

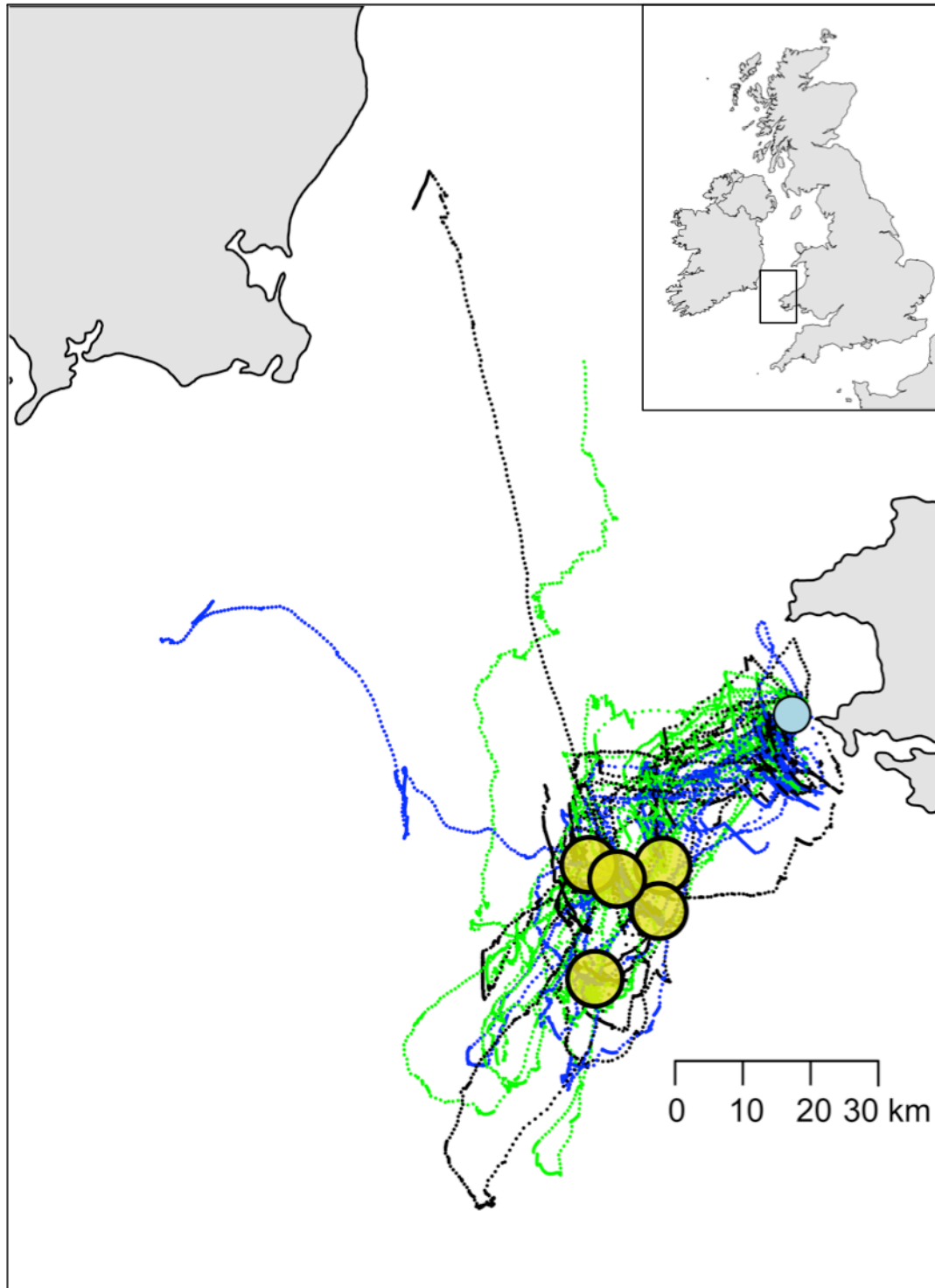


Figure S1. The tracks of all displaced birds up to the end of nautical twilight on the day of release (related to **Figure 2**). Release sites are shown as yellow circles. Skomer Island is shown as a blue circle. Tracks with no homeward oriented movement on the day of release were excluded for analysis.

