

## Wintering-site fidelity of Brünnich's Guillemot (*Uria lomvia*) breeding in Greenland colonies

### Appendix

#### A.1 Overview of data for individuals and tracks used

Table A1: Overview for each individual Brünnich's Guillemot included in the study. This includes information on colony affiliation; individual identification; wintering periods tracked; sex; number of tracks, GLS positions, and gaps. Gaps are defined as days with zero GLS positions recorded.

Colony	Individual	Wintering periods	Sex	Tracks	GLS positions	Gaps
Kippaku	DKC_4286789	2019_20, 2020_21	Female	2	482	0
Kippaku	DKC_4286801	2009_10	Male	1	236	2
Kippaku	DKC_4286802	2009_10	Male	1	238	0
Kippaku	DKC_4286808	2009_10, 2010_11	Female	2	456	6
Kippaku	DKC_4286809	2009_10, 2010_11, 2011_12	Female	3	712	1
Kippaku	DKC_4286811	2009_10	Male	1	240	0
Kippaku	DKC_4286812	2009_10	Male	1	238	0
Kippaku	DKC_4286813	2009_10	Male	1	236	0
Kippaku	DKC_4286814	2009_10	Female	1	240	0
Kippaku	DKC_4286815	2009_10	Female	1	240	0
Kippaku	DKC_4286816	2009_10	Male	1	236	1
Kippaku	DKC_4286819	2009_10	Male	1	240	0
Kippaku	DKC_4286820	2009_10	Female	1	229	3
Kippaku	DKC_4286821	2009_10	Male	1	240	0
Kippaku	DKC_4286824	2009_10	Male	1	218	9
Kippaku	DKC_4286826	2009_10, 2010_11	Female	2	438	12

<b>Kippaku</b>	DKC_4286828	2009_10, 2010_11, 2011_12	Female	3	647	24
<b>Kippaku</b>	DKC_4286829	2009_10, 2010_11	Male	2	463	3
<b>Kippaku</b>	DKC_4286904	2009_10	Male	1	230	2
<b>Kippaku</b>	DKC_4286914	2008_09, 2009_10	Female	2	474	1
<b>Kippaku</b>	DKC_4286915	2008_09, 2009_10	Male	2	455	7
<b>Kippaku</b>	DKC_4286916	2008_09, 2009_10	Male	2	453	12
<b>Kippaku</b>	DKC_4286917	2008_09, 2009_10	Male	2	480	0
<b>Kippaku</b>	DKC_4286918	2008_09, 2009_10	Female	2	411	0
<b>Kippaku</b>	DKC_4286919	2008_09	Male	1	229	3
<b>Kippaku</b>	DKC_4286920	2008_09, 2009_10	Female	2	463	5
<b>Kippaku</b>	DKC_4286923	2008_09, 2009_10	Male	2	461	4
<b>Kippaku</b>	DKC_4286927	2008_09, 2009_10, 2010_11	Male	3	693	9
<b>Kippaku</b>	DKC_4286929	2008_09, 2009_10	Male	2	478	0
<b>Kippaku</b>	DKC_4286930	2008_09, 2009_10, 2010_11	Female	3	697	6
<b>Kippaku</b>	DKC_4286931	2008_09, 2009_10, 2010_11, 2011_12	Female	4	948	5
<b>Kippaku</b>	DKC_4286932	2008_09, 2009_10	Male	2	462	4

<b>Kippaku</b>	DKC_4286933	2008_09, 2009_10	Male	2	469	2
<b>Kippaku</b>	DKC_4287000	2019_20, 2020_21, 2021_22	Male	3	681	10
<b>Kippaku</b>	DKC_4292640	2019_20	Male	1	238	0
<b>Kippaku</b>	DKC_4292641	2020_21	Unknown	1	240	0
<b>Kippaku</b>	DKC_4292646	2019_20, 2020_21	Female	2	470	3
<b>Kippaku</b>	DKC_4292659	2021_22	Unknown	1	95	0
<b>Kippaku</b>	DKC_4292698	2019_20, 2020_21	Male	2	468	4
<b>Kippaku</b>	DKC_4298509	2019_20, 2020_21, 2021_22	Female	3	708	5
<b>Kippaku</b>	DKC_4298533	2021_22	Male	1	37	1
<b>Kippaku</b>	DKC_4415021	2020_21, 2021_22	Female	2	463	3
<b>Kippaku</b>	DKC_4415028	2019_20, 2020_21, 2021_22	Male	3	634	28
<b>Kippaku</b>	DKC_4415044	2019_20, 2020_21, 2021_22	Male	3	704	4
<b>Kippaku</b>	DKC_4415045	2019_20, 2020_21, 2021_22	Male	3	711	3
<b>Kippaku</b>	DKC_4415046	2019_20, 2020_21	Male	2	478	1
<b>Kippaku</b>	DKC_4415048	2019_20, 2020_21	Male	2	470	4
<b>Kippaku</b>	DKC_4415049	2019_20, 2020_21, 2021_22	Male	3	509	104

<b>Kippaku</b>	DKC_4415051	2019_20, 2020_21, 2021_22	Male	3	704	5
<b>Kippaku</b>	DKC_4415068	2020_21	Male	1	240	0
<b>Kippaku</b>	DKC_4415070	2020_21		1	233	2
<b>Kippaku</b>	DKC_4415084	2021_22		1	230	2
<b>Kitsissut Avalliit</b>	DKC_4286757	2009_10, 2010_11	Unknown	2	467	3
<b>Kitsissut Avalliit</b>	DKC_4286758	2009_10, 2010_11	Female	2	479	0
<b>Kitsissut Avalliit</b>	DKC_4286771	2009_10, 2010_11, 2011_12	Female	3	656	8
<b>Kitsissut Avalliit</b>	DKC_4286774	2009_10, 2010_11	Male	2	412	23
<b>Sermilinnguaq</b>	DKC_4284259	2019_20, 2020_21, 2021_22	Male	3	721	0
<b>Sermilinnguaq</b>	DKC_4284261	2019_20, 2020_21	Male	2	481	0
<b>Sermilinnguaq</b>	DKC_4284263	2019_20, 2020_21, 2021_22	Male	3	719	0
<b>Sermilinnguaq</b>	DKC_4284266	2019_20, 2020_21	Female	2	482	0
<b>Sermilinnguaq</b>	DKC_4284267	2019_20, 2020_21	Male	2	477	1
<b>Sermilinnguaq</b>	DKC_4284269	2019_20, 2020_21, 2021_22	Male	3	709	1
<b>Sermilinnguaq</b>	DKC_4284273	2019_20, 2020_21, 2021_22	Male	3	717	0
<b>Sermilinnguaq</b>	DKC_4284274	2019_20, 2020_21	Male	2	482	0

<b>Sermilinnguaq</b>	DKC_4284276	2019_20, 2020_21, 2021_22	Male	3	722	0
<b>Sermilinnguaq</b>	DKC_4284277	2019_20, 2020_21	Female	2	481	0
<b>Sermilinnguaq</b>	DKC_4284278	2019_20, 2020_21	Male	2	480	1
<b>Sermilinnguaq</b>	DKC_4284279	2019_20, 2020_21, 2021_22	Male	3	709	3
<b>Sermilinnguaq</b>	DKC_4284280	2019_20	Female	1	238	2
<b>Sermilinnguaq</b>	DKC_4284281	2019_20, 2020_21, 2021_22	Female	3	671	16
<b>Sermilinnguaq</b>	DKC_4284282	2019_20, 2020_21	Unknown	2	473	1
<b>Sermilinnguaq</b>	DKC_4284283	2019_20, 2020_21	Male	2	460	10
<b>Sermilinnguaq</b>	DKC_4284293	2020_21, 2021_22	Unknown	2	451	3
<b>Sermilinnguaq</b>	DKC_4284302	2020_21	Unknown	1	237	0
<b>Sermilinnguaq</b>	DKC_4284308	2020_21	Unknown	1	232	3
<b>Sermilinnguaq</b>	DKC_4284311	2021_22	Unknown	1	21	0
<b>Sermilinnguaq</b>	DKC_4284315	2021_22	Unknown	1	235	0

Table A2: Number of individuals tracked during wintering periods from different colonies during the period of 2008-2022

<b>Colony</b>	<b>N birds tracked</b>	<b>Wintering period</b>
Kippaku	14	2008-09
Kippaku	31	2009-10
Kippaku	8	2010-11
Kippaku	3	2011-12
Kippaku	13	2019-20

Kippaku	16	2020-21
Kippaku	11	2021-22
Kitsissut Avalliit	4	2009-10
Kitsissut Avalliit	4	2010-11
Kitsissut Avalliit	1	2011-12
Sermilinnguaq	16	2019-20
Sermilinnguaq	18	2020-21
Sermilinnguaq	10	2021-22
<b>Total</b>	<b>149</b>	

## A.2 Description of daily inter-track distance functions

The function *rdist.earth2* provides a vectorized method for calculating greatcircle distances between two sets of geographic coordinates. It converts longitude and latitude values from degrees to a format compatible with the functions *cospi* and *sinpi* (base R functions) for efficient trigonometric computation, uses the function *tcrossprod* (base R function) to generate all pairwise dot products between points, and returns a matrix of Earthsurface distances in kilometres. The *nearest* function then uses this distance calculator to determine the closest point in a second dataset (p2) to a given location (p1), computes all distances from p1 to p2, and identifies the smallest value. These two functions are combined in *track.consistency.near*, which computes daily intertrack distances for all track pairs listed in *comp.df* (the data frame specifying the comparisons). For each comparison, the function extracts the focal track (*trk1*) and comparison track (*trk2*), then iterates through every position in *trk1*. For each day, it selects only those points in *trk2* that fall within a given time window (e.g.,  $\pm 7$  days), calls *nearest* to determine the closest spatial match, and records the resulting distance. The daily distances are then aligned to a full 1–365 day sequence, day 1 being 1st of August to account for a “bird year” which runs from summer to summer, ensuring consistent output even if some tracks lack data on certain days. Repeating this process for all comparisons produces a 365row matrix in which each column represents one pair of tracks and each entry corresponds to the nearestneighbour distance between the two individuals on that calendar day.

### A.3 Results using a 10-day and 30-day time window

Table A3: Summary of model selection results showing  $\Delta AIC$  (difference between each model's AIC and the lowest AIC in the set) and  $R^2$  for within-individual distance compared to among-individual distance. Comparison type and colony are fixed effects with the best supported model marked in bold. Daily inter-track distances were calculated using a 10-day window. Compare with Table 2.

Model	$\Delta AIC$	$R^2$
$\log(\text{Distance}) \sim 1$	476.5	0
$\log(\text{Distance}) \sim \text{colony}$	180.6	0.070
<b><math>\log(\text{Distance}) \sim \text{comparison type} + \text{colony}</math></b>	<b>0.6</b>	<b>0.11</b>
$\log(\text{Distance}) \sim \text{comparison type} * \text{colony}$	0	0.11

Table A4: Estimated fixed and random effects for the model including additive effects of comparison type and colony (Table A3). Kippaku as the reference value for colony and among-bird as the reference value for comparison type. Daily inter-track distances were calculated using a 10-day window. Compare with Table 3.

Fixed effects	Estimate (log km)	Confidence interval 2.5%	Confidence interval 97.5%	Std. Error	t value	p value
Intercept	6.34	6.37	6.43	0.0152	419.94	
Sermilinnguaq	-0.654	-0.731	-0.578	0.0388	-16.86	<0.001
Within-bird	-1.315	-1.504	-1.126	0.0964	-13.64	<0.001

Table A5: Summary of model selection results showing  $\Delta AIC$  (difference between each model's AIC and the lowest AIC in the set) and  $R^2$  for within-individual distance compared to among-individual distance. Comparison type and colony are fixed effects with the best supported model marked in bold. Daily inter-track distances were calculated using a 30-day window. Compare with Table 2.

<b>Model</b>	<b>ΔAIC</b>	<b>R<sup>2</sup></b>
log(Distance) ~ 1	410.8	0
log(Distance) ~ colony	180.2	0.058
<b>log(Distance) ~ comparison type * colony</b>	<b>0.7</b>	<b>0.10</b>
log(Distance) ~ comparison type + colony	0	0.10

Table A6: Estimated fixed and random effects for the model including additive effects of comparison type and colony (Table A5). Kippaku as the reference value for colony and among-bird as the reference value for comparison type. Daily inter-track distances were calculated using a 30-day window. Compare with Table 3.

<b>Fixed effects</b>	<b>Estimate (log km)</b>	<b>Confidence interval 2.5%</b>	<b>Confidence interval 97.5%</b>	<b>Std. Error</b>	<b>t value</b>	<b>p value</b>
Intercept	6.078	6.053	6.123	0.0179	340.09	
Sermilinnuaq	-0.653	-0.739	-0.566	0.0442	-14.78	<0.001
Within-bird	-1.493	-1.707	-1.279	0.109	-13.68	<0.001

Table A7: Summary of model selection results showing ΔAIC (difference between each model's AIC and the lowest AIC in the set) and R<sup>2</sup> for intra individual variation. Sex and colony are fixed effects with the best supported model marked in bold. Daily inter-track distances were calculated using a 10-day window. Compare with Table 4.

<b>Model</b>	<b>ΔAIC</b>	<b>R<sup>2</sup></b>
log(Distance) ~ 1	42.17	0
log(Distance) ~ colony * sex	1.99	0.394
<b>log(Distance) ~ colony</b>	<b>1.14</b>	<b>0.387</b>
log(Distance) ~ colony + sex	0	0.394

Table A8: Estimated fixed effects for the model including colony (Table A7). Kippaku as the reference value for colony. Daily inter-track distances were calculated using a 10-day window. Compare with Table 5.

<b>Fixed effects</b>	<b>Estimate (log km)</b>	<b>Confidence interval 2.5%</b>	<b>Confidence interval 97.5%</b>	<b>Std. Error</b>	<b>t value</b>	<b>p value</b>
<u>log(Distance) ~ colony</u>						
Intercept	5.192	5.0397	5.346	0.0771	67.371	
Sermilinnuaq	-0.972	-1.235	-0.71	0.132	-7.365	<0.001

Table A9: Summary of model selection results showing  $\Delta$ AIC (difference between each model's AIC and the lowest AIC in the set) and  $R^2$  for intra individual variation. Sex and colony are fixed effects with the best supported model marked in bold. Daily inter-track distances were calculated using a 30-day window. Compare with Table 4.

<b>Model</b>	<b><math>\Delta</math>AIC</b>	<b><math>R^2</math></b>
log(Distance) ~ 1	32.36	0
log(Distance) ~ colony	2.023	0.307
<b>log(Distance) ~ colony * sex</b>	<b>1.72</b>	<b>0.324</b>
log(Distance) ~ colony + sex	0	0.322

Table A10: Estimated fixed effects for the model including colony (Table A9). Kippaku as the reference value for colony. Daily inter-track distances were calculated using a 30-day window. Compare with Table 5.

<b>Fixed effects</b>	<b>Estimate (log km)</b>	<b>Confidence interval 2.5%</b>	<b>Confidence interval 97.5%</b>	<b>Std. Error</b>	<b>t value</b>	<b>p value</b>
<u>log(Distance) ~ colony</u>						
Intercept	4.668	4.499	4.837	0.0850	54.94	
Sermilinnuaq	-0.899	-1.188	-0.61	0.146	-6.18	<0.001

## A.4 Performance package diagnostic plot output

Figure A1: Diagnostic plots for the model including the additive effects of comparison type and colony (Table 2), generated using the *model\_check* function in the *performance* package.

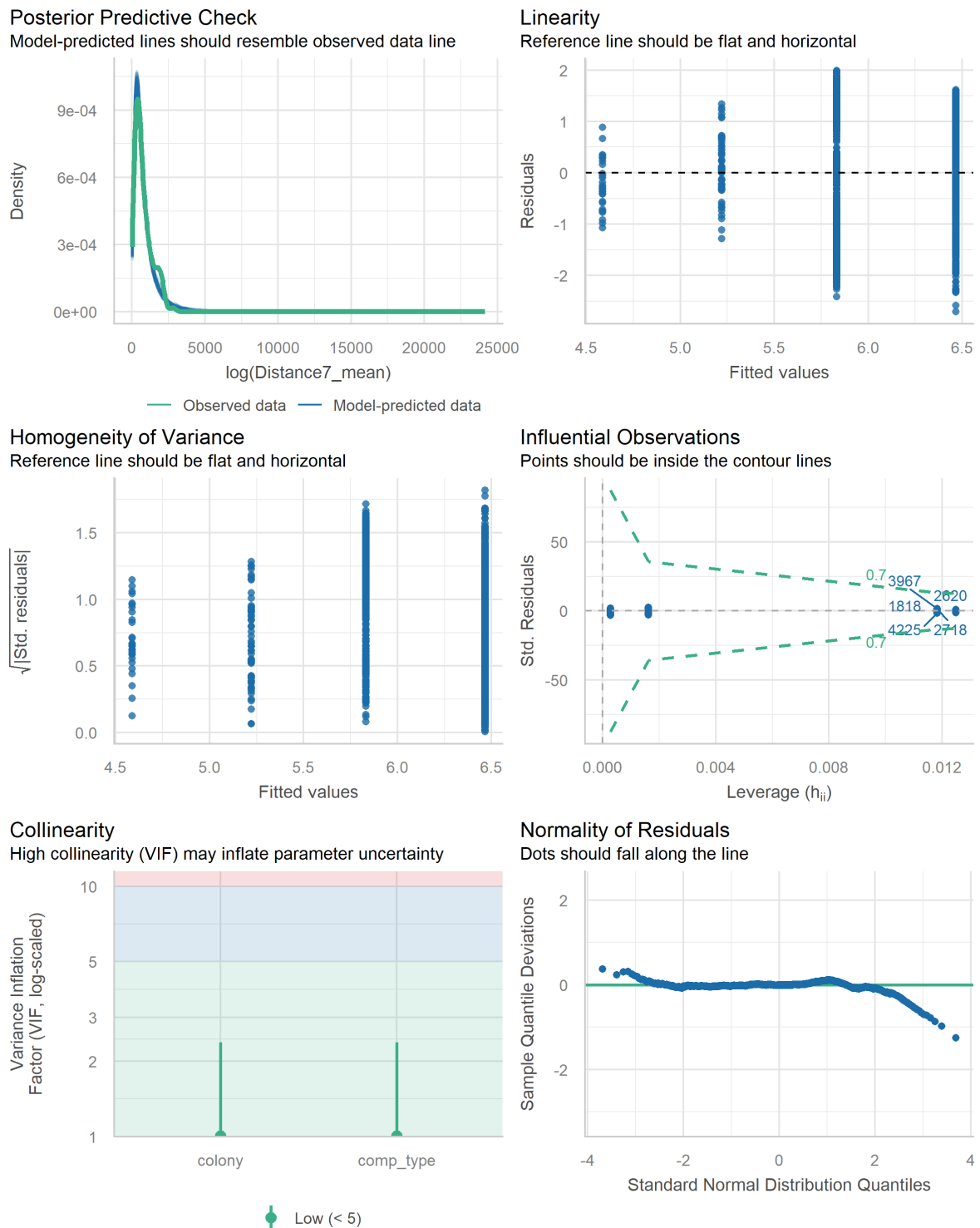
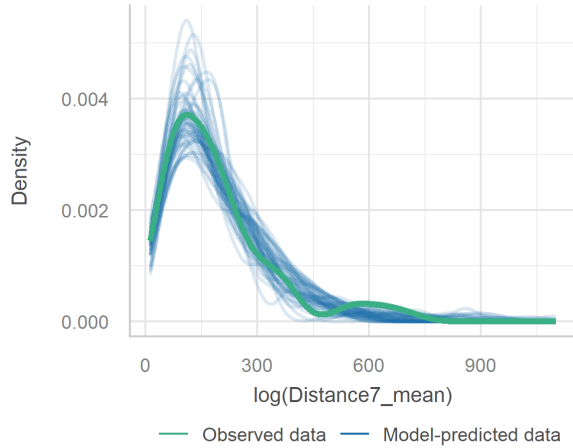


Figure A2: Diagnostic plots for the model including colony (Table 4), generated using the `model_check` function in the `performance` package.

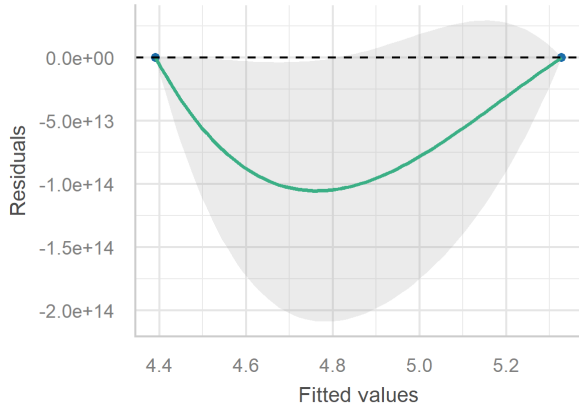
### Posterior Predictive Check

Model-predicted lines should resemble observed data line



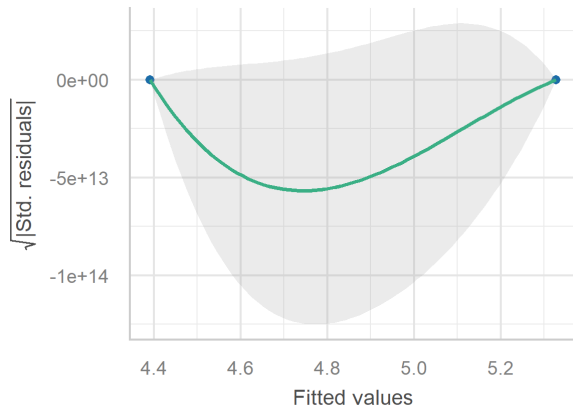
### Linearity

Reference line should be flat and horizontal



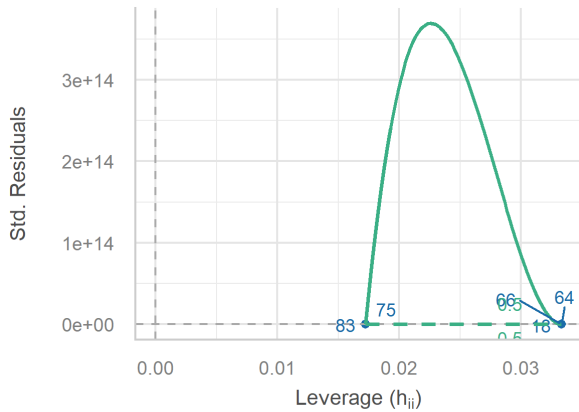
### Homogeneity of Variance

Reference line should be flat and horizontal



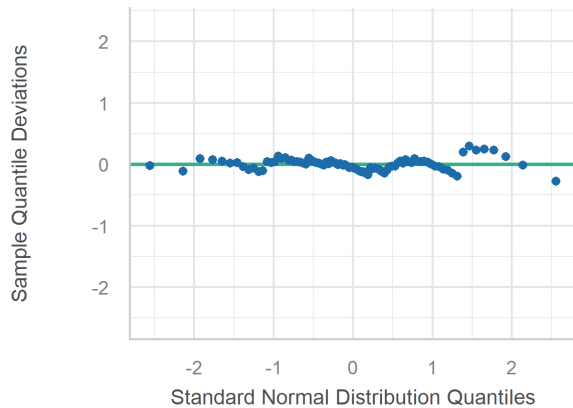
### Influential Observations

Points should be inside the contour lines



### Normality of Residuals

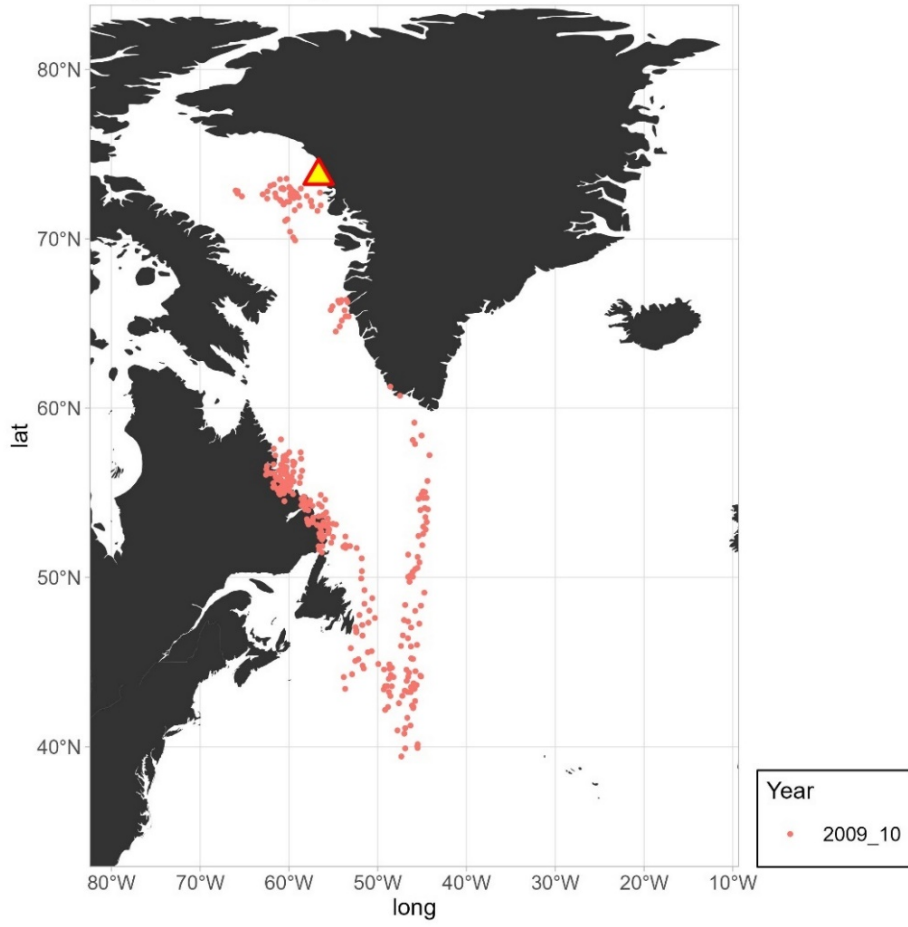
Dots should fall along the line



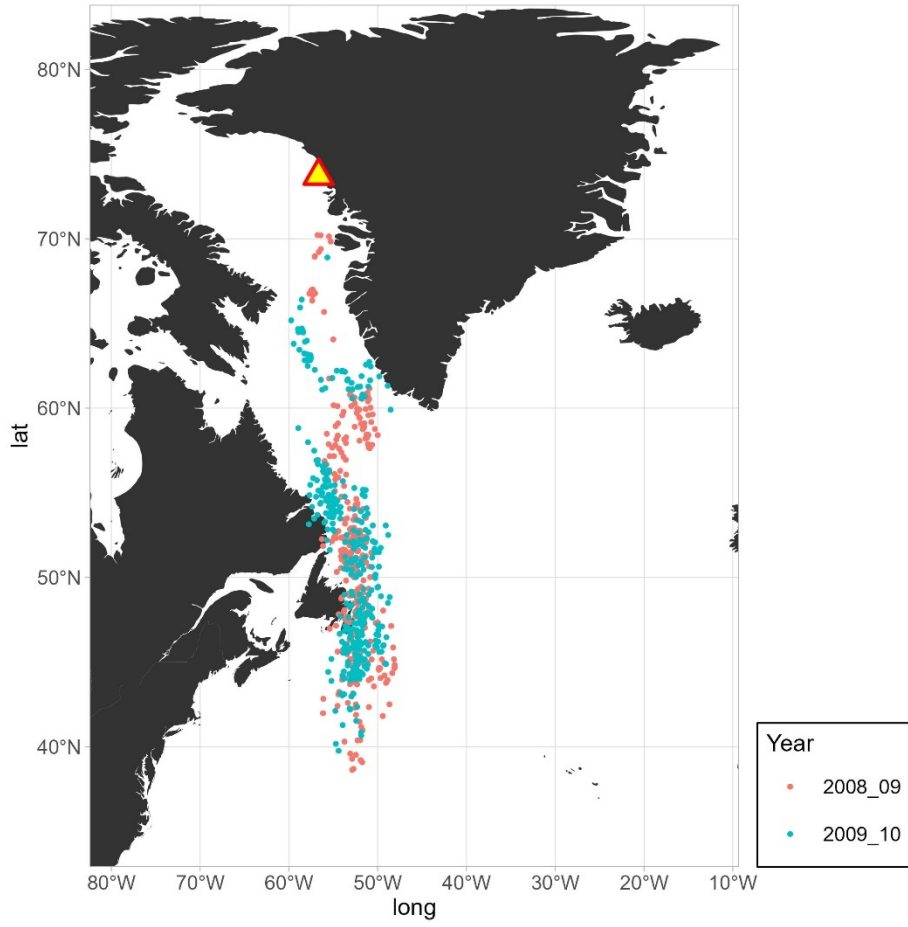
## A.5 Maps of temporal distribution during wintering periods for each individual Brünnich's Guillemot

Position data at the individual level throughout the tracked wintering periods. Individual identity is indicated as “DKC\_” followed by a unique 7-digit number. Colonies are marked with a yellow triangle outlined in red, while GLS positions are marked with different coloured dots which represent different wintering periods.

