Supplement

Text S1: Informed Random Movement Algorithm (IRMA)

It is not always possible to estimate positions from geolocator raw light data: positions estimated during equinoxes is very inaccurate and filtered, and it is impossible to estimate a position when birds are above the Arctic Circle in the summer and in the winter due to midnight sun/polar night. To fill these gaps and reduce biases along the trajectories, missing locations are re-estimated at 12-h time interval by interpolation between known locations using an algorithm that was specifically developed for SEATRACK (Fauchald et al. 2019), based on a method originally proposed by Technitis et al. (2015). In short, this algorithm is based on the determination of so-called space-time prisms, which are 3-dimensional volumes defined by the coordinates (x,y) and time (z). The space-time prism delineates all the potential paths that can be followed by an individual moving from point A to point B, given three parameters: the distance from A to B, the time budget available, and the maximum rate of movement (Miller 1991). When projected onto a 2-dimensional plane, the space-time prism becomes the potential point area, (hereafter *Ppa*; Technitis et al. 2015). Although the 3-dimensional representation of the space-time prism is useful to understand its concept (Neutens et al. 2007), it is naturally more convenient to work with only two dimensions when dealing with discrete time steps, as is the case with tracking studies where locations are obtained at specific time intervals. Computing the *Ppa* in this context is straightforward (Technitis et al. 2015), given that the three above-mentioned parameters are known. Let us consider a startpoint (A) and start time (t_{i-1}), and an endpoint (B) and end time (t_{i+1}). Knowing the maximum rate of movement and the time t_i at which a new location (N_i) is to be created, one can determine the circle defining the maximum range (r_{i-1}) from point A to the new location, and that defining the maximum range (r_{i+1}) from the new location to point B. The *Ppa* corresponds to the area of overlap between those two circles of maximum range, i.e. the area delimiting all locations that are reachable from both A and B, given the time budget and maximum movement rate. This process can be repeated any number of times, depending on the number of new locations that need to be generated. The new locations are generated in a random order (i.e., not chronological), thus creating a sort of correlated random walk respecting the constraints set by the relative position of A and B, the time budget, and the maximum movement rate. Here, we used a dynamic value for the maximum movement rate parameter, based on the distribution of observed movement rates as a function of time elapsed between two locations from the dataset. To do so we calculated, based on each individual track, the movement rates for random combinations of known locations separated by varying time-intervals. We used the 75th percentile from that distribution as the maximum movement rate. The 75th percentile was computed by quantile regression, using the function 'rq' from package *quantreg* (Koenker 2018). Finally, the algorithm uses additional information to constrain the new positions obtained : 1) saltwater immersion data to determine attendance at the colony and force a new location to remain close to the colony during the breeding season, 2) land masks to constrain positions over the ocean, 3) longitudes (obtained from the GLS data, as longitude can still be estimated during the equinoxes) and 4) light levels to determine whether the new position was north of the latitudinal limit of the polar day (summer) or night (winter) (i.e., continuous day/night recorded by the loggers).

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Table S1: Number of tracks per colony and per species. One track corresponds to one year (i.e. a deployment of 2 years counts for 2). (-) species absent or no data collected

Colony	Number on Figure S1	Country	Longitude	Latitude	Little auk	Atlantic puffin	Common guillemot	Brünnich's guillemot	Black-legged kittiwake	Northern fulmar
Alkefjellet	1	Norway	18.459	79.585	-	-	-	66	64	34
Anda	2	Norway	15.170	69.065	-	31	-	-	133	-
Bjørnøya	3	Norway	18.956	74.503	77	1	134	99	105	87
Breidafjordur	4	Iceland	-22.740	65.081	-	-	-	-	-	10
Cape Gorodetskiy	5	Russia	32.937	69.583	-	-	20	33	-	-
Cape Krutik	6	Russia	35.948	69.151	-	-	-	-	110	-
Eynhallow	7	United Kingdom	-3.115	59.142	-	-	-	-	-	298
Faroe Islands	8	Faroe Islands	-6.798	61.950	-	32	14	-	106	26
Franz Josef Land	9	Russia	51.468	80.144	59	-	-	6	111	-
Grimsey	10	Iceland	-17.992	66.529	-	49	10	42	-	1
Hjelmsøya	11	Norway	24.732	71.113	-	43	65	-	6	-
Hólmanes	12	Iceland	-13.994	65.044	-	6	-	-	-	1
Hornsund	13	Norway	15.550	77.000	103	-	-	-	-	-
Hornøya	14	Norway	31.150	70.383	-	122	117	126	87	-
Isfjorden	15	Norway	15.508	78.253	24	-	-	39	103	-
Isle of May	16	United Kingdom	-2.558	56.186	-	80	98	-	95	-
Jan Mayen	17	Norway	-8.718	70.921	-	-	118	177	-	111
Jarsteinen	18	Norway	5.174	59.150	-	-	-	-	-	28
Kara Gate	19	Russia	55.021	70.593	-	-	-	85	37	-
Kongsfjorden	20	Svalbard, Norway	12.217	78.900	16	-	-	-	202	-
Langanes and Skjalfandi	21	Iceland	-15.985	66.180	-	-	85	41	74	129
Latrabjarg	22	Iceland	-24.467	65.483	-	-	22	16	-	-
Oranskie Islands	23	Russia	67.642	77.069	-	-	-	9	-	-
Papey	24	Iceland	-14.172	64.588	-	59	-	-	-	9
Reykjanes	25	Iceland	-22.221	63.968	-	-	-	-	-	6
Runde and Ålesund	26	Norway	5.874	62.436	-	28	-	-	68	-
Røst	27	Norway	11.910	67.447	-	153	-	-	143	-
Seven Islands	28	Russia	37.570	68.748	-	7	-	-	-	-
Sklinna	29	Norway	10.995	65.202	-	39	152	-	122	-

Table S2: Logger types per species, number of deployments.

Species	Migrate Technology					BAS/Biotrack									Total
	c250	c330	c65	w65	f100	mk13	mk14	mk15	mk18	mk19	mk3006	mk4	mk4083	mk4093	
Little auk	0	0	165	0	60	0	0	0	7	0	0	0	0	18	250
Atlantic puffin	0	0	267	32	155	0	0	0	0	0	0	0	58	54	566
Common guillemot	184	2	0	0	0	0	0	1	0	0	568	0	18	9	804
Brünnich's guillemot	155	0	4	0	2	0	0	0	0	0	482	0	32	3	704
Black-legged kittiwake	0	0	8	0	62	21	1	0	56	0	0	0	1211	45	1404
Northern fulmar	248	0	3	0	0	34	32	39	5	3	99	3	120	8	594

Table S3: Total attachment mass in g (logger + ring and cable ties), mean ± SD bird weight in g and mean ± SD percent of the bird mass for each logger model and species. Bird weight is the mean ± SD weight of individuals tagged with each logger model. Mass of ring and cable ties was 0.8 g for little auks, 1.5 g for Atlantic puffins, 1.8 g for common and Brünnich's guillemots, 1.4 g for black-legged kittiwakes and 1.1 g for northern fulmars.

Species	**Producer**	**Model**	**Attachment mass (g)**	**Bird weight (g)**	**% of bird weight**	
				Mean ± SD	Mean ± SD	Range
Atlantic puffin	Migrate Technology	c65	2.5	477.61 ± 42.61	0.53 ± 0.05	0.43-0.66
	Migrate Technology	f100	2.5	471.67 ± 46.48	0.54 ± 0.06	0.41-0.85
	Biotrack	mk4083	3.4	456.21 ± 50.98	0.75 ± 0.09	0.59-1.01
	Biotrack	mk4093	3	459.22 ± 47.86	0.66 ± 0.07	0.53-0.83
Black-legged kittiwake	Migrate Technology	c65	2.4	405.71 ± 32.59	0.59 ± 0.05	0.53-0.65
	Migrate Technology	f100	2.4	412.52 ± 45.23	0.59 ± 0.07	0.41-0.76
	BAS	mk13	3.2	373.61 ± 30.01	0.86 ± 0.07	0.79-0.94
	BAS	mk14	2.9	380.88 ± 33.33	0.77 ± 0.07	0.69-0.86
	BAS	mk18	2.9	360.06 ± 20.26	0.81 ± 0.05	0.76-0.87
	Biotrack	mk4083	3.3	400.74 ± 38.88	0.83 ± 0.08	0.61-1.07
	Biotrack	mk4093	2.9	404.64 ± 30.31	0.72 ± 0.05	0.62-0.86
Brünnich's guillemot	Migrate Technology	c250	4.3	996.25 ± 66.44	0.43 ± 0.03	0.35-0.52
	Migrate Technology	c65	2.8	910 ± 56.12	0.31 ± 0.02	0.29-0.33
	Migrate Technology	f100	2.8	960 ± 14.14	0.29 ± 0.00	0.29-0.29
	Biotrack	mk3006	4.3	1001.84 ± 64.92	0.43 ± 0.03	0.37-0.51
	Biotrack	mk4083	3.7	982.81 ± 62.53	0.38 ± 0.02	0.34-0.44
	Biotrack	mk4093	3.3	966.67 ± 25.17	0.34 ± 0.01	0.33-0.35
Common guillemot	Migrate Technology	c250	4.3	995.86 ± 81.06	0.43 ± 0.04	0.35-0.55
	Migrate Technology	c330	5.2	887.5 ± 25.37	0.59 ± 0.02	0.57-0.6
	BAS	mk15	4.3	995.17 ± 116.8	0.44 ± 0.05	0.38-0.51
	Biotrack	mk3006	4.3	1004.93 ± 85.75	0.43 ± 0.04	0.35-0.58
	Biotrack	mk4083	3.7	971.82 ± 43.83	0.38 ± 0.02	0.35-0.42
	Biotrack	mk4093	3.3	914.44 ± 51.84	0.36 ± 0.02	0.33-0.39
Little auk	Migrate Technology	c65	1.8	172.3 ± 15.34	1.05 ± 0.09	0.84-1.38
	Migrate Technology	f100	1.8	171.41 ± 14.4	1.06 ± 0.09	0.82-1.29
	BAS	mk18	2.3	167.86 ± 9.83	1.37 ± 0.08	1.25-1.44
	Biotrack	mk4093	2.3	166.3 ± 13.02	1.39 ± 0.11	1.21-1.58
Northern fulmar	Migrate Technology	c250	3.6	805.84 ± 104.22	0.45 ± 0.07	0.36-0.78
	Migrate Technology	c65	2.1	793.33 ± 105.87	0.27 ± 0.04	0.23-0.3
	BAS	mk18	2.6	846.67 ± 75.06	0.31 ± 0.03	0.29-0.34
	Biotrack	mk3006	3.6	795.86 ± 112.5	0.46 ± 0.07	0.32-0.78
	Biotrack	mk4083	3	807.17 ± 115.53	0.38 ± 0.05	0.25-0.5
	Biotrack	mk4093	2.6	857.5 ± 105.06	0.31 ± 0.04	0.27-0.37

Table S4: Summary of the number of tracks per wet/dry recording mode and per species. Only the recording mode 30s_10min and 3s_10min were used in the statistical analyses.