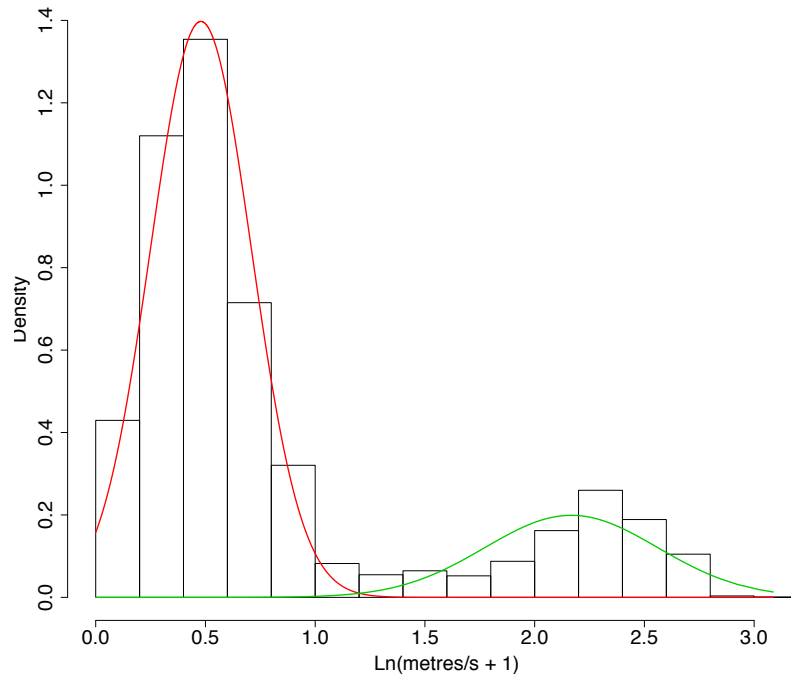


Figure S2. Mixture model behaviour assignment (related to Figure 2). Relative probability density of assignment of different log-transformed speeds (no units) to each underlying behaviour. The red line is the probability density of the ‘slow’ behaviour and the green line is the probability density of the ‘fast’ behaviour resulting in the observed emission speed. We considered homing to start when eight consecutive fixes (one per minute) were high speed and oriented towards Skomer (within 65 degrees). A Gaussian Mixture Model was fitted to log transformed bimodally distributed speed data calculated between consecutive GPS fixes. Data were logged so that a positive probability could not be assigned to a negative speed (Slow peak mean = 0.6597 ms^{-1} and var = 0.1609. Fast peak mean = 8.3883 ms^{-1} and var = 9.9180). Fitting was done using Expectation Maximisation in the Mixtools package in R. The resulting cut-off speed was at $\ln(\text{speed} + 1) = 1.2$, hence 2.32 ms^{-1} . Only high-speed fixes were used in analysis because low-speed fixes meant birds were rafting on water and their instantaneous deflection was related to the direction of the water’s current rather than the birds’ orientation decisions.

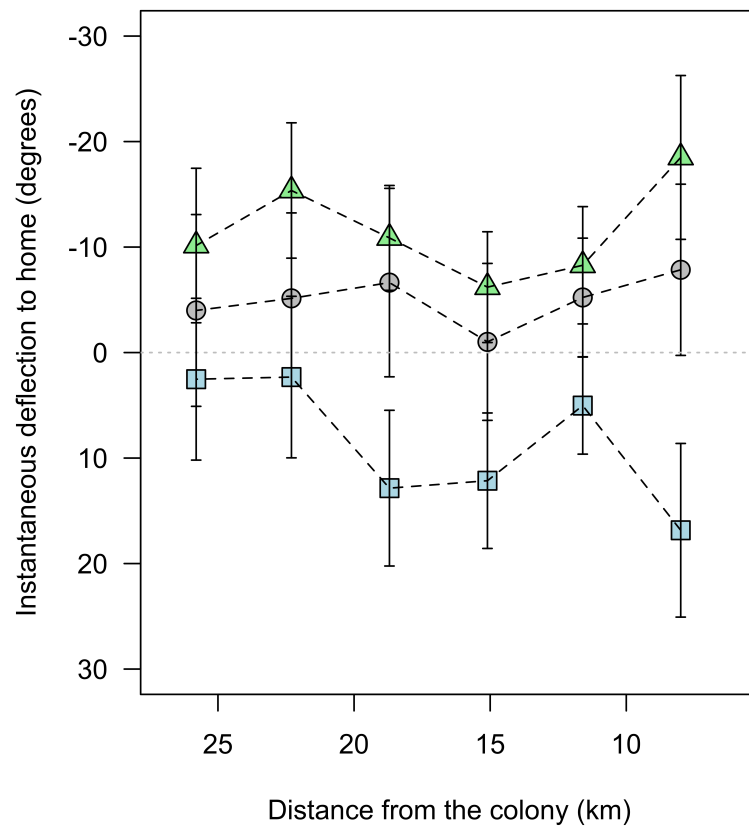


Figure S3. Mean ($\pm$ se) instantaneous deflections as shearwaters get closer to the colony during directed homing flight (related to Figure 4). Control (grey circles), fast (green triangles) and slow-shifted (blue squares) birds are shown for the distances for which we recorded homing flights from all releases. The x and y -axes are reversed (they ascend downward in the y axis and to the right in the x axis) such that positive and negative deflections from the beeline are still viewed as clockwise and anti-clockwise for a birds homing roughly west-east.

