

Year-round movements of a small seabird and oceanic isotopic gradient in the tropical Atlantic

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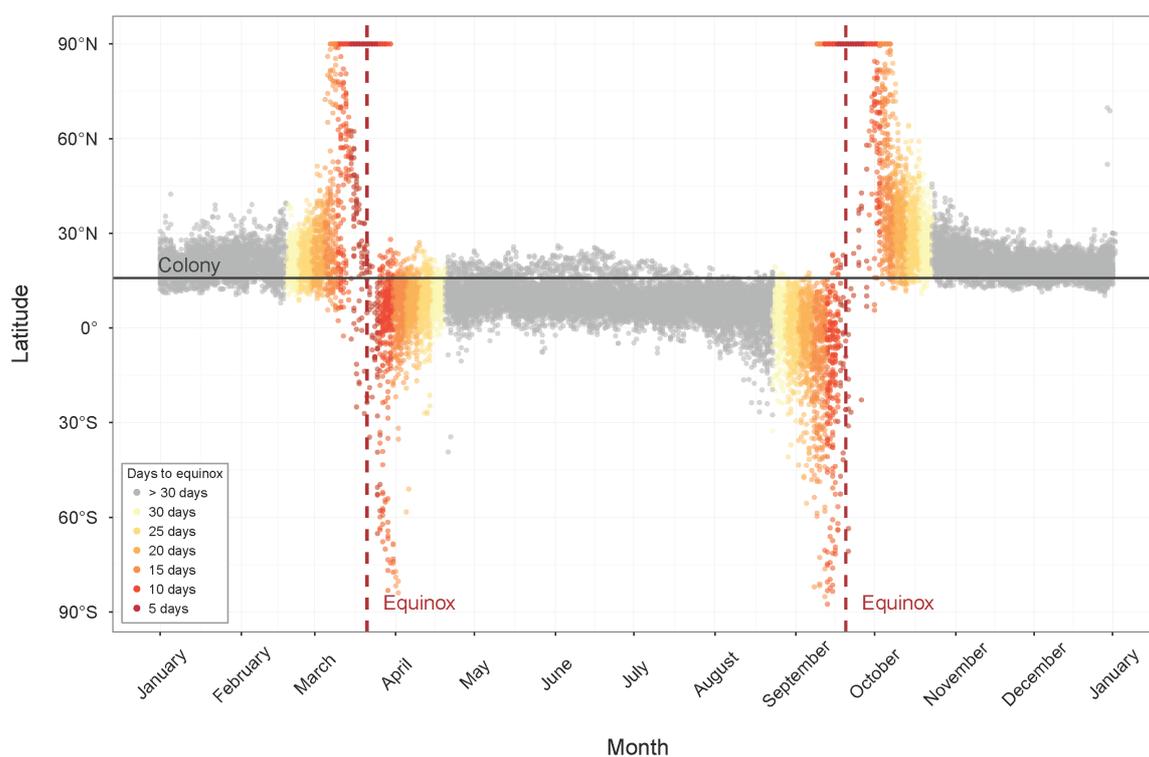