Species	30s_10min	30s_240min	3s_10min	6s_5min
Little auk	223	0	35	0
Atlantic puffin	424	24	143	0
Common guillemot	168	0	598	0
Brünnich's guillemot	175	0	528	0
Black-legged kittiwake	66	0	1519	0
Northern fulmar	222	0	413	79

Table S5: Characteristics of active migration segments (AMSs) and stationary segments per species and colony. Data are mean ± SE. Distance covered: sum of the daily distances covered for each active migration segment

Species /colony	No. of AMSs per year	% of the year in migration	AMS duration (d)	Apparent movement rate (km.h^{-1}), AMS	Apparent movement rate (km.h^{-1}), stationary segments	Distance covered (km)	No. of tracks
Little auk							
Bjørnøya	4.04 ± 0.15	23.66 ± 1.02	13.32 ± 0.67	5.72 ± 0.07	5.34 ± 0.04	1521.18 ± 67.4	77
Franz Josef Land	2.93 ± 0.14	22.15 ± 1.43	10.98 ± 0.67	4.45 ± 0.08	4.28 ± 0.07	881.78 ± 44.5	60
Hornsund	3.65 ± 0.12	24.38 ± 0.93	12.15 ± 0.51	5.56 ± 0.05	5.12 ± 0.03	1483.4 ± 53.57	105
Isfjorden	3.68 ± 0.3	27.65 ± 2.05	14.41 ± 1.05	5.17 ± 0.09	5.2 ± 0.08	1543.65 ± 107.93	25
Kongsfjorden	2.75 ± 0.21	21.33 ± 2.31	17.91 ± 1.76	6.73 ± 0.23	5.37 ± 0.08	2545.69 ± 228.08	16
Atlantic puffin							
Anda	4 ± 0.2	18.15 ± 1.15	10.9 ± 0.78	6.34 ± 0.13	5.16 ± 0.06	1425.99 ± 87.96	31
Bjørnøya	3 ± NA	18.51 ± NA	15.55 ± 6.46	5.62 ± 0.45	6.05 ± 0.29	2230.34 ± 311.24	1
Faroe Islands	4.56 ± 0.18	25.66 ± 1.59	16.42 ± 1.16	6.55 ± 0.08	6.7 ± 0.07	2358.17 ± 161.89	32
Grimsey	4.22 ± 0.16	20 ± 1.04	14.08 ± 0.8	7.24 ± 0.09	6.39 ± 0.05	2248.26 ± 118.34	49
Hjelmsøya	3.79 ± 0.2	20.55 ± 1.43	13.29 ± 0.84	4.88 ± 0.09	4.26 ± 0.05	1115.39 ± 69.6	43
Holmahals	4.5 ± 0.22	19.57 ± 2.63	12.29 ± 2.17	6.3 ± 0.21	5.89 ± 0.13	1891.98 ± 256.46	6
Hornøya	4.08 ± 0.14	18.88 ± 0.81	12.16 ± 0.51	4.74 ± 0.05	4.34 ± 0.03	1003.27 ± 34.87	123
Isle of May	3.16 ± 0.19	11.73 ± 0.95	9.83 ± 0.68	7.12 ± 0.11	6.24 ± 0.05	1251.57 ± 84.87	86
Papey	4.69 ± 0.14	23.89 ± 0.98	15.45 ± 0.75	7.14 ± 0.07	6.9 ± 0.05	2376.84 ± 112.17	59
Runde and Ålesund	4.29 ± 0.27	21.49 ± 1.7	13.7 ± 1	6.05 ± 0.12	5.08 ± 0.06	1770.02 ± 129.7	28
Røst	4.16 ± 0.1	19.67 ± 0.66	13.56 ± 0.48	5.93 ± 0.05	4.93 ± 0.02	1734.39 ± 51.51	153
Seven Islands	4.62 ± 0.71	18.55 ± 3.09	10.56 ± 1.44	5.43 ± 0.27	4.51 ± 0.11	940.4 ± 115.88	8
Sklinna	3.87 ± 0.21	18.12 ± 1.31	12.81 ± 1	6.09 ± 0.11	5.27 ± 0.05	1692.85 ± 96.66	39
Northern fulmar							
Alkefjellet	5 ± 0.3	17.73 ± 1.51	8.85 ± 0.65	8.21 ± 0.23	7.04 ± 0.12	1377.27 ± 83.99	34
Bjørnøya	4.47 ± 0.18	17.67 ± 1.08	10.48 ± 0.66	8.04 ± 0.12	7.28 ± 0.09	1535.21 ± 92.4	87
Breidafjordur	3.7 ± 0.3	16.86 ± 3.07	14.52 ± 2.58	11.42 ± 0.4	10.28 ± 0.18	3036.89 ± 446.49	10
Eynhallow	3.72 ± 0.09	12.74 ± 0.51	10.12 ± 0.37	11.97 ± 0.09	9.65 ± 0.04	2529.2 ± 87.97	300
Faroe Islands	3.31 ± 0.23	10.58 ± 1.57	9.32 ± 1.16	15.35 ± 0.53	11.81 ± 0.15	2897.87 ± 429.78	26
Grimsey	2 ± NA	3.83 ± NA	3.47 ± NA	15.1 ± 4.05	11.1 ± 1.1	1416.76 ± NA	1
Holmahals	3 ± NA	8.03 ± NA	7.41 ± 1.07	9.06 ± 3.27	4.28 ± 1.31	1658.08 ± 361.45	1
Jan Mayen	3.23 ± 0.13	11.03 ± 0.66	10.1 ± 0.65	12.47 ± 0.17	10.22 ± 0.08	2554.26 ± 144.37	111
Jarsteinen	4.21 ± 0.24	15.49 ± 1.54	11.91 ± 1.26	12.23 ± 0.26	9.69 ± 0.14	2882.51 ± 300.01	28
Langanes and Skjalfandi	3.56 ± 0.12	12 ± 0.66	10.53 ± 0.54	12 ± 0.14	9.93 ± 0.06	2577.99 ± 123.26	129
Papey	3.6 ± 0.4	11.89 ± 2.11	9.39 ± 1.74	10.54 ± 0.39	9.84 ± 0.22	2088.59 ± 405.45	10
Reykjanes	3.29 ± 0.57	14.35 ± 4.13	13.38 ± 4.62	11.21 ± 0.4	10.77 ± 0.26	3201.18 ± 997.67	7
Black-legged kittiwake							
Alkefjellet	2.55 ± 0.13	14.33 ± 1.31	12.38 ± 0.94	12.75 ± 0.23	10.06 ± 0.08	3684.71 ± 224.46	64
Anda	2.66 ± 0.08	10.14 ± 0.42	10.39 ± 0.37	13.49 ± 0.14	9.24 ± 0.05	3017.05 ± 85.61	136
Bjørnøya	2.73 ± 0.09	12.7 ± 0.71	12.29 ± 0.65	11.84 ± 0.15	8.69 ± 0.06	2849.69 ± 118.84	105
Cape Krutik	2.66 ± 0.08	11.45 ± 0.57	13.1 ± 0.55	13.72 ± 0.17	9.03 ± 0.05	3774.84 ± 123.57	110
Faroe Islands	3.9 ± 0.1	16.71 ± 0.75	14.21 ± 0.67	10.93 ± 0.09	9.22 ± 0.05	3099.22 ± 127.81	107
Franz Josef Land	2.29 ± 0.1	14.6 ± 1.11	13.49 ± 0.78	12.94 ± 0.16	10.58 ± 0.07	4141.19 ± 188.77	111
Hjelmsøya	2.33 ± 0.21	10.39 ± 2.14	12.65 ± 2.94	12.71 ± 0.64	10.1 ± 0.25	3898.33 ± 677.15	6
Hornøya	2.51 ± 0.09	12.55 ± 0.81	11.73 ± 0.61	13.84 ± 0.19	9.16 ± 0.06	3606.48 ± 127.92	87
Isfjorden	2.95 ± 0.09	16.23 ± 0.99	13.53 ± 0.76	12.76 ± 0.14	9.91 ± 0.06	3626.94 ± 175.23	103
Isle of May	4.25 ± 0.11	15.83 ± 0.65	12.1 ± 0.58	11.36 ± 0.11	9.15 ± 0.06	2789.87 ± 111.66	95
Kara Gate	3.43 ± 0.26	13.71 ± 1.17	10.87 ± 0.9	11.95 ± 0.27	8.28 ± 0.12	2550.85 ± 182.34	37
Kongsfjorden	3.08 ± 0.08	18.58 ± 0.71	13.7 ± 0.51	12.31 ± 0.09	10.03 ± 0.04	3657.31 ± 116.62	202