Release date	Sample sizes			Release coordinates		Release conditions
	n fast	n control	n slow	Latitude	Longitude	
22nd May 2015	4	1	0	51°23'N	5°42'W	Thick fog but sun's disc visible. Cleared later.
11th June 2015	5	5	4	51°31'N	5°34'W	Good visibility 1/8 cloud
9th July 2015	1	4	2	51°32'N	5°43'W	Good visibility 4/8 cloud
29th May 2017	6	3	3	51°39'N	5°35'W	Good visibility 7/8 cloud
4th June 2017	3	3	4	51°31'N	5°40'W	Good visibility 1/8 cloud
Total	19	16	13			

Table S1. Release information for the five release dates (related to Figure 2).

Release date	Objective / control		Subjective slow		Subjective fast	
	sunrise	sunset	light on	light off	light on	light off
22nd May 2015	04:18	20:16	08:18	00:16 (+1)	00:18	16:16
11th June 2015	04:01	20:38	08:01	00:38 (+1)	00:01	16:38
9th July 2015	04:12	20:38	08:12	00:38 (+1)	00:12	16:38
29th May 2017	04:09	20:26	08:09	00:26 (+1)	00:09	16:26
4th June 2017	04:04	20:33	08:04	00:33 (+1)	00:04	16:33

Table S2. Objective and subjective photoperiods (related to Figure 1). Table shows the photoperiods birds were subject to before releases for the control, slow and fast levels of our clock-shift treatment. All times in GMT. (+1) indicates the next day.

Bird ID/mass/GPS	Date	Shift	Flight speed (ms ⁻¹)	Start	Mean deflection to goal	Mean for release
EK59703/ 446g/ 16.7g	22/05/2015	C	12.5	20:17	-2°	-2°
EK59699/ 403g/ 17.1g	22/05/2015	F	11.4	18:50	1°	
EK59749/ 386g/ 17.0g	22/05/2015	F	11.6	20:40	3°	-3.25°
EK59833/ 398g/ 16.7g	22/05/2015	F	12.8	20:04	-14°	
EK59863/ 458g/ 16.7g	22/05/2015	F	11.4	20:19	-3°	
EB52824/ 365g/ 16.7g	11/06/2015	C	7.1	18:25	26°	
EK59745/ 380g/ 16.8g	11/06/2015	C	7.8	15:43	-33°	
EX93861/ 370g/ 16.7g	11/06/2015	C	7.6	18:23	-1°	-7.2°
EZ01678/ 410g/ 16.6g	11/06/2015	C	6.9	15:43	-11°	
EZ01766/ 430g/ 16.8g	11/06/2015	C	7.5	15:43	-17°	
EK59942/ 430g/ 16.7g	11/06/2015	F	7.5	15:24	-51°	
EZ01651/ 380g/ 16.7g	11/06/2015	F	7.1	16:12	-4°	
FB24686/ 465g/ 16.8g	11/06/2015	F	7.0	15:42	-27°	-26.8°
FB30100/ 380g/ 16.7g	11/06/2015	F	7.7	19:14	-26°	
FB32189/ 415g/ 17.1g	11/06/2015	F	7.1	15:50	-26°	
EK59846/ 385g/ 16.8g	11/06/2015	S	9.6	20:52	3°	
EX93846/ 410g/ 16.7g	11/06/2015	S	6.3	16:08	3°	10.5°
EZ01753/ 405g/ 16.7g	11/06/2015	S	6.7	15:43	16°	
EZ01755/ 410g/ 16.6g	11/06/2015	S	7.4	20:11	20°	
EK59608/ 413g/ 16.6g	09/07/2015	C	11.8	19:10	17°	
EK59806/ 425g/ 16.6g	09/07/2015	C	9.1	18:23	28°	6.5°
EZ01643/ 430g/ 16.9g	09/07/2015	C	11.4	17:40	-10°	
FB32166/ 415g/ 16.7g	09/07/2015	C	11.1	17:26	-9°	
EK59854/ 395g/ 16.8g	09/07/2015	F	9.6	18:42	-17°	-17.0°
EY07276/ 448g/ 16.5g	09/07/2015	S	11.9	20:17	-5°	8.5°
EZ01631/ 358g/ 16.6g	09/07/2015	S	10.4	19:45	22°	
EK59962/ 440g/ 16.6g	29/05/2017	C	11.2	15:07	-15°	
EY07280/ 430g/ 16.8g	29/05/2017	C	9.6	19:20	-49°	-27.0°
EZ72887/ 415g/ 16.6g	29/05/2017	C	13.9	20:23	-17°	
EK59827/ 435g/ 16.7g	29/05/2017	F	12.2	18:23	-31°	
EK59869/ 375g/ 16.7g	29/05/2017	F	12.0	20:18	-19°	
EZ72787/ 420g/ 16.7g	29/05/2017	F	13.4	19:11	-23°	-34.7°
EZ72873/ 390g/ 16.8g	29/05/2017	F	4.9	16:33	-74°	
EZ72875/ 400g/ 16.6g	29/05/2017	F	12.1	19:44	-23°	
EZ72879/ 405g/ 16.8g	29/05/2017	F	8.9	20:07	-38°	
EK59965/ 410g/ 16.6g	29/05/2017	S	11.6	18:30	-7°	
EZ72872/ 385g/ 16.7g	29/05/2017	S	13.3	20:23	-1°	-5.3°
EZ72884/ 395g/ 16.7g	29/05/2017	S	10.7	13:12	-8°	
EK59734/ 400g/ 17.1g	04/06/2017	C	10.3	19:04	7°	
EZ72956/ 440g/ 16.9g	04/06/2017	C	10.4	20:47	16°	18.7°
FB24600/ 395g/ 16.7g	04/06/2017	C	11.6	18:49	33°	
EK59607/ 465g/ 16.6g	04/06/2017	F	11.7	20:13	22°	
EK59747/ 435g/ 16.8g	04/06/2017	F	11.9	20:40	20°	11.3°
EZ72856/ 415g/ 16.8g	04/06/2017	F	13.6	20:09	-8°	
EZ72953/ 410g/ 16.7g	04/06/2017	S	9.9	20:22	15°	
EZ72954/ 420g/ 16.7g	04/06/2017	S	9.7	19:50	23°	29.3°
EZ72955/ 420g/ 16.6g	04/06/2017	S	7.7	19:46	45°	
FB05283/ 420g/ 16.7g	04/06/2017	S	11.6	20:29	34°	

