

Supplement

Table S1. Overview of the filtering of erroneous positions. Positions are filtered directly by first a speed filter, following a distribution filter, a "distance + angle filter" and at last indirectly through filtering erroneous twilights by local regression filtering (loess). Functions and R packages are listed in the table. For a more detailed description, see Bråthen et al. (2021).

Speed (positions)	Distribution (positions)	Distance + angle (positions)	Local regression (loess, twilights)
Remove both positions if the movement rate between them is above >90 km/h	Remove positions south of 20°S	Remove positions that create "spikes" in the track, which are EITHER >540 km away from the track and where the position creating the spike is $\leq 15^\circ$ to its adjacent positions OR are >1080 km away from the track and where the position creating the spike is $\leq 35^\circ$ to its adjacent positions	k = 6 (how many interquartile ranges it takes before a twilight event is identified as an outlier)
<code>distanceFilter</code> function in the <code>GeoLight</code> package (Lisovski & Hahn 2012)		<code>dafilter</code> from the <code>argosfilter</code> package (Freitas 2012)	<code>loessFilter</code> from the <code>GeoLight</code> package (Lisovski & Hahn 2012)

Table S2. Results of linear mixed models without intercepts.

Dependent variable	Fixed effects	Random effects	Estimate	SE	df	t	p
Distance from colony, December	North Pacific	BirdID + Year	6690.6	416.40	21.01	16.1	<0.001
	North Atlantic		3896.5	250.3	15.8	15.6	<0.001
	Barents Sea		795.0	382.9	30.4	2.1	0.05
Average in daily foraging time	North Pacific		4.6	0.1	74.8	64.0	<0.001
	North Atlantic		4.7	0.1	76.9	34.0	<0.001
	Barents Sea		4.6	0.1	76.3	38.1	<0.001
Colony arrival	North Pacific		123.2	4.8	5.9	25.9	<0.001
	North Atlantic		95.9	4.2	3.7	23.0	<0.001
	Barents Sea		95.0	4.9	6.4	19.4	<0.001
Colony departure	North Pacific		236.3	2.4	15.0	99.0	<0.001
	North Atlantic		234.1	1.7	2.9	140.1	<0.001
	Barents Sea		238.6	2.5	13.3	94.3	<0.001
Crossing 66°N, spring	North Pacific		114.4	13.3	19.2	8.6	<0.001
	North Atlantic		55.8	7.4	19.1	7.5	<0.001
Crossing 66°N, autumn	North Pacific		288.5	5.6	19.8	51.4	<0.001
	North Atlantic	326.4	3.8	9.5	85.3	<0.001	

PS19897_2017_18_Autumn



PS19897_2017_18_Winter



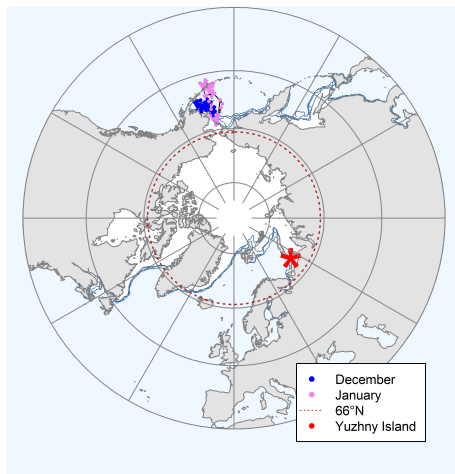
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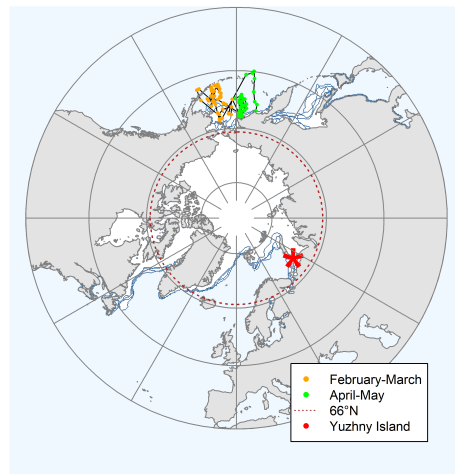
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PS19898_2017_18_Winter



PS19898_2017_18_Spring



PS19902_2015_16_Autumn



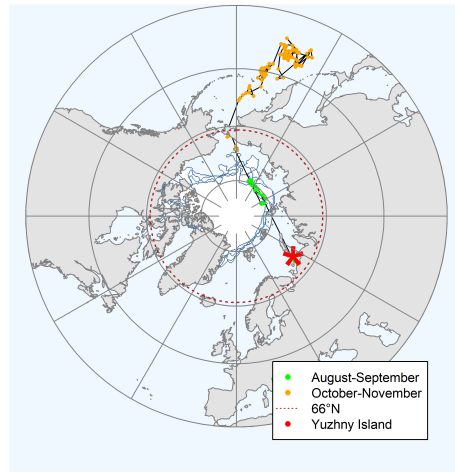
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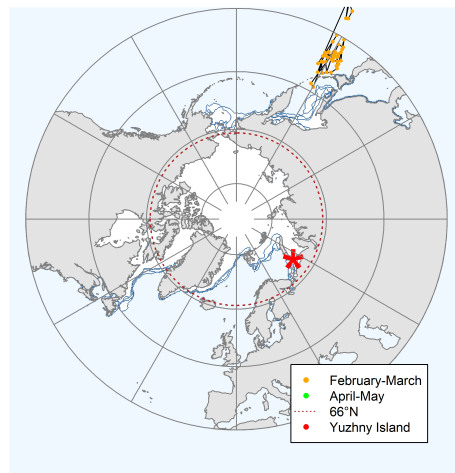
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PS19904_2015_16_Spring



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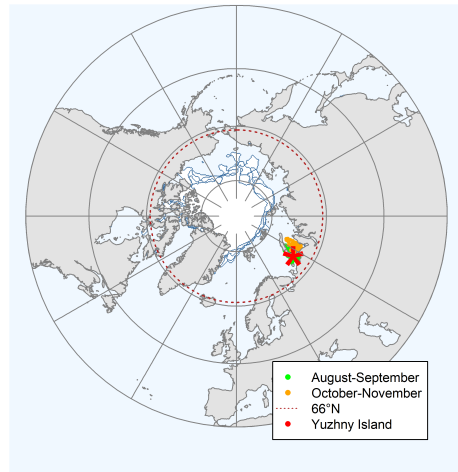
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PS19909_2018_19_Spring



