

SUPPLEMENTAL MATERIALS

Figures

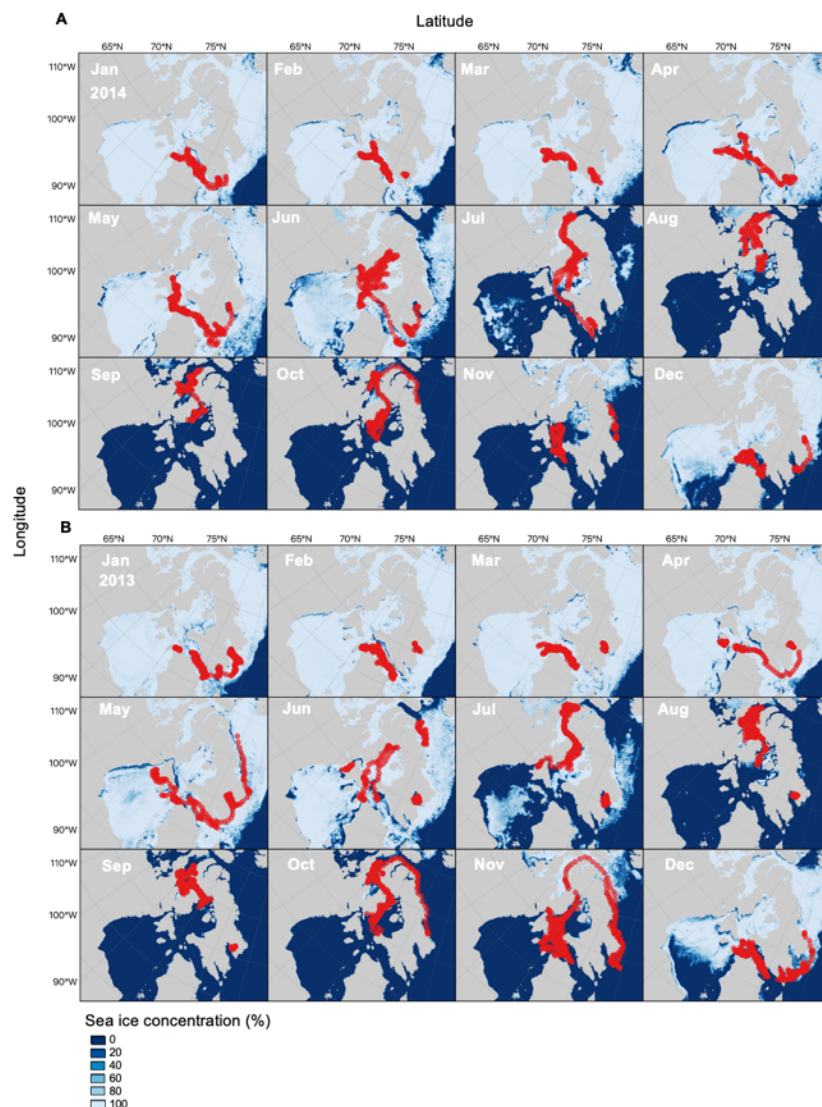


Figure S1. Predicted HSSSM locations (red dots) for all behavioural states (resident, travelling and unknown) for years with complete datasets (2014 and 2013) by month with satellite derived sea-ice concentration data from the Advanced Microwave Scanning Radiometer 2 (AMSR2) sensor (Institute of Environmental Physics, University of Bremen) (Spren et al., 2008). Areas of open water are indicated by dark blue whereas regions with complete sea ice cover are indicated in white.