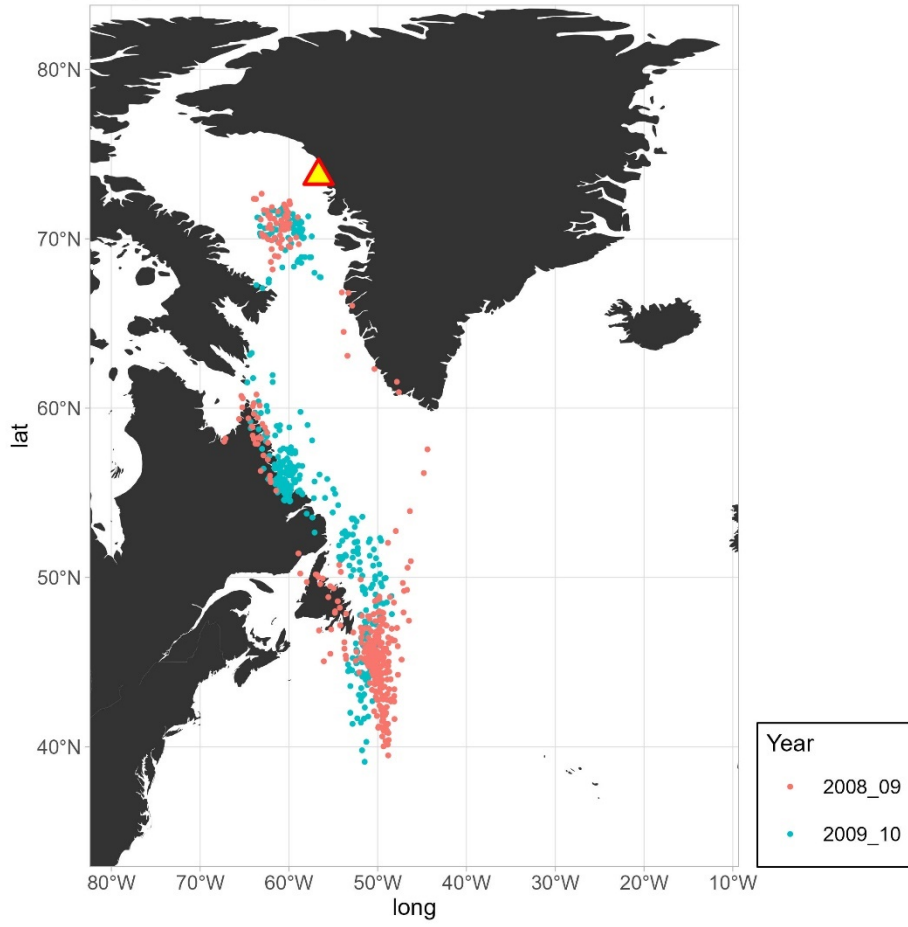
DKC\_4286904 from Kippaku



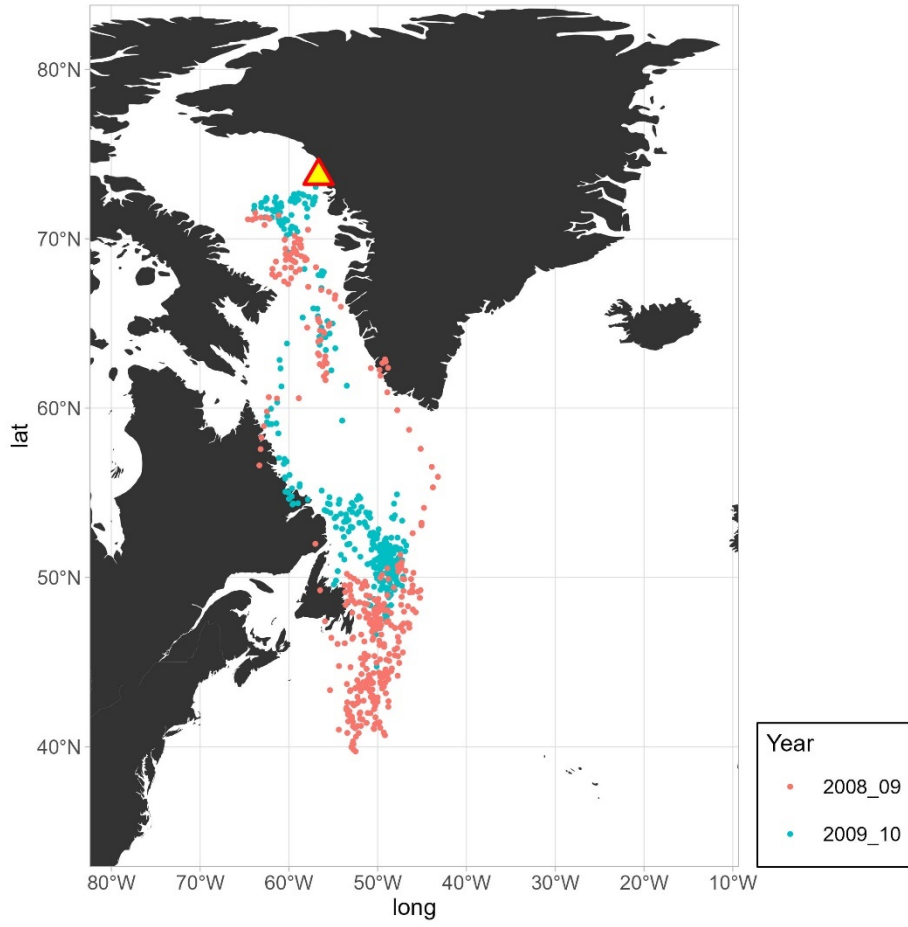
DKC\_4286914 from Kippaku



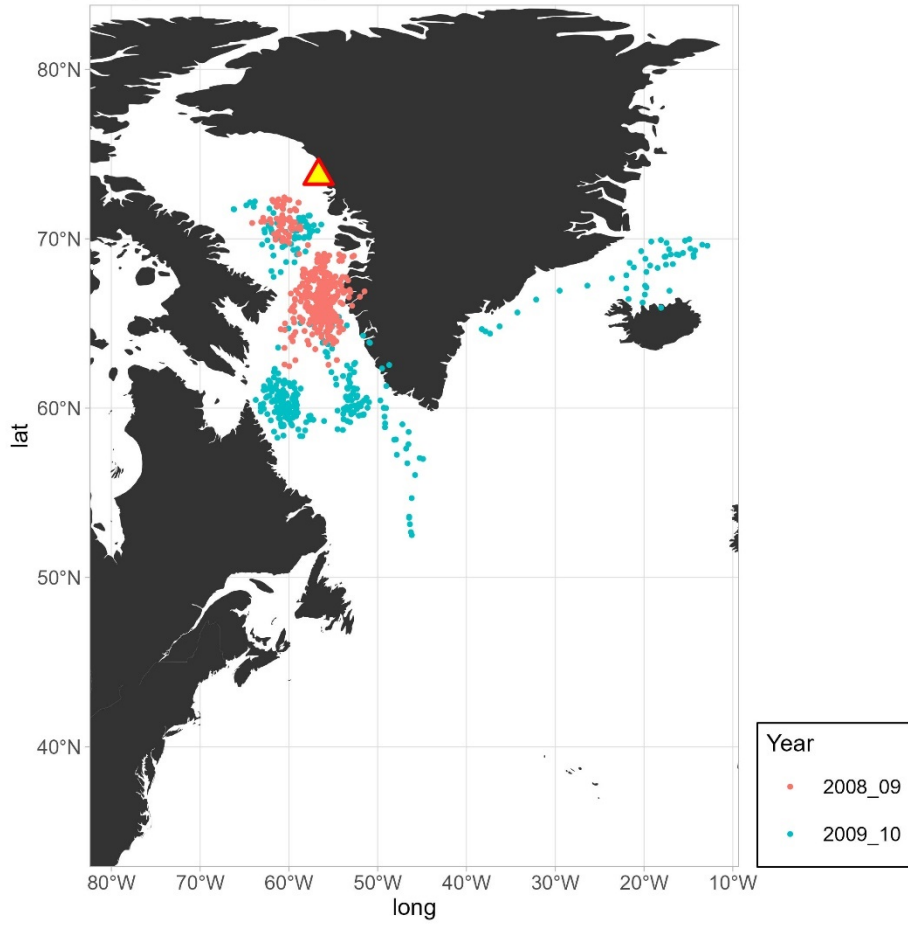
DKC\_4286915 from Kippaku



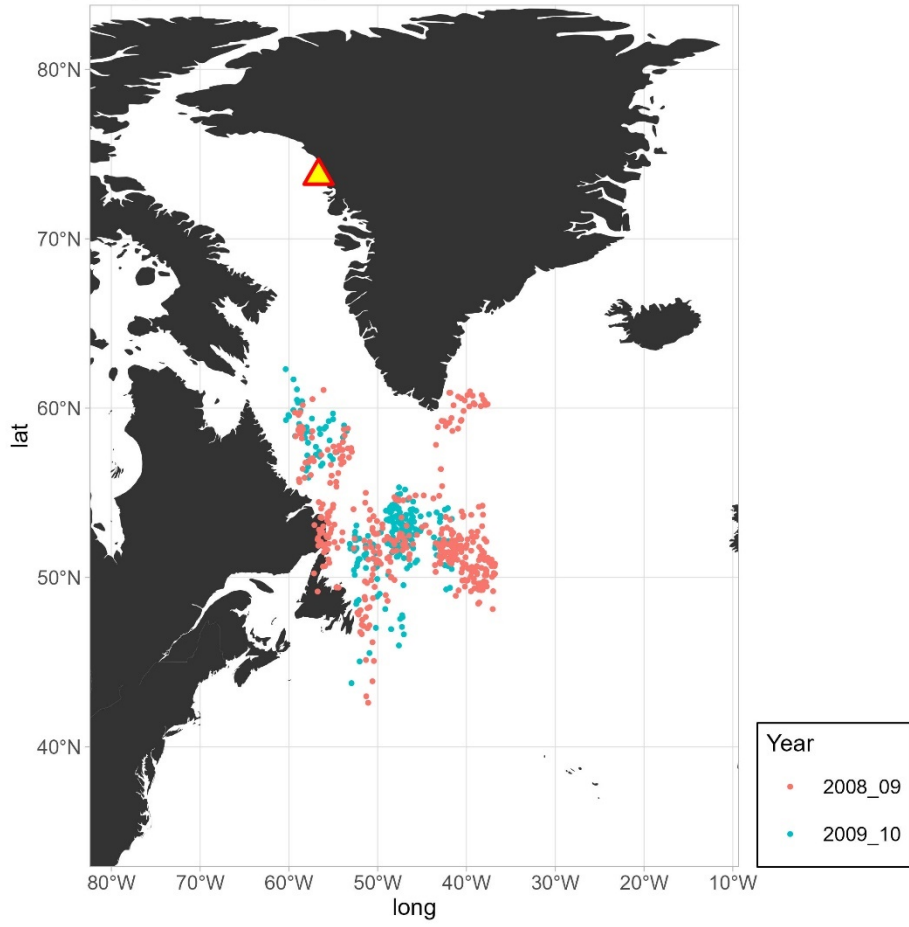
DKC\_4286916 from Kippaku



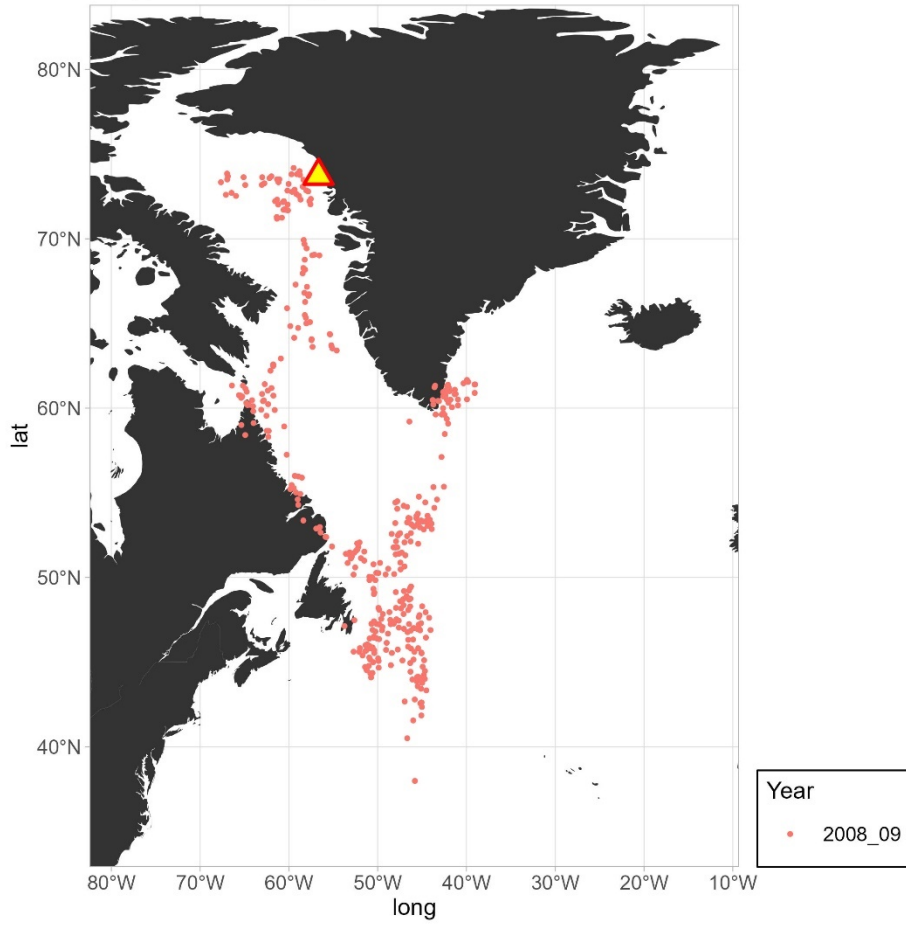
DKC\_4286917 from Kippaku



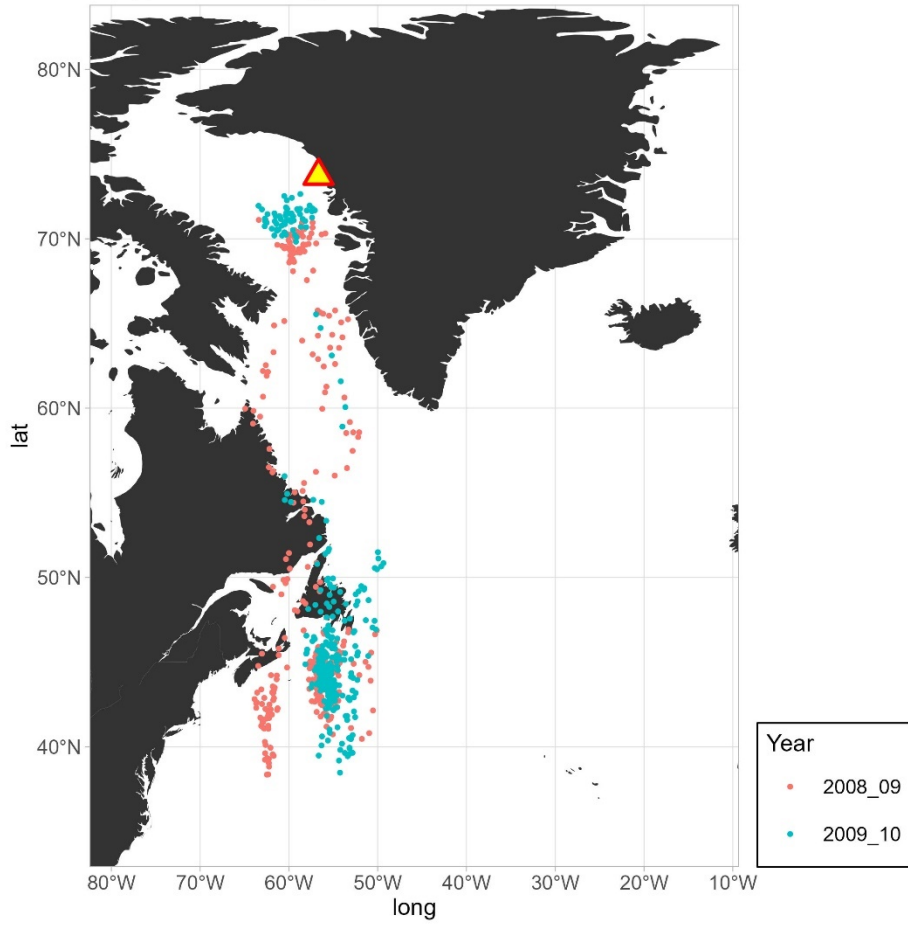
DKC\_4286918 from Kippaku



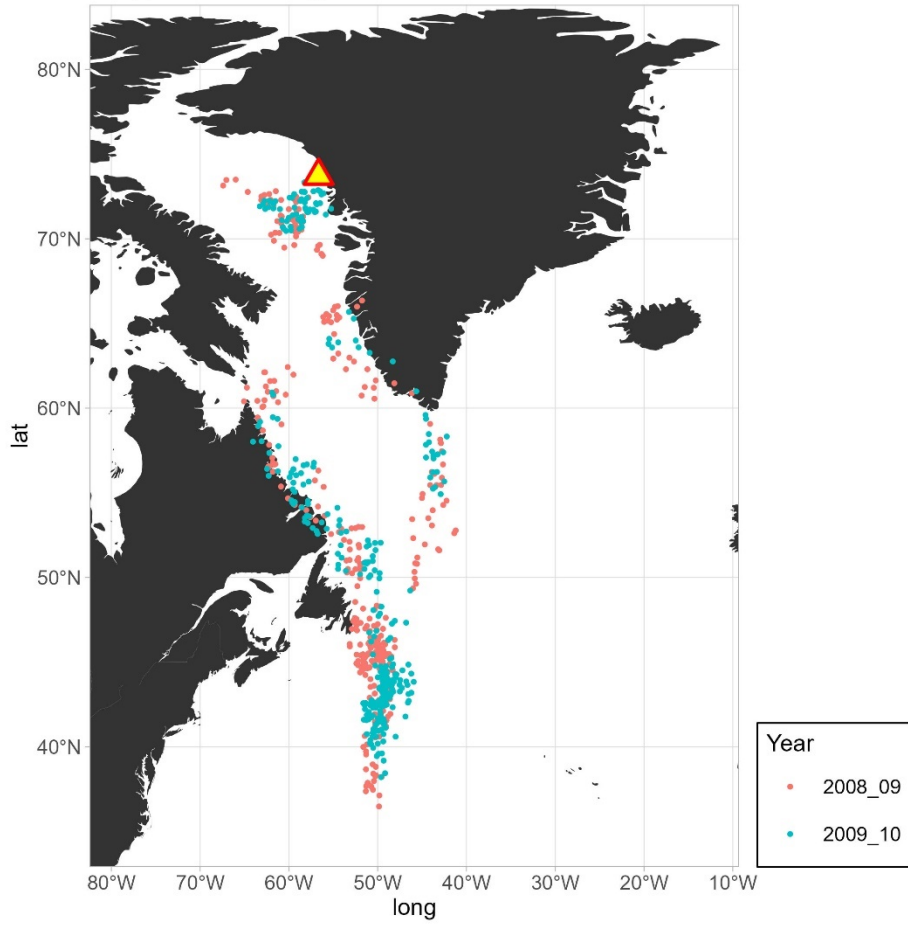
DKC\_4286919 from Kippaku



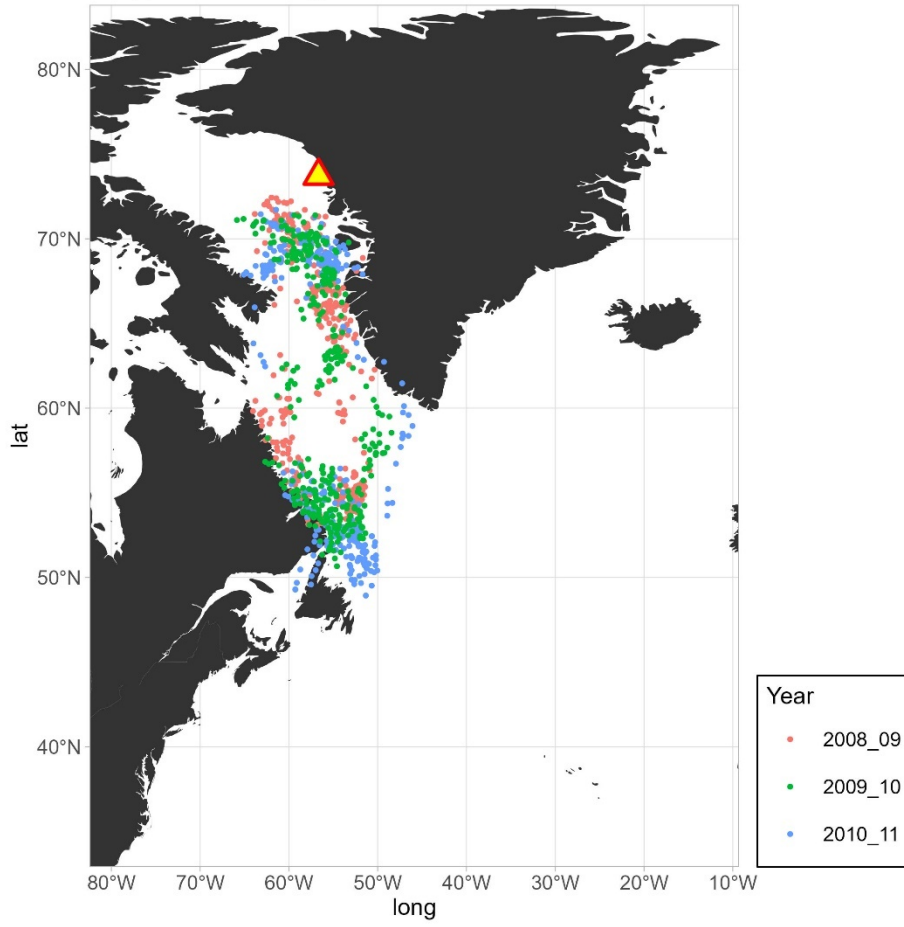
DKC\_4286920 from Kippaku



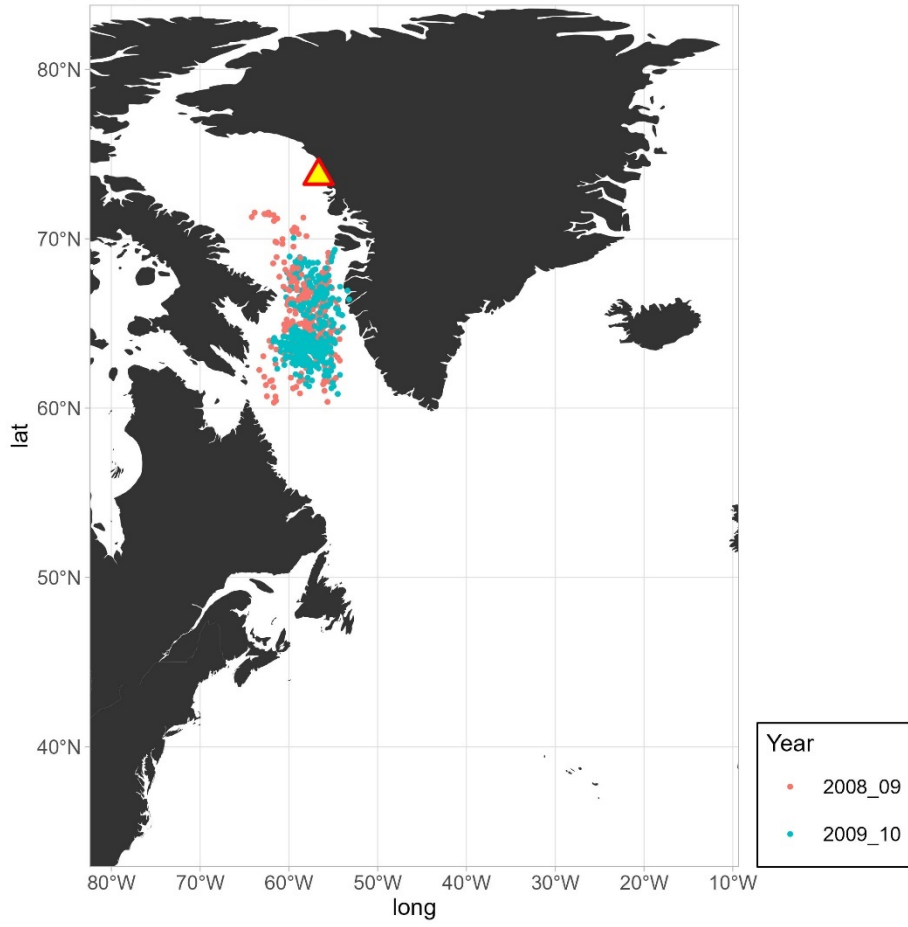
DKC\_4286923 from Kippaku



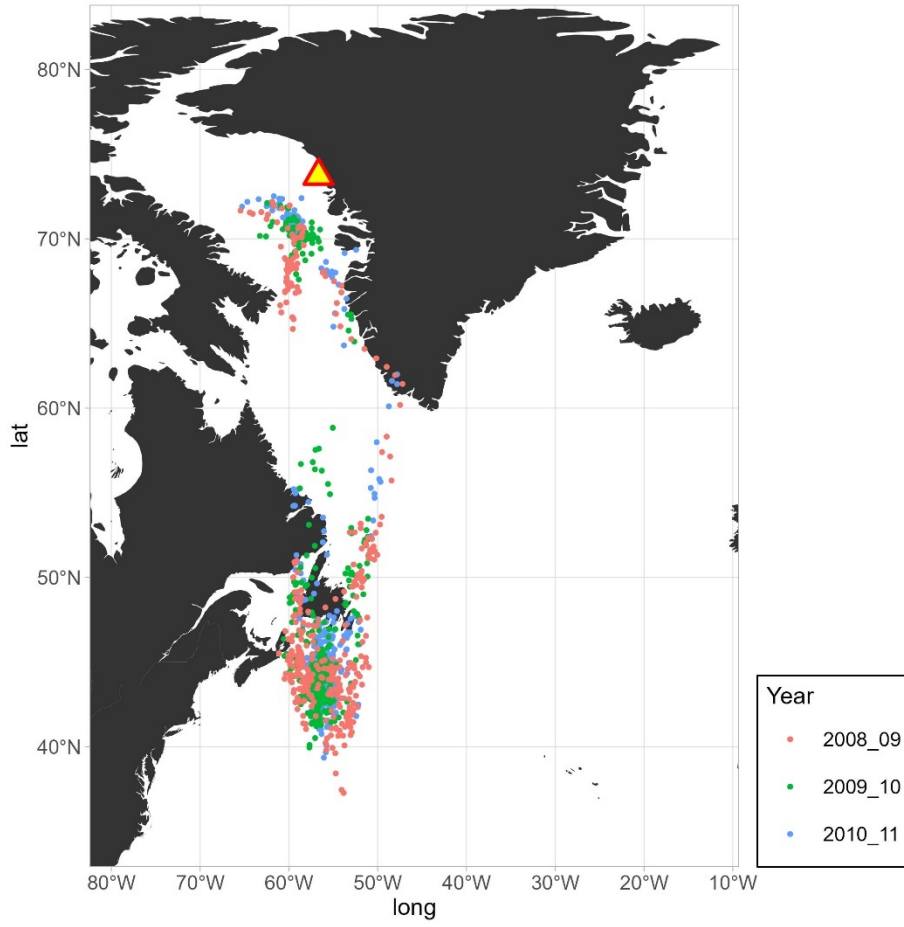
DKC\_4286927 from Kippaku



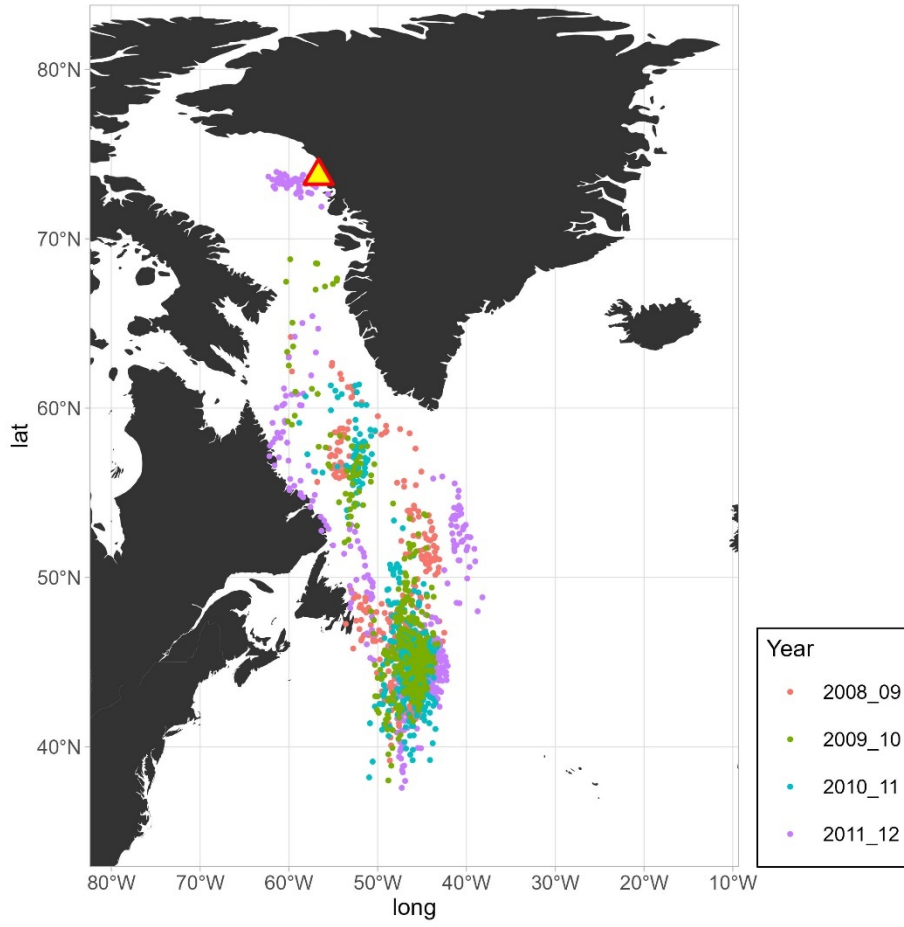
DKC\_4286929 from Kippaku



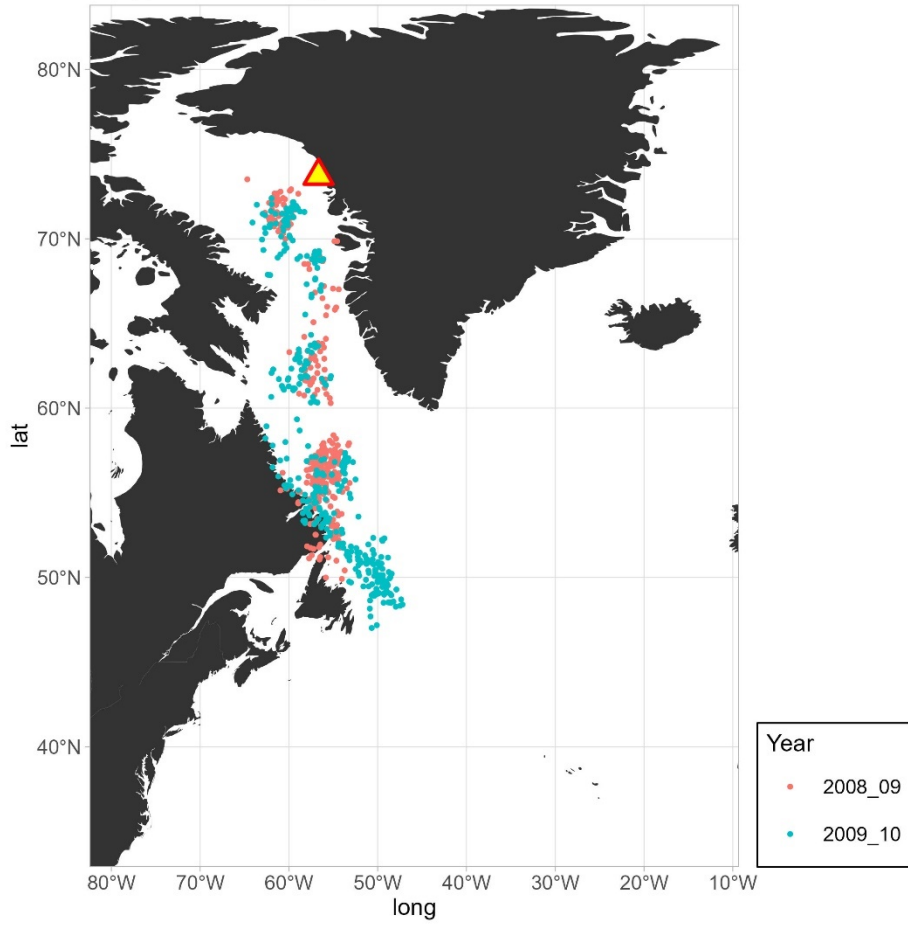
DKC\_4286930 from Kippaku



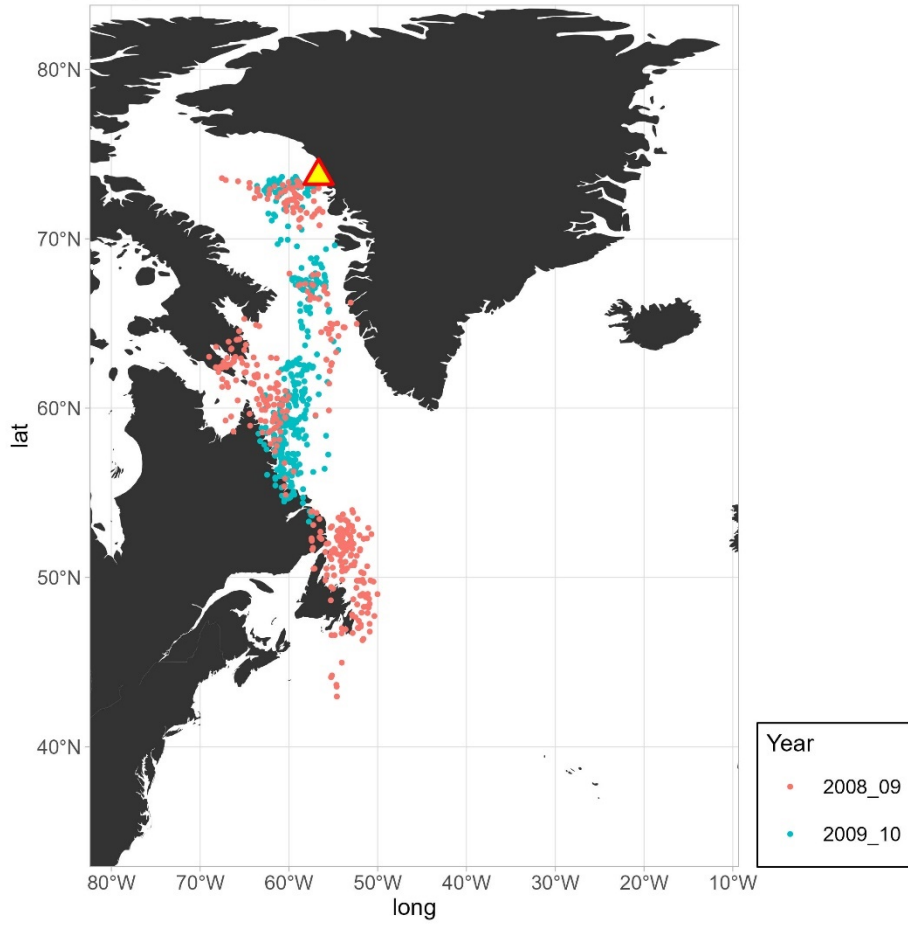
DKC\_4286931 from Kippaku