Langanes and Skjalfandi	3.8 ± 0.16	17.42 ± 1.07	12.84 ± 0.65	10.33 ± 0.12	9.06 ± 0.06	2502.51 ± 115.41	75
Runde and Ålesund	3.59 ± 0.13	12.75 ± 0.81	10.45 ± 0.58	11.92 ± 0.16	8.64 ± 0.06	2641.38 ± 128.08	68
Røst	3.01 ± 0.08	10.71 ± 0.53	9.96 ± 0.45	13.85 ± 0.14	9.08 ± 0.05	2846.66 ± 89.08	143
Sklinna	3.24 ± 0.1	10.75 ± 0.51	10.11 ± 0.44	12.55 ± 0.13	9.2 ± 0.05	2676.1 ± 90.5	123
Brünnich’s guillemot							
Alkefjellet	2.59 ± 0.16	15.47 ± 1.12	12.1 ± 0.93	4.22 ± 0.09	4.25 ± 0.07	840.67 ± 51.94	68
Bjørnøya	2.84 ± 0.11	11.84 ± 0.75	10.49 ± 0.54	6.41 ± 0.09	4.79 ± 0.03	1463.77 ± 54.85	100
Cape Gorodetskiy	3.39 ± 0.3	18.34 ± 1.87	14.08 ± 1.54	5.12 ± 0.1	4.59 ± 0.06	1262.82 ± 118.93	36
Franz Josef Land	3.17 ± 0.17	19.73 ± 2.56	11.16 ± 1.84	4.86 ± 0.26	5.07 ± 0.19	994.58 ± 173.21	6
Grimsey	3.26 ± 0.2	11.75 ± 1.05	11.18 ± 0.75	6.6 ± 0.14	5.46 ± 0.06	1505.4 ± 93.24	42
Hornøya	3.1 ± 0.13	13.61 ± 0.76	11.84 ± 0.58	5.37 ± 0.06	4.7 ± 0.03	1229.84 ± 60.89	129
Isfjorden	3.41 ± 0.23	15.31 ± 1.3	11.06 ± 0.72	6.86 ± 0.17	5.04 ± 0.05	1537.4 ± 76.71	39
Jan Mayen	3.67 ± 0.1	19.16 ± 0.7	14.73 ± 0.53	5.88 ± 0.05	5.01 ± 0.02	1670.52 ± 46.69	179
Kara Gate	4.06 ± 0.17	16.02 ± 1.05	10.06 ± 0.52	5.02 ± 0.06	4.42 ± 0.03	1011.47 ± 47.61	86
Langanes and Skjalfandi	3.78 ± 0.24	17.09 ± 1.58	12.08 ± 0.91	5.68 ± 0.11	4.88 ± 0.05	1296.71 ± 87.83	41
Latrabjarg	2.94 ± 0.42	16.31 ± 3.28	15.52 ± 2.16	7.35 ± 0.24	6.24 ± 0.11	1972.32 ± 247.32	16
Oranskie Islands	3.67 ± 0.58	23.47 ± 2.46	12.33 ± 1.96	4.62 ± 0.18	4.8 ± 0.16	1019.15 ± 137.13	9
Common guillemot							
Bjørnøya	3.23 ± 0.1	16.44 ± 0.87	14.42 ± 0.69	5.13 ± 0.05	4.49 ± 0.03	1330.36 ± 64.31	134
Cape Gorodetskiy	2.13 ± 0.3	11.93 ± 2.7	13.72 ± 2.4	4.62 ± 0.13	4.83 ± 0.1	1179.44 ± 179.82	23
Faroe Islands	4.86 ± 0.46	20.12 ± 2.46	12.13 ± 1.7	5.98 ± 0.14	5.94 ± 0.09	1476.79 ± 160.94	14
Grimsey	3.18 ± 0.58	13.1 ± 2.4	9.38 ± 1.52	5.72 ± 0.22	5.76 ± 0.12	1061.35 ± 175	11
Hjelmsøya	2.56 ± 0.16	11.52 ± 0.98	11.2 ± 1.01	4.8 ± 0.08	4.62 ± 0.05	1045.15 ± 81.62	70
Hornøya	2.18 ± 0.12	9.85 ± 0.69	11.72 ± 0.81	4.25 ± 0.05	4 ± 0.03	978.76 ± 59.27	131
Isle of May	3.33 ± 0.18	11.89 ± 0.82	10.15 ± 0.64	6.21 ± 0.08	5.84 ± 0.04	1244.56 ± 66.73	104
Jan Mayen	4.04 ± 0.13	20.76 ± 0.93	13.86 ± 0.58	5.45 ± 0.05	4.9 ± 0.03	1452.72 ± 57.38	119
Langanes and Skjalfandi	4.31 ± 0.14	16.35 ± 0.9	10.82 ± 0.61	5.6 ± 0.06	4.9 ± 0.03	1210.52 ± 64.54	85
Latrabjarg	3.59 ± 0.33	12.84 ± 1.41	10.04 ± 1.06	5.77 ± 0.16	4.95 ± 0.07	1098 ± 114.57	22
Sklinna	3.02 ± 0.11	13.4 ± 0.74	12.21 ± 0.51	5.01 ± 0.05	4.56 ± 0.03	1182.71 ± 39.63	157

Table S6: Apparent movement rate: estimates for the best model including segment type, species and their interaction as fixed effects. Segtype = segment type (migratory/stationary). Apparent movement rate was log transformed. Intercept represents migratory segments for little auks. Model structure: log(mvt rate) ~ 1 + segtype * species

	Value	**SE**	**df**	***t***	**p**
(Intercept)	1.684	0.032	15791	53.130	<0.001
Segtype stationary	-0.108	0.022	15791	-4.884	<0.001
Species Fratercula_arctica	0.117	0.028	2363	4.170	<0.001
Species Fulmarus_glacialis	0.645	0.029	2363	22.150	<0.001
Species Rissa_tridactyla	0.883	0.025	2363	35.160	<0.001
Species Uria_lomvia	0.123	0.028	2363	4.454	<0.001
Species Uria_aalge	-0.004	0.027	2363	-0.161	0.872
Segtype stationary : Species Fratercula_arctica	-0.015	0.026	15791	-0.588	0.557
Segtype stationary : Species Fulmarus_glacialis	-0.104	0.026	15791	-3.992	<0.001
Segtype stationary : Species Rissa_tridactyla	-0.217	0.024	15791	-8.983	<0.001
Segtype stationary : Species Uria_lomvia	-0.056	0.026	15791	-2.131	0.033
Segtype stationary : Species Uria_aalge	0.025	0.026	15791	0.959	0.337

Table S7: Sinuosity: estimates for the best model including segment type and species as fixed effects. Segtype = segment type (migratory/stationary). Sinuosity was transformed (asin(log(sinuosity)). Intercept represents migratory segments and little auks. Model structure: sinuosity ~ 1 + segtype * species

	Value	**SE**	**df**	***t***	**p**
(Intercept)	0.306	0.005	24647	61.370	<0.001
segtypestat	0.103	0.004	24647	25.540	<0.001
species Fratercula_arctica	0.007	0.005	2377	1.362	0.173
species Fulmarus_glacialis	-0.034	0.005	2377	-6.663	<0.001
species Rissa_tridactyla	-0.065	0.004	2377	-14.580	<0.001
Species Uria_lomvia	-0.002	0.005	2377	-0.384	0.701
Species Uria_aalge	0.024	0.005	2377	5.072	<0.001
Segtype stationary : species Fratercula_arctica	-0.006	0.005	24647	-1.318	0.188
Segtype stationary : species Fulmarus_glacialis	-0.010	0.005	24647	-2.030	0.042
Segtype stationary : species Rissa_tridactyla	-0.010	0.004	24647	-2.158	0.031
Segtype stationary : species Uria_lomvia	0.007	0.005	24647	1.481	0.139
Segtype stationary : species Uria_aalge	-0.006	0.005	24647	-1.304	0.192

Table S8: Difference in latitude modelled as a function of season and species: estimates for the best model including segment type and species as fixed effects. Season = autumn, spring, summer. Intercept represents autumn and little auks. Model structure: latitude_difference ~ 1 + season * species

	Value	SE	df	*t*	p
(Intercept)	-4.209	1.162	9671	-3.623	<0.001
Season spring	2.559	0.525	9671	4.878	<0.001
Season winter	5.634	0.412	9671	13.690	<0.001
Species Fratercula_arctica	7.078	0.633	2360	11.180	<0.001
Species Fulmarus_glacialis	5.199	0.653	2360	7.968	<0.001
Species Rissa_tridactyla	15.680	0.576	2360	27.230	<0.001
Species Uria_lomvia	5.949	0.616	2360	9.666	<0.001
Species Uria_aalge	6.546	0.609	2360	10.760	<0.001
Season spring : species Fratercula_arctica	-0.712	0.591	9671	-1.206	0.228
seasonwinter : species Fratercula_arctica	-2.999	0.465	9671	-6.445	<0.001
Season spring : species Fulmarus_glacialis	-3.618	0.638	9671	-5.667	<0.001
Season winter : species Fulmarus_glacialis	-4.753	0.475	9671	-10.010	<0.001
Season spring : species Rissa_tridactyla	-4.903	0.583	9671	-8.418	<0.001
Season winter : species Rissa_tridactyla	0.232	0.455	9671	0.509	0.611
Season spring : species Uria_lomvia	-2.347	0.597	9671	-3.933	<0.001
Season winter : species Uria_lomvia	-4.626	0.465	9671	-9.957	<0.001
Season spring : species Uria_aalge	-2.474	0.584	9671	-4.236	<0.001
Season winter : species Uria_aalge	-5.023	0.453	9671	-11.090	<0.001

Table S9: Time spent dry: estimates for the best model including segment type, family and mode as fixed effects. Segtype = segment type (migratory/stationary). Mode = saltwater immersion recording mode (30s_10min, 3s_10min). Intercept represents migratory segments and Alcidae. Model structure: ResTimeSpent ~ 1 + segtype * family + mode

	Value	SE	df	*t*	p
(Intercept)	-3.100	1.956	20370	-1.585	0.113
Segtype stationary	0.822	1.060	20370	0.775	0.438
Family Laridae	2.779	1.885	2298	1.474	0.141
Family Procellariidae	18.890	2.564	2298	7.369	<0.001
Mode 3s_10min	5.152	1.337	2112	3.854	<0.001
Segtype stationary : family Laridae	-10.460	1.768	20370	-5.914	<0.001
Segtype stationary : family Procellariidae	-36.320	2.275	20370	-15.960	<0.001

Table S10: Time spent wet: estimates for the best model including segment type, family and mode as fixed effects. Segtype = segment type (migratory/stationary). Mode = saltwater immersion recording mode (30s_10min, 3s_10min). Intercept represents migratory segments and Alcidae. Model structure: ResTimeSpent ~ 1 + segtype * family + mode

	Value	**SE**	**df**	***t***	**p**
(Intercept)	15.580	3.335	20522	4.671	<0.001
Segtype stationary	1.319	1.483	20522	0.889	0.374
Family Laridae	14.760	2.531	2299	5.832	<0.001
Family Procellariidae	-28.500	3.496	2299	-8.154	<0.001
Mode 3s_10min	-27.170	1.713	2115	-15.860	<0.001
Segtype stationary : Family Laridae	4.518	2.481	20522	1.821	0.069
Segtype stationary : Family Procellariidae	41.550	3.195	20522	13.010	<0.001

Table S11: Time spent intermediate: estimates for the best model including segment type, species and mode as fixed effects. Segtype = segment type (migratory/stationary). Mode = saltwater immersion recording mode (30s_10min, 3s_10min). Intercept represents migratory segments and little auks. Model structure: ResTimeSpent ~ 1 + segtype * species + mode

	Value	**SE**	**df**	***t***	**p**
(Intercept)	1.338	4.435	20505	0.302	0.763
Segtype stationary	-6.119	2.927	20505	-2.090	0.037
Species Fratercula_arctica	-14.550	4.276	2296	-3.403	0.001
Species Fulmarus_glacialis	-6.406	4.380	2296	-1.463	0.144
Species Rissa_tridactyla	-32.680	3.932	2296	-8.310	<0.001
Species Uria_lomvia	-16.900	4.205	2296	-4.017	<0.001
Species Uria_aalge	-19.440	4.199	2296	-4.631	<0.001
Mode 3s_10min	23.710	1.395	2114	17.000	<0.001
Segtype stationary : Species Fratercula_arctica	4.305	3.462	20505	1.243	0.214
Segtype stationary : Species Fulmarus_glacialis	-1.708	3.488	20505	-0.490	0.624
Segtype stationary : Species Rissa_tridactyla	9.860	3.216	20505	3.065	0.002
Segtype stationary : Species Uria_lomvia	4.357	3.461	20505	1.259	0.208
Segtype stationary : Species Uria_aalge	5.685	3.435	20505	1.655	0.098