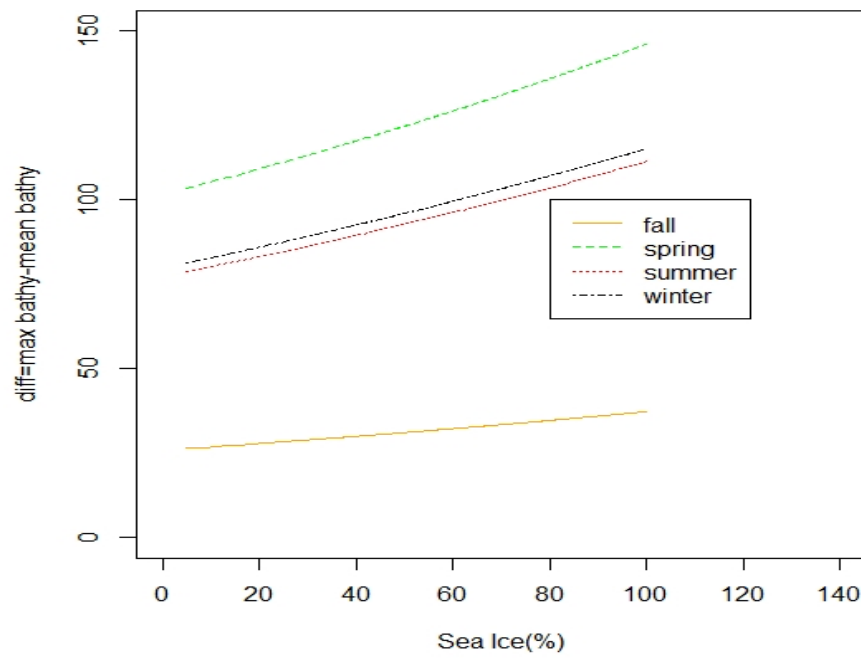


Figure S2. Relationship between difference between maximum depth of bathymetry and daily average of the maximum depth of square-shaped dives by season (Table S2).

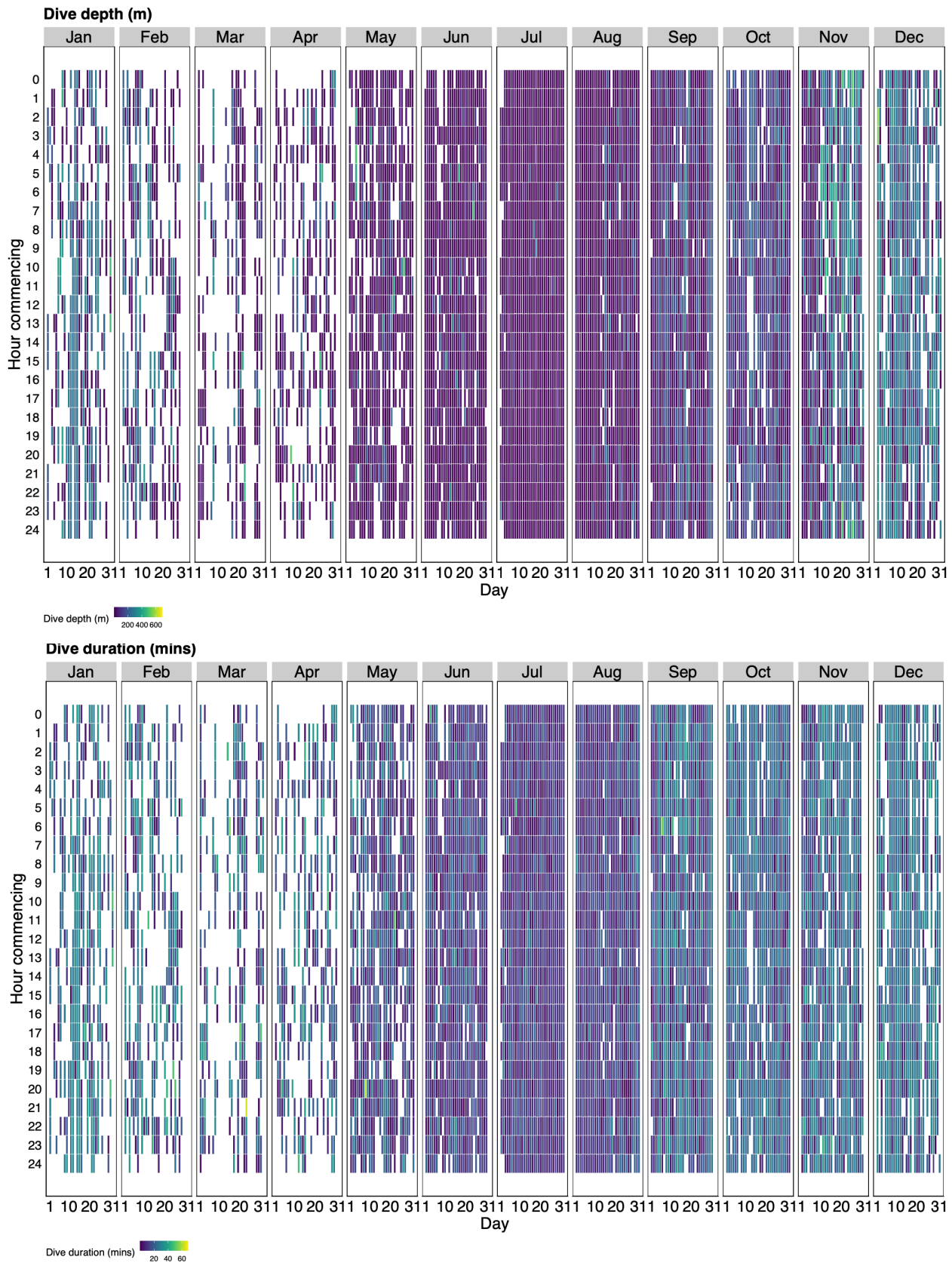


Figure S3. Heatmap of the maximum dive depth (m) (top) and minimum dive duration (mins) (bottom) of square-shaped dives associated with transit and unknown locations for all animals (n=25) by time of

day (**Hour commencing**) and day of the month (**Day**). Data are pooled across years (2012-2015) and includes dives throughout their range (both inside and outside regions of interest).