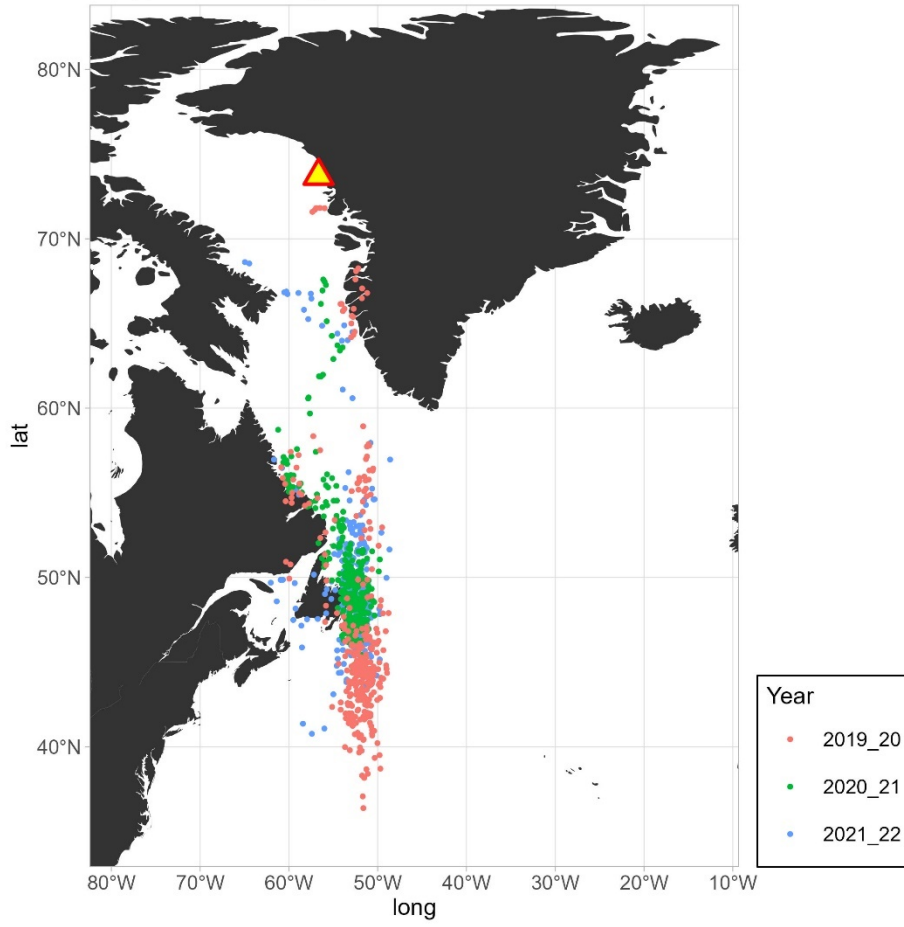
DKC\_4286932 from Kippaku



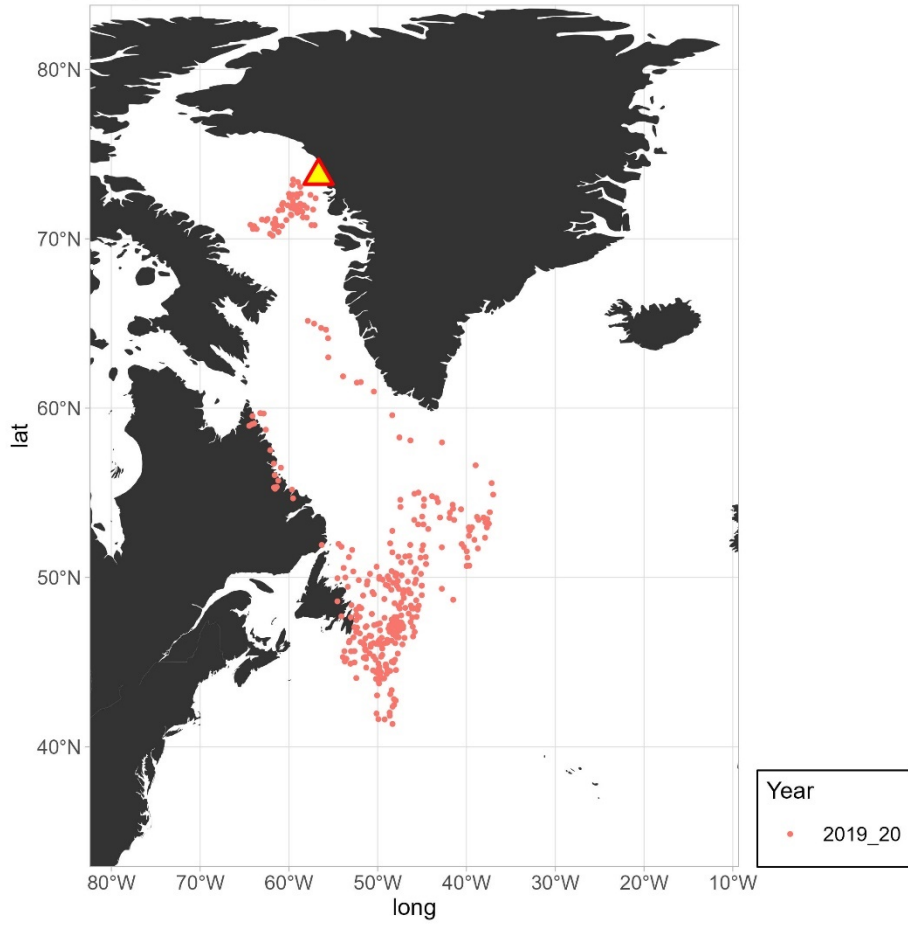
DKC\_4286933 from Kippaku



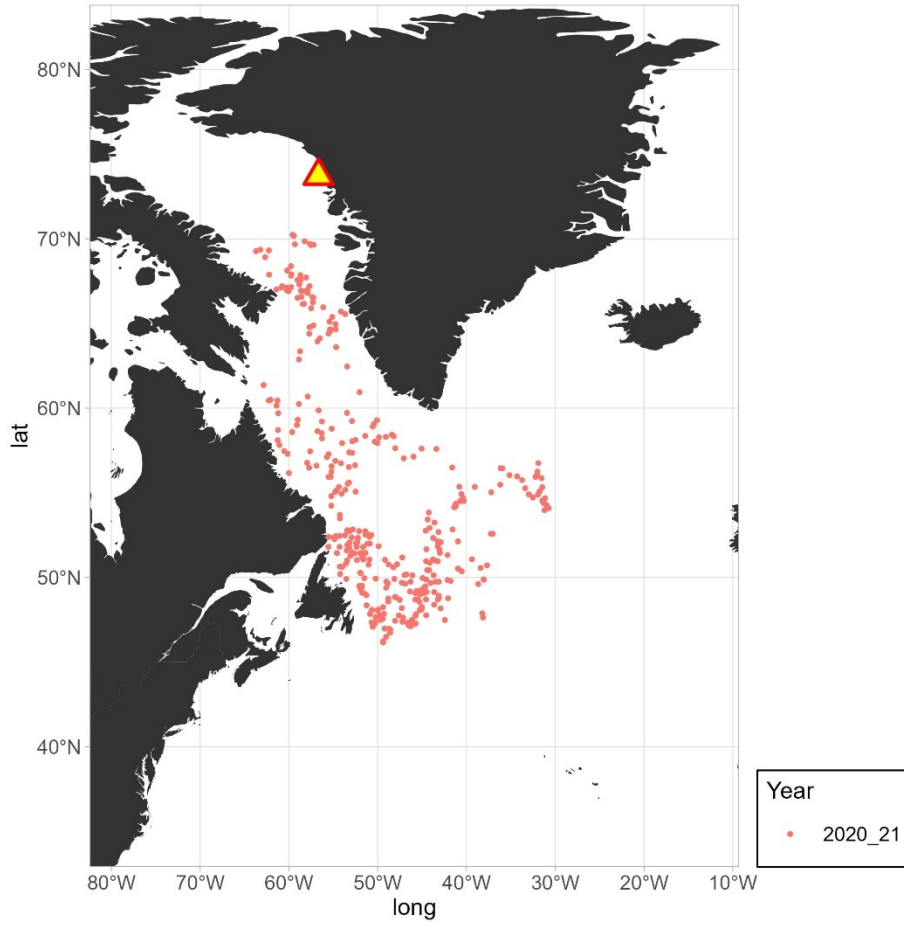
DKC\_4287000 from Kippaku



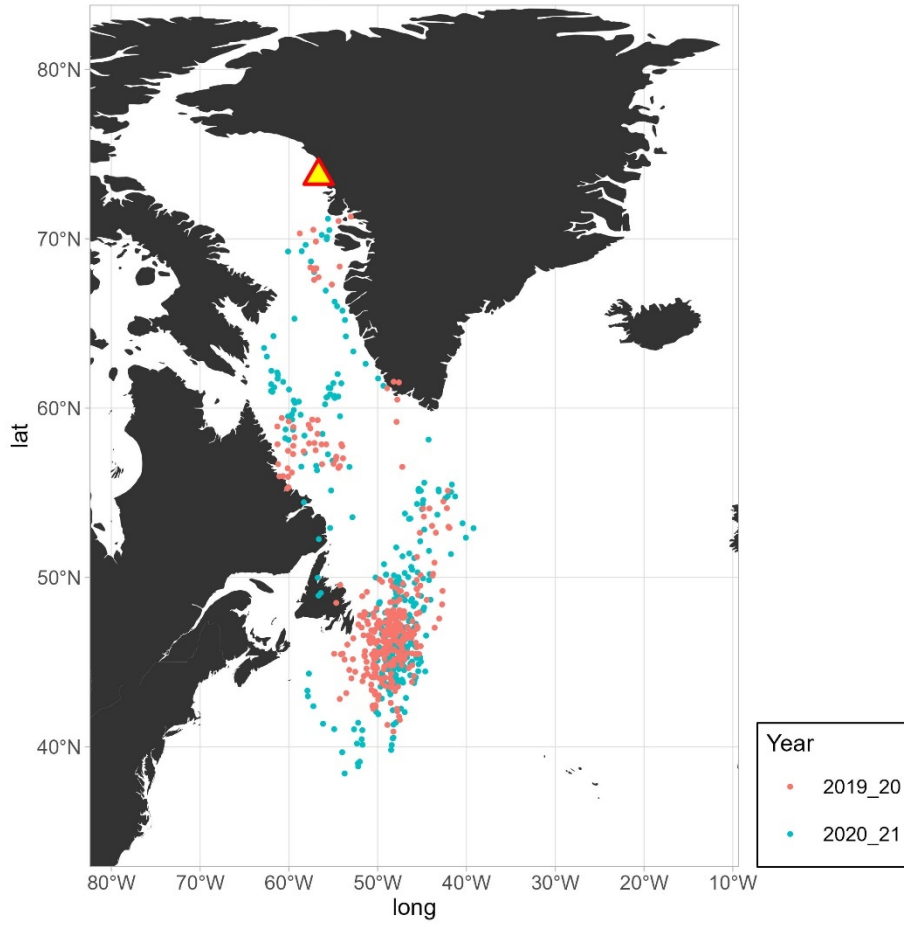
DKC\_4292640 from Kippaku



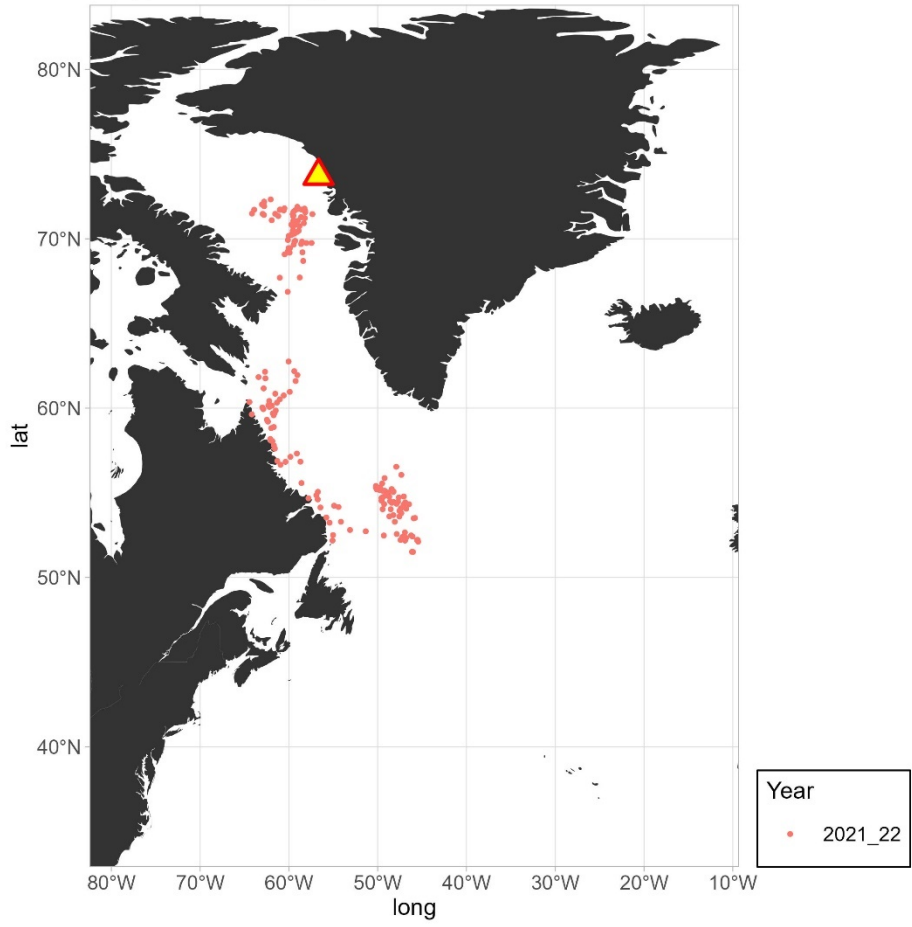
DKC\_4292641 from Kippaku



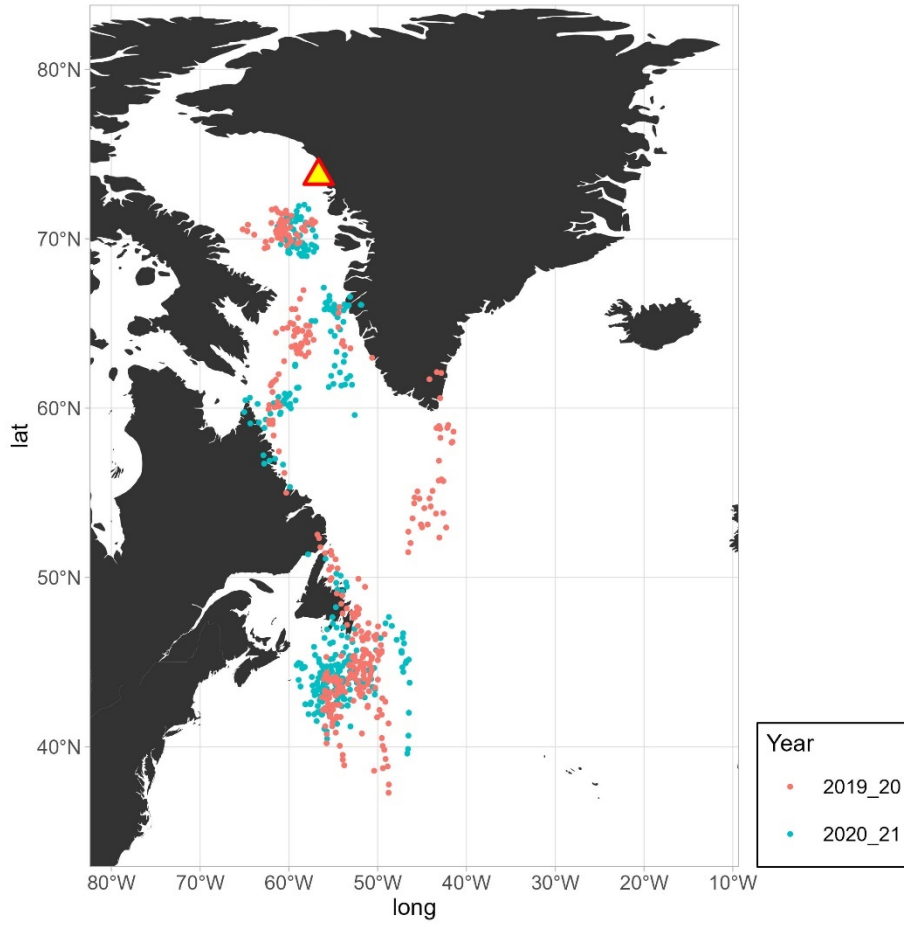
DKC\_4292646 from Kippaku



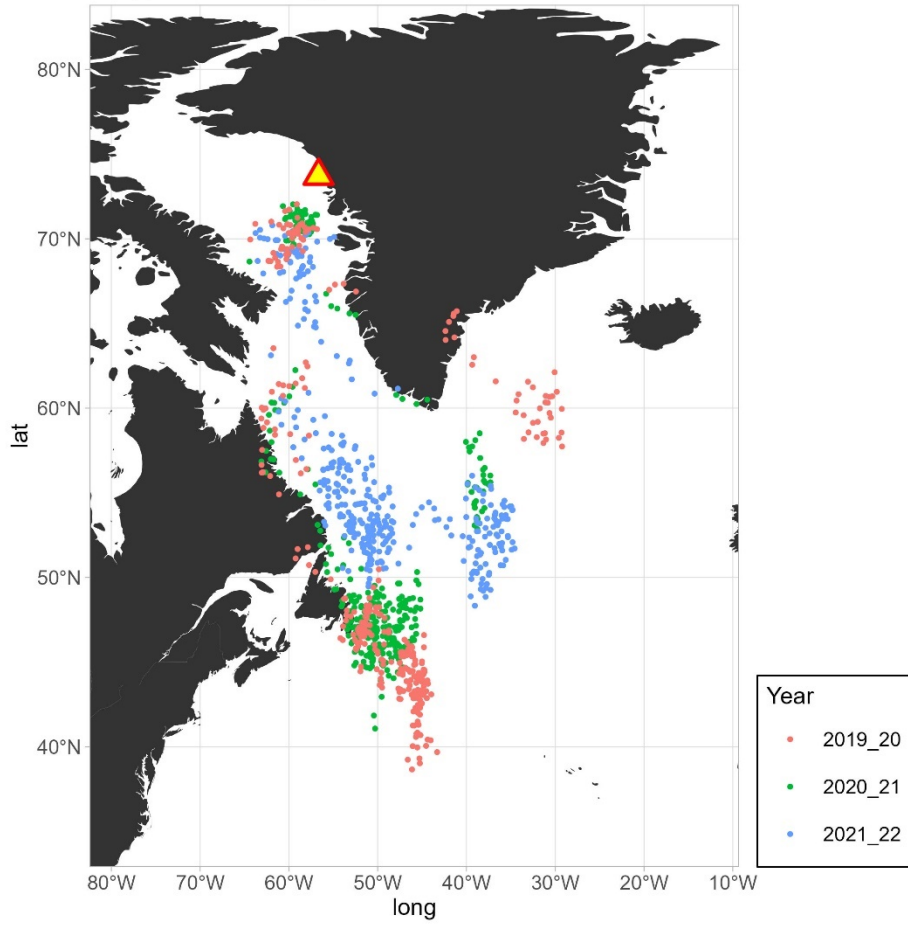
DKC\_4292659 from Kippaku



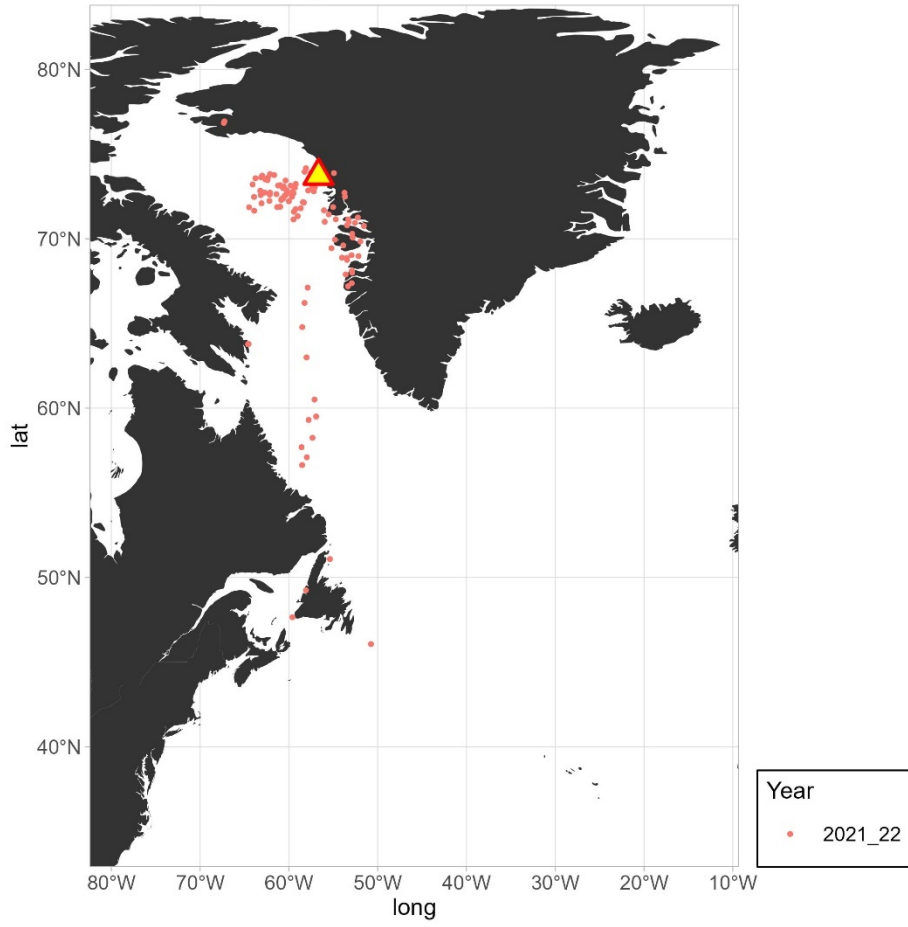
DKC\_4292698 from Kippaku



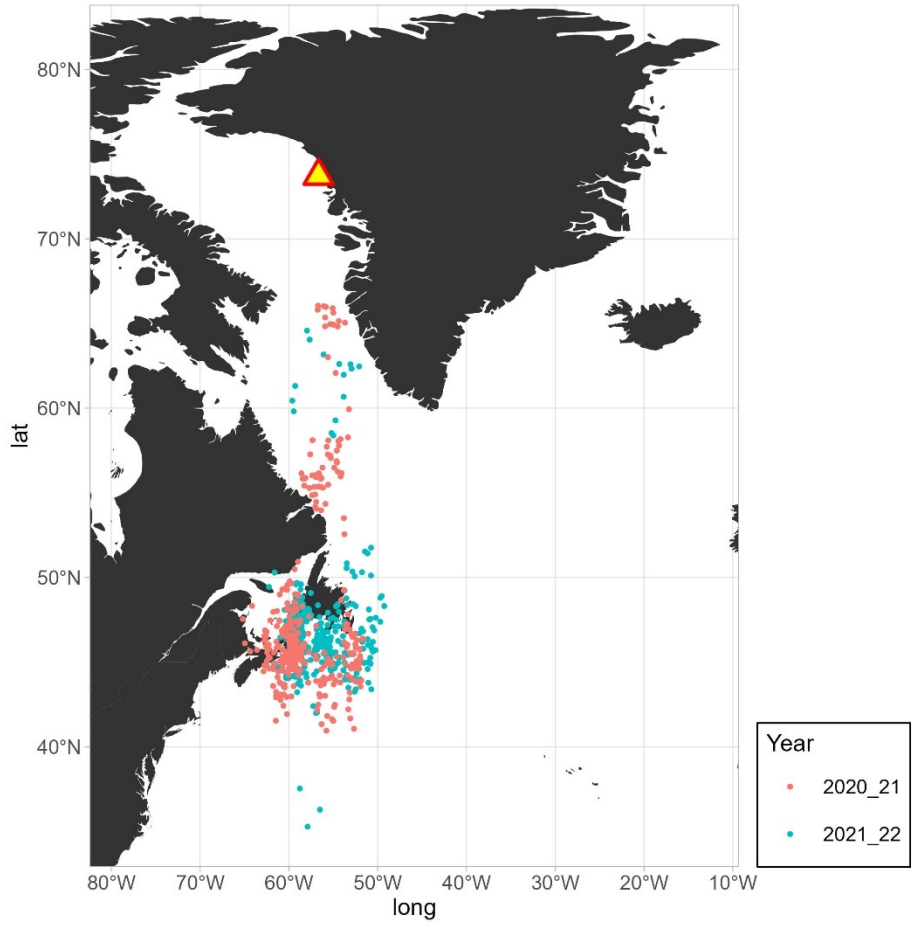
DKC\_4298509 from Kippaku



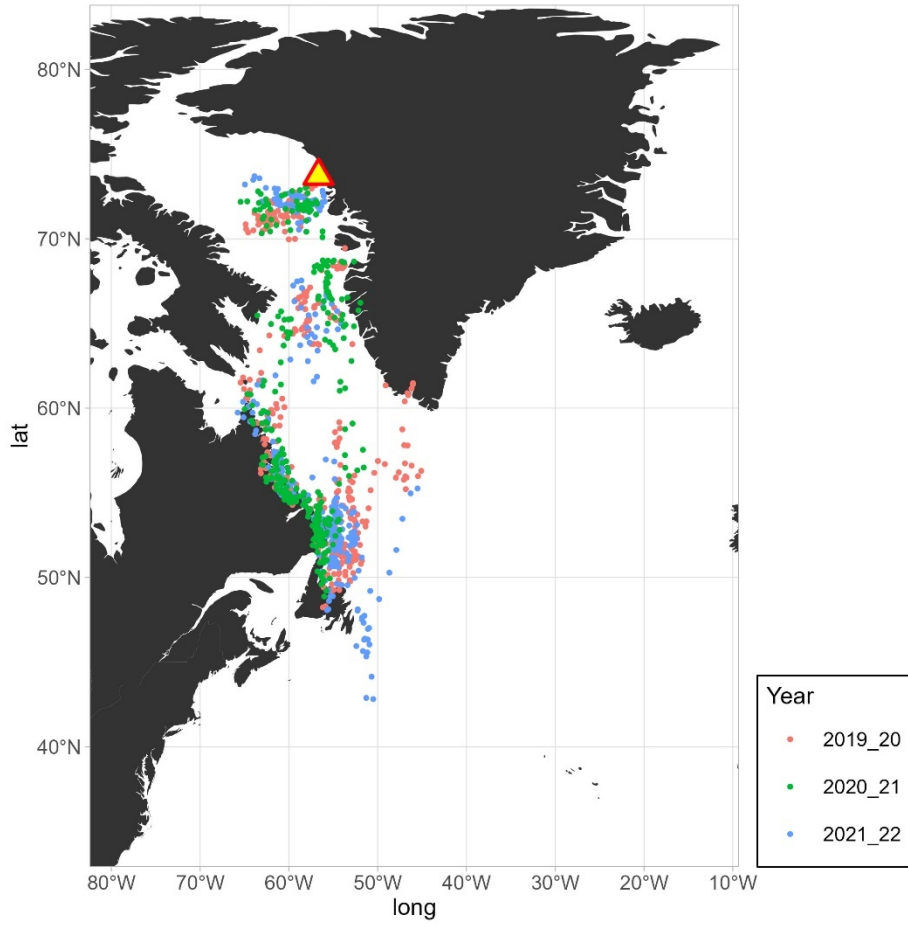
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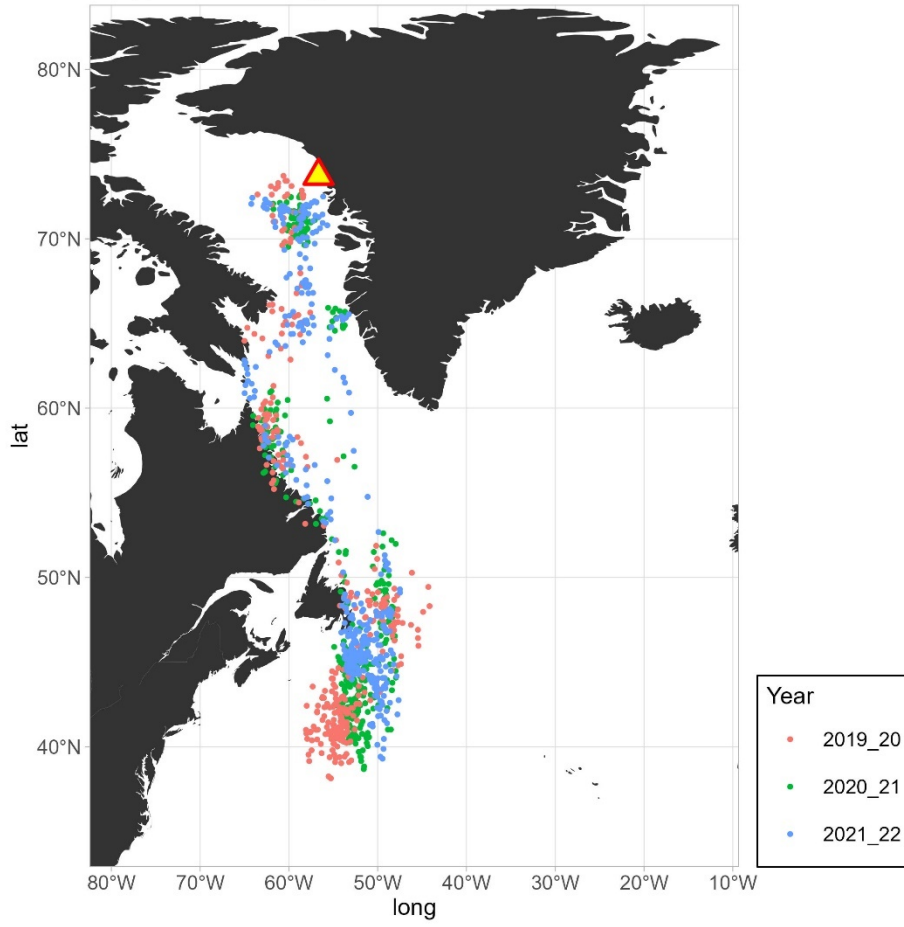
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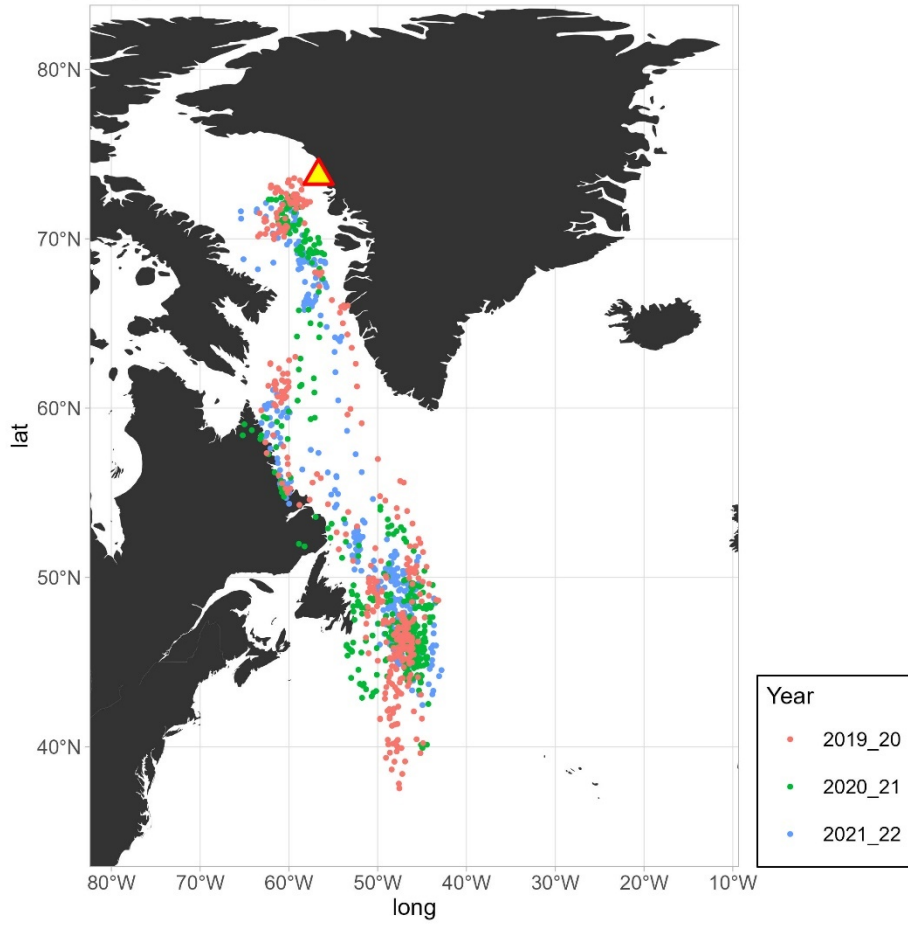
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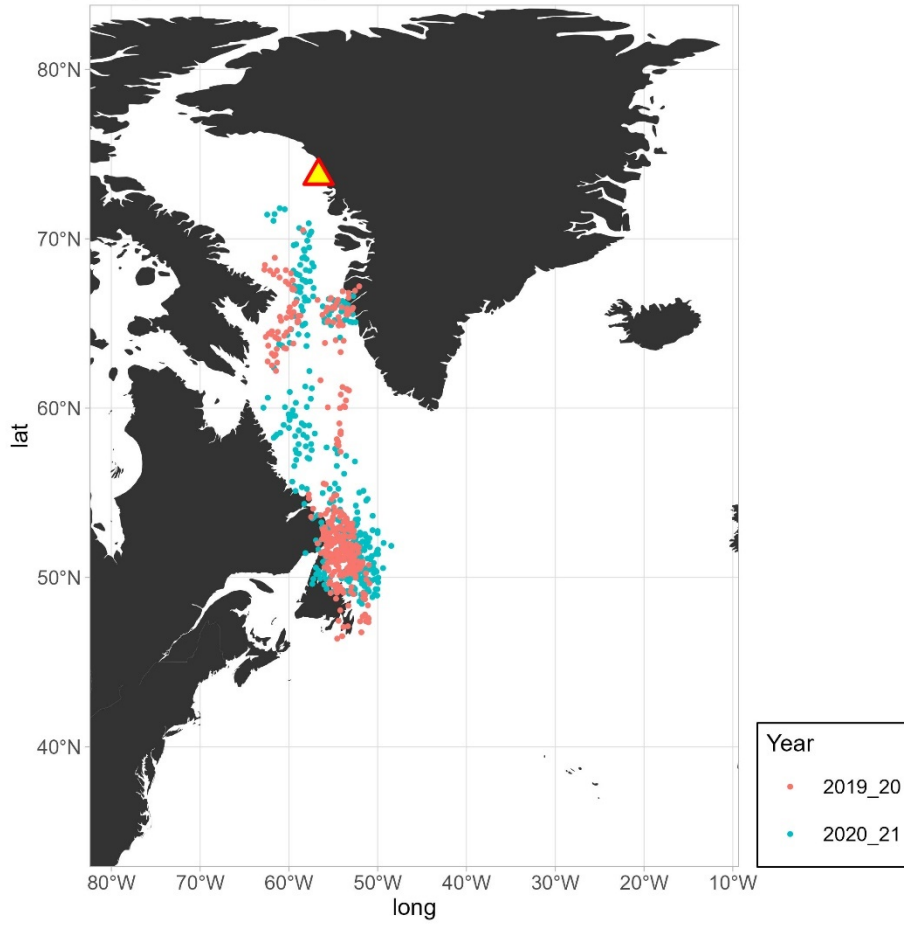