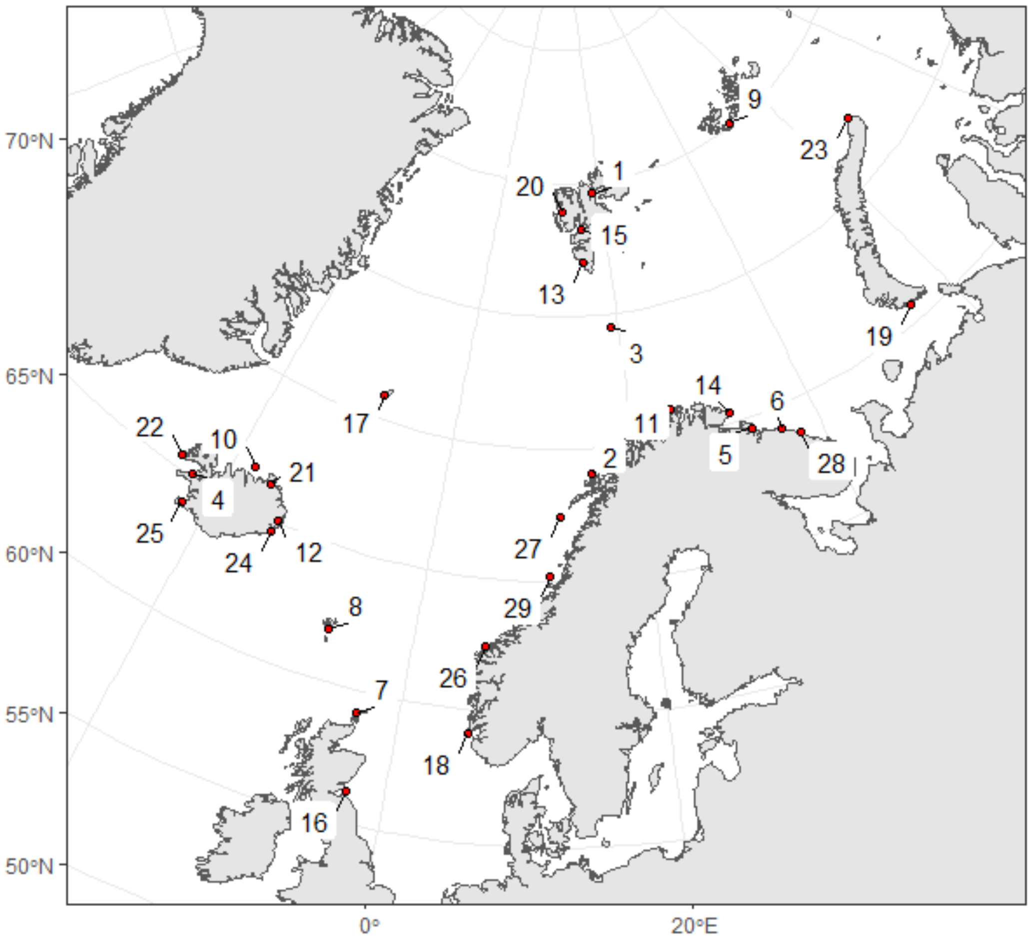
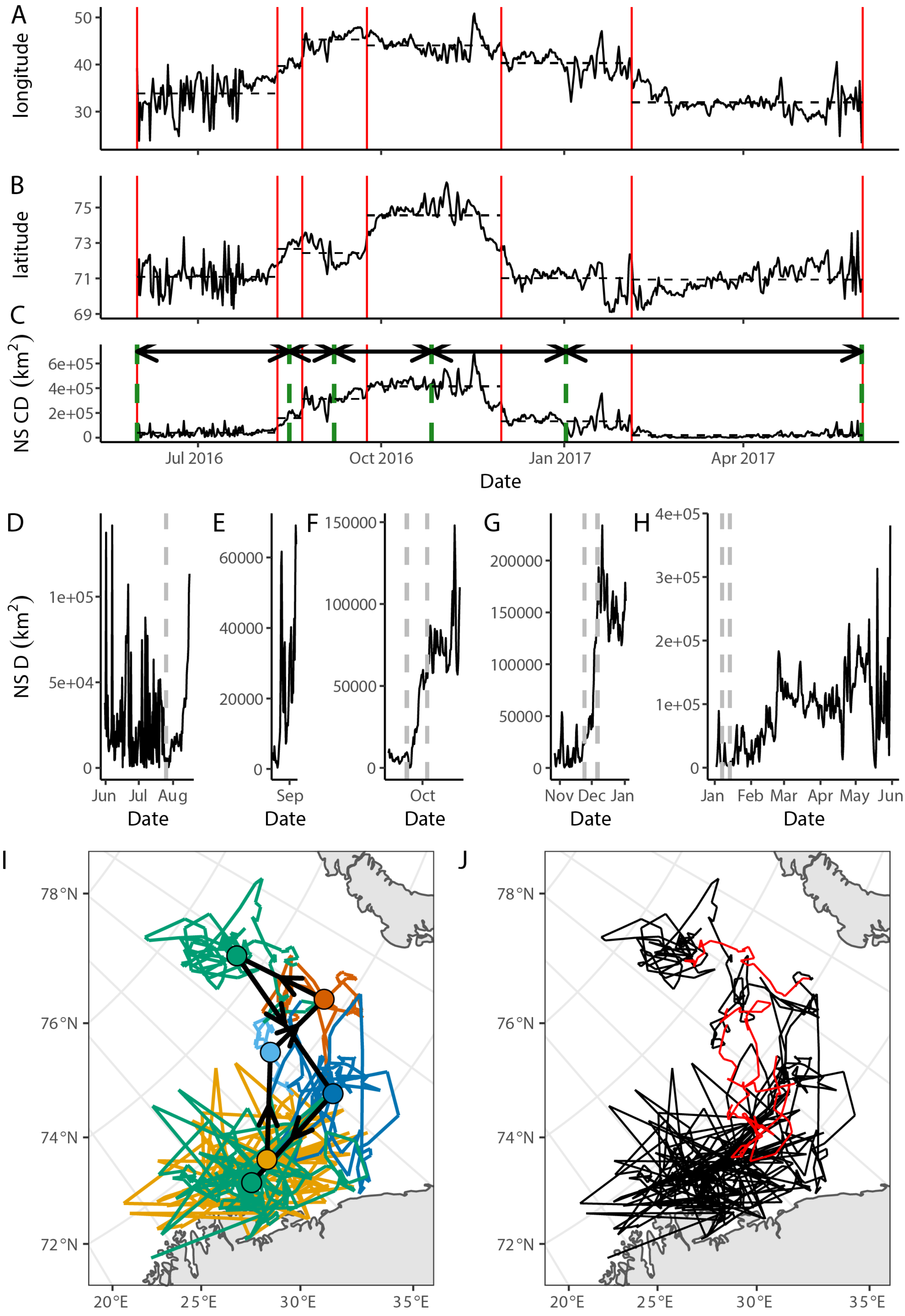


Figure S1: map of the Seatrack colonies included in this study. The names of colonies are detailed in Table S1.

1


A
longitude
50
40
30
B
latitude
75
73
71
69
C
NS CD (km²)
6e+05
4e+05
2e+05
0
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Date
D
NS D (km²)
1e+05
5e+04
0
Jun Jul Aug
Date
E
60000
40000
20000
0
Sep
Date
F
150000
100000
50000
0
Oct
Date
G
200000
150000
100000
50000
0
Nov Dec Jan
Date
H
4e+05
3e+05
2e+05
1e+05
0
Jan Feb Mar Apr May Jun
Date
I
78°N
76°N
74°N
72°N
20°E 25°E 30°E 35°E
J
78°N
76°N
74°N
72°N
20°E 25°E 30°E 35°E

2

Figure S2: Example of Lavielle and migrateR segmentation for one Brünnich's guillemot from Hornøya, Norway. Step 1: The Lavielle segmentation delimits the stationary periods; the limits represent the midpoint of a migratory movement. A-C: time series used for Lavielle segmentation: Longitude, Latitude and net-squared colony distance (NSCD). Red segments represent Lavielle segmentation cut-offs, in the middle of a migratory movement. Black dotted lines represent the mean value for each Lavielle segment. Step 2: migrateR is used to delimit the start and the end of each active migration segment. *MigrateR* models the net squared displacement (NSD) from one stationary area to the next, it is therefore necessary to run it on "migrateR segments" comprising the migratory movement and stationary periods preceding and following the movement. MigrateR segments are delimited by the middle of Lavielle segments (the first and last Lavielle segments are fully included to the first and last *migrateR*-segments respectively). Green dotted lines represent cut-offs used for the five migrateR segments. The five arrows in C represent the five *migrateR*-segments represented in D-H. D-H: NSD for the five migrateR-segments. Dotted lines represent the start and end of active migration segments determined by migrateR. I: Map of the Lavielle segmentation that emphasizes stationary areas. Each colour represents the six Lavielle segments. Bold points and arrows represent the centroids of the stationary periods and simplified migration tracks (link between the centroids) respectively. J: migratory segments identified by migrateR in red.