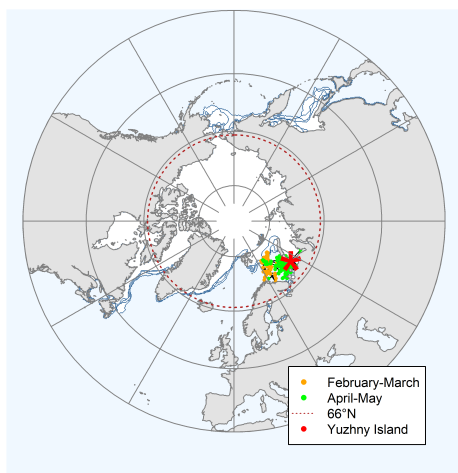
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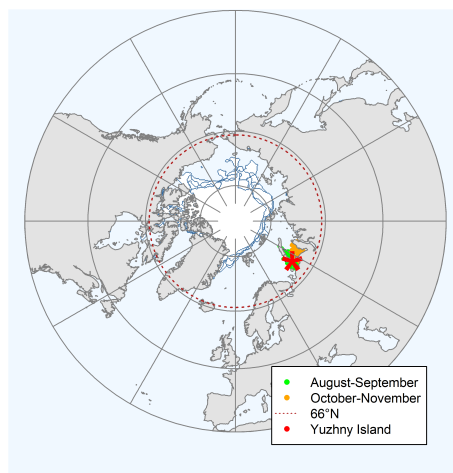
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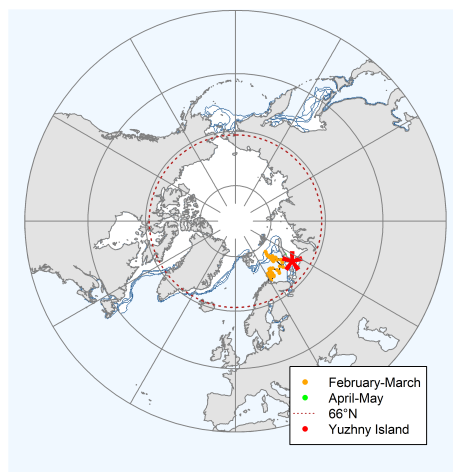
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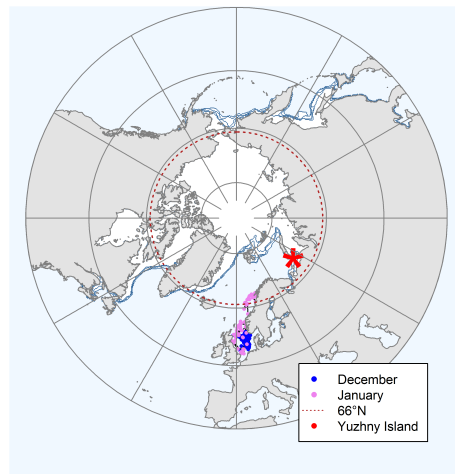
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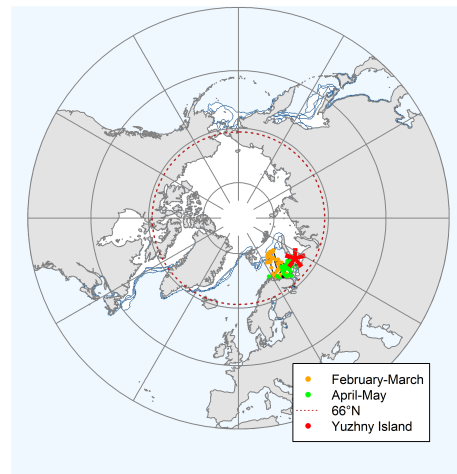
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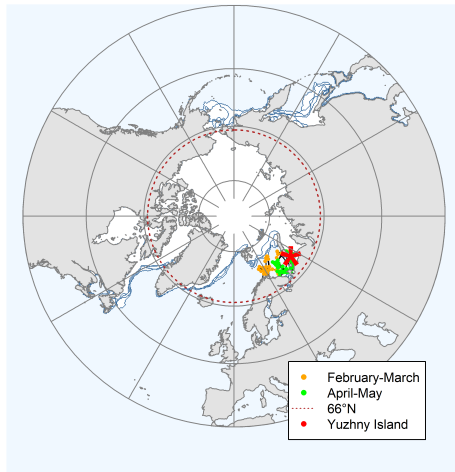
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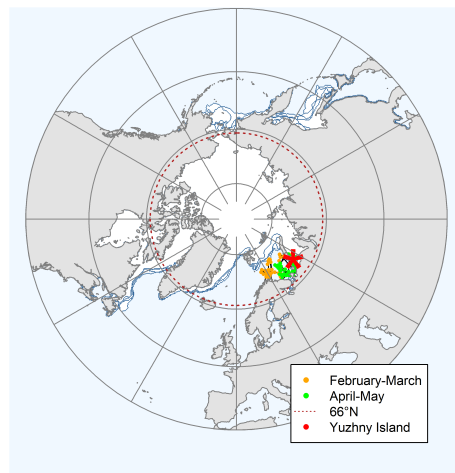
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PS19921_2018_19_Spring