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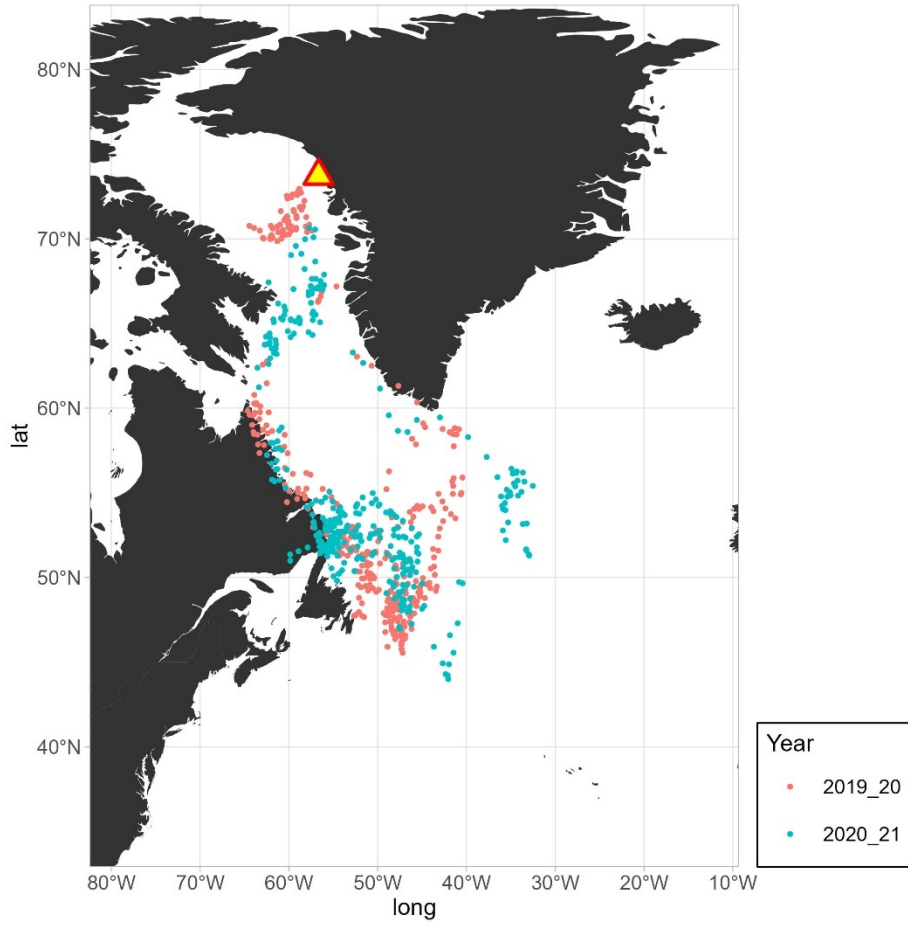
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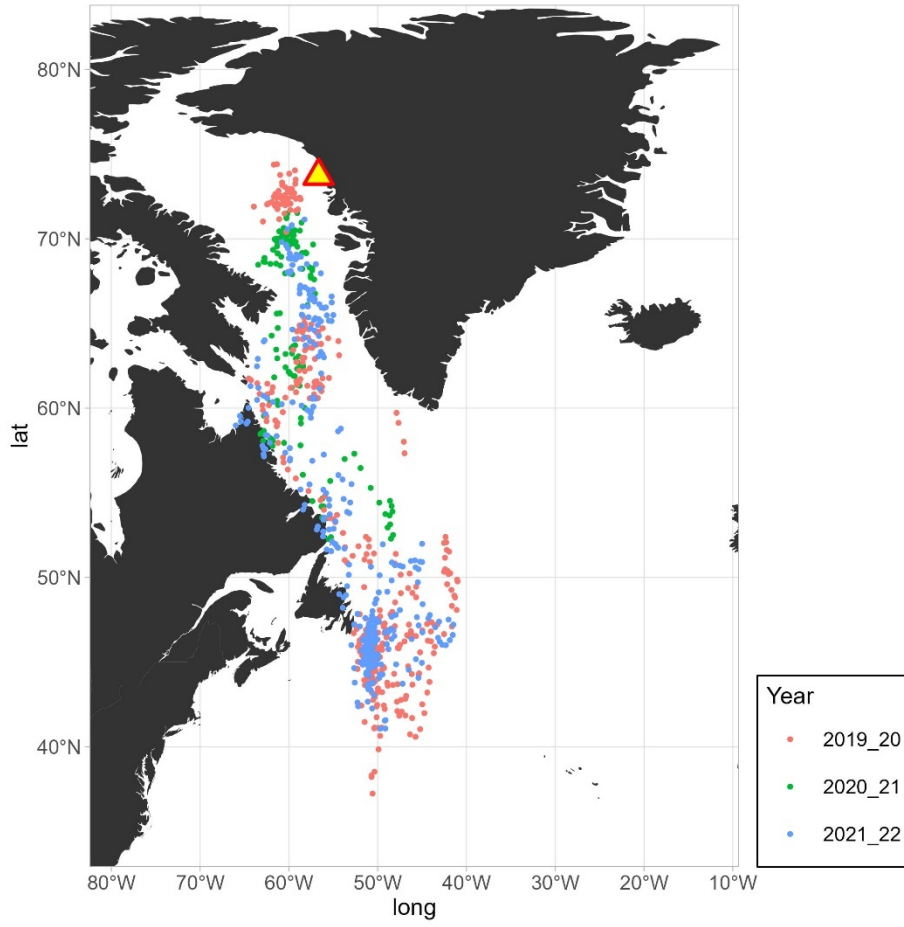
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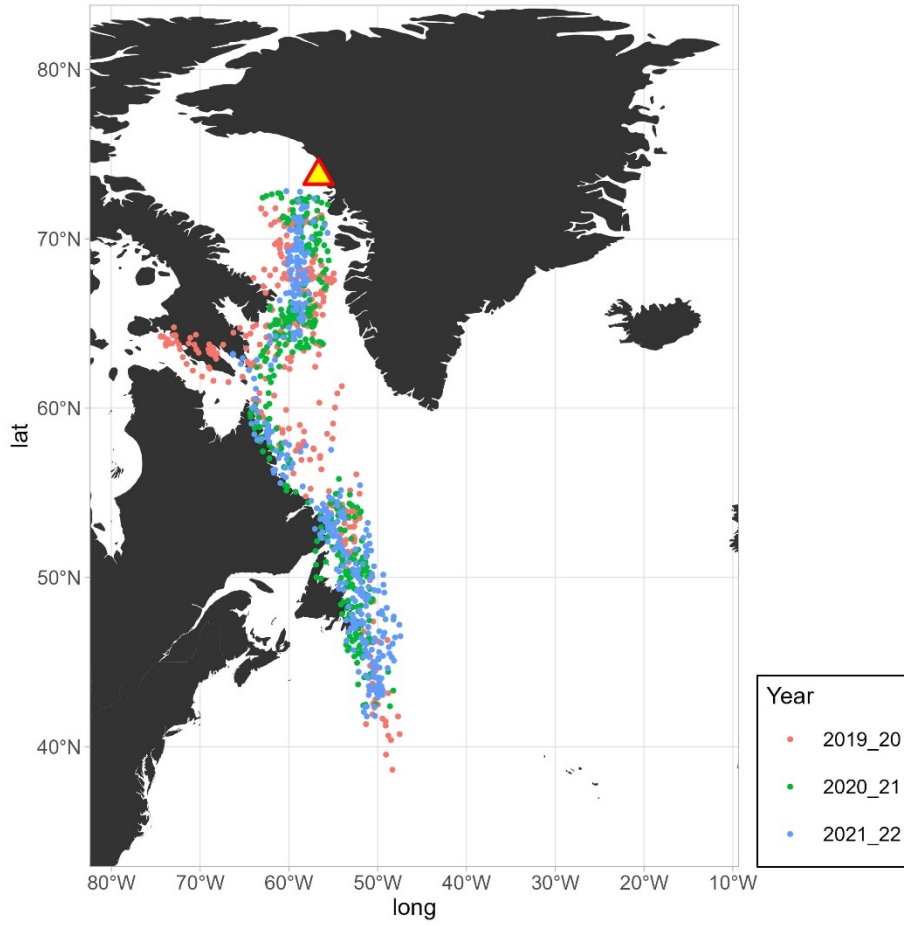
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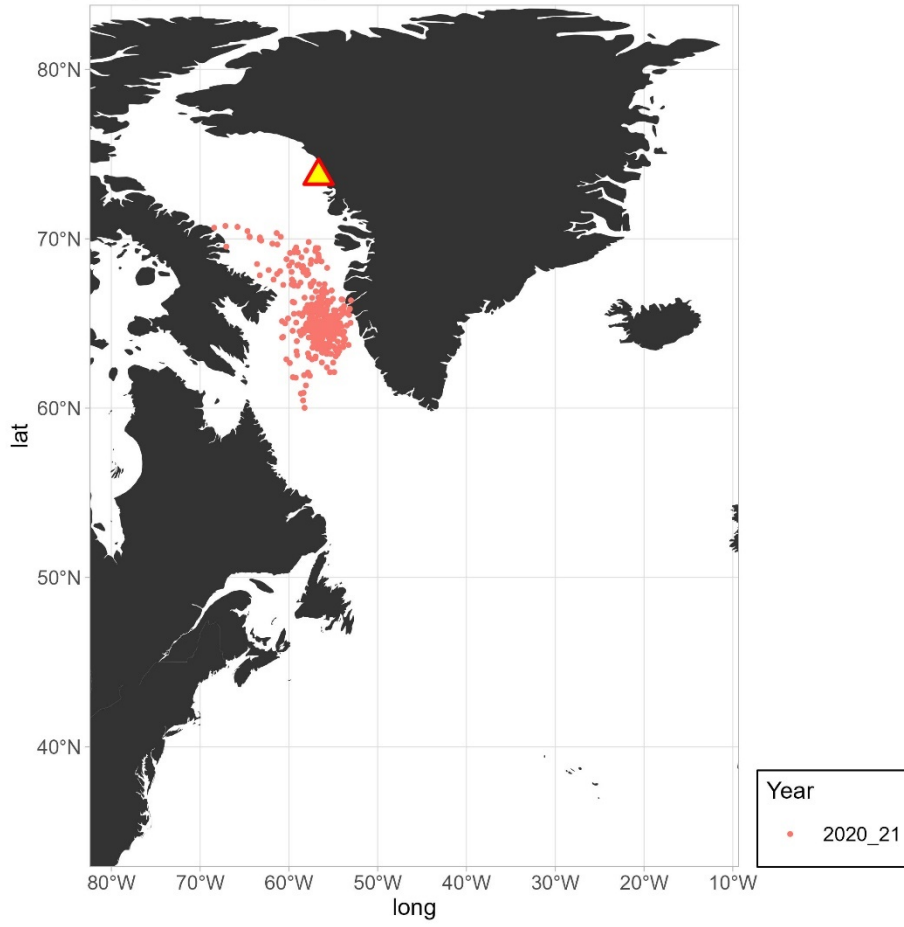
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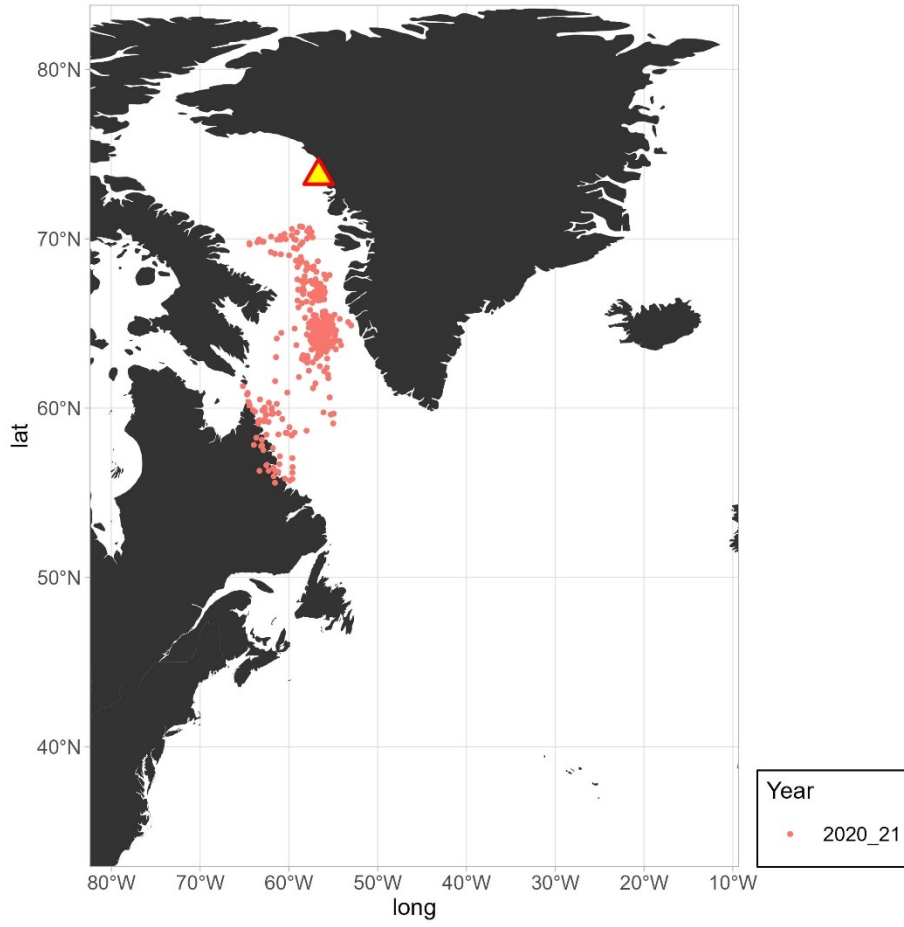
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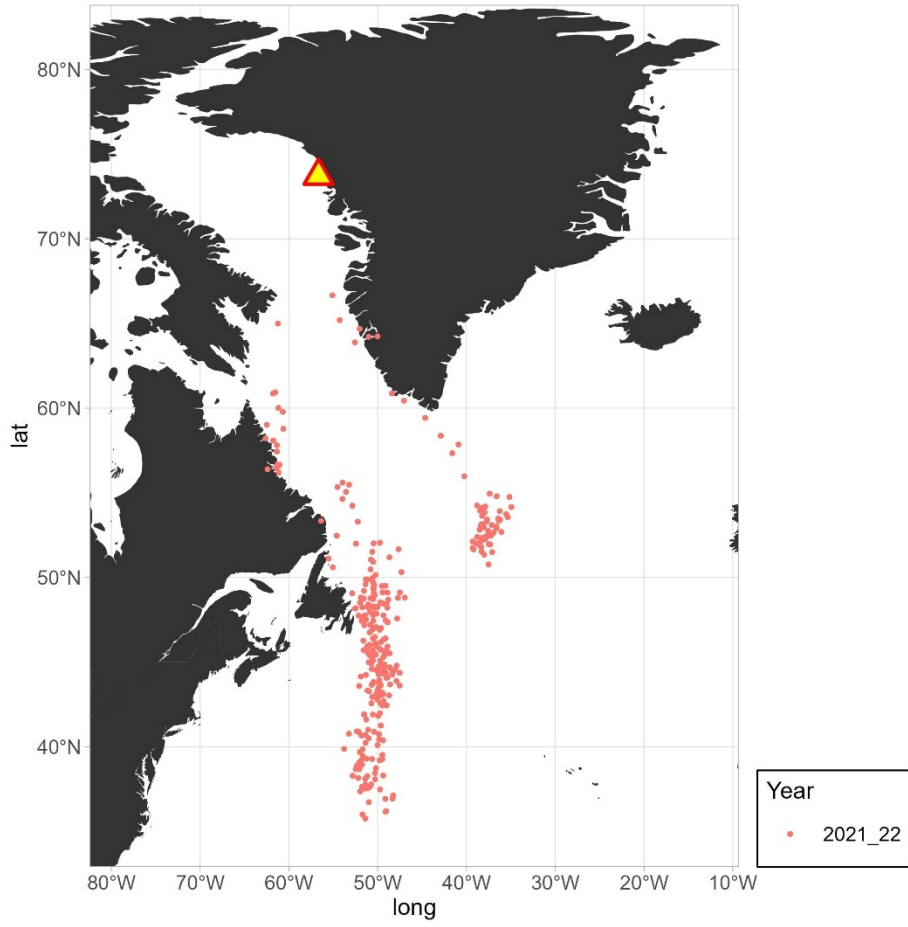
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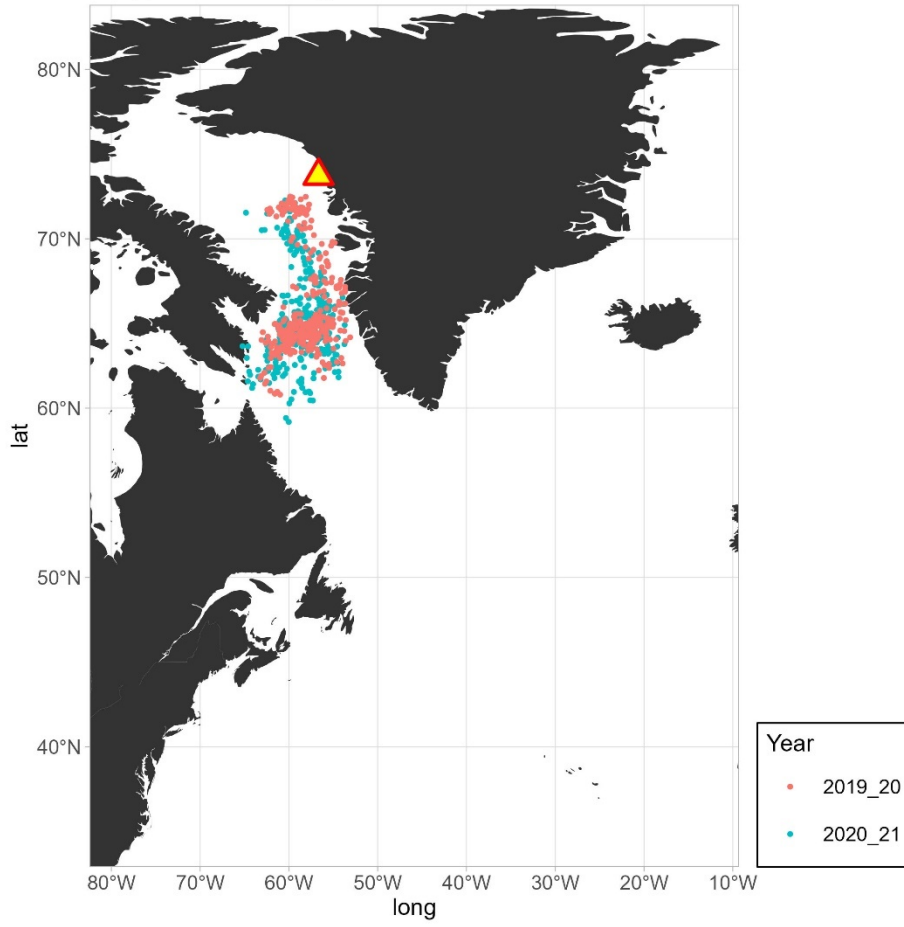
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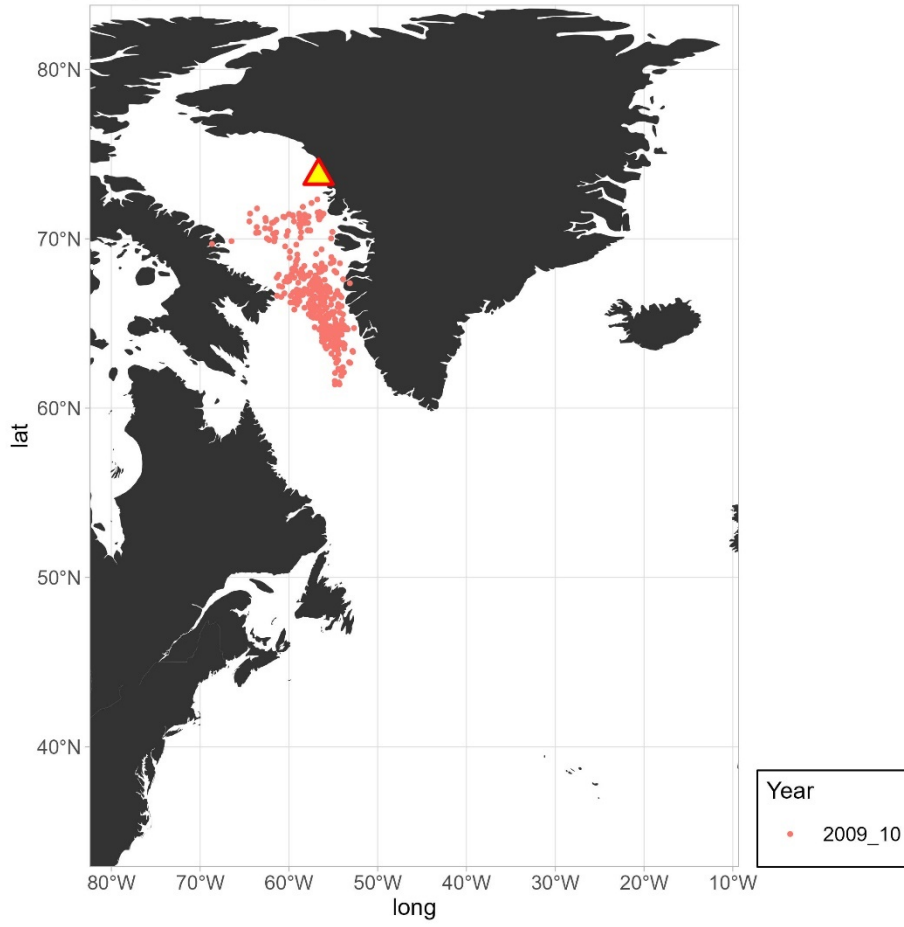
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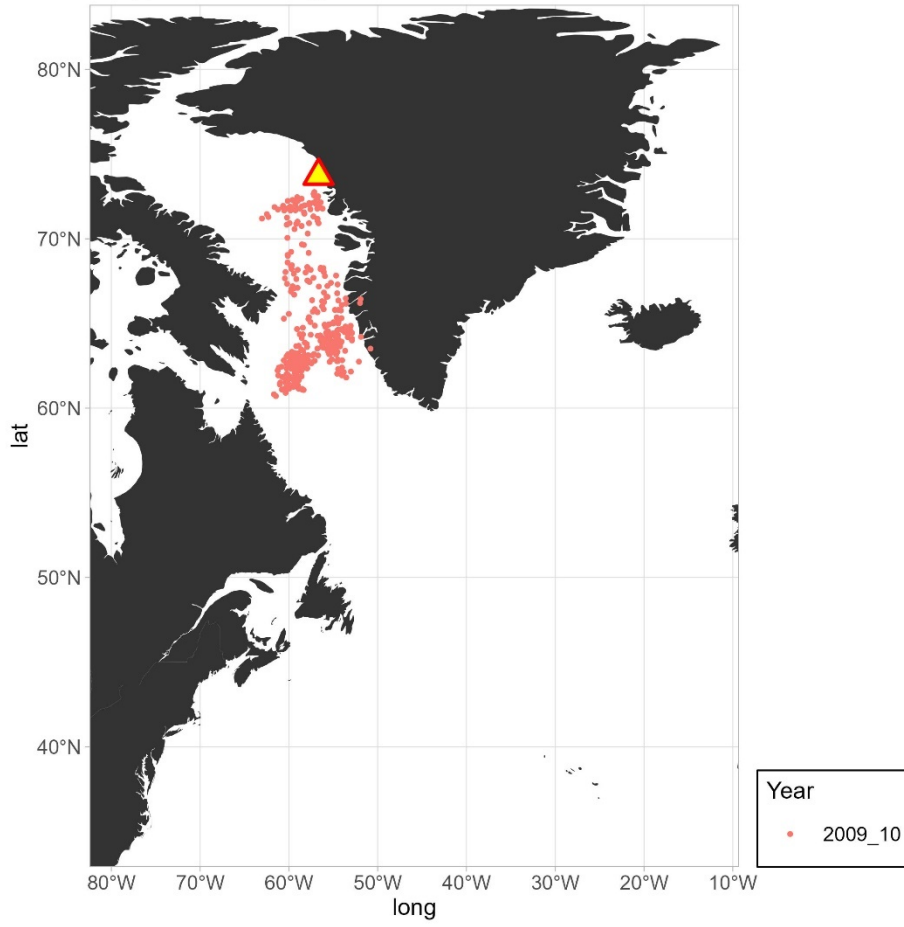