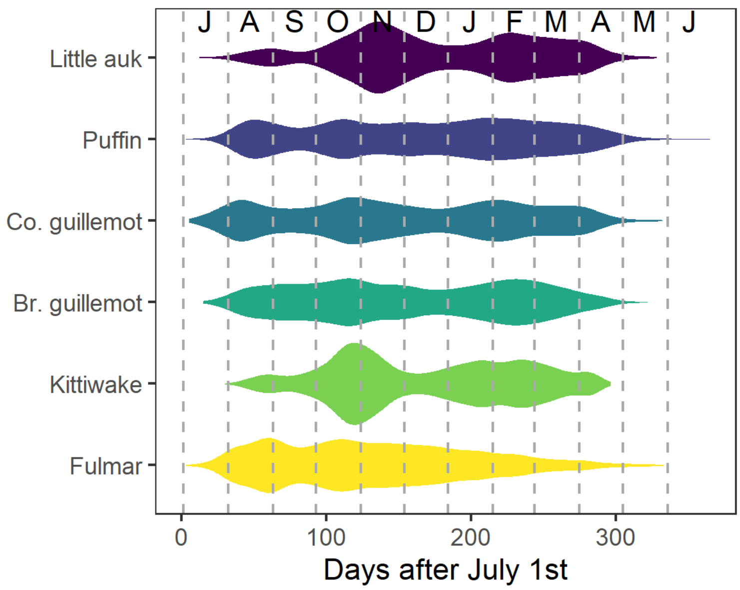
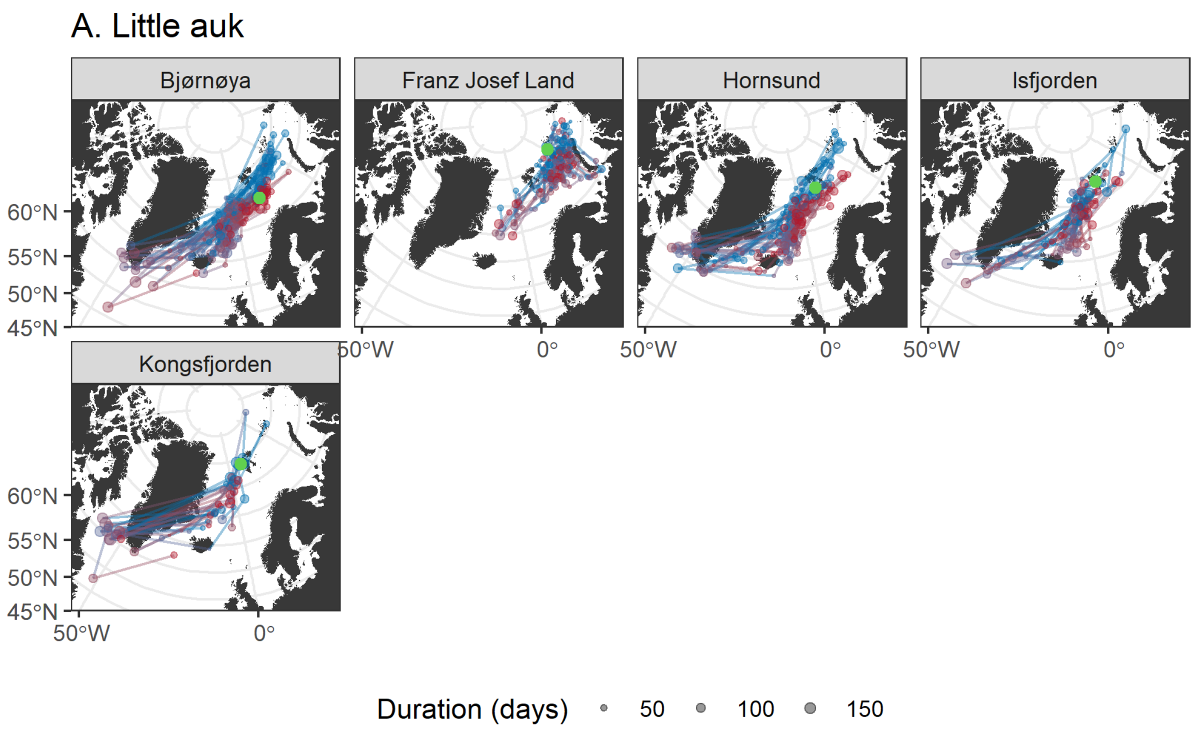
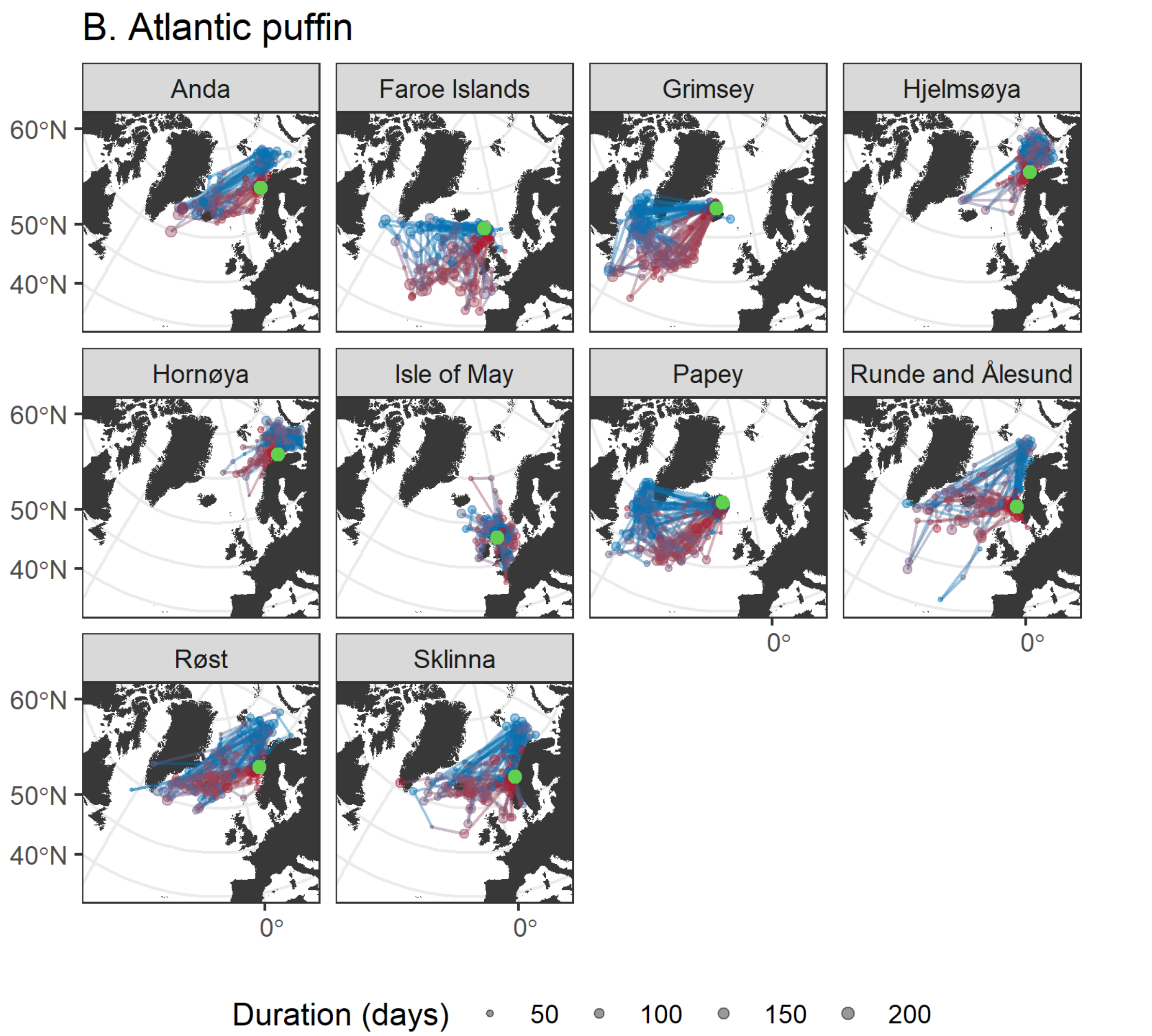
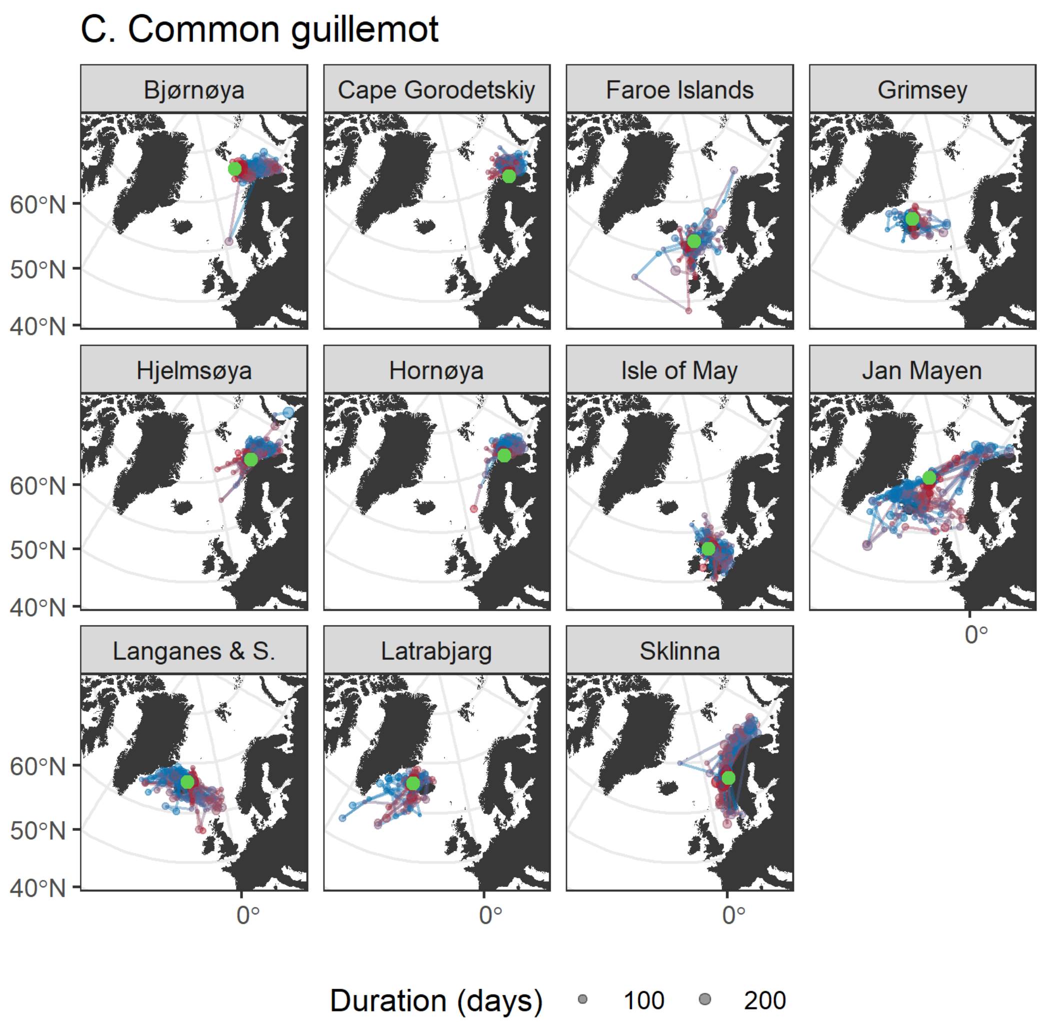
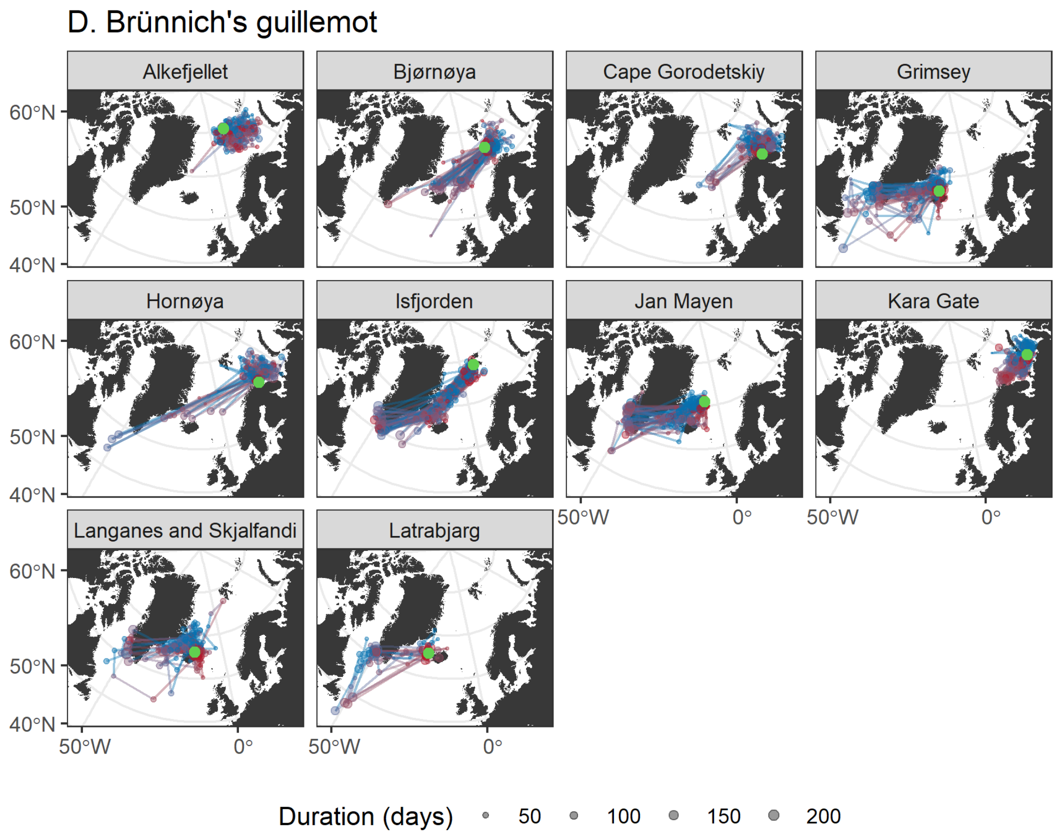