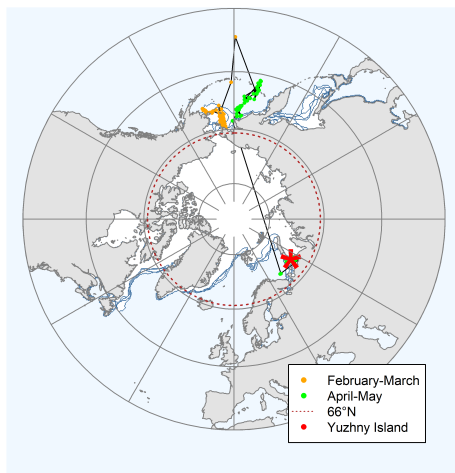
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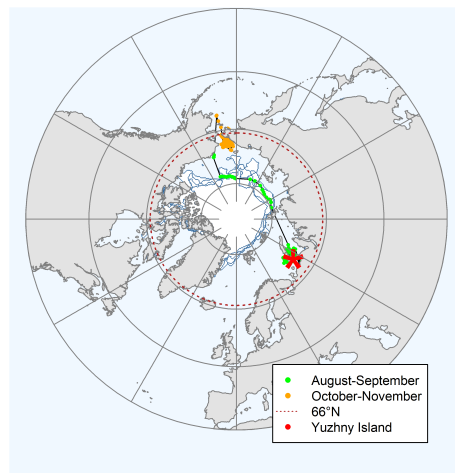
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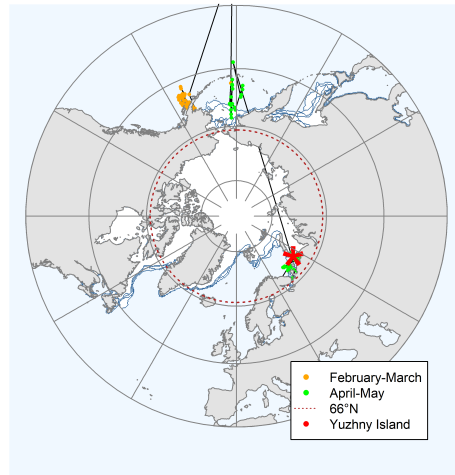
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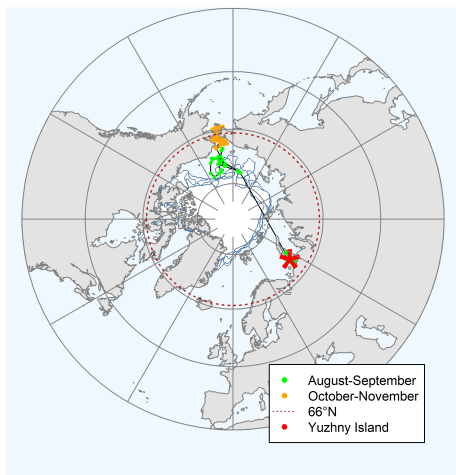
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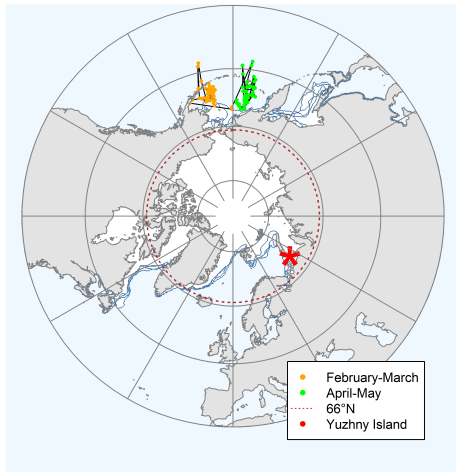
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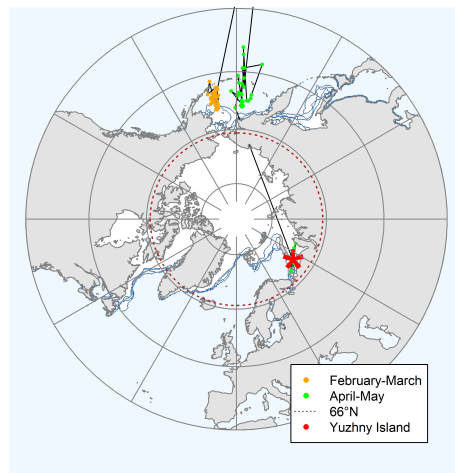
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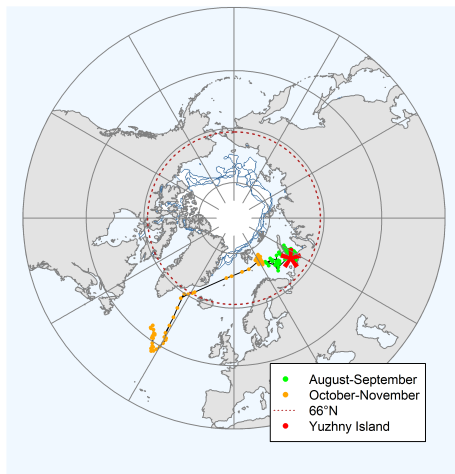
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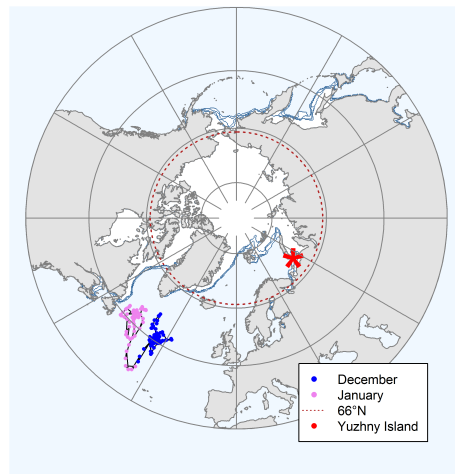
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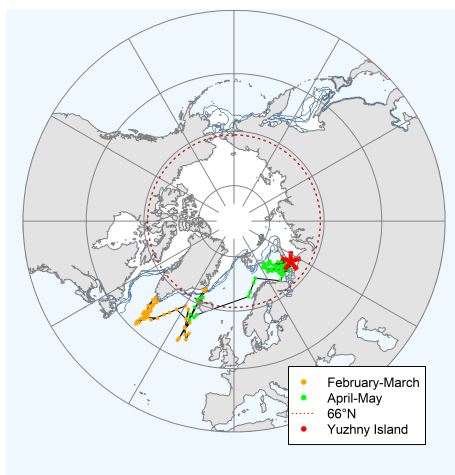
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PS21232_2016_17_Spring