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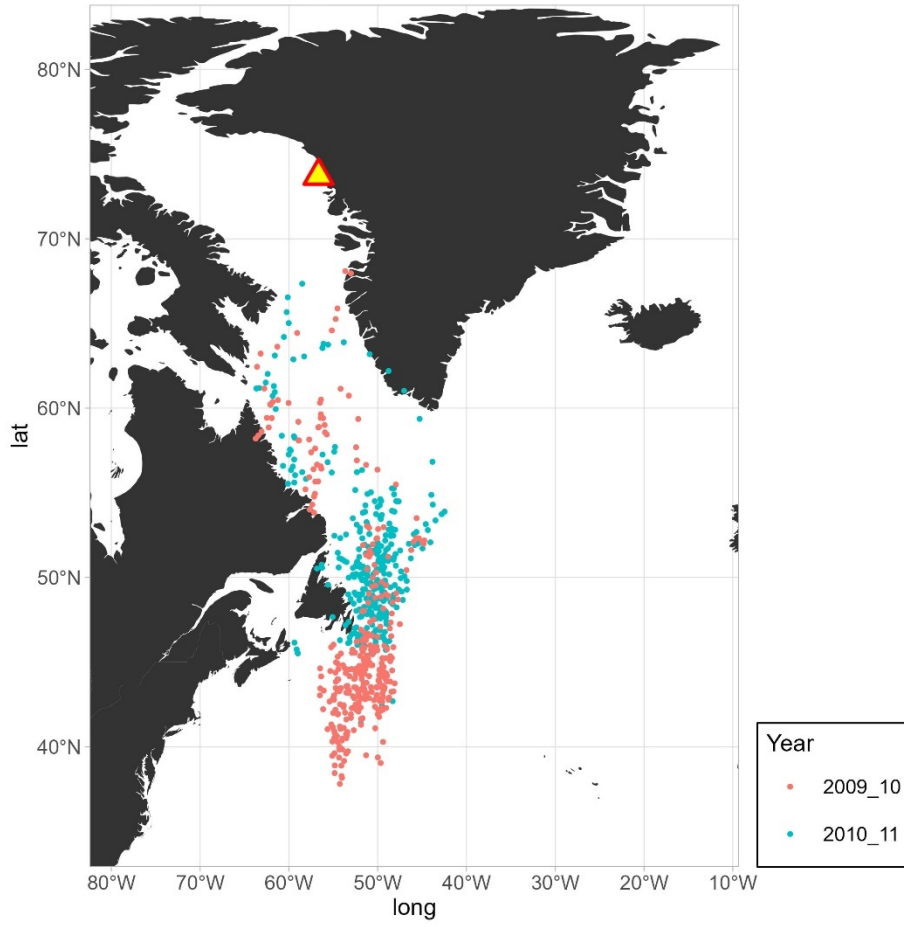
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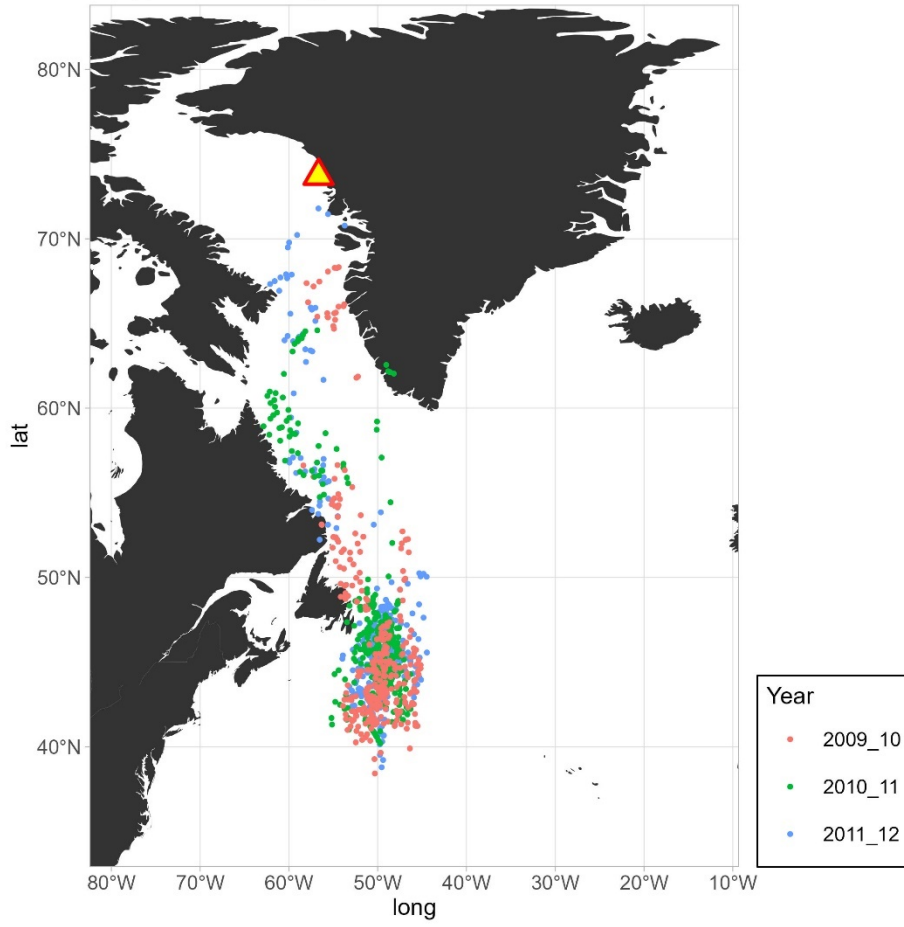
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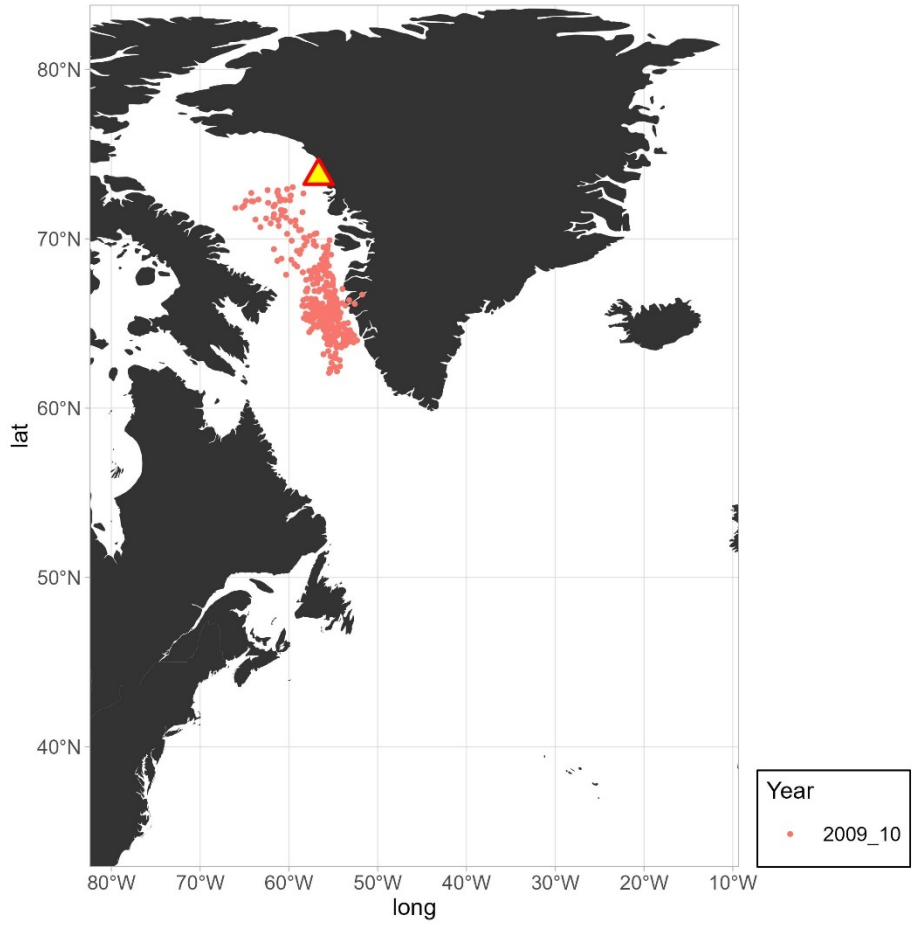
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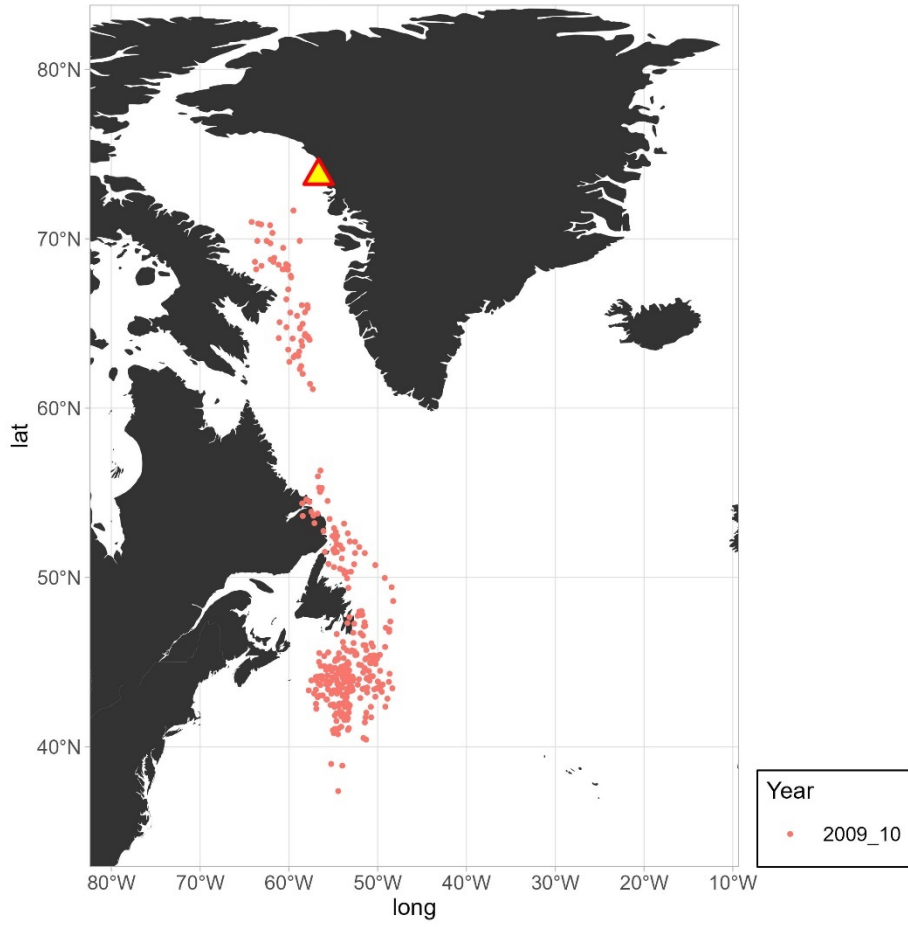
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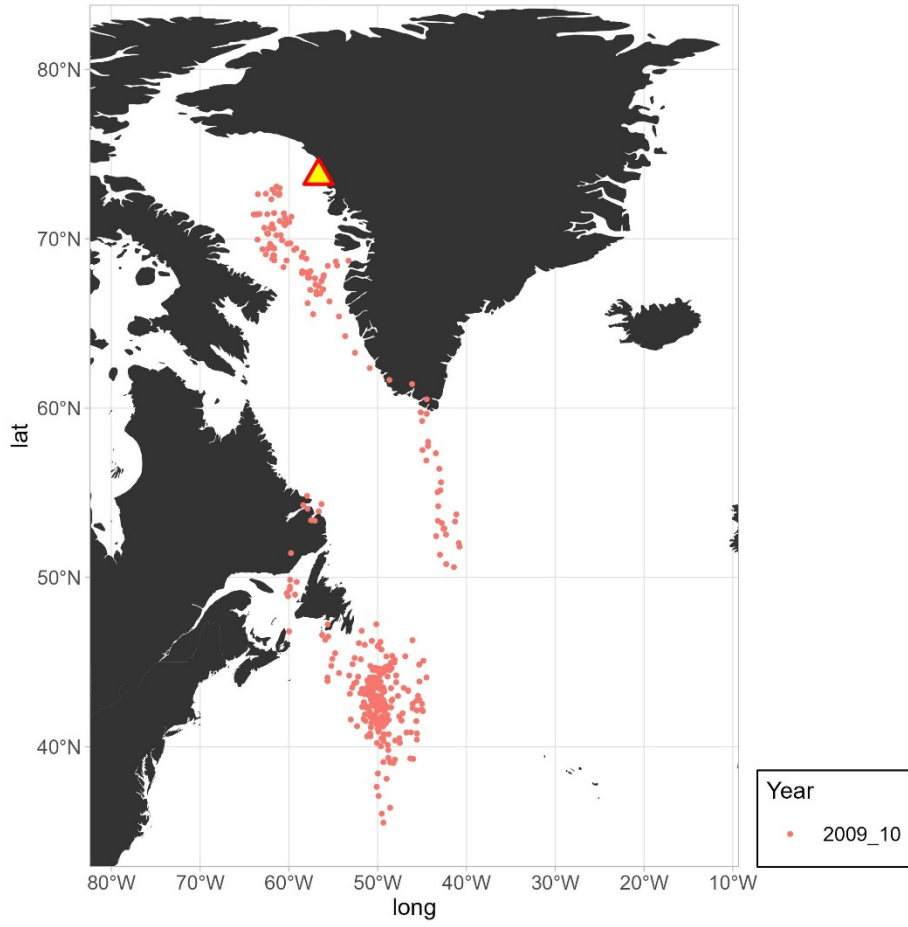
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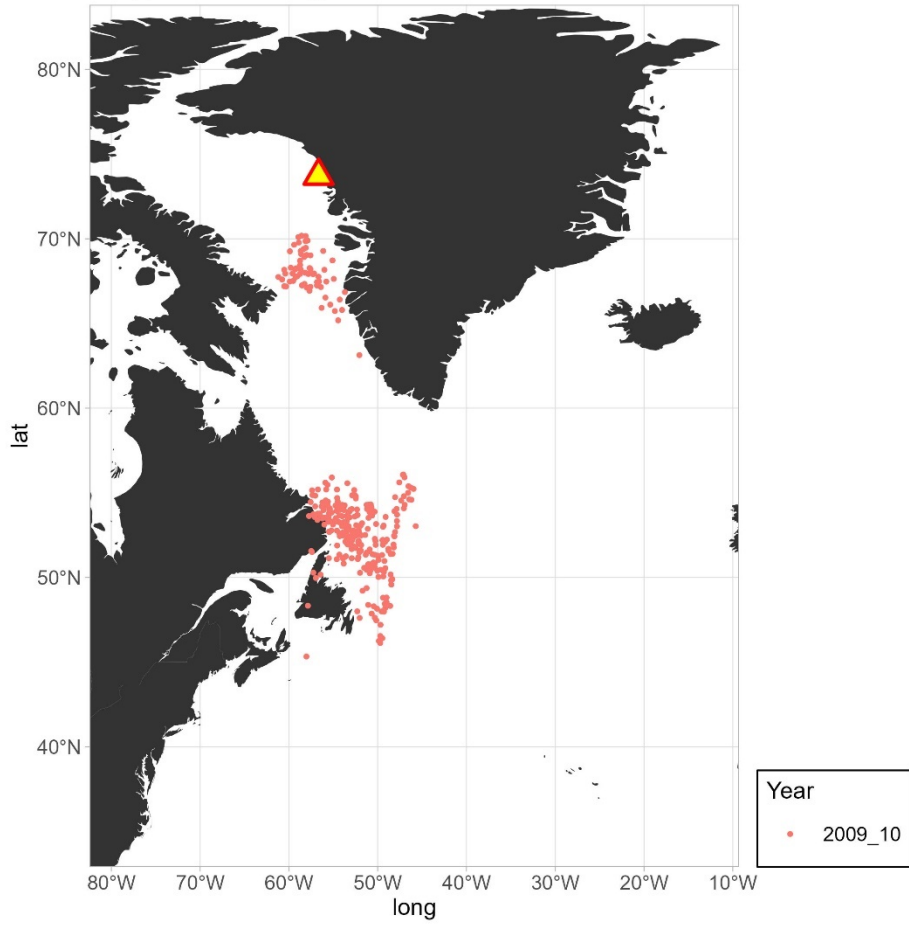
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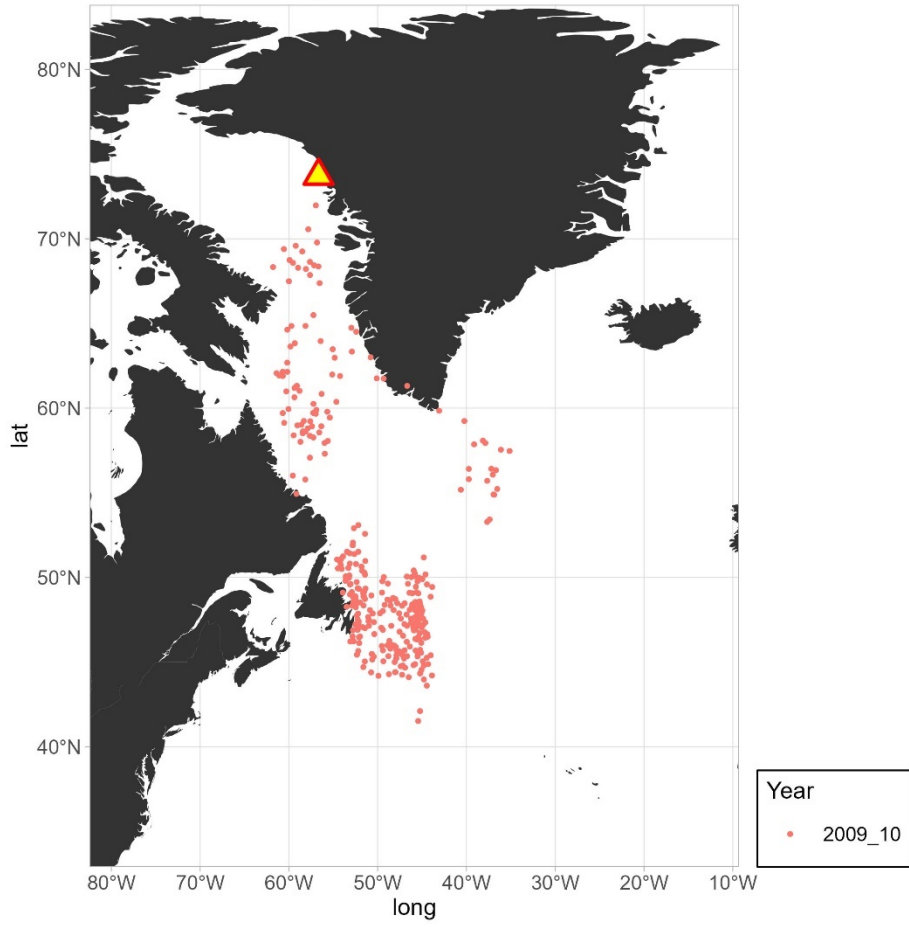
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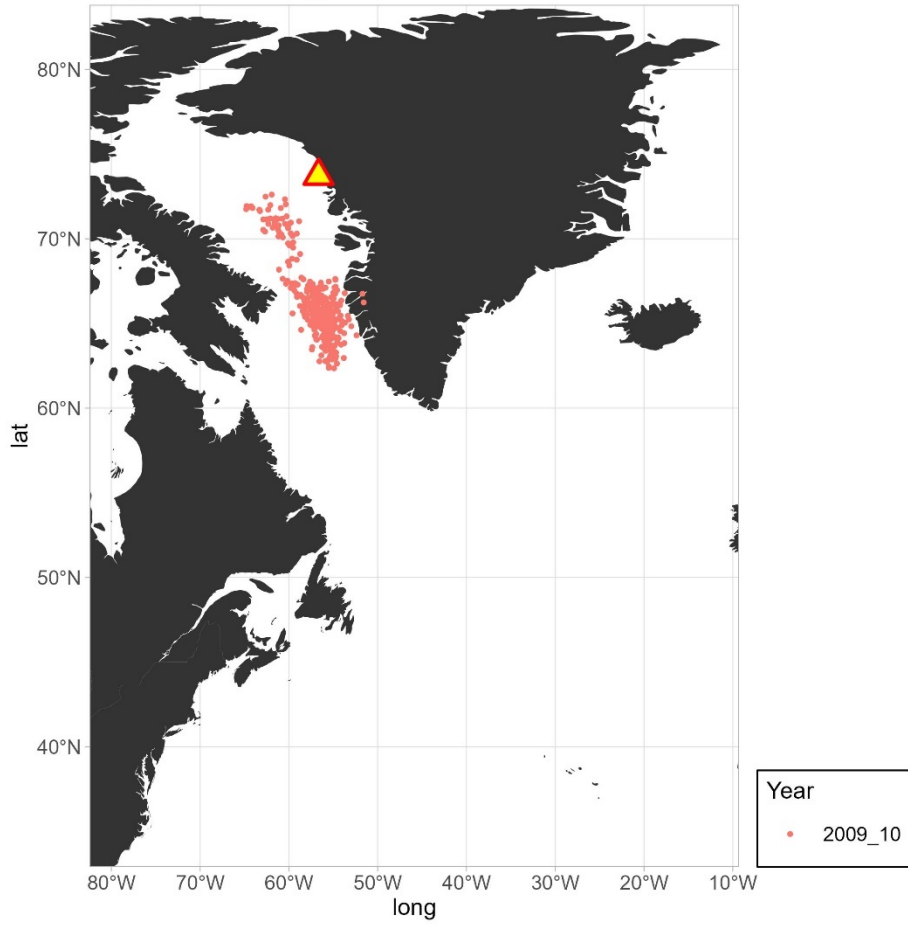
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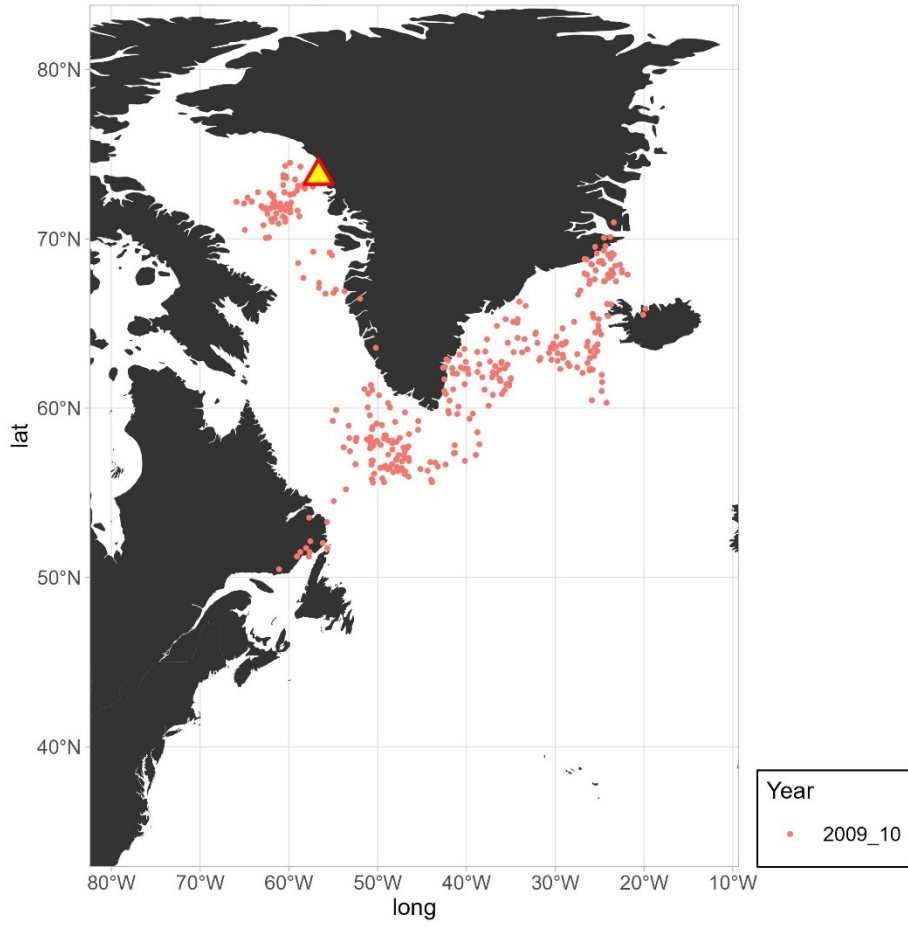
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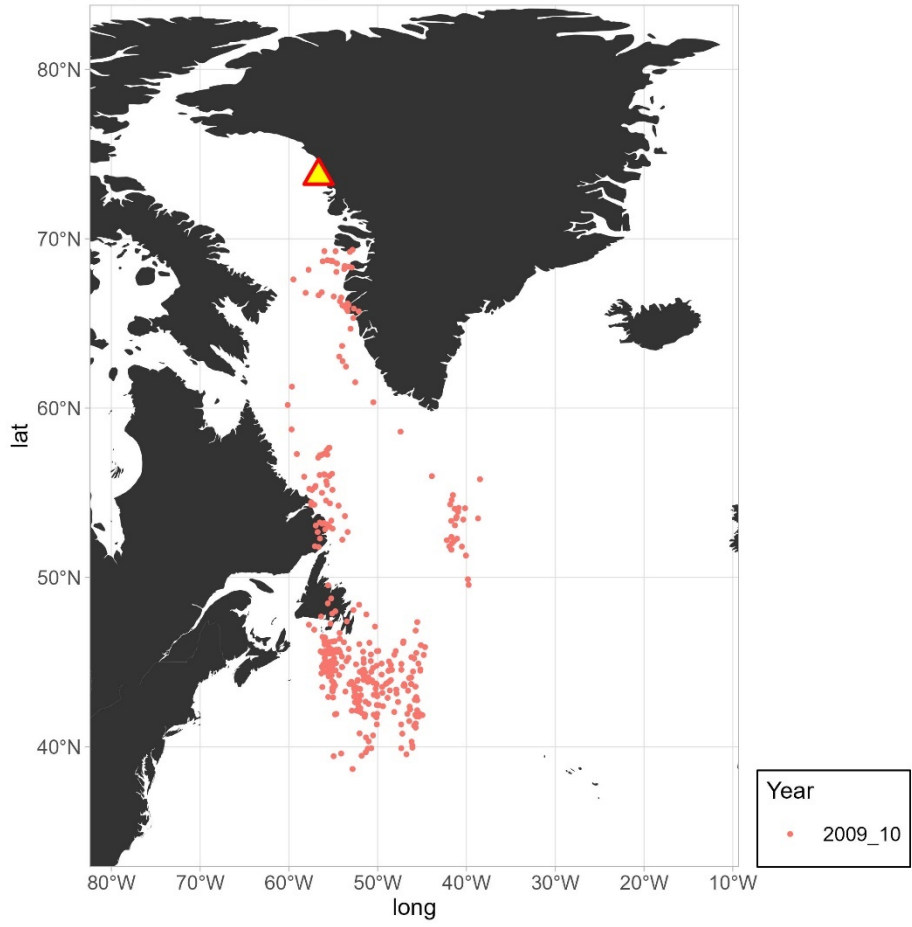