Tables

Table S1. Summary square-shaped dive information (n=25) for bowhead whales pooled across individuals and years. Data were aggregated by **A: decimal time (Time)** and **Month** and by **B: Month** for maximum dive depth (metres) and minimum dive duration (mins) (mean $\pm$ SD).

A

Time (hr)	Month	Dive depth (m)	Duration (mins)
0-4	Jan	216.24 $\pm$ 110.596	25.21 $\pm$ 9.159
4-8	Jan	211.97 $\pm$ 100.376	24.97 $\pm$ 8.944
8-12	Jan	218.28 $\pm$ 99.018	24.85 $\pm$ 8.622
12-16	Jan	221.74 $\pm$ 97.368	24.87 $\pm$ 7.936
16-20	Jan	205.86 $\pm$ 107.718	24.22 $\pm$ 9.195
20-24	Jan	215.21 $\pm$ 103.577	24.93 $\pm$ 8.789
0-4	Feb	162.88 $\pm$ 122.54	23.60 $\pm$ 12.156
4-8	Feb	174.5 $\pm$ 116.717	24.37 $\pm$ 11.645
8-12	Feb	205.44 $\pm$ 112.068	25.65 $\pm$ 9.878
12-16	Feb	185.21 $\pm$ 113.317	23.50 $\pm$ 10.098
16-20	Feb	144.78 $\pm$ 124.527	21.15 $\pm$ 11.526
20-24	Feb	158.35 $\pm$ 126.305	23.15 $\pm$ 11.125
0-4	Mar	143.37 $\pm$ 142.204	20.56 $\pm$ 12.352
4-8	Mar	146.15 $\pm$ 142.656	21.04 $\pm$ 12.852
8-12	Mar	166.78 $\pm$ 136.096	21.38 $\pm$ 11.909
12-16	Mar	167.82 $\pm$ 142.667	21.24 $\pm$ 12.365
16-20	Mar	135.19 $\pm$ 136.238	19.86 $\pm$ 12.509
20-24	Mar	124.72 $\pm$ 145.787	19.15 $\pm$ 12.371
0-4	Apr	134.54 $\pm$ 125.012	19.66 $\pm$ 10.688
4-8	Apr	126.21 $\pm$ 104.8	19.13 $\pm$ 10.609
8-12	Apr	126.87 $\pm$ 115.3	18.72 $\pm$ 11.574
12-16	Apr	140.1 $\pm$ 116.107	19.09 $\pm$ 11.136
16-20	Apr	128.03 $\pm$ 114.837	17.97 $\pm$ 10.722
20-24	Apr	107.19 $\pm$ 109.18	16.82 $\pm$ 11.419
0-4	May	78.65 $\pm$ 96.576	13.73 $\pm$ 8.468
4-8	May	87.95 $\pm$ 94.095	14.93 $\pm$ 8.493
8-12	May	89.22 $\pm$ 101.622	15.07 $\pm$ 8.908
12-16	May	74.77 $\pm$ 91.073	14.15 $\pm$ 8.32
16-20	May	73.52 $\pm$ 95.776	12.86 $\pm$ 8.144
20-24	May	62.75 $\pm$ 86.637	12.81 $\pm$ 8.568
0-4	Jun	45.97 $\pm$ 65.369	9.88 $\pm$ 5.389
4-8	Jun	46.14 $\pm$ 63.387	10.12 $\pm$ 5.313
8-12	Jun	50.01 $\pm$ 66.493	10.34 $\pm$ 5.086
12-16	Jun	46.82 $\pm$ 71.215	10.01 $\pm$ 5.413
16-20	Jun	53.05 $\pm$ 75.55	10.44 $\pm$ 5.581
20-24	Jun	48.8 $\pm$ 70.423	9.88 $\pm$ 5.052
0-4	Jul	29.00 $\pm$ 22.572	8.74 $\pm$ 4.258
4-8	Jul	30.33 $\pm$ 21.953	8.86 $\pm$ 4.15
8-12	Jul	30.69 $\pm$ 22.285	9.04 $\pm$ 4.067
12-16	Jul	31.32 $\pm$ 25.473	9.1 $\pm$ 4.381
16-20	Jul	28.68 $\pm$ 19.775	8.93 $\pm$ 4.439
20-24	Jul	27.82 $\pm$ 16.577	8.64 $\pm$ 3.942
0-4	Aug	52.47 $\pm$ 76.898	10.94 $\pm$ 6.456
4-8	Aug	64.02 $\pm$ 87.525	11.72 $\pm$ 6.449
8-12	Aug	59.92 $\pm$ 81.361	11.94 $\pm$ 6.374
12-16	Aug	68.68 $\pm$ 89.832	12.3 $\pm$ 6.187