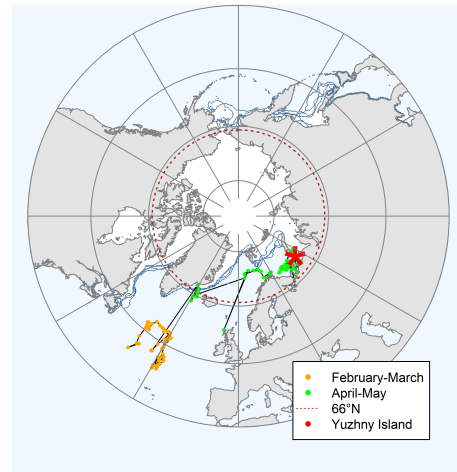
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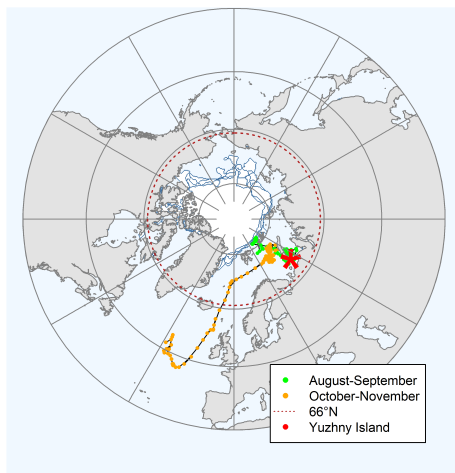
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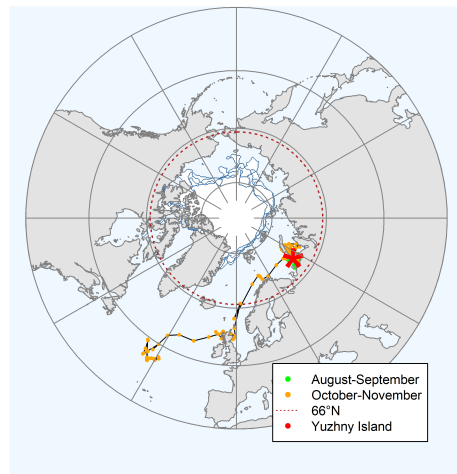
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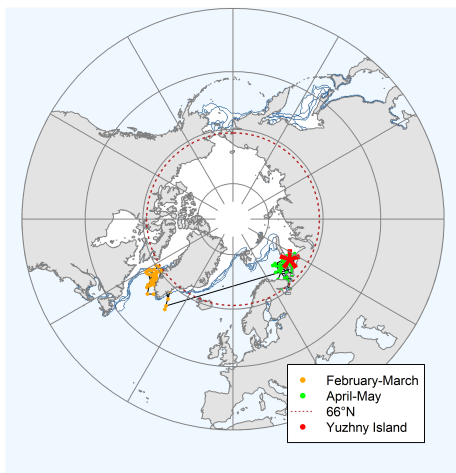
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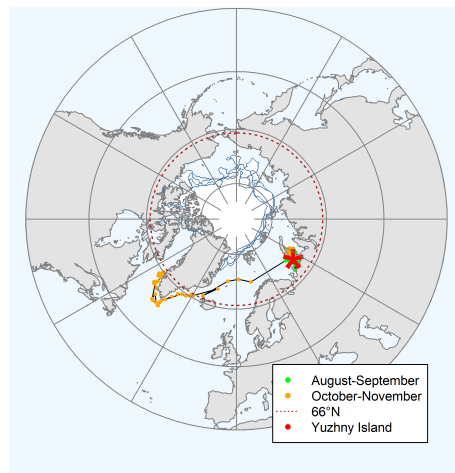
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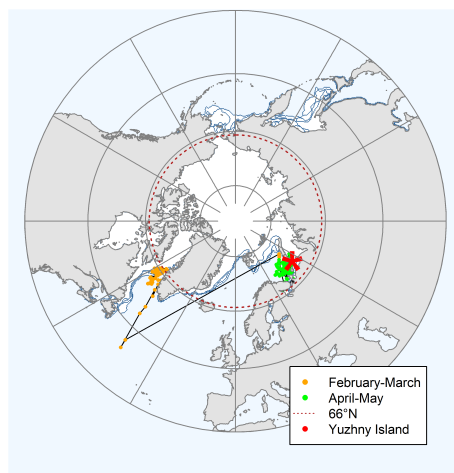
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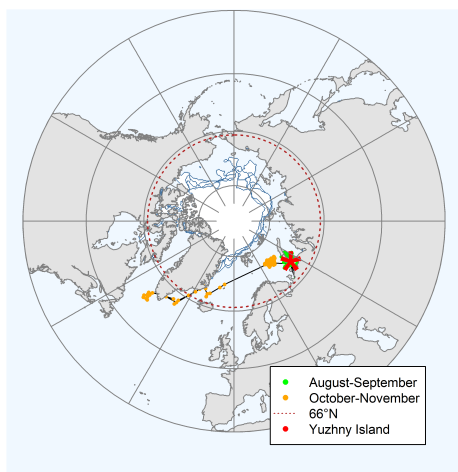
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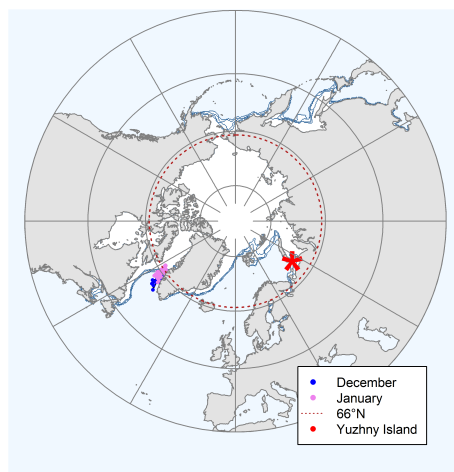
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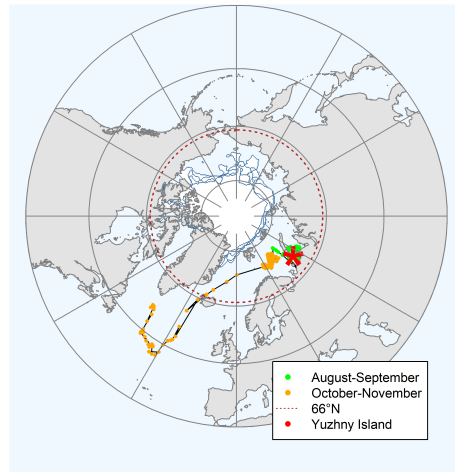
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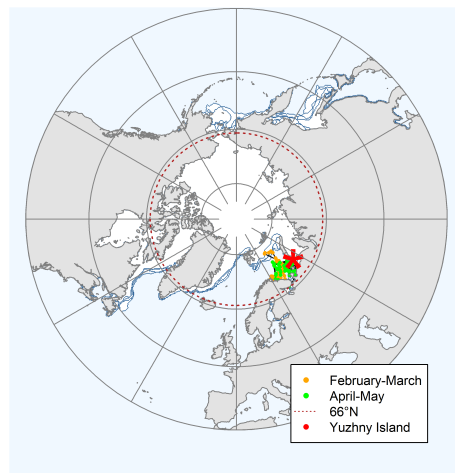
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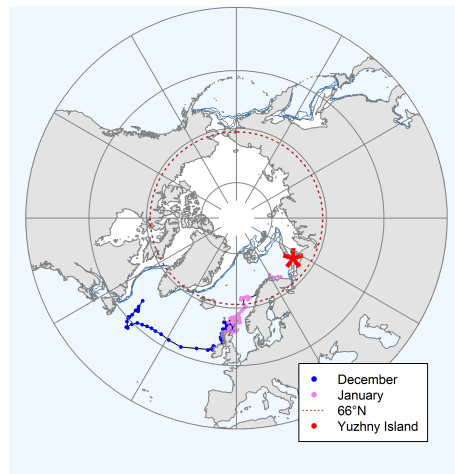
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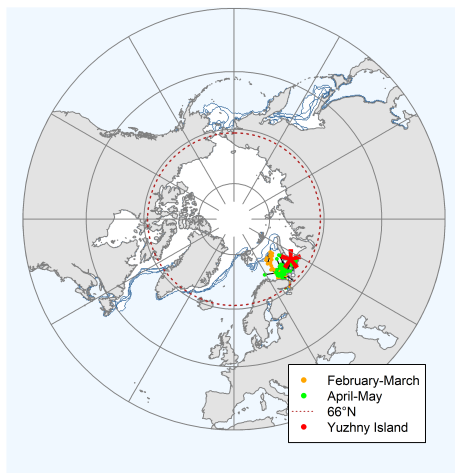
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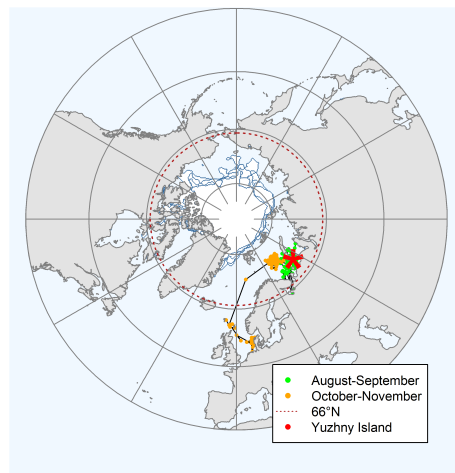
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PS21237_2017_18_Spring



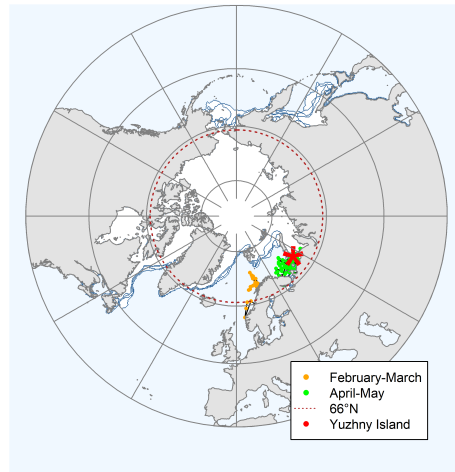
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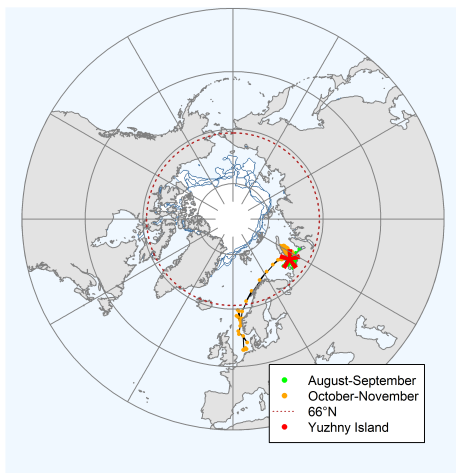
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PS21238_2016_17_Spring