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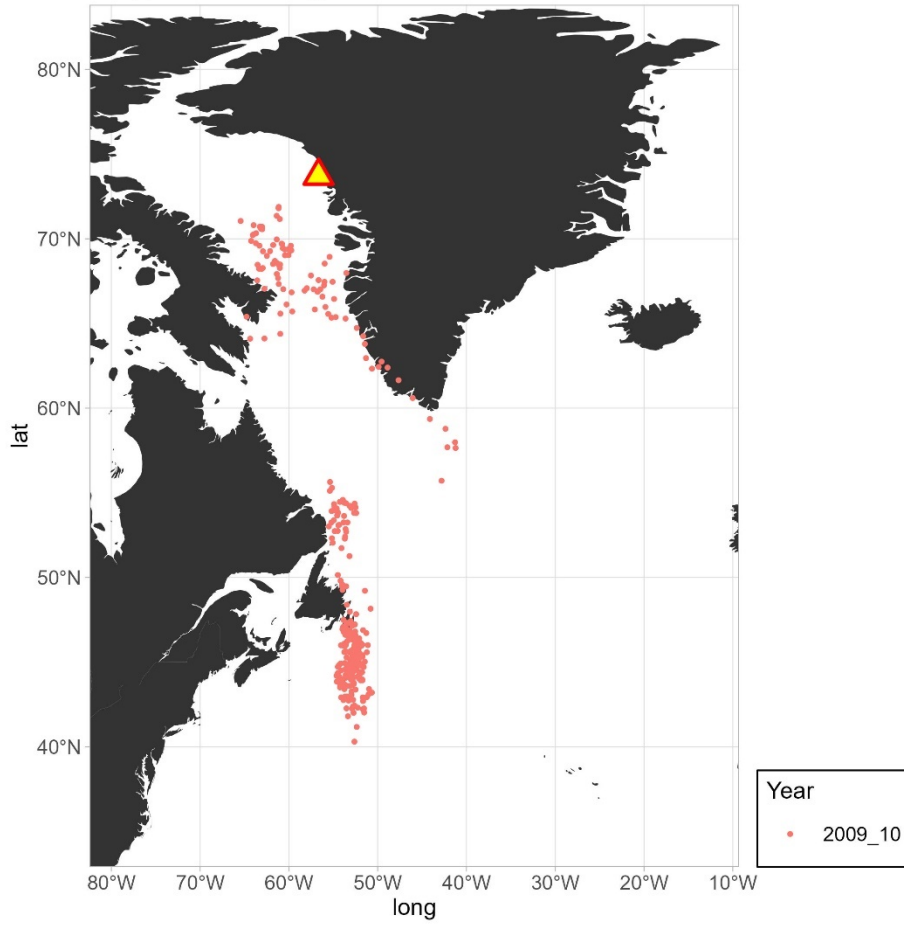
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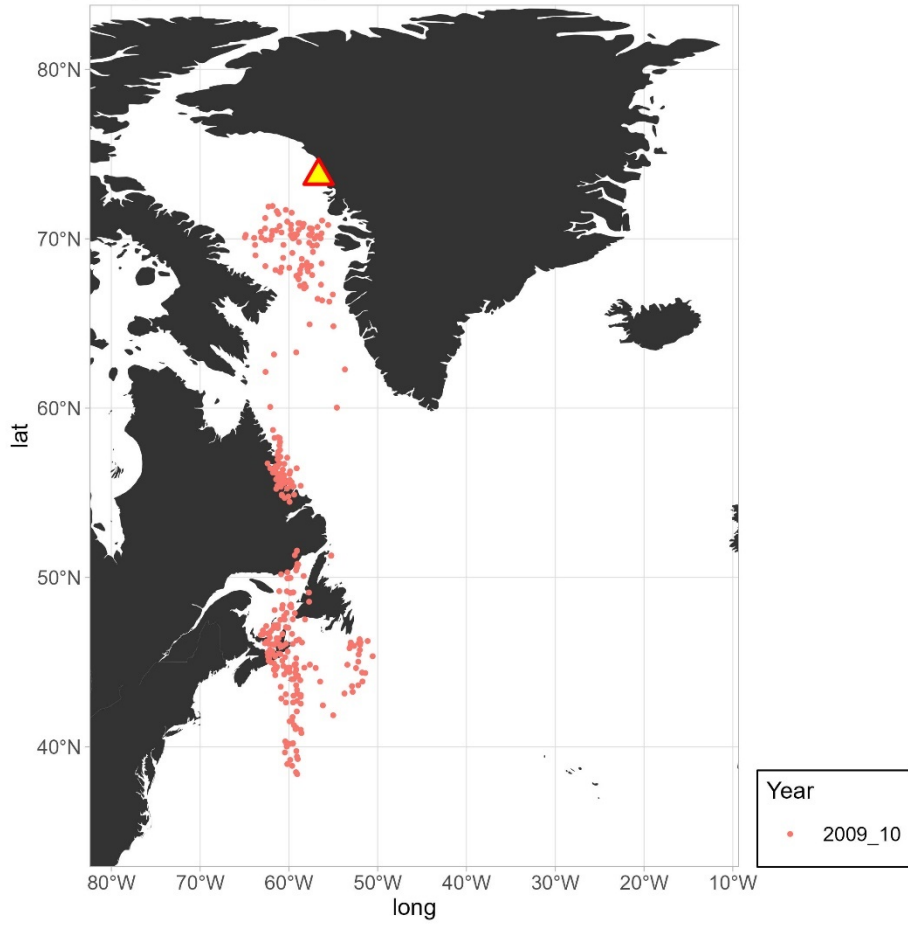
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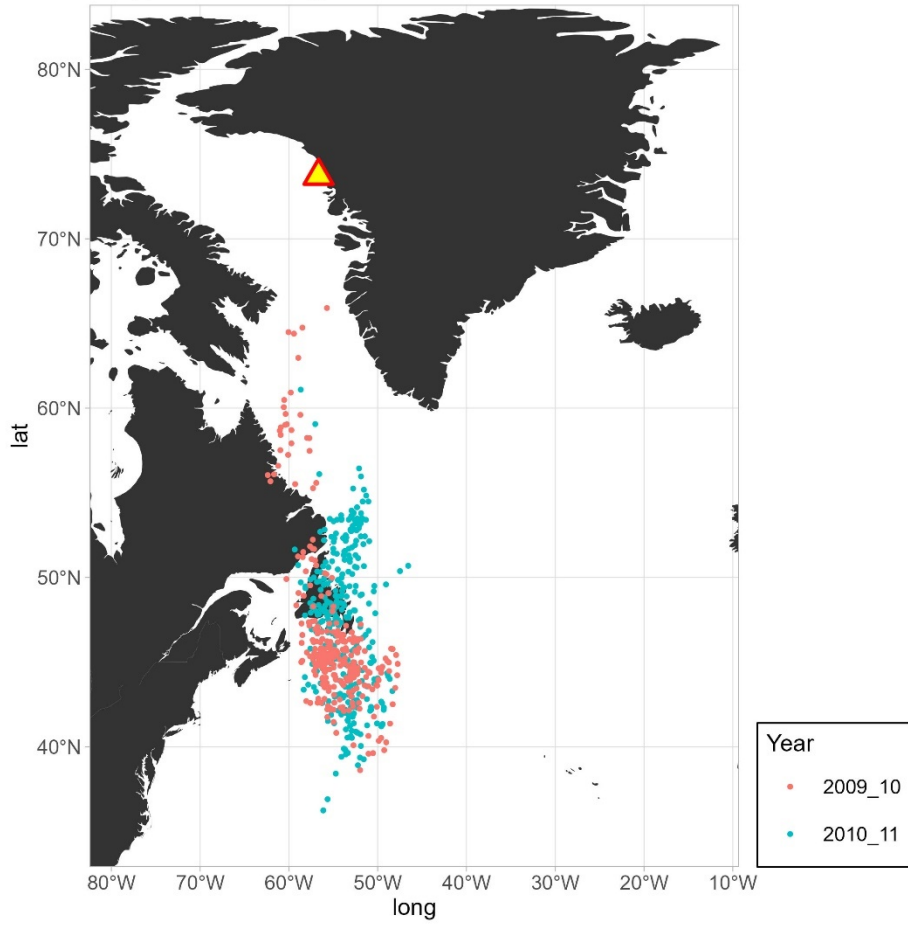
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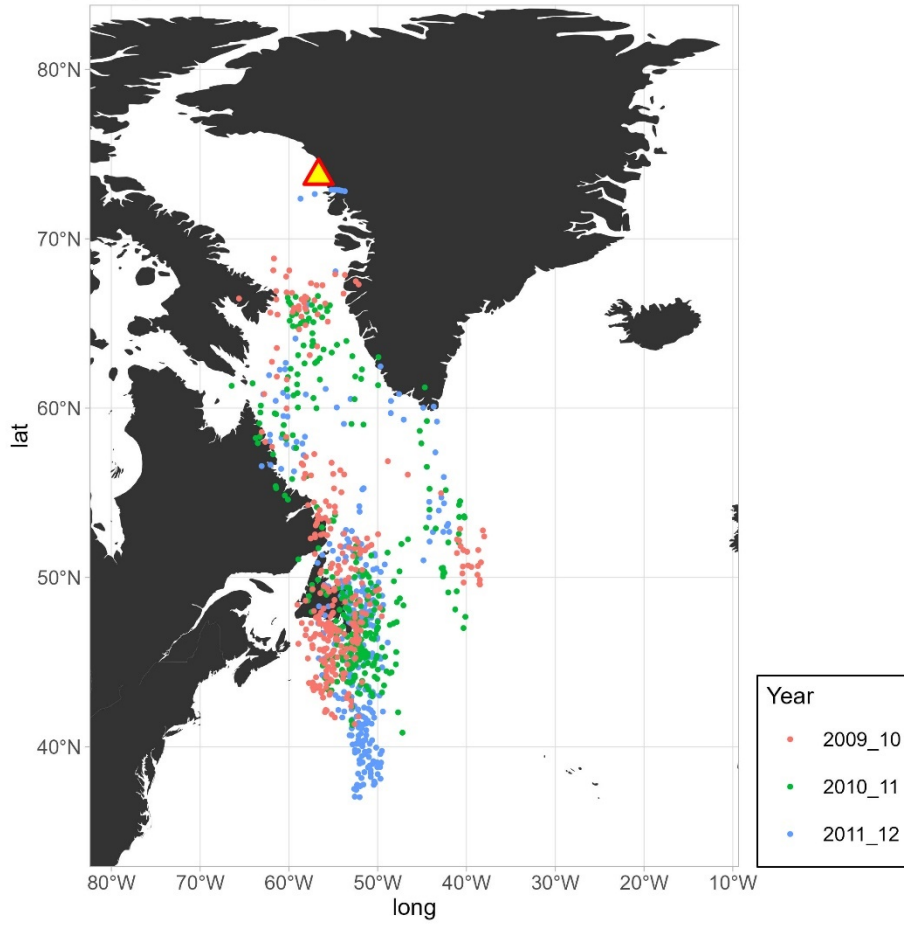
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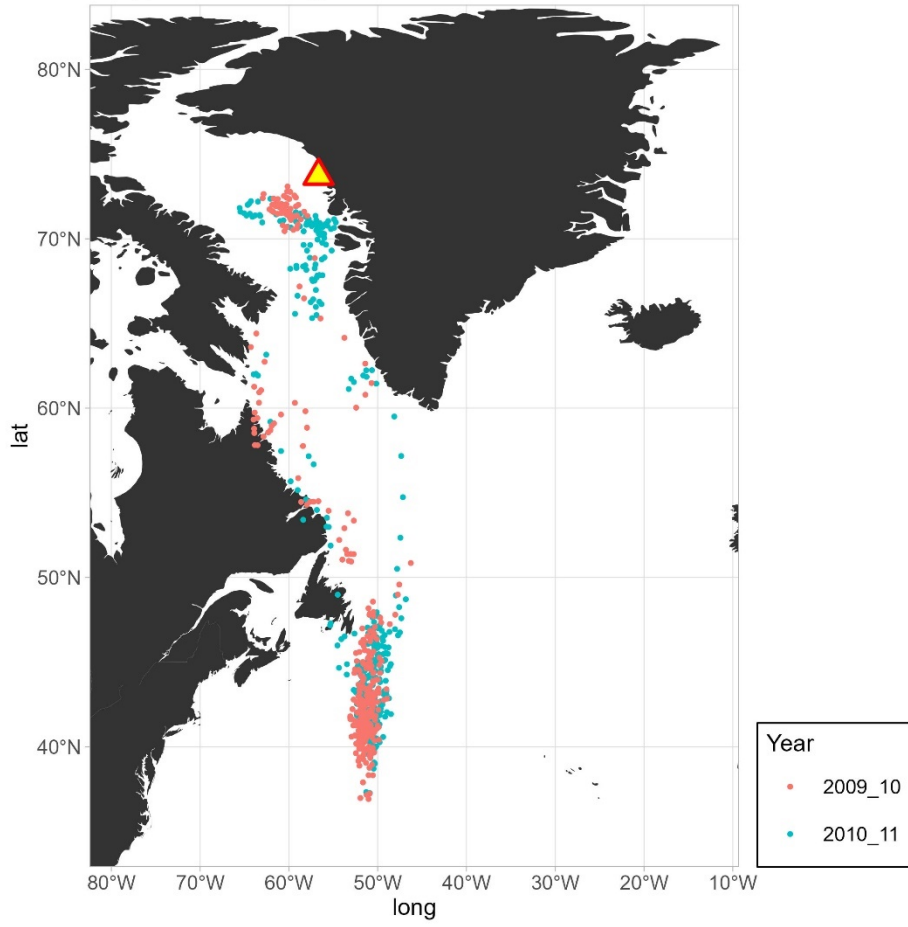
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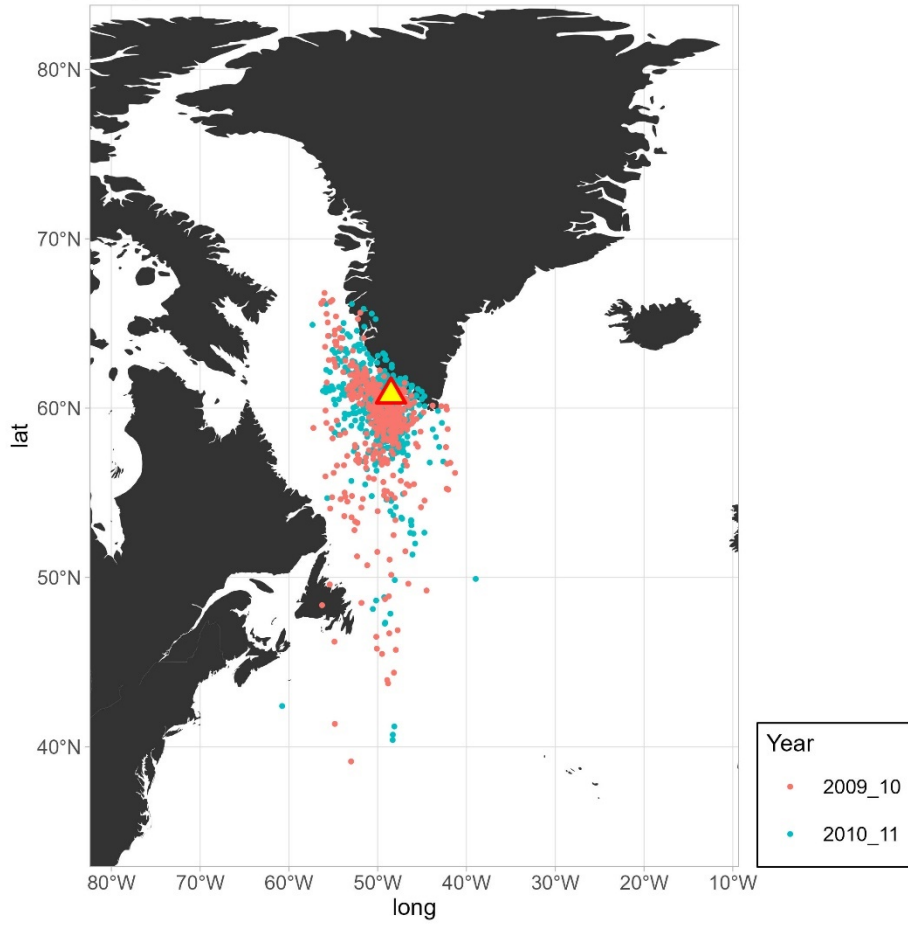
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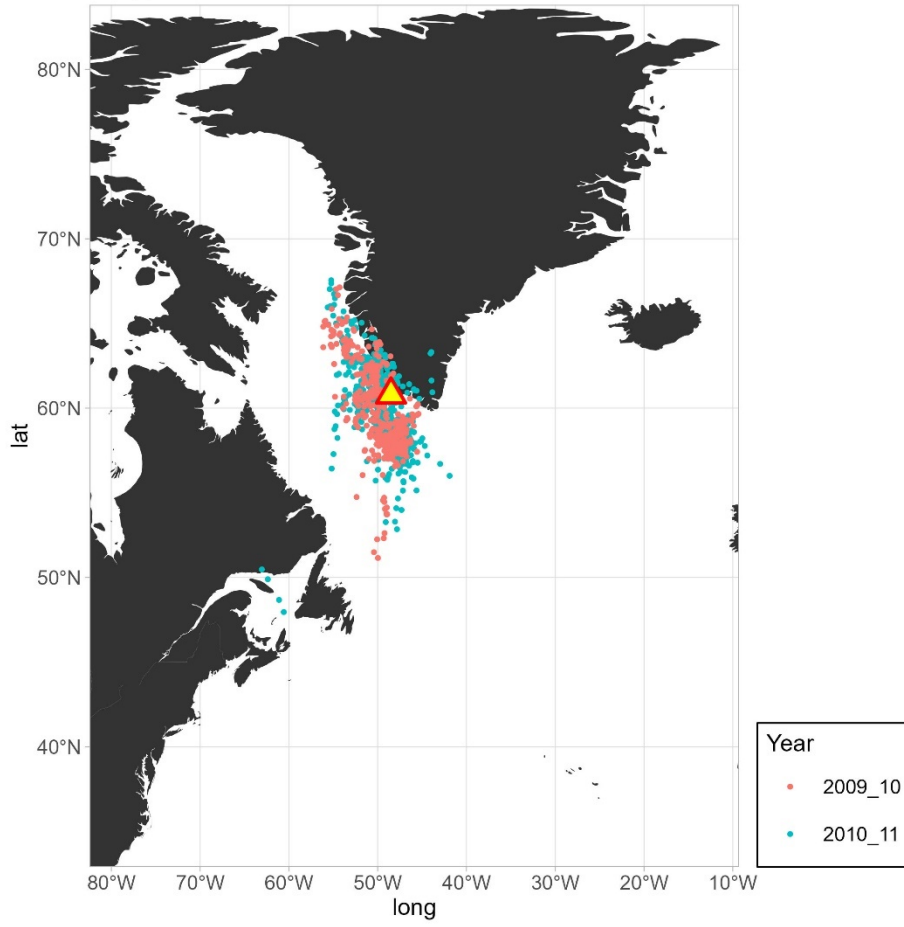
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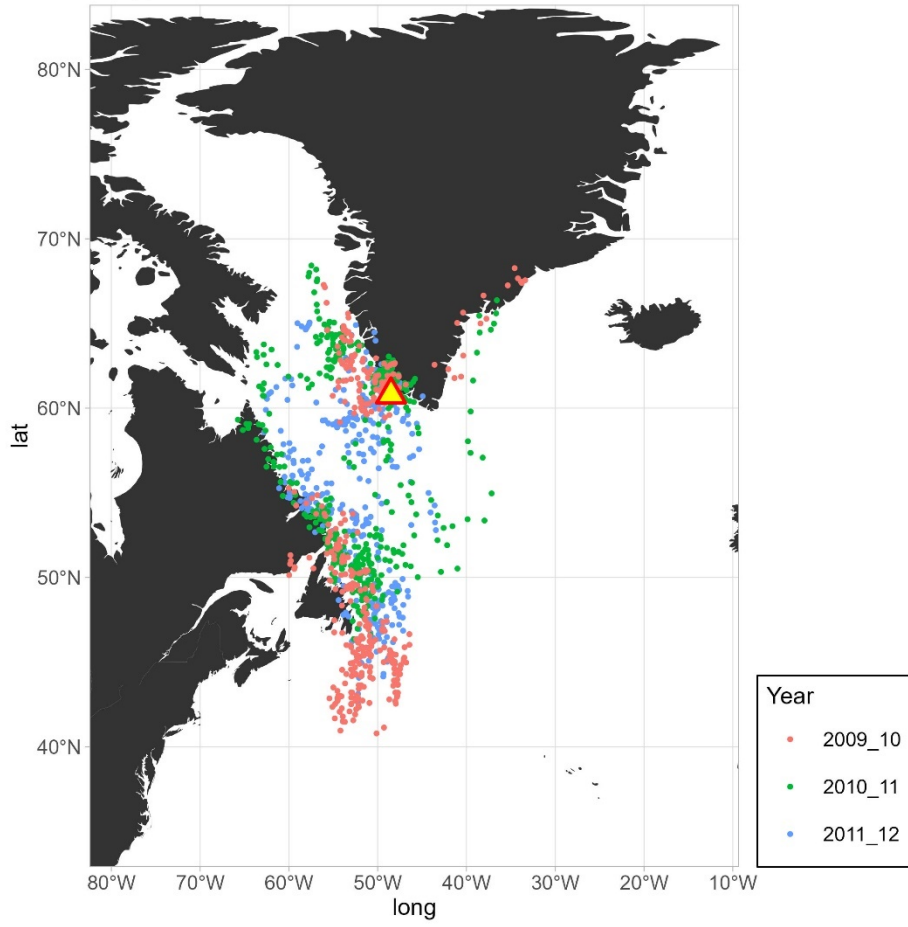
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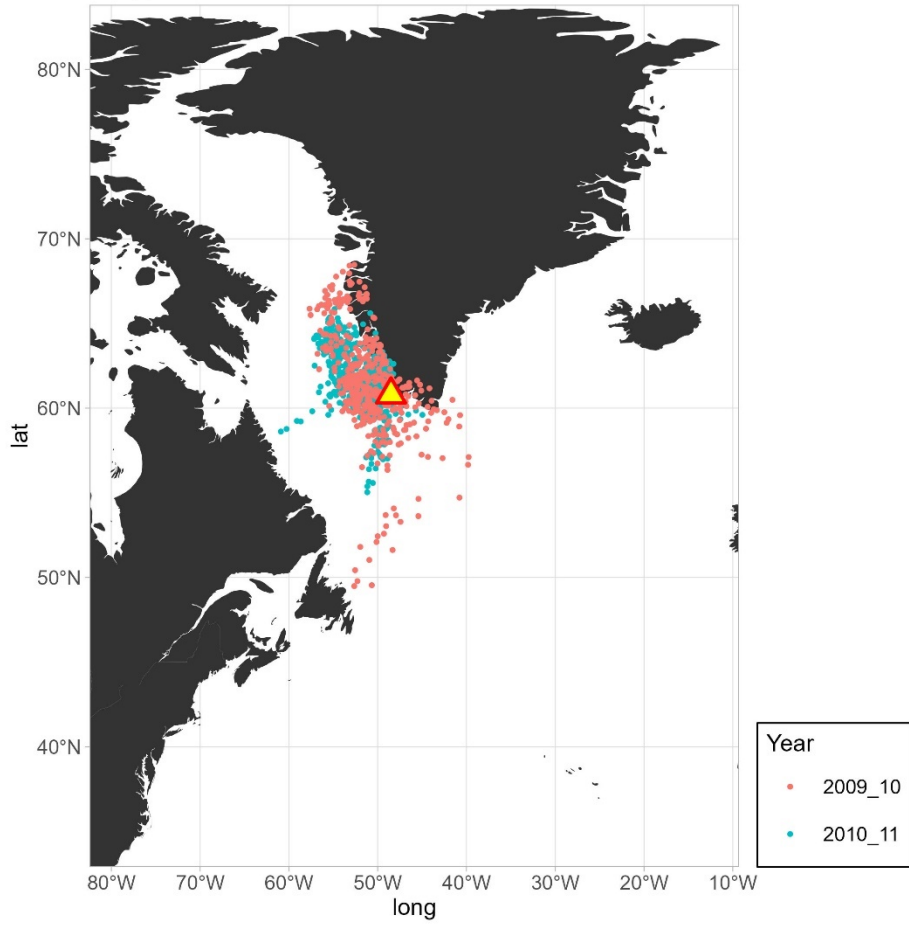
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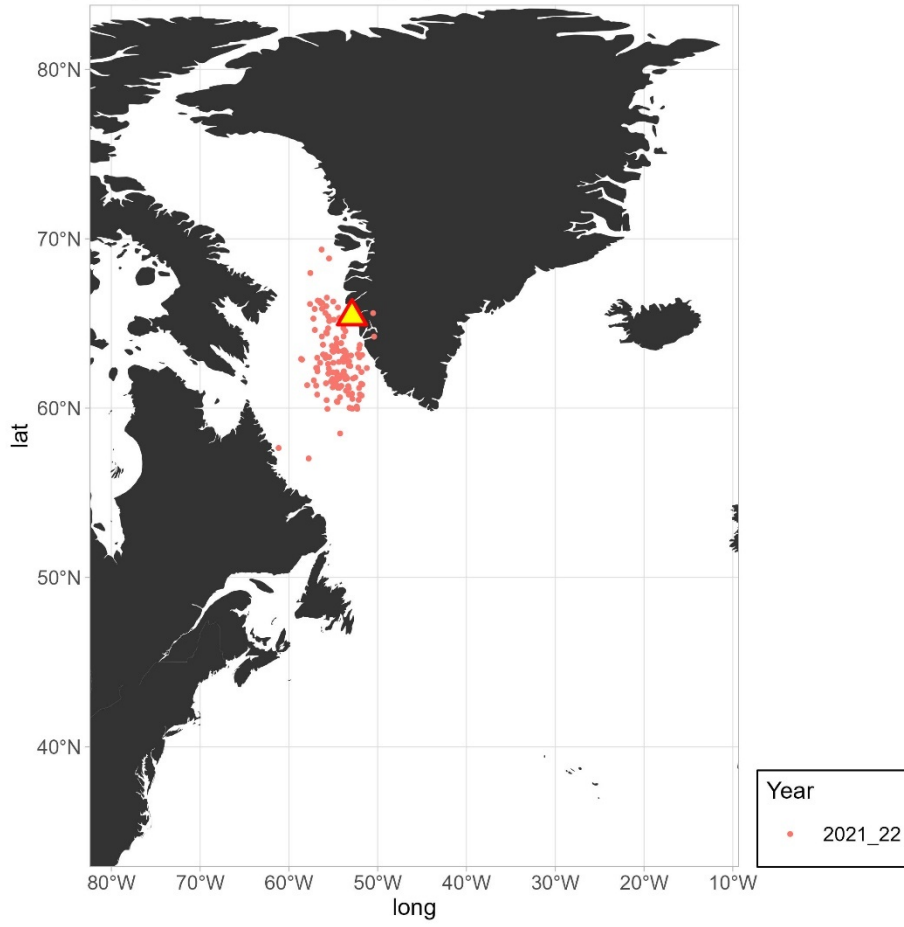
