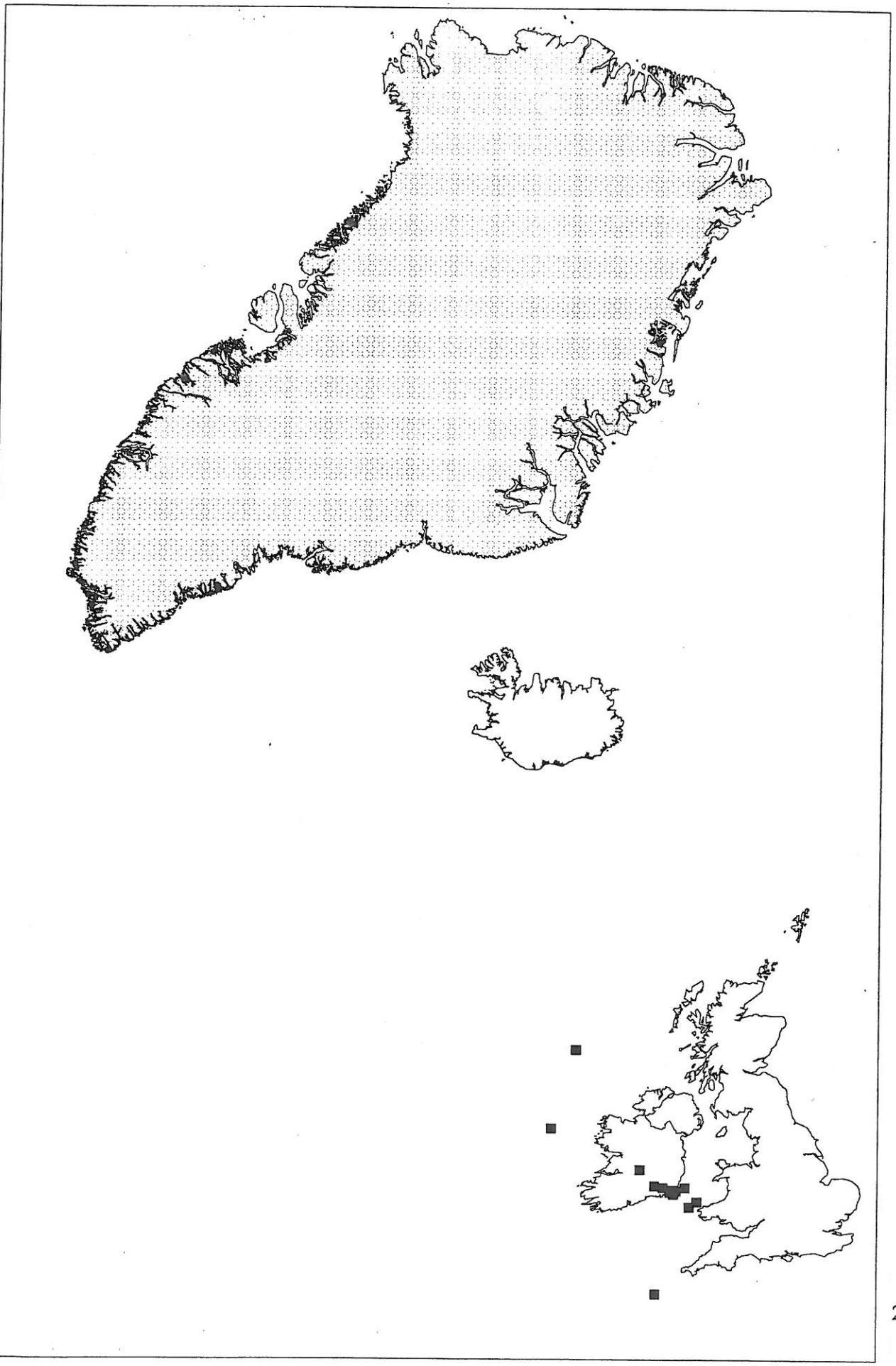
Appendix 4: Positions for K2A, 6934



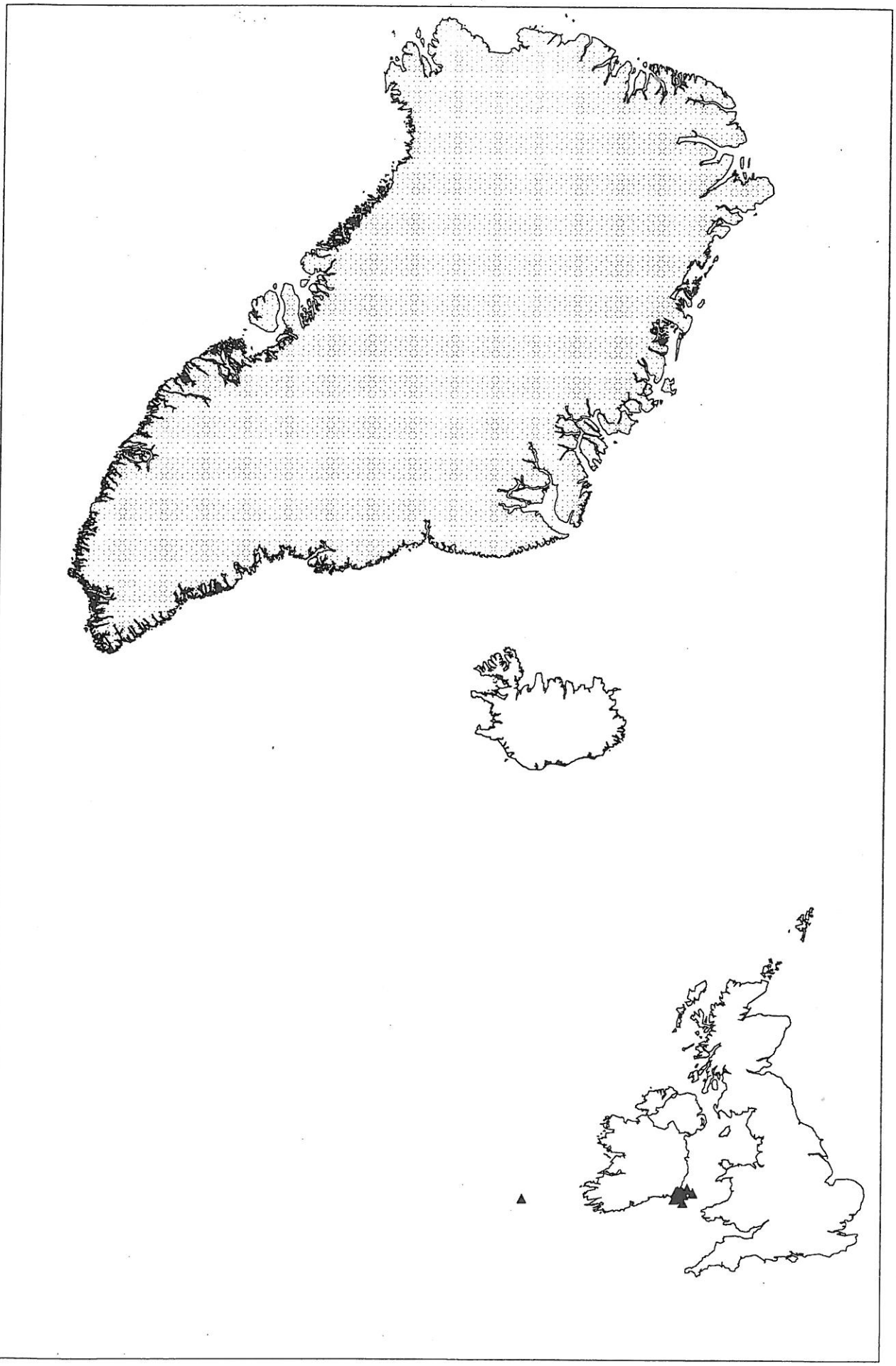
Appendix 5: Positions for K4A, 6935



Appendix 6: Positions for K2C, 6936



Appendix 7: Positions for K3C, 6937



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