PS21238_2017_18_Autumn



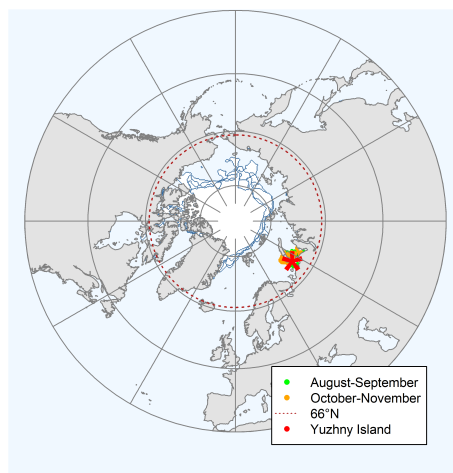
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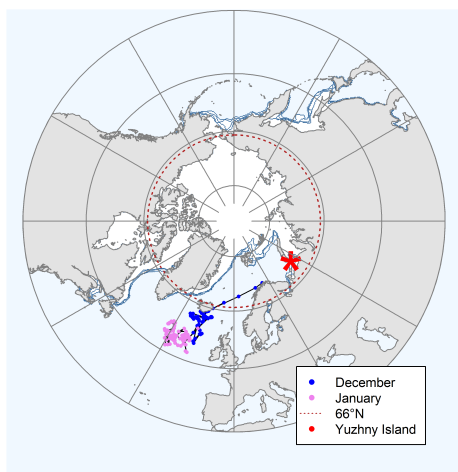
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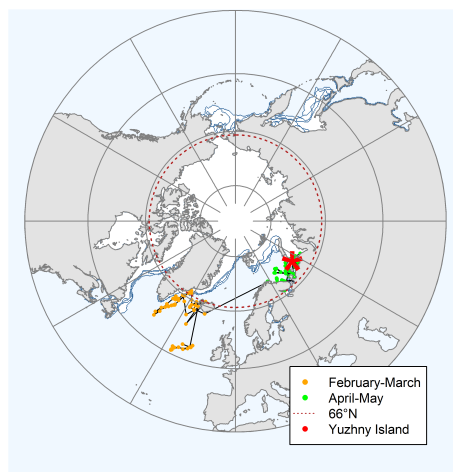
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PS21239_2016_17_Winter



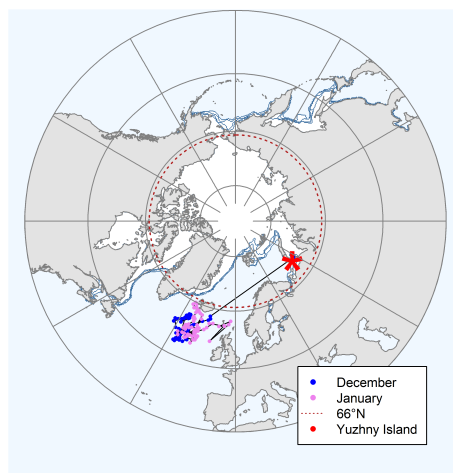
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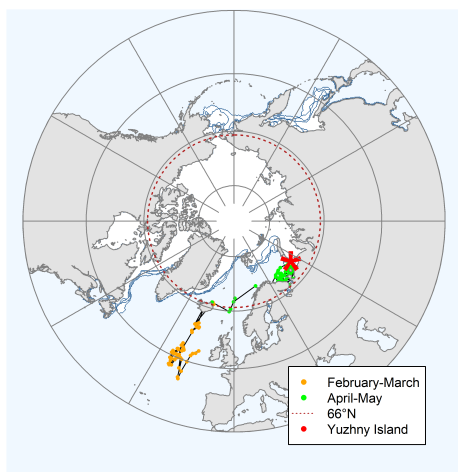
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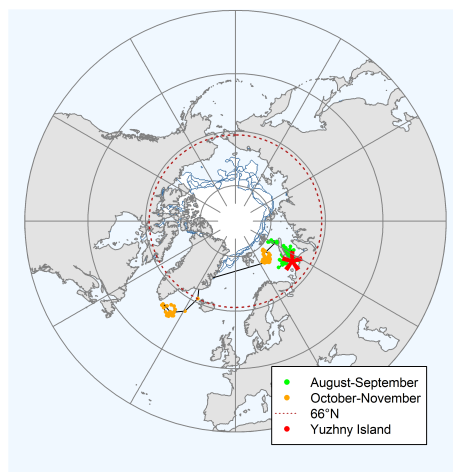
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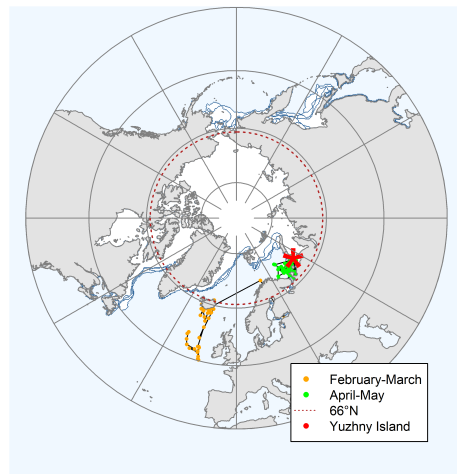
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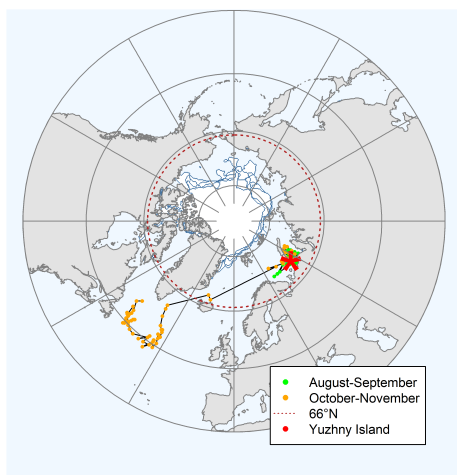
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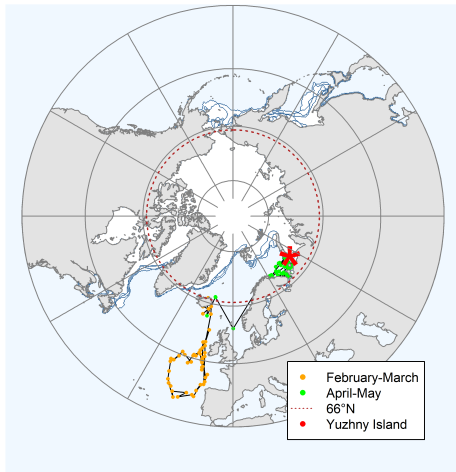
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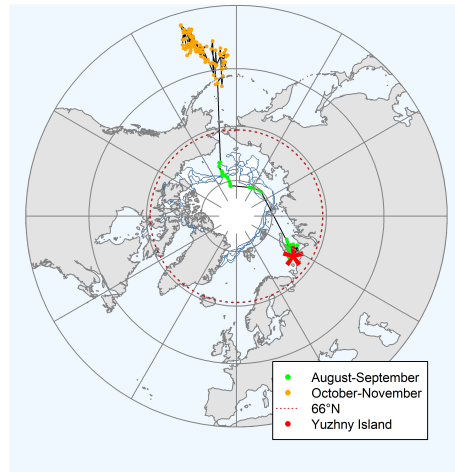
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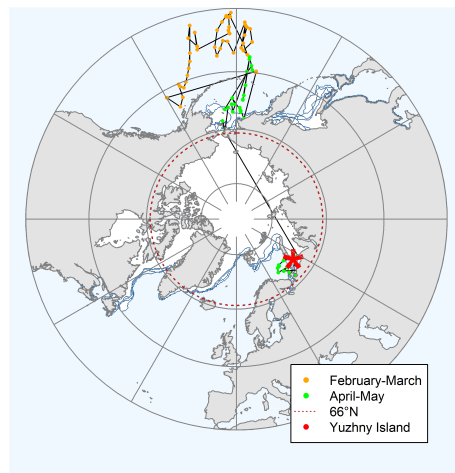
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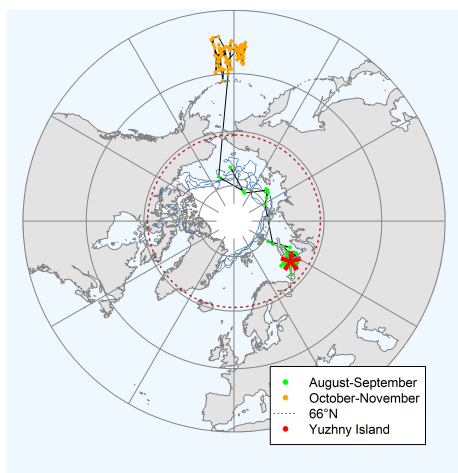
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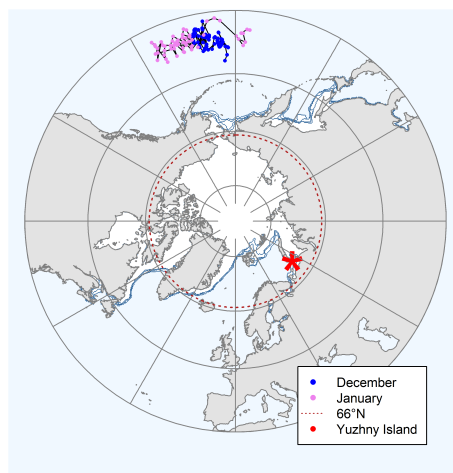
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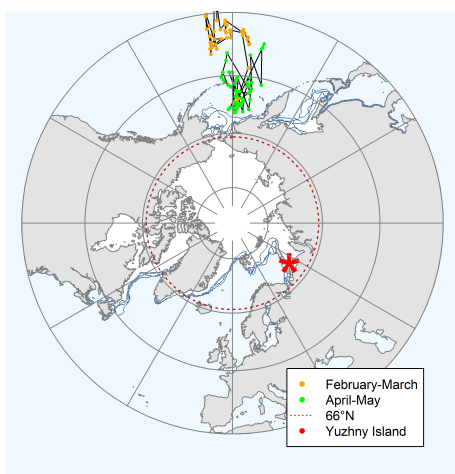
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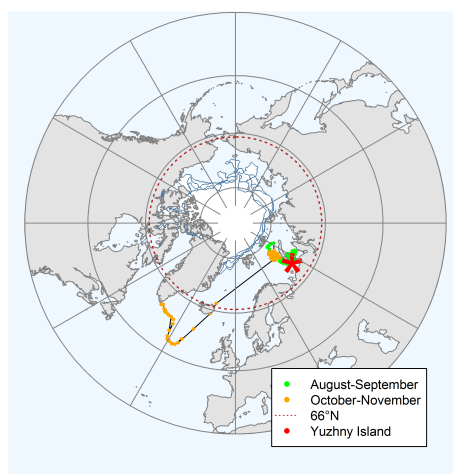
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PS21242_2017_18_Spring