16-20	Aug	67.46 ± 93.939	11.92 ± 6.447
20-24	Aug	50.13 ± 78.008	10.19 ± 6.221
0-4	Sep	114.38 ± 117.438	16.56 ± 8.919
4-8	Sep	111.44 ± 106.672	16.52 ± 9.028
8-12	Sep	115.39 ± 104.429	16.37 ± 8.29
12-16	Sep	117.85 ± 108.057	16.31 ± 8.084
16-20	Sep	113.01 ± 111.846	15.88 ± 8.647
20-24	Sep	103.00 ± 117.74	14.61 ± 9.046
0-4	Oct	167.73 ± 107.763	20.99 ± 6.177
4-8	Oct	168.55 ± 100.878	21.00 ± 5.966
8-12	Oct	164.97 ± 90.506	20.09 ± 5.583
12-16	Oct	161.68 ± 97.056	19.53 ± 5.876
16-20	Oct	155.8 ± 106.333	19.52 ± 6.694
20-24	Oct	161.12 ± 112.583	20.61 ± 6.649
0-4	Nov	223.46 ± 136.375	22.84 ± 7.483
4-8	Nov	256.02 ± 122.694	24.14 ± 6.384
8-12	Nov	257.29 ± 111.206	24.03 ± 5.708
12-16	Nov	241.24 ± 117.321	23.46 ± 6.103
16-20	Nov	246.53 ± 132.911	23.51 ± 7.074
20-24	Nov	233.93 ± 134.798	23.15 ± 7.275
0-4	Dec	241.72 ± 78.156	24.44 ± 5.798
4-8	Dec	243.11 ± 77.483	24.47 ± 5.665
8-12	Dec	248.16 ± 72.01	24.12 ± 5.689
12-16	Dec	239.55 ± 79.894	23.94 ± 5.997
16-20	Dec	240.86 ± 89.15	23.83 ± 6.222
20-24	Dec	240.72 ± 83.948	24.21 ± 6.184

B

Month	Dive depth (m)	Dive duration (mins)
Jan	214.74 ± 103.544	24.84 ± 8.804
Feb	172.22 ± 120.81	23.6 ± 11.197
Mar	147.69 ± 141.584	20.57 ± 12.415
Apr	128.03 ± 114.972	18.64 ± 11.03
May	77.9 ± 94.89	13.9 ± 8.518
Jun	48.44 ± 68.848	10.11 ± 5.318
Jul	29.63 ± 21.685	8.88 ± 4.215
Aug	60.08 ± 84.838	11.47 ± 6.401
Sep	112.67 ± 111.272	16.07 ± 8.696
Oct	163.39 ± 102.573	20.28 ± 6.185
Nov	242.31 ± 127.412	23.49 ± 6.761
Dec	242.37 ± 80.274	24.17 ± 5.929

Table S2. Impacts of season (spring, summer, winter, fall), sex (male or female), median body length (m), and percent sea ice cover on the natural logarithm of daily differences between the maximum depth of probable bowhead whale foraging dives (i.e., square-shaped dives) and the bottom depth (bathymetry) averaged daily (n=23 whales) using gls models. In **A**, models with the lowest AIC and highest log likelihood (logLik) values are in **bold**. Selected likelihood ratio test results shown in **B** support M16 (shown in **C** and illustrated in **D**).