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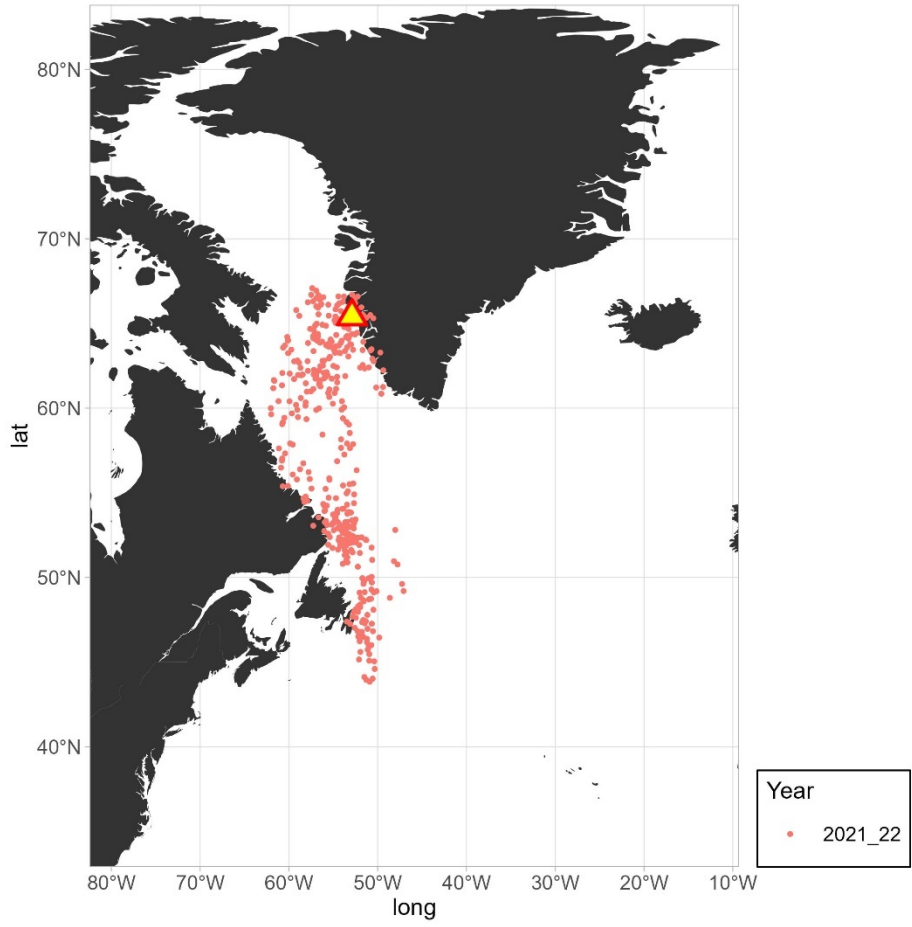
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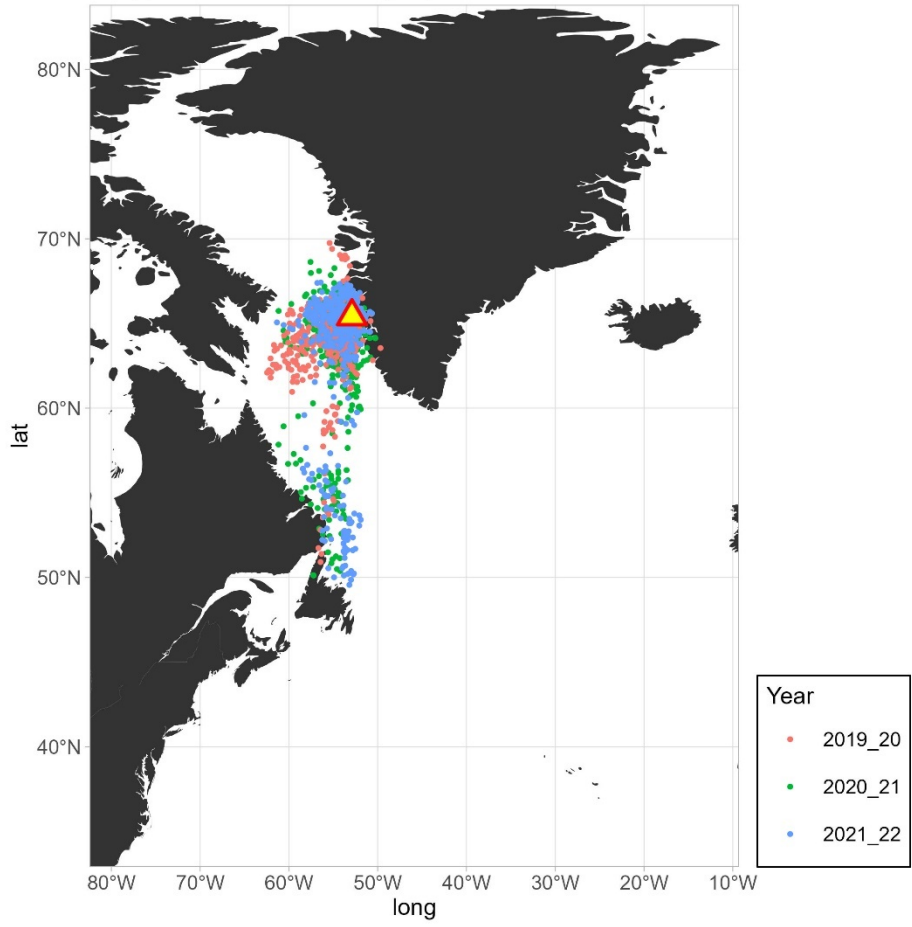
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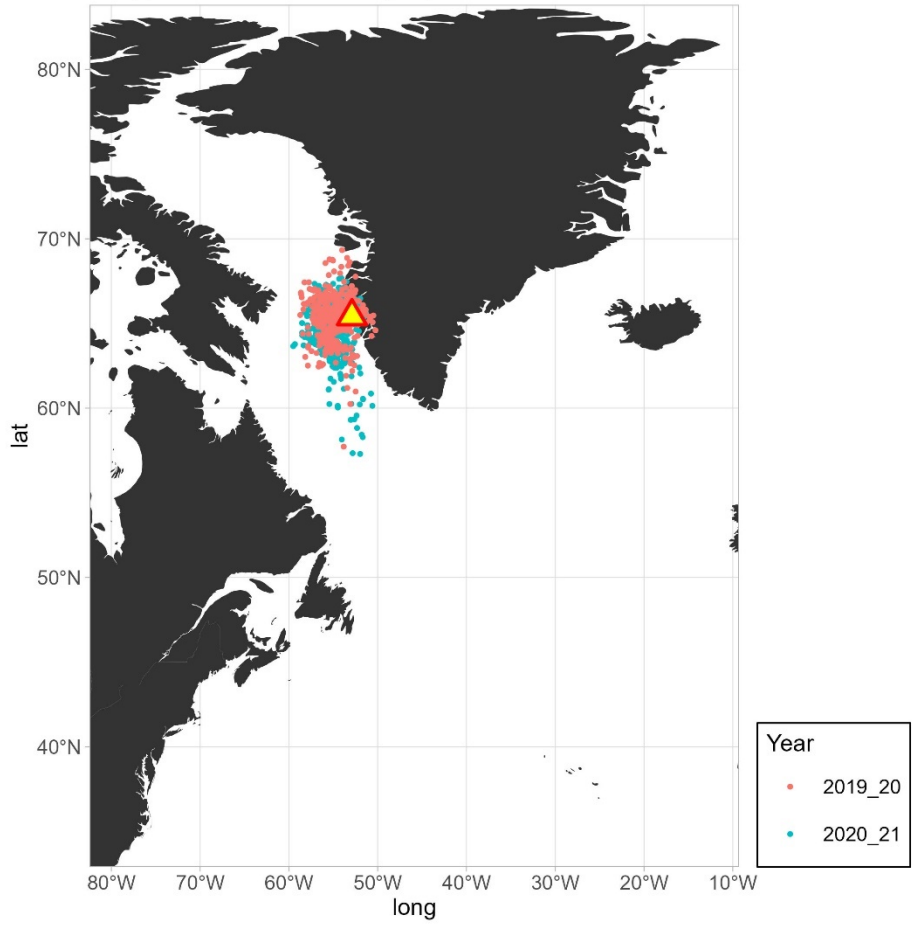
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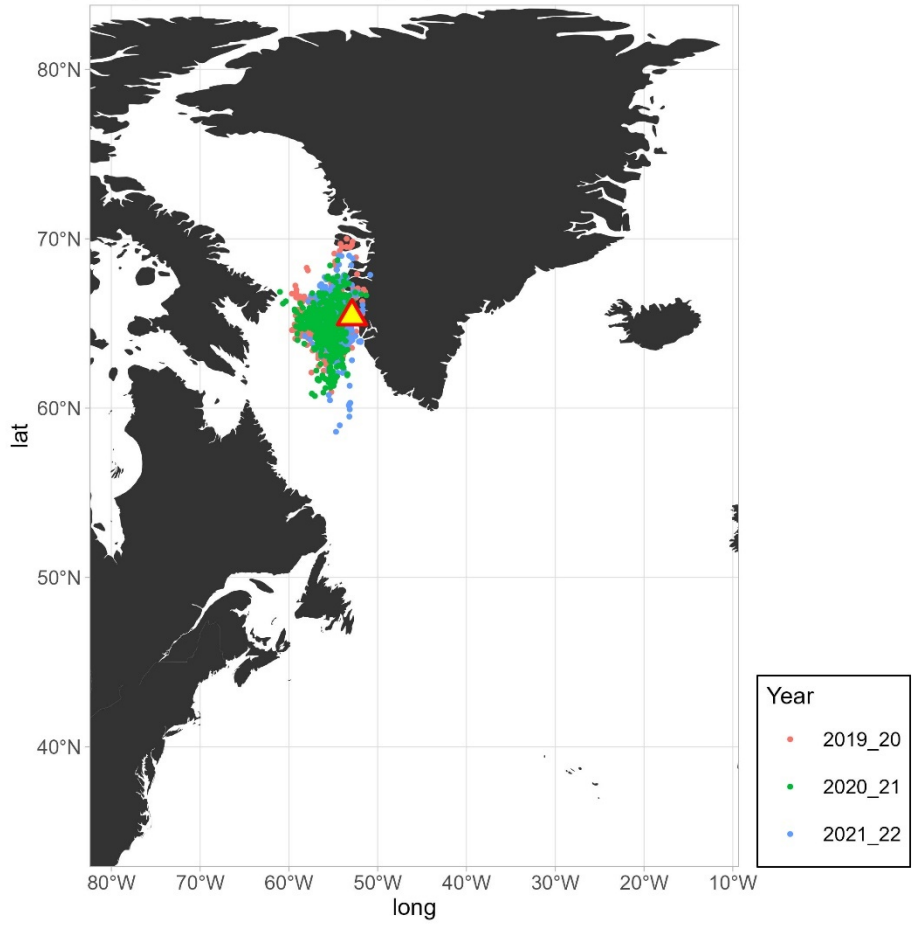
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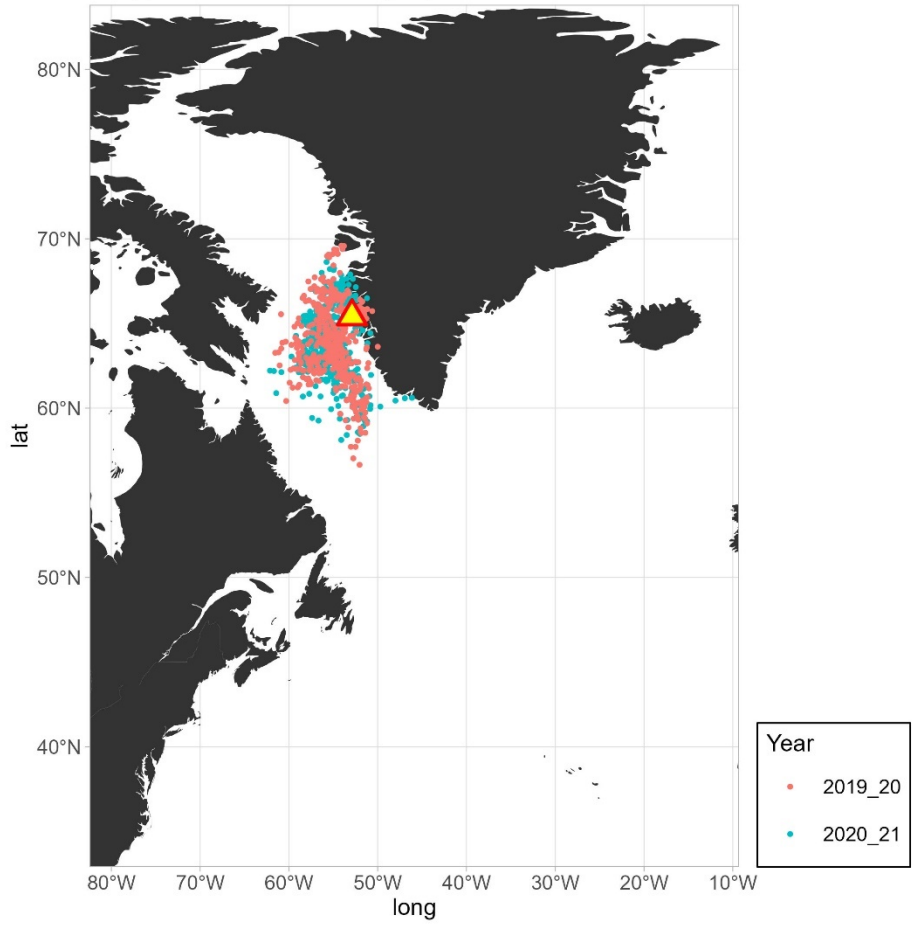
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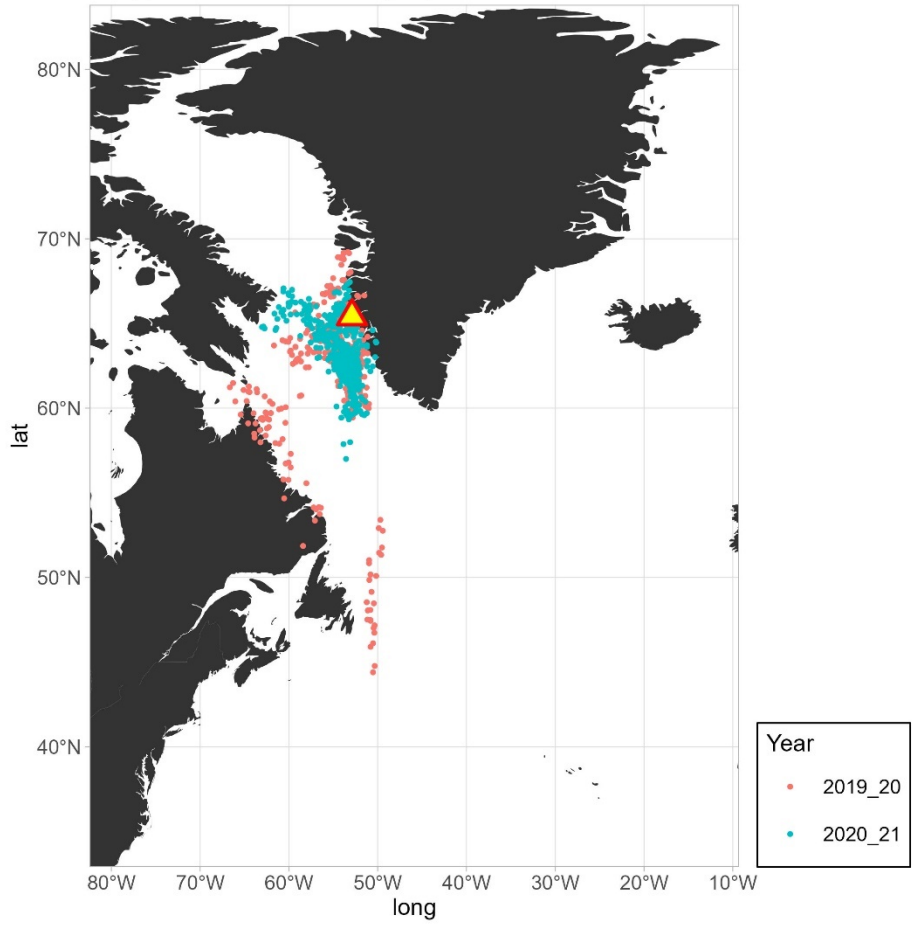
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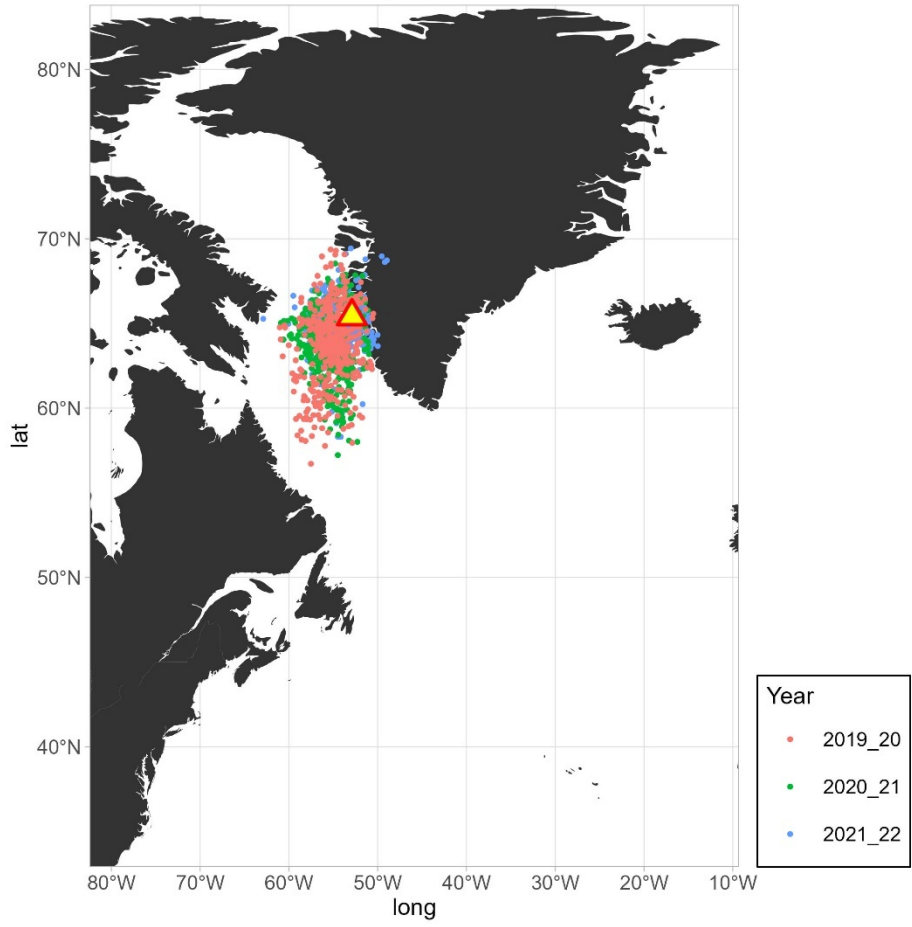
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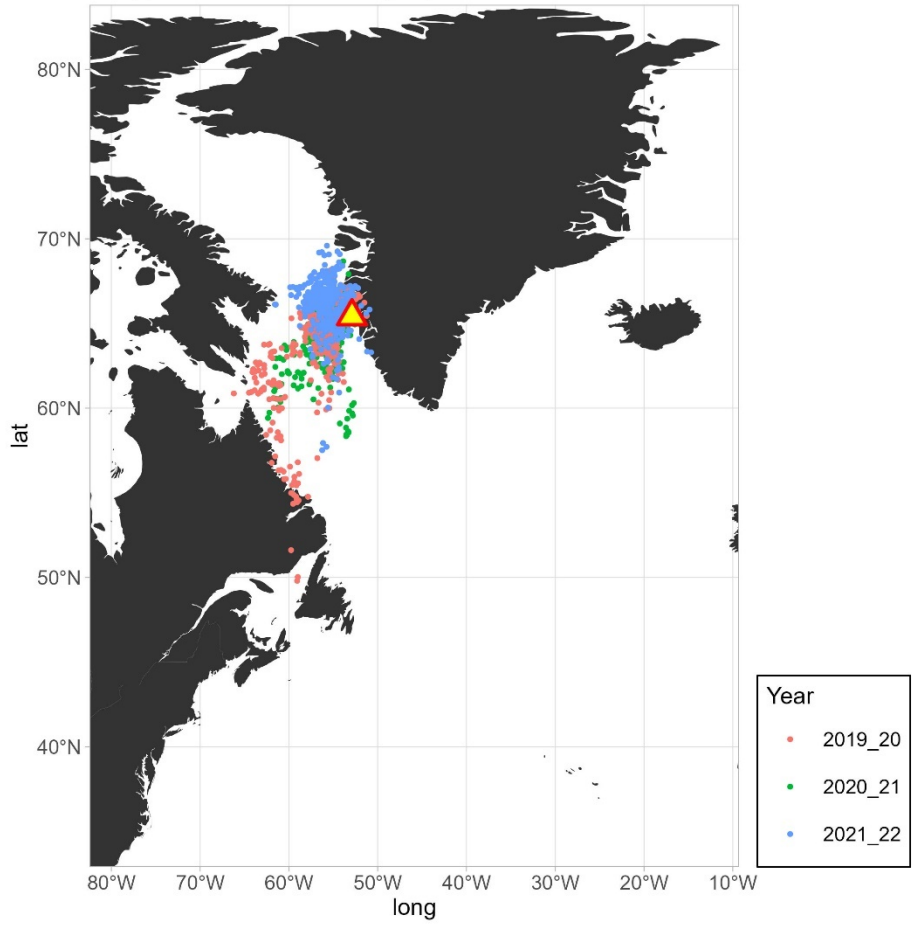
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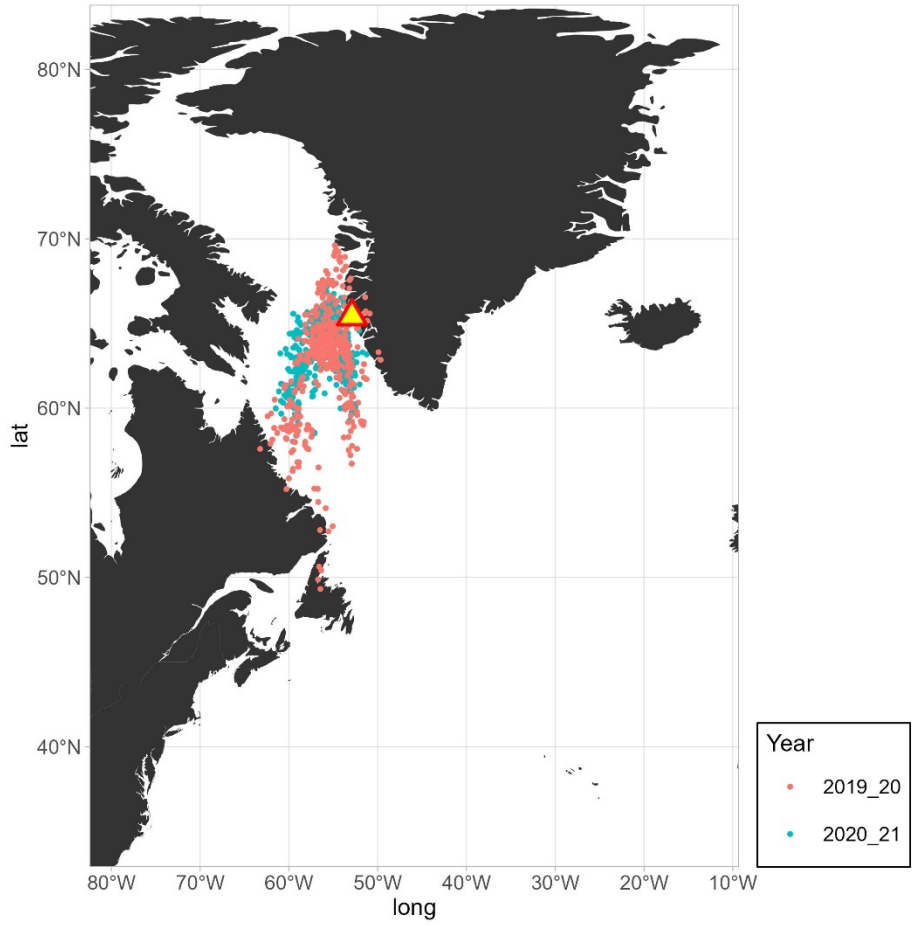
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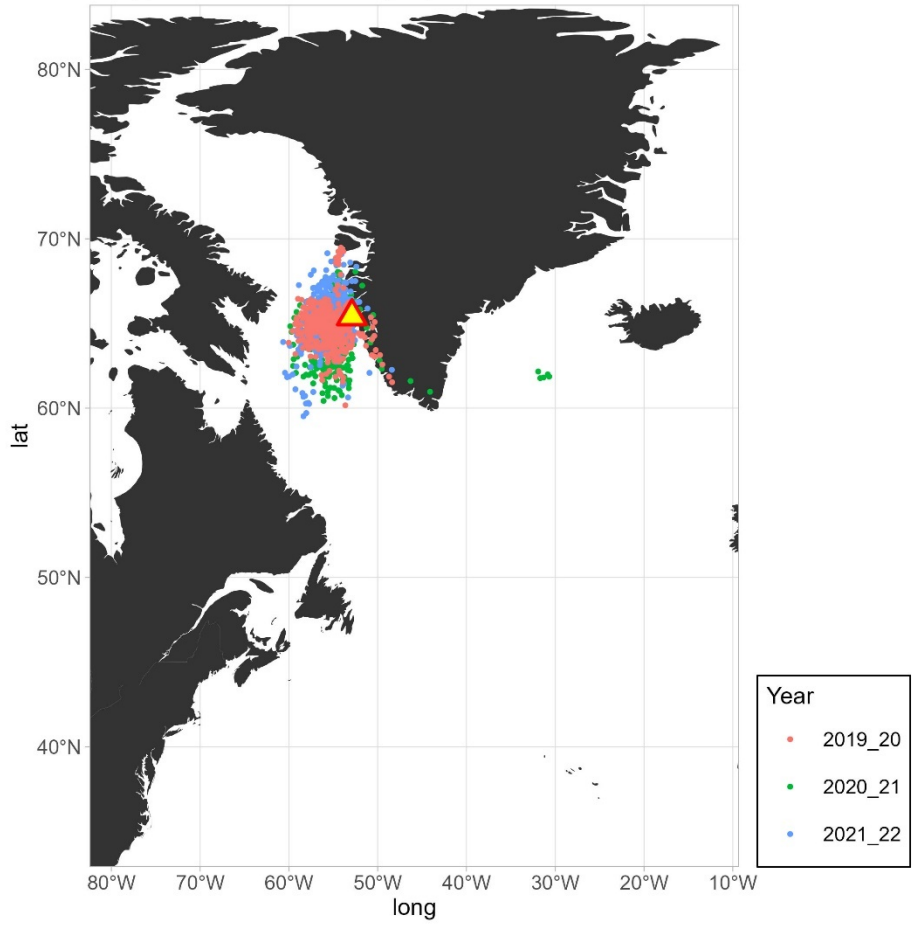