PS21243_2016_17_Autumn



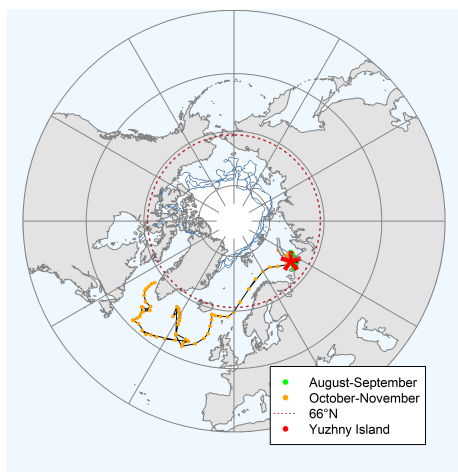
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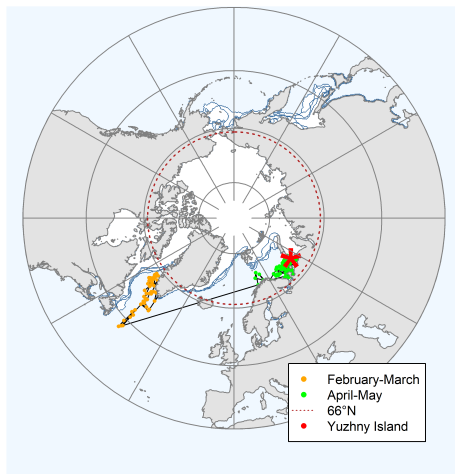
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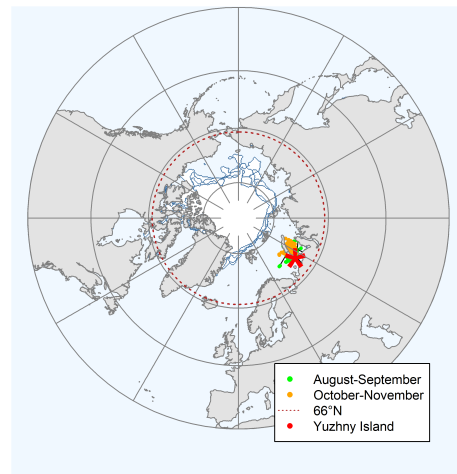
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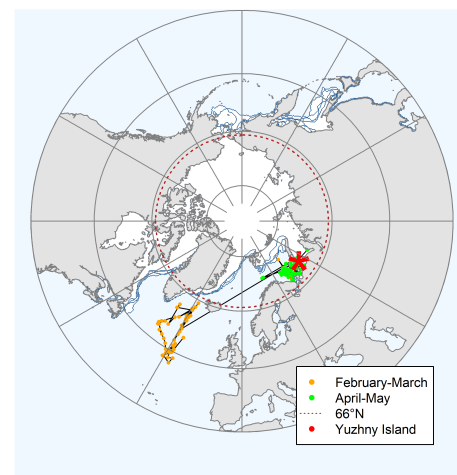
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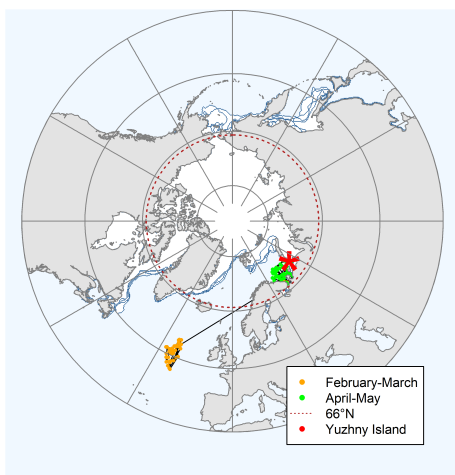
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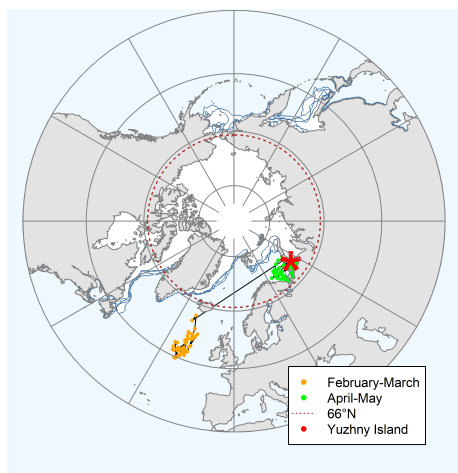
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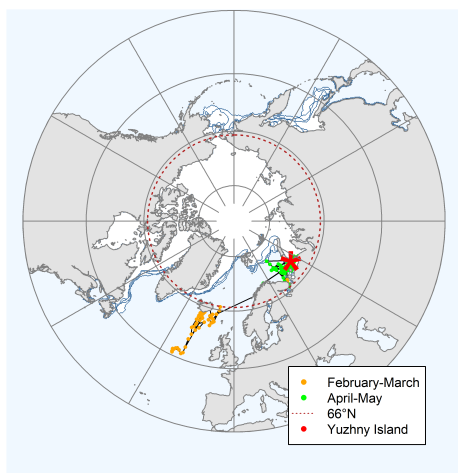
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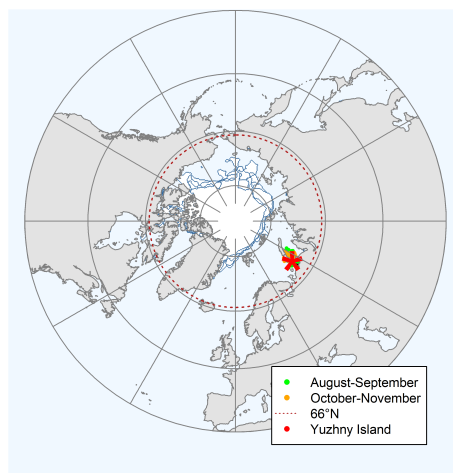
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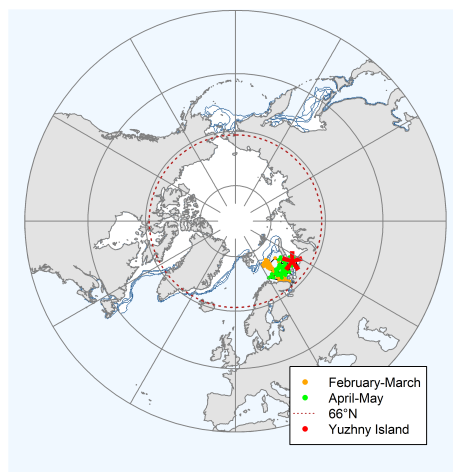
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PS21245_2017_18_Spring