A

Model	Fixed-effects variables	AIC	logLik
M0	Null model, no fixed-effects variables ^a	10620.52	-5307.258
M1	sex	10620.67	-5306.333
M2	season	10365.29	-5176.647
M3	length ^b	10622.12	-5307.059
M4	sex, season, sex*season	10371.07	-5175.534
M5	sex, season	10366.14	-5176.071
M6	sex, length, sex*length	10623.50	-5305.75
M7	sex, length	10622.64	-5306.320
M8	season, length, season*length	10370.55	-5175.273
M9	season, length	10367.27	-5176.637
M10	sex, season, length, sex*season, sex*length, season.*length, sex*season*length	10380.31	-5172.153
M11	sex, season, length	10367.83	-5175.915
M12	sea ice ^b	10541.98	-5266.991
M13	sex, sea ice, sex*sea ice	10544.45	-5266.223
M14	sex, sea ice	10542.48	-5266.242
M15	season, sea ice, season*sea ice	10365.32	-5172.660
M16	season, sea ice	10360.85	-5173.424
M17	sex, season, sea ice, sex*season, sex*sea ice, season*sea ice, sex*season*sea ice	10377.62	-5170.809
M18	sex, season, sea ice	10361.73	-5172.867
M19	Full model: sex, season, length, sea ice, sex*season, sex*length, sex*sea ice, season*length, season*sea ice, sex*season*length*sea ice	10386.52	-5167.261
M20	sex, season, length, sea ice ^c	10363.43	-5172.714
M21	length, sea ice ^c	10543.78	-5266.891

^a First order continuous autoregressive (CAR(1)) parameters estimated as 0.6919765 the null model(M0) and as 0.5842326 for the full model (M19).

^b length and sea ice were standardized to a mean=0 and a standard deviation=1 for all models.

^c variance inflation values all < 1.5.

B

Model comparisons	AIC	logLik	Likelihood ratio test	
M0 (null)	10620.52	-5307.258	p value=	<.0001
M19 (full)	10386.52	-5167.261		
difference	-234.00	139.997		
M20 (four factors)	10363.43	-5172.714	p value=	0.8614
M19	10386.52	-5167.261		
difference	1.86	-3.933		
M16 (season, sea ice)	10360.85	-5173.424	p-value =	0.4918
M20	10363.43	-5172.714		
difference	2.58	0.71		
M2 (season)	10365.29	-5176.647	p value=	0.0111
M16	10360.85	-5173.424		
difference	-4.44	3.223		

C

Season	Model with Season and Sea Ice
Fall	Estimated diff.=exp(3.544803+0.073560 * sea ice scaled)
Spring	Estimated diff.=exp(4.910897+0.073560 * sea ice scaled)
Summer	Estimated diff.=exp(4.639020+0.073560 * sea ice scaled)
Winter	Estimated diff.=exp(4.672716+0.073560 * sea ice scaled)

Table S3. Impacts of season (spring, summer, winter, fall), sex (male or female), median body length (m), and percent sea ice cover on delta, the maximum depth of square dives relative to maximum bathymetry (sea bottom) (n=23 whales) using glmmPQL models. Six models with the lowest squared sum of squared deviances and lowest sum of squared differences (measured versus estimated, SSE) values are in **bold** in **A**. Biggest drop from the null model (M0) occurred with just season (M2). Impacts of season are given in **B**.

A

Model	Fixed-effects variables	Sum of Squared Deviances	SSE
M0	null, no fixed-effects variables	6007.49	358.93
M1	sex	6010.30	359.10
M2	season	5386.00	263.86

M3	length ^a	6017.49	359.55
M4	sex, season, sex*season	5379.81	263.24
M5	sex, season	5386.07	263.87
M6	sex, length, sex*length	6009.10	359.02
M7	sex, length	6007.82	358.95
M8	season, length, season*length	5397.54	264.65
M9	season, length	5393.49	264.45
M10	sex, season, length, sex*season, sex*length, season.*length, sex*season*length	5381.15	263.49
M11	sex, season, length	5390.33	264.13
M12	sea ice	5875.96	345.48
M13	sex, sea ice, sex*sea ice ^a	5875.46	345.32
M14	sex, sea ice	5878.25	345.62
M15	season, sea ice, season*sea ice	5393.76	263.01
M16	season, sea ice	5383.17	262.99
M17	sex, season, sea ice, sex*season, sex*sea ice, season*sea ice, sex*season*sea ice	5382.56	261.83
M18	sex, season, sea ice	5394.15	263.05
M19	Full model: sex, season, length, sea ice, sex*season, sex*length, sex*sea ice, season*length, season*sea ice, sex*season*length*sea ice	5373.40	261.33
M20	sex, season, length, sea ice	5388.35	263.29
M21	length, sea ice	5885.03	346.13

^a length and sea ice were standardized to a mean=0 and a standard deviation=1 for all models.

^b All models included a random intercept by animal and first order continuous autoregressive (CAR (1)) temporal correlations within each animal.

B

	M2 log odds-ratio	Estimated delta	
Fall	0.6631703	0.659972192	More than half of depth
Spring	-1.3406352	0.20740562	
Summer	-1.7049871	0.153815043	Only 0.15 of depth
Winter	-0.4734367	0.383803146	