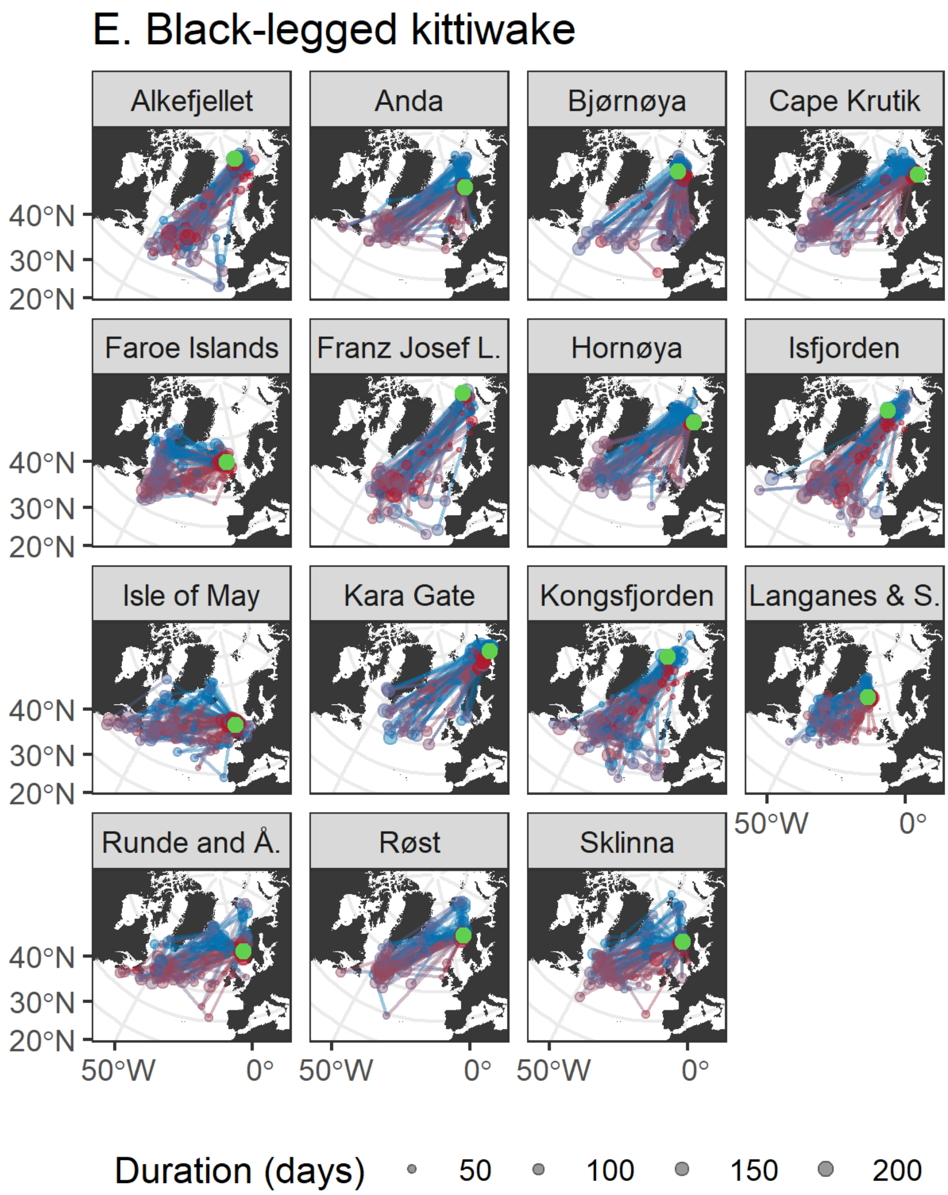
Figure S3: Timing of active migration segments: distribution of the middle dates of active migration segments. Months are indicated by dashed lines. 0 = July 1st; 100 = October 9th, 200 = January 17th; 300 = April 27th.


A. Little auk
Bjørnøya
Franz Josef Land
Hornsund
Isfjorden
Kongsfjorden
60°N
55°N
50°N
45°N
50°W
0°
Duration (days)
50
100
150


B. Atlantic puffin
Anda
Faroe Islands
Grimsey
Hjelmsøya
Hornøya
Isle of May
Papey
Runde and Ålesund
Røst
Sklinna
60°N
50°N
40°N
0°
Duration (days)
50
100
150
200


C. Common guillemot
Bjørnøya
Cape Gorodetskiy
Faroe Islands
Grimsey
Hjelmsøya
Hornøya
Isle of May
Jan Mayen
Langanes & S.
Latrabjarg
Sklinna
60°N
50°N
40°N
0°
Duration (days)
100
200


D. Brünnich's guillemot
Alkefjellet
Bjørnøya
Cape Gorodetskiy
Grimsey
Hornøya
Isfjorden
Jan Mayen
Kara Gate
Langanes and Skjalfandi
Latrabjarg
60°N
50°N
40°N
50°W
0°
Duration (days)
50
100
150
200


E. Black-legged kittiwake
Alkefjellet
Anda
Bjørnøya
Cape Krutik
Faroe Islands
Franz Josef L.
Hornøya
Isfjorden
Isle of May
Kara Gate
Kongsfjorden
Langanes & S.
Runde and Å.
Røst
Sklinna
40°N
30°N
20°N
50°W
0°
Duration (days)
50
100
150
200