PS21247_2016_17_Autumn



PS21247_2016_17_Winter



PS21247_2016_17_Spring



PS21250_2016_17_Autumn



PS21250_2016_17_Winter



PS21250_2016_17_Spring



PS21251_2016_17_Autumn



PS21251_2016_17_Winter



PS21251_2016_17_Spring



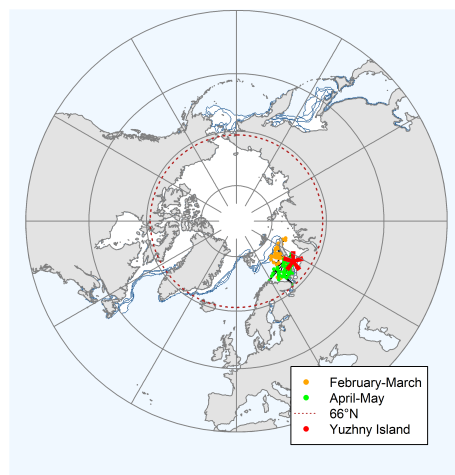
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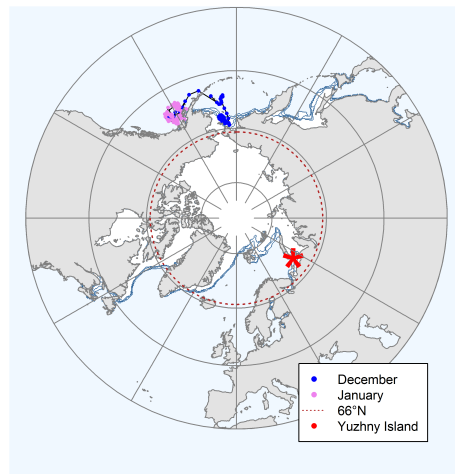
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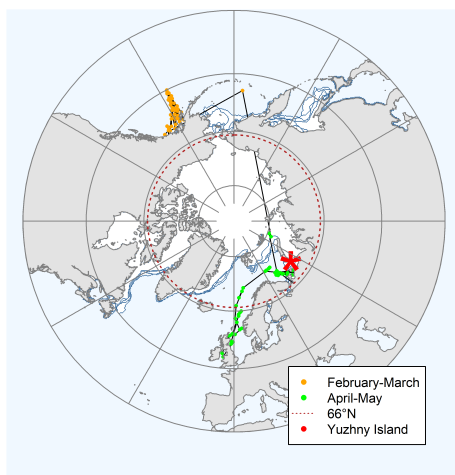
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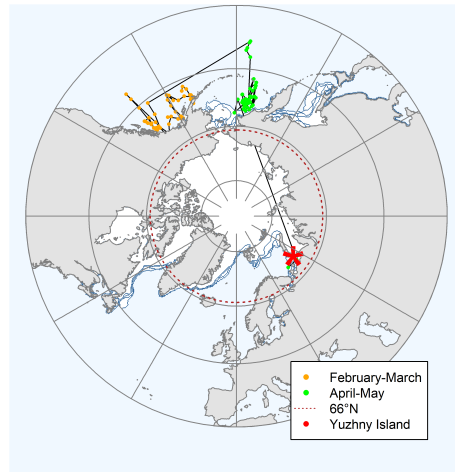
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PS21255_2017_18_Winter