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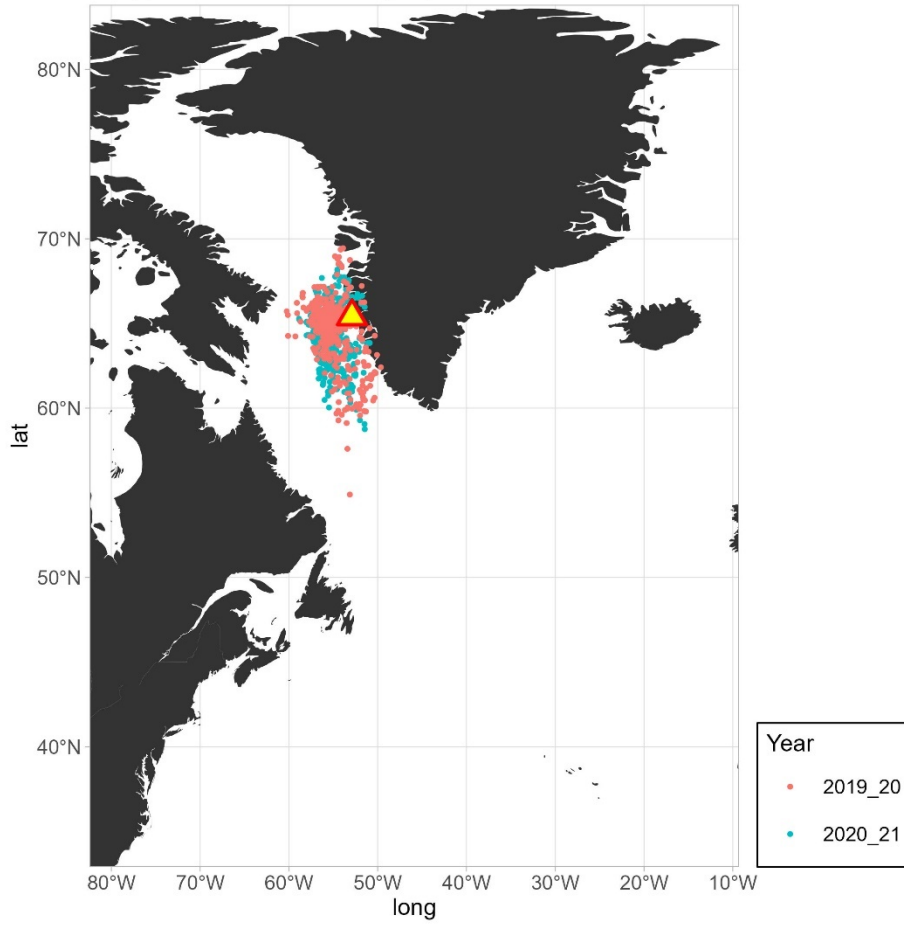
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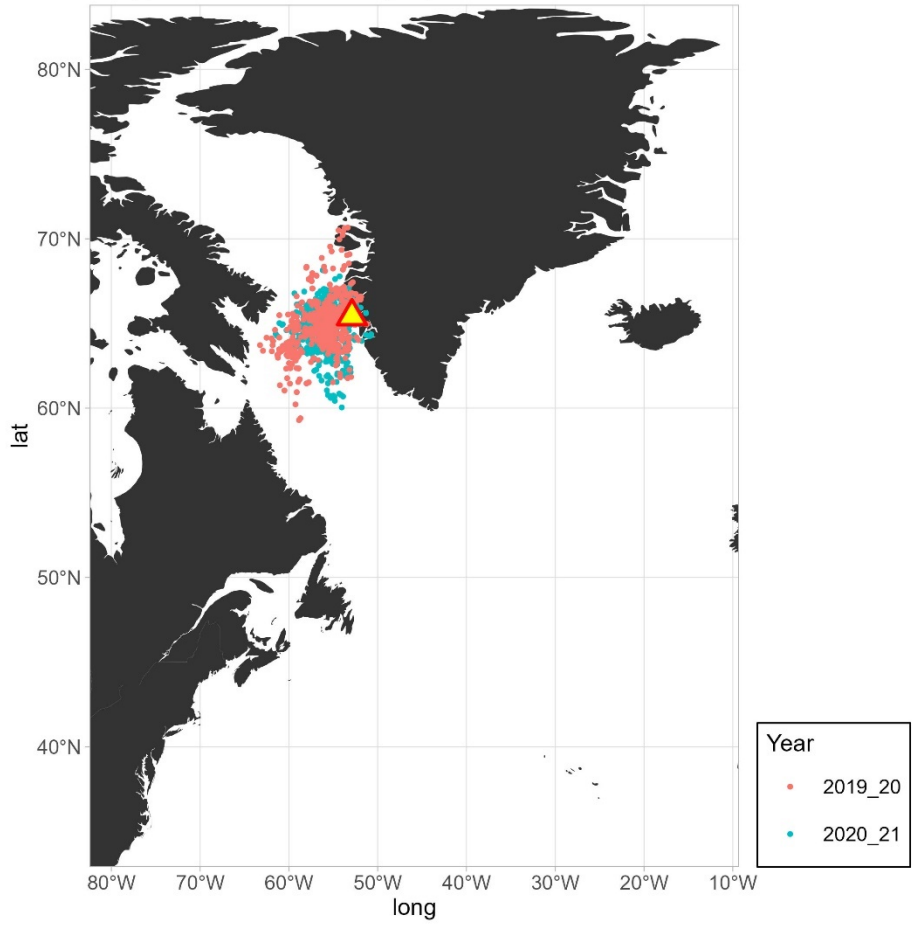
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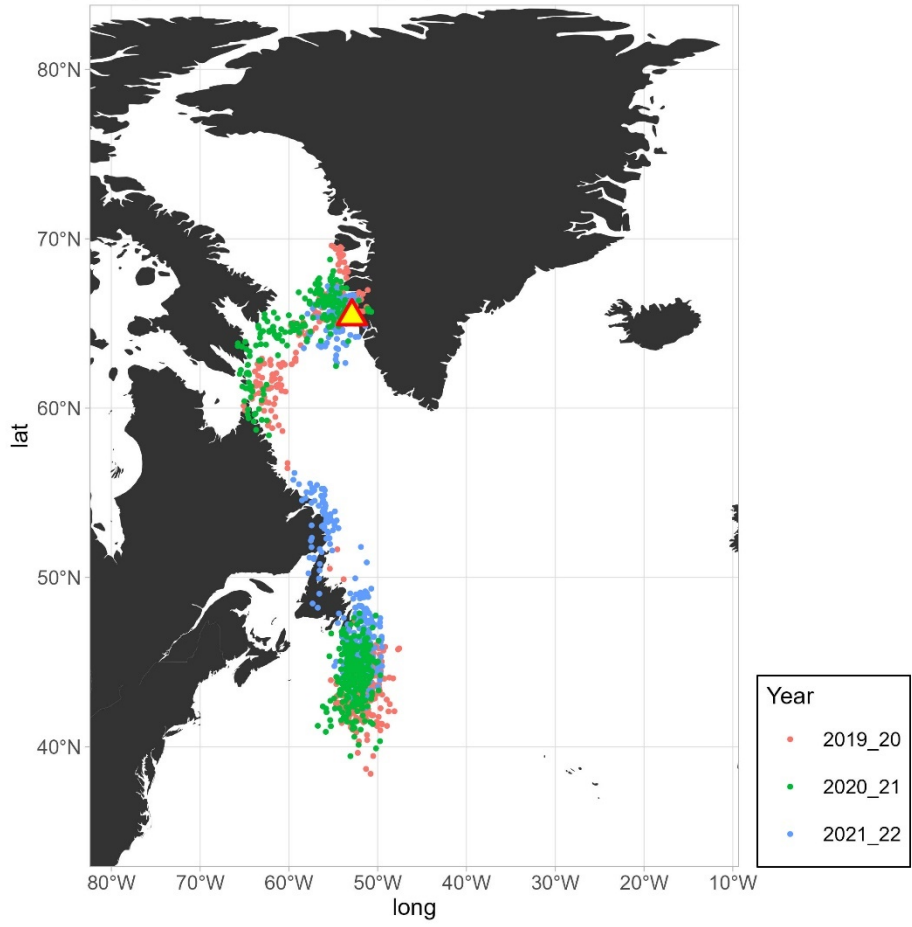
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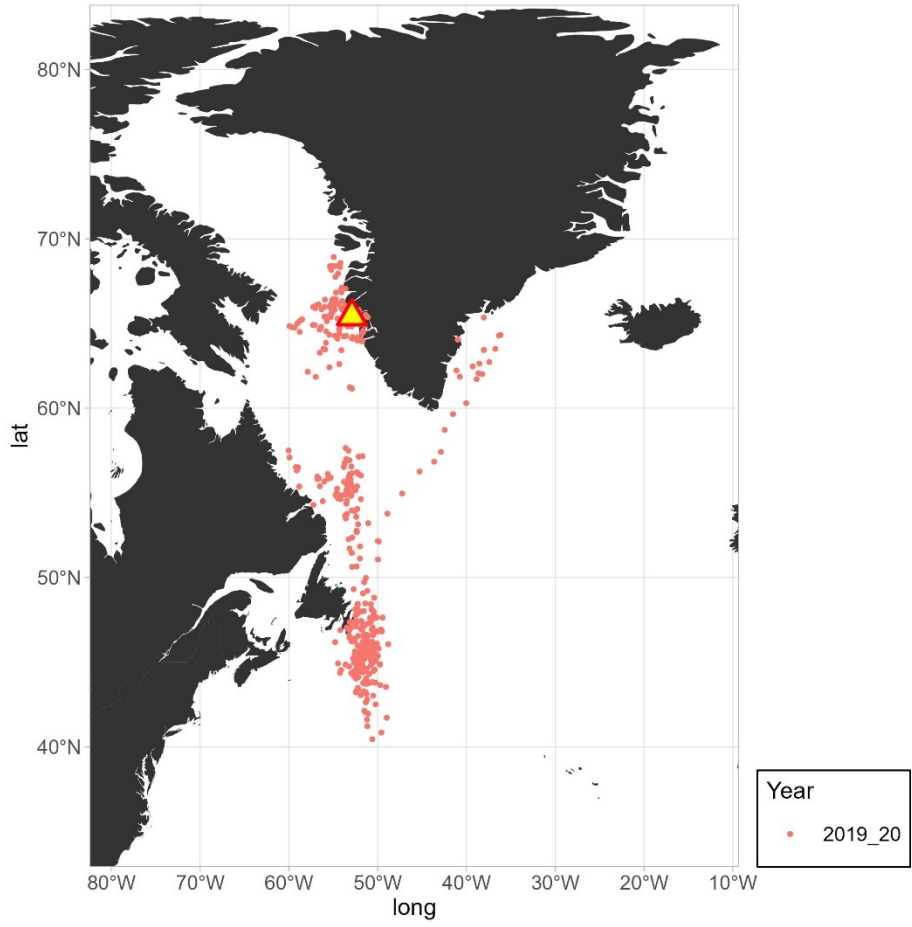
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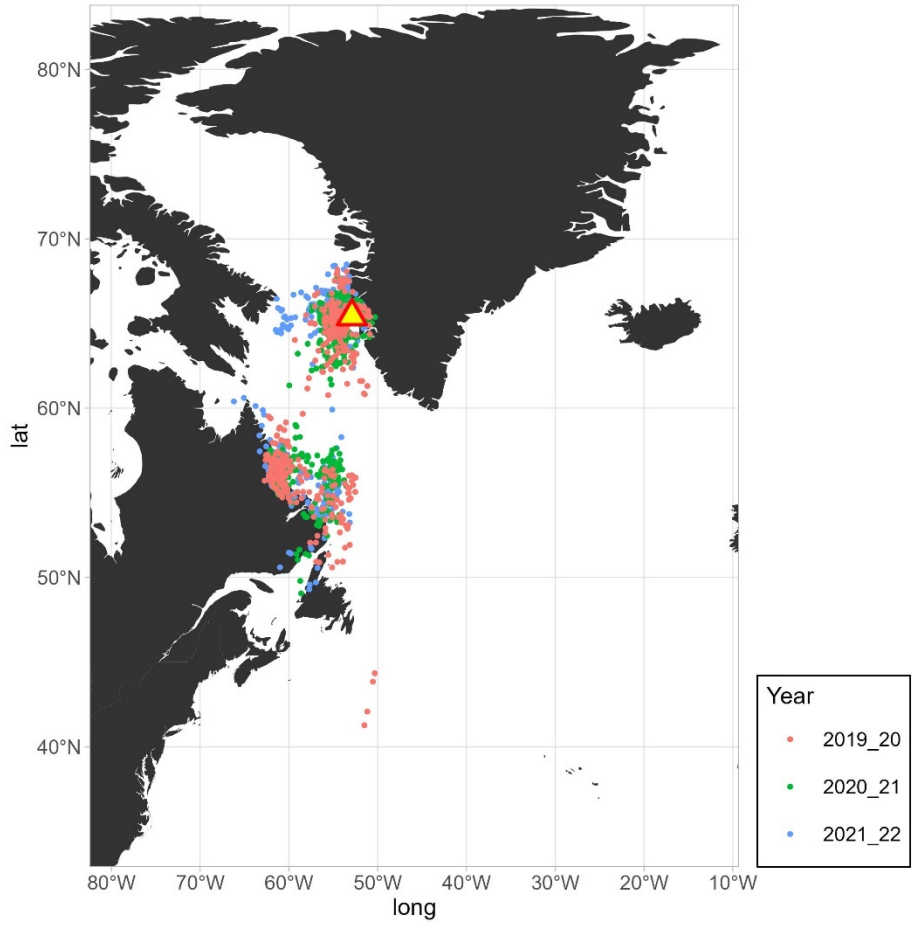
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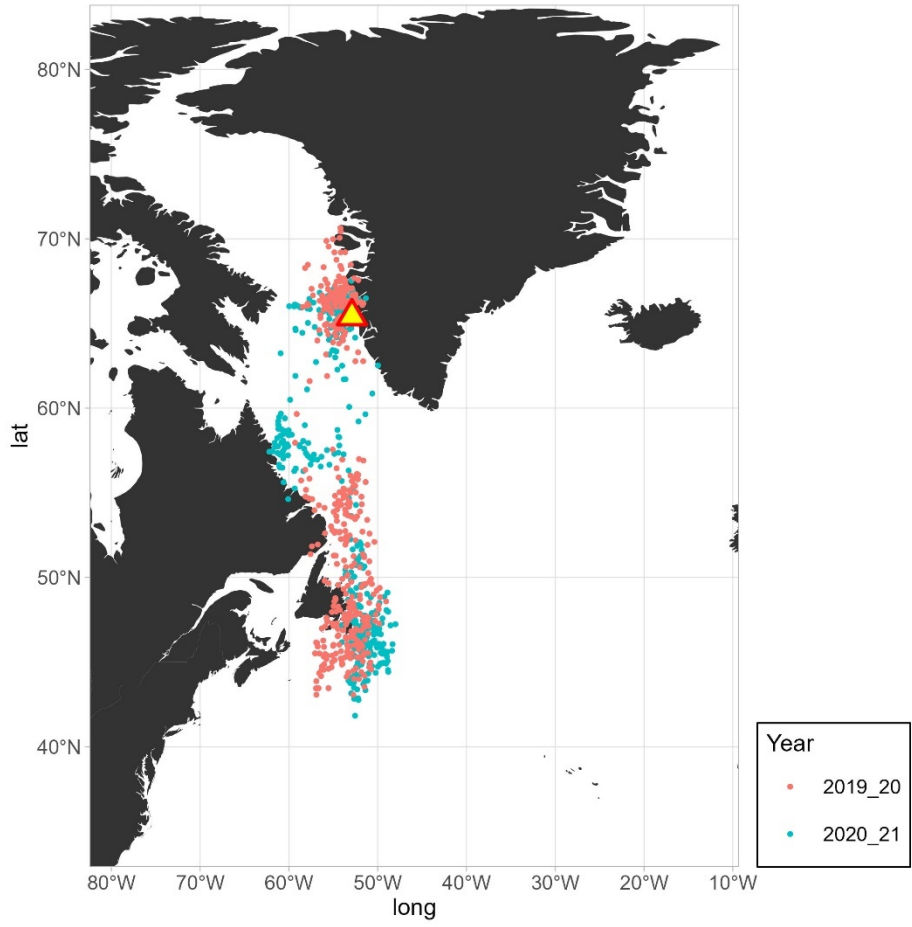
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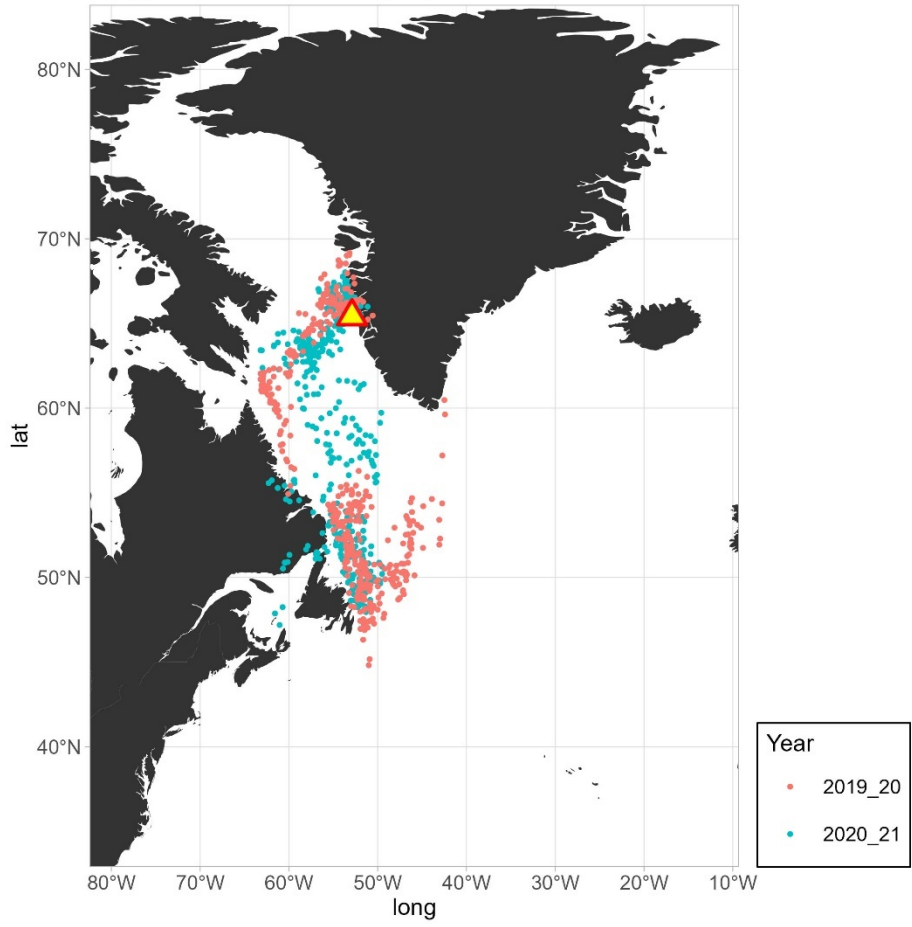
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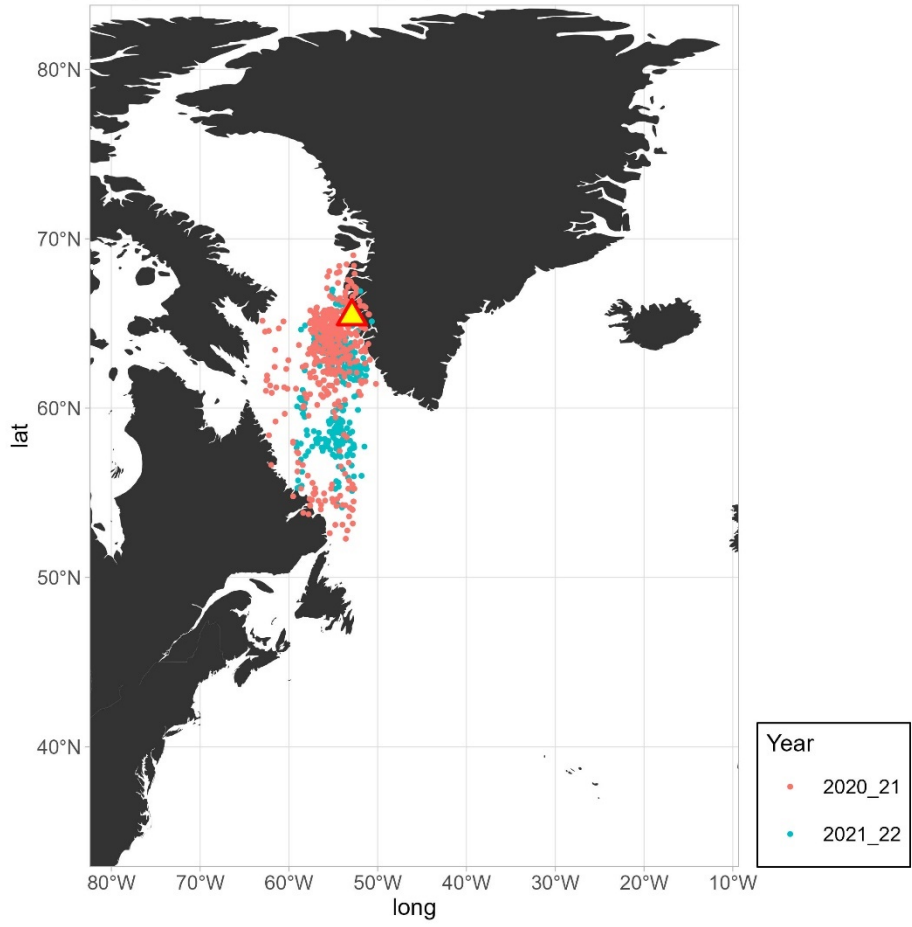
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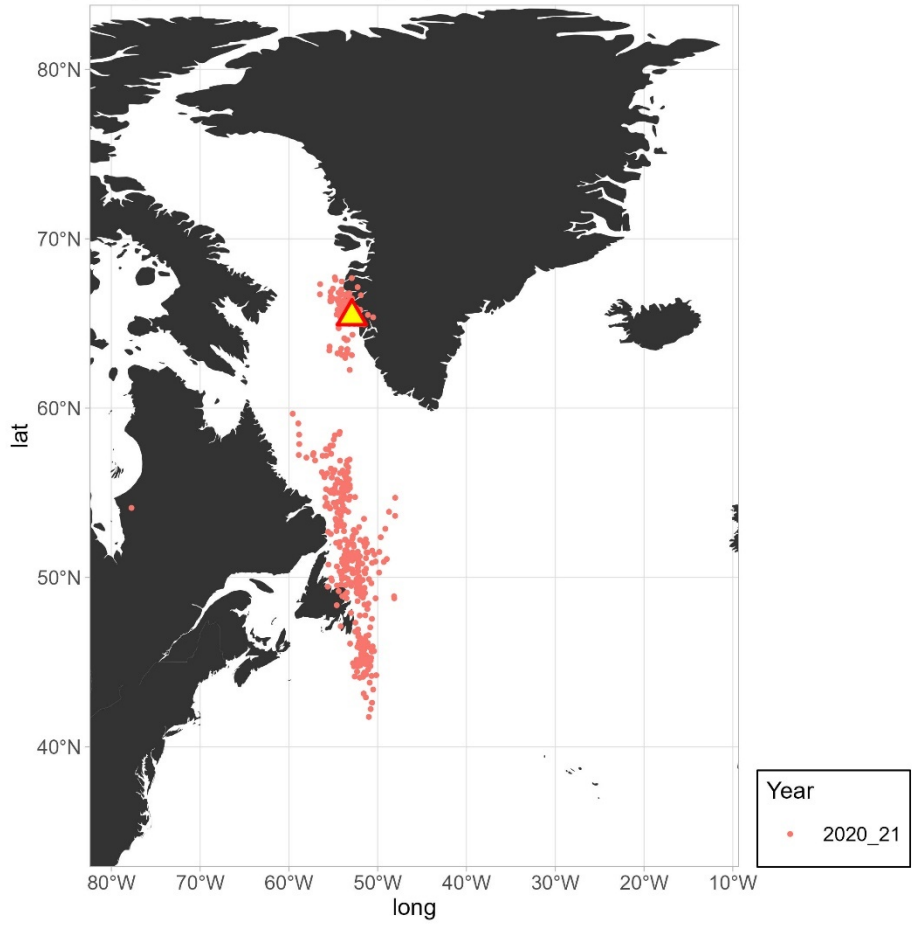
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