1

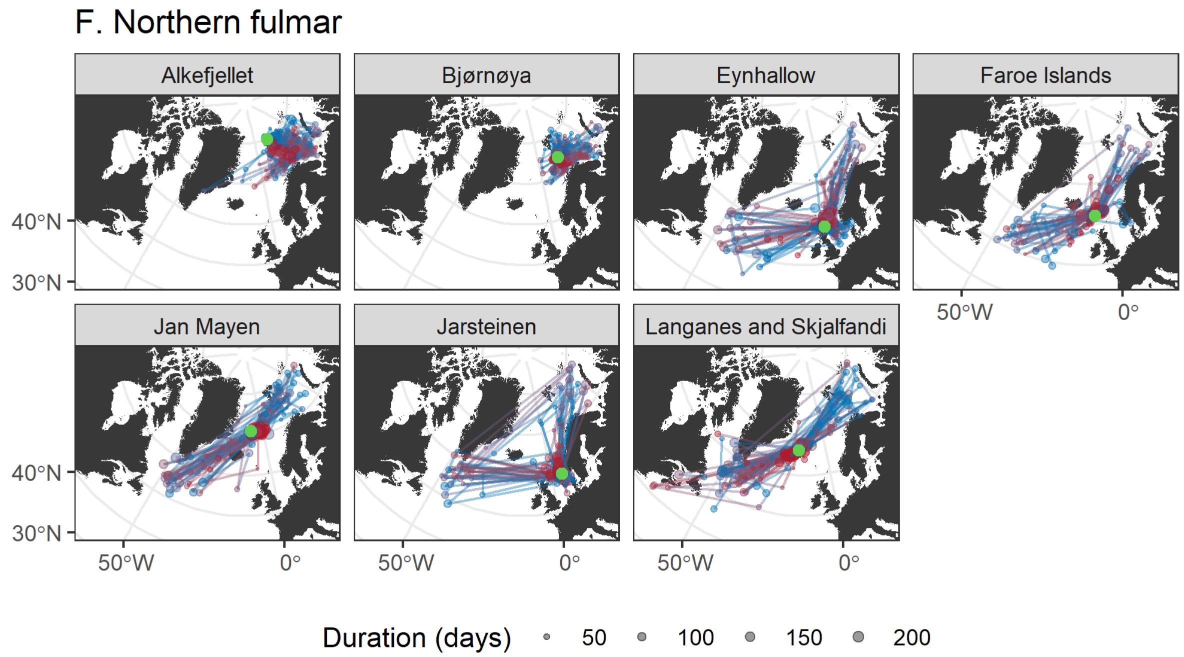
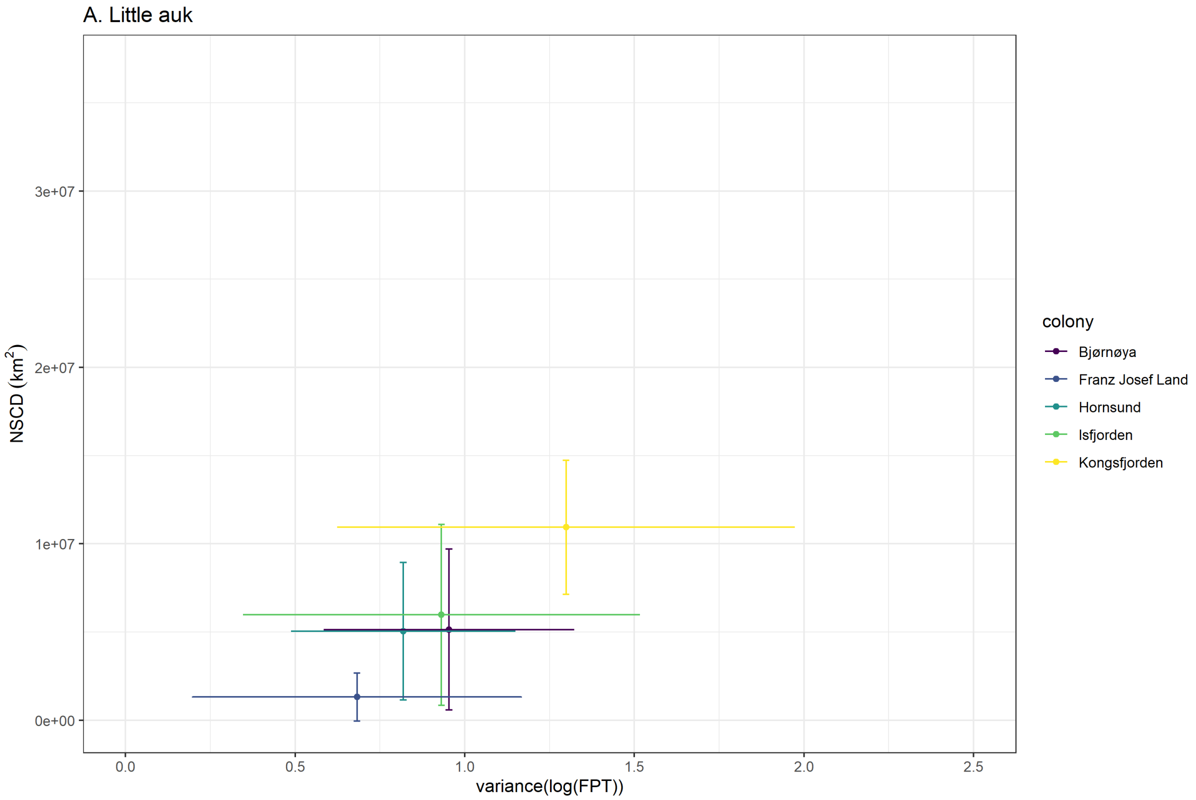
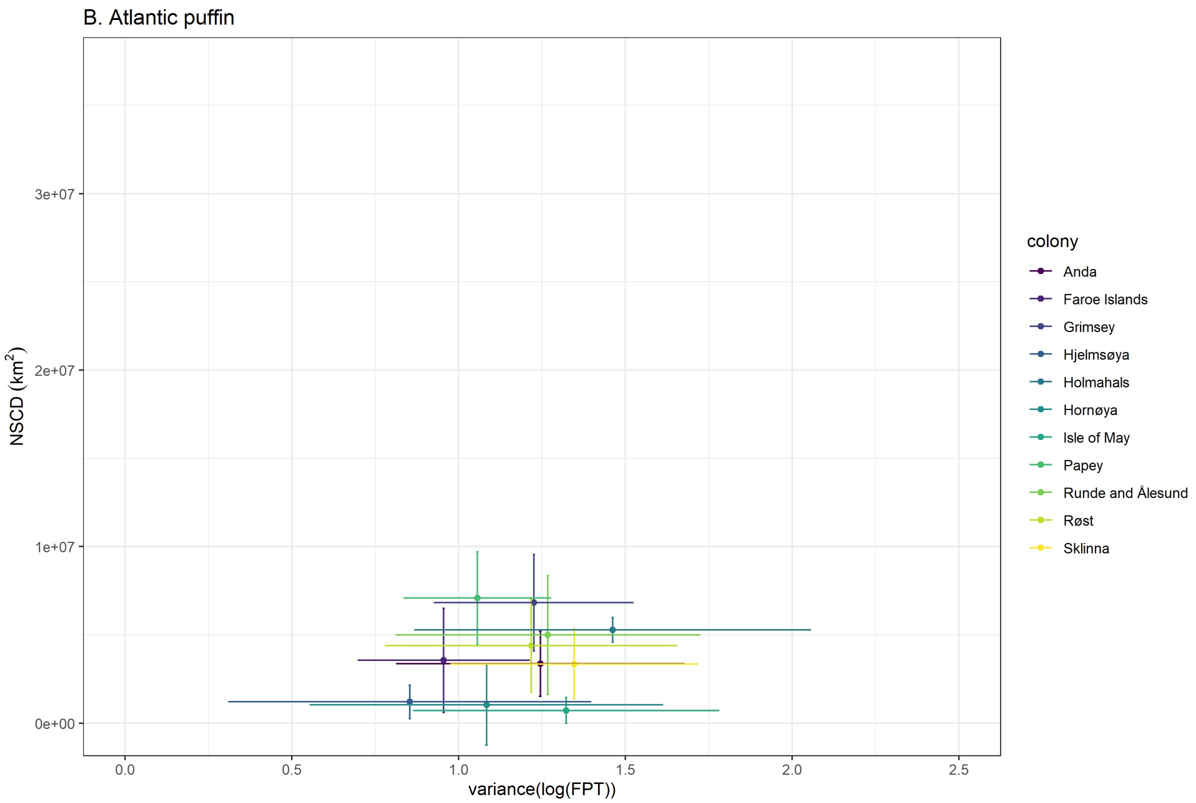
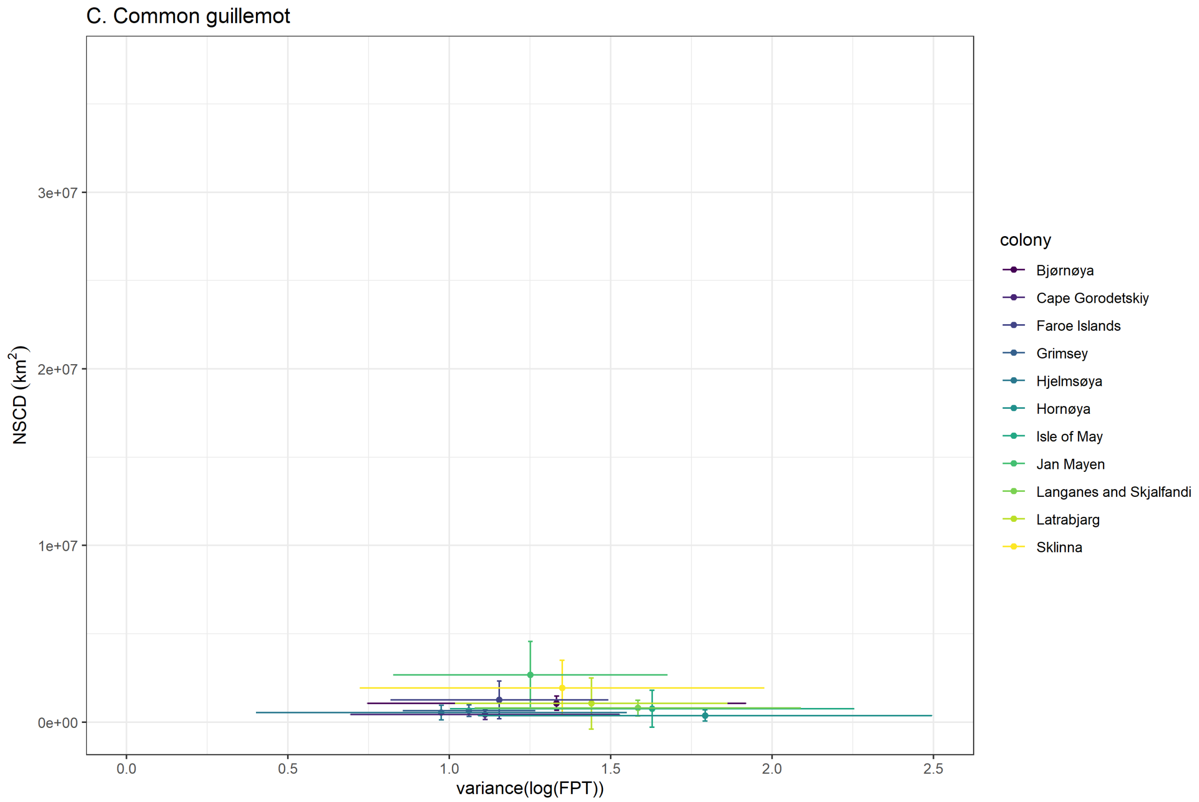
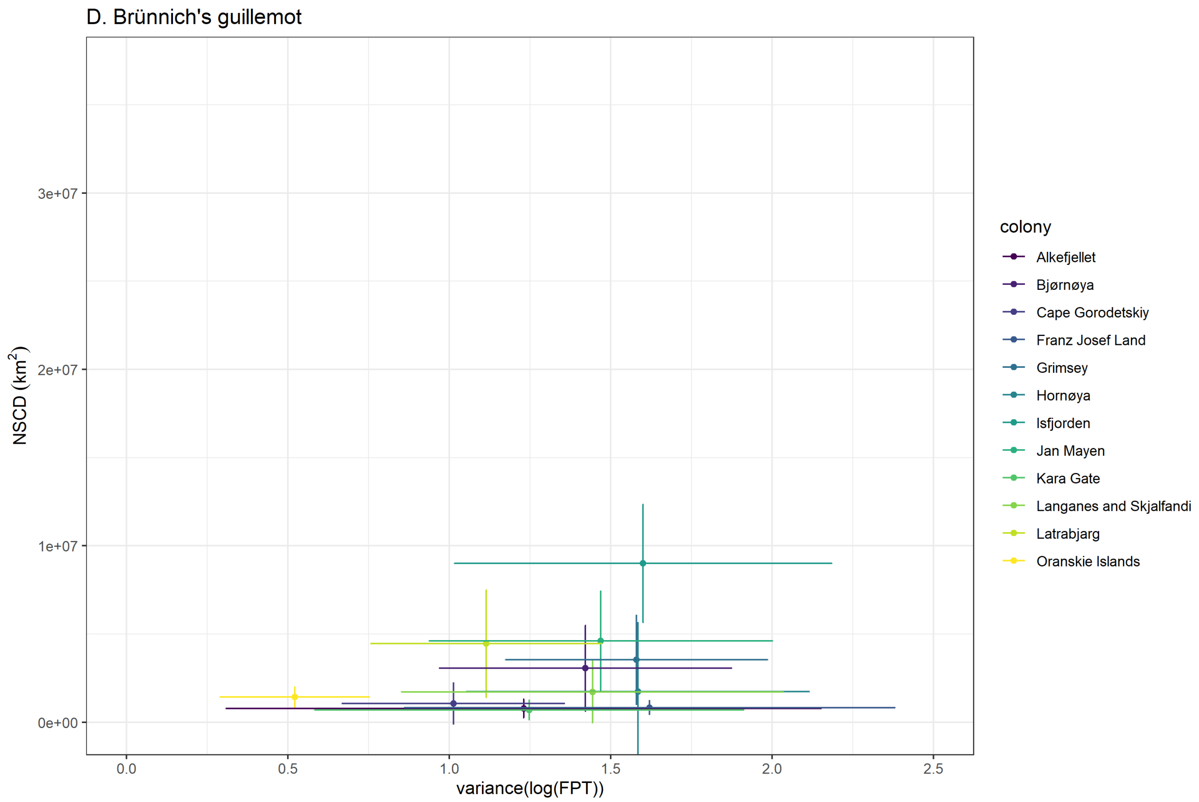