PS21255_2017_18_Spring



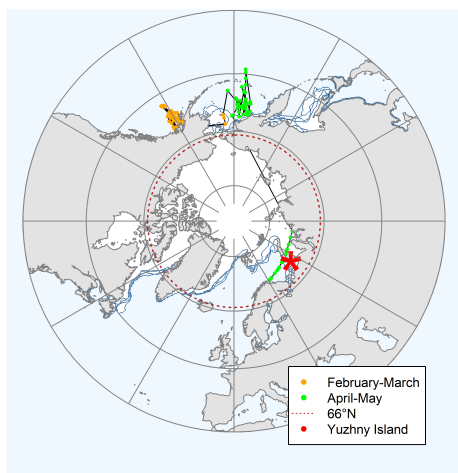
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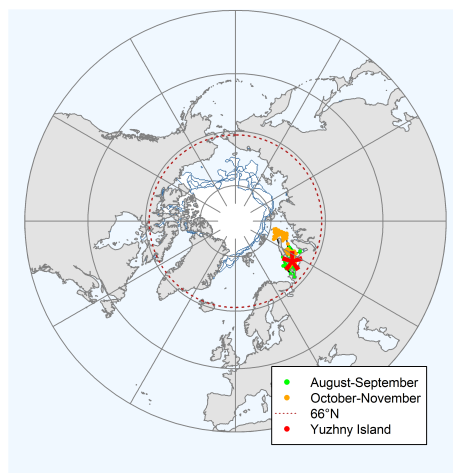
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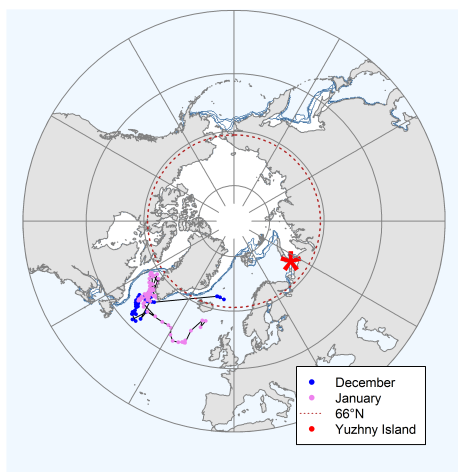
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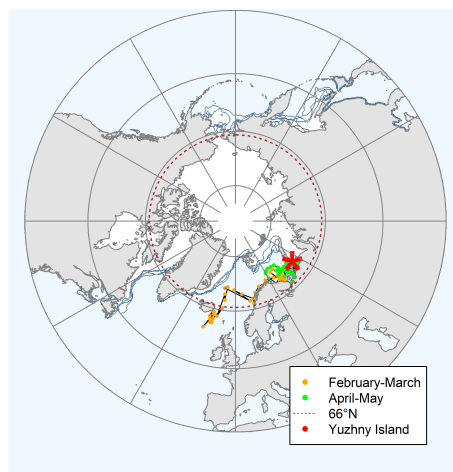
PS21256_2016_17_Autumn



PS21256_2016_17_Winter



PS21256_2016_17_Spring



PS21256_2017_18_Autumn



PS21256_2017_18_Winter



PS21256_2017_18_Spring



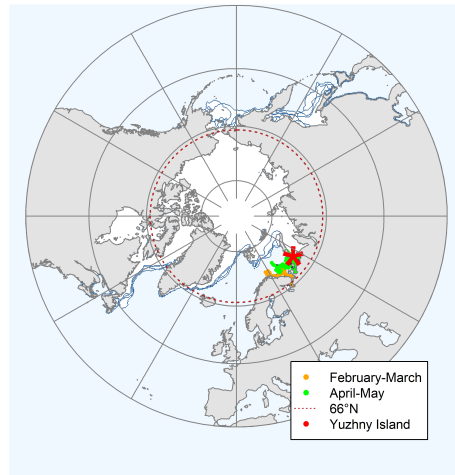
PS21256_2018_19_Autumn



PS21256_2018_19_Winter



PS21256_2018_19_Spring



PS21259_2016_17_Autumn



PS21259_2016_17_Winter



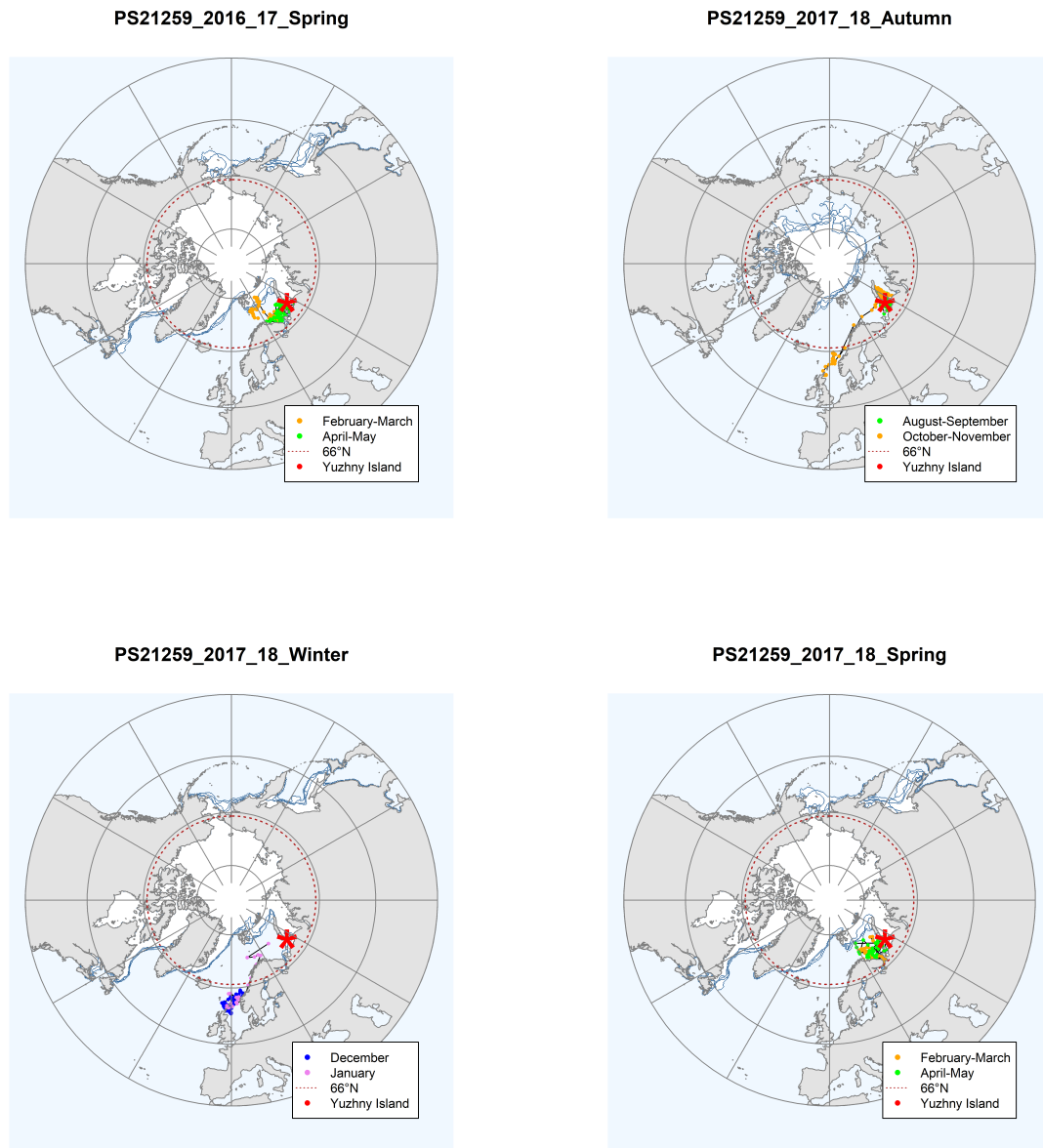


Figure S1. Maps for all of the kittiwakes breeding in the colony on Yuzhny Island, Novaya Zemlya (shown as an asterisk). To aid the interpretation of each track, each non-breeding season is split into three separate maps, representing the autumn migration (August-November), presence at wintering sites (December-January) and the spring migration (February-May). Note that these temporal classifications does not fit with all the tracked individuals. Light blue color shows the median sea ice extents in September (representing sea ice extent during autumn migration), January (representing sea ice extent during the wintering) and April (representing sea ice extent during spring migration) in each respective year, derived from the National Snow and Ice Data Center (Fetterer et al. 2017). Each date is commonly represented by two positions, where the color of each plotted

position indicates the months. Positions close to the equinoxes have been excluded due to unreliable latitudes (autumn, 13 September-October; spring, 27 February - 29 March).

Literature cited

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