Table S3. Homing information for each bird (related to Figure 2). Treatment, mean flight speed (periods identified as flight), time that homing commenced, mean deflection home for each individual and the mean deflection from the goal for each treatment on each release are shown. Bird and GPS mass for each deployment are also shown with each bird ID.

Time in continuous flight (<i>t</i>)	Orientation cut-off (<i>a</i>)	Estimates			Test statistics		
		Control	Fast	Slow	Chi-squared	d.f.	p-value
5	45°	0.6°	-14.4°	11.7°	16.3	1	< 0.0001
6	45°	1.5°	-17.1°	11.4°	15.9	1	< 0.0001
7	45°	-0.8°	-12.4°	13.2°	15.0	1	<0.001
8	45°	-3.3°	-10.7°	15.0°	13.2	1	<0.001
9	45°	-2.9°	-11.1°	15.0°	13.4	1	<0.001
10	45°	-1.3°	-9.0°	14.0°	11.3	1	<0.001
5	65°	-1.8°	-13.3°	11.6°	17.4	1	< 0.0001
6	65°	1.7°	-16.1°	11.3°	22.4	1	< 0.00001
7	65°	0.4°	-14.1°	12.5°	22.9	1	< 0.00001
8	65°	0.3°	-12.5°	13.0°	17.9	1	< 0.0001
9	65°	0.0°	-12.0°	12.3°	16.5	1	< 0.0001
10	65°	0.5°	-11.9°	12.2°	15.5	1	< 0.0001
5	90°	-7.8°	-11.1°	11.1°	13.3	1	<0.001
6	90°	-7.3°	-11.4°	10.9°	13.3	1	<0.001
7	90°	-5.8°	-13.2°	13.2°	18.4	1	< 0.0001
8	90°	-4.7°	-12.7°	11.9°	17.4	1	< 0.0001
9	90°	-4.3°	-11.3°	10.7°	12.7	1	< 0.001
10	90°	-7.8°	-9.5°	12.7°	13.8	1	< 0.001

Table S4. Sensitivity of our overall clock-shift deflections to different locations identified as the start of homing (related to Figure 3). From the point of release, the first time the bird underwent a period of flight of length *t* that was oriented within *a*° of the colony was interpreted as the start of homing. The table shows the model estimates for treatment deflections with various realistic parameters for *t* and *a*. two-tailed p-values are shown (LR test of nested mixed models as in methods) for the relationship between hours of clock-shift (-4, 0, +4) and orientation with respect to the colony.