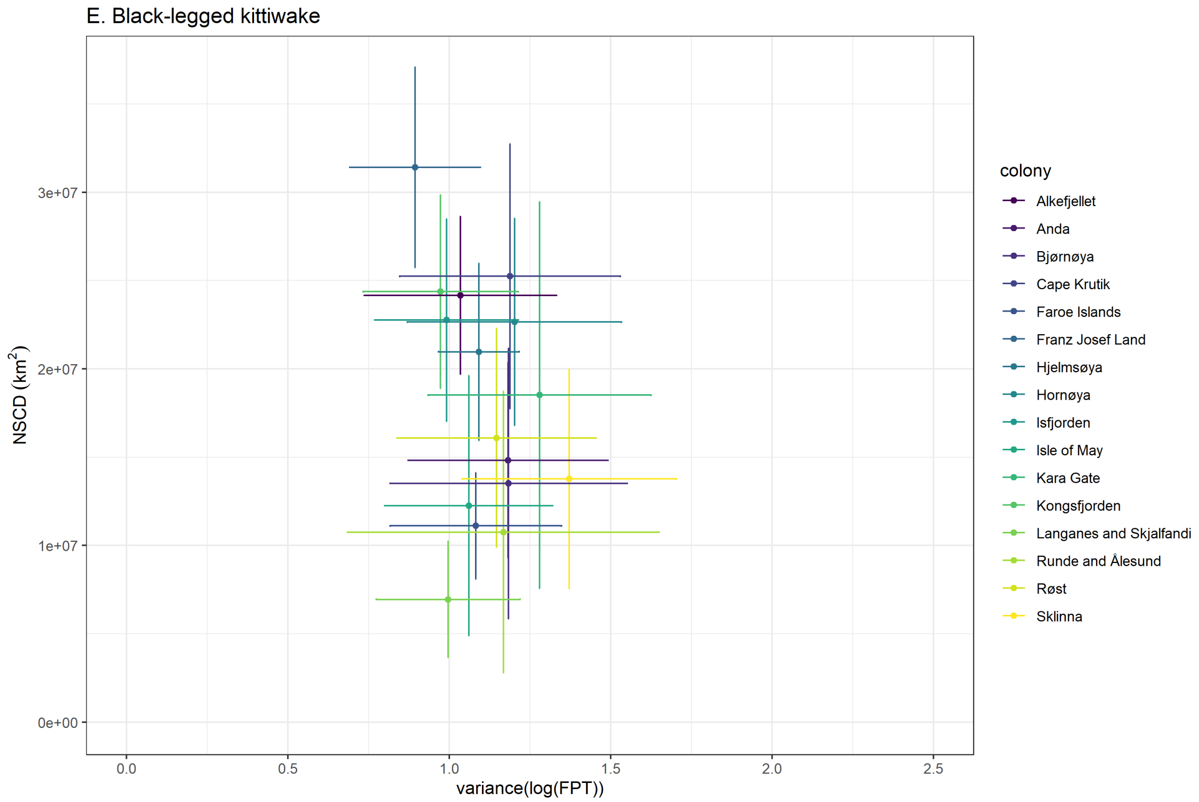
Figure S4: Migration routes for different species and colonies. One track is represented by segments linking the stationary areas (dots, centroid of the Lavielle segments). Tracks are coloured along a blue (start) – red (end) gradient. The size of each dot is proportional to time spent in the area. Colonies are represented by a green dot. Only colonies with more than 10 tracks are presented and a subset of 40 randomly selected tracks is presented for colonies with more than 40 tracks. Number of tracks presented per species and colonies: (A) Little auks: Bjørnøya n = 40; Franz Josef Land n = 40; Hornsund n = 40; Isfjorden n = 25; Kongsfjorden n = 16. (B) Atlantic puffins: Anda n = 31; Faroe Islands n = 32; Grimsey n = 40; Hjelmsøya n = 40; Hornøya n = 40; Isle of May n = 40; Papey n = 40; Røst n = 40; Runde and Ålesund n = 28; Sklinna n = 39. (C) Common guillemots: Bjørnøya n = 40; Cape Gorodetskiy n = 23; Faroe Islands n = 14; Grimsey n = 11; Hjelmsøya n = 40; Hornøya n = 40; Isle of May n = 40; Jan Mayen n = 40; Langanes and Skjalfandi n = 40; Latrabjarg n = 22; Sklinna n = 40. (D) Brünnich's guillemots: Alkefjellet n = 40; Bjørnøya n = 40; Cape Gorodetskiy n = 36; Grimsey n = 40; Hornøya n = 40; Isfjorden n = 39; Jan Mayen n = 40; Kara Gate n = 40; Langanes and Skjalfandi n = 40; Latrabjarg n = 16. (E) Black-legged kittiwakes: Alkefjellet n = 40; Anda n = 40; Bjørnøya n = 40; Cape Krutik n = 40; Faroe Islands n = 40; Franz Josef Land n = 40; Hornøya n = 40; Isfjorden n = 40; Isle of May n = 40; Kara Gate n = 37; Kongsfjorden n = 40; Langanes and Skjalfandi n = 40; Røst n = 40; Runde and Ålesund n = 40; Sklinna n = 40. (F) Northern fulmars: Alkefjellet n = 34; Bjørnøya n = 40; Eynhallow n = 40; Faroe Islands n = 26; Jan Mayen n = 40; Jarsteinen n = 28; Langanes and Skjalfandi 40.


A. Little auk
NSCD (km²)
3e+07
2e+07
1e+07
0e+00
0.0
0.5
1.0
1.5
2.0
2.5
variance(log(FPT))
colony
Bjørnøya
Franz Josef Land
Hornsund
Isfjorden
Kongsfjorden


B. Atlantic puffin
NSCD (km²)
3e+07
2e+07
1e+07
0e+00
0.0
0.5
1.0
1.5
2.0
2.5
variance(log(FPT))
colony
Anda
Faroe Islands
Grimsey
Hjelmsøya
Holmahals
Hornøya
Isle of May
Papey
Runde and Ålesund
Røst
Sklinna


C. Common guillemot
NSCD (km²)
3e+07
2e+07
1e+07
0e+00
0.0
0.5
1.0
1.5
2.0
2.5
variance(log(FPT))
colony
Bjørnøya
Cape Gorodetskiy
Faroe Islands
Grimsey
Hjelmsøya
Hornøya
Isle of May
Jan Mayen
Langanes and Skjalfandi
Latrabjarg
Sklinna


D. Brünnich's guillemot
NSCD (km²)
3e+07
2e+07
1e+07
0e+00
0.0
0.5
1.0
1.5
2.0
2.5
variance(log(FPT))
colony
Alkefjellet
Bjørnøya
Cape Gorodetskiy
Franz Josef Land
Grimsey
Hornøya
Isfjorden
Jan Mayen
Kara Gate
Langanes and Skjalfandi
Latrabjarg
Oranskie Islands



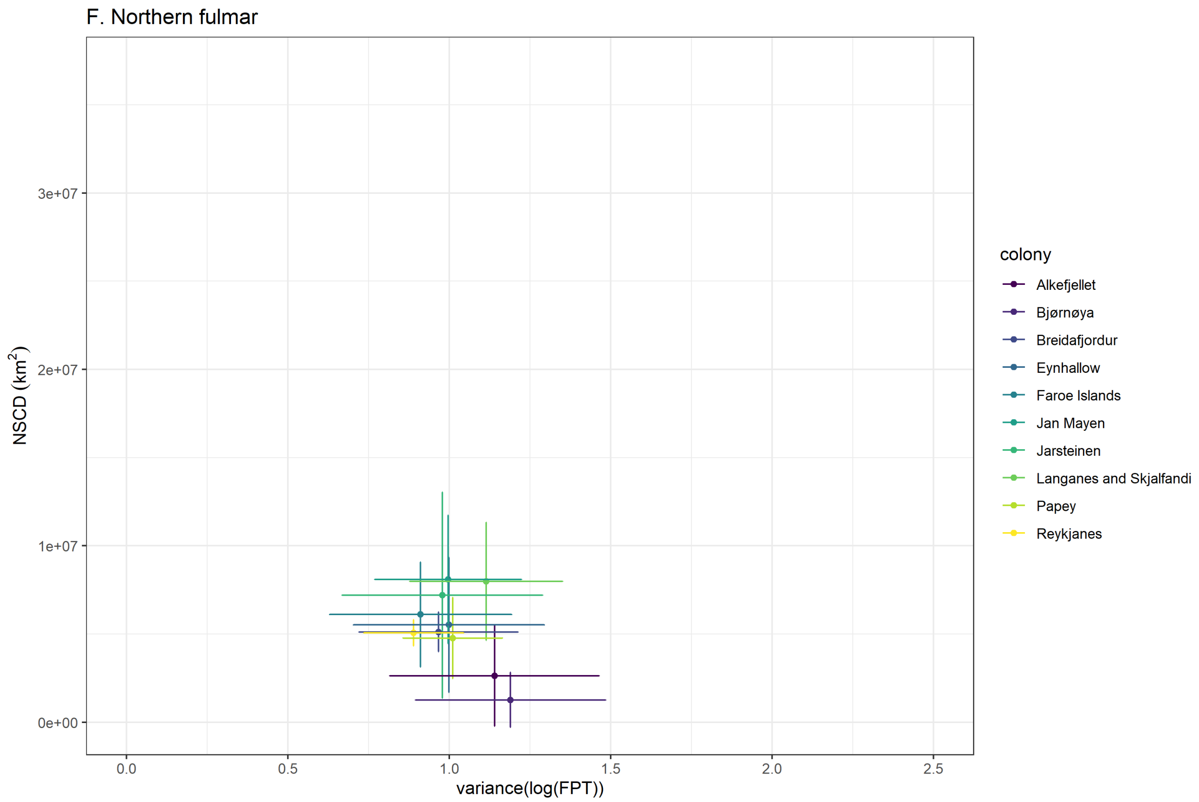


Figure S5: Classification of migratory behaviour based on the net-squared colony distance (NSCD) and the variance in first-passage time (FPT), per species and colony. X-axis = mean ± SD variance(log(FPT)) = a measure of how variable the first passage time is (the higher it is, the more differences there are between migratory and stationary movements). Y-axis = Mean ± SD maximum net-squared distance to the colony = a measure of how far birds go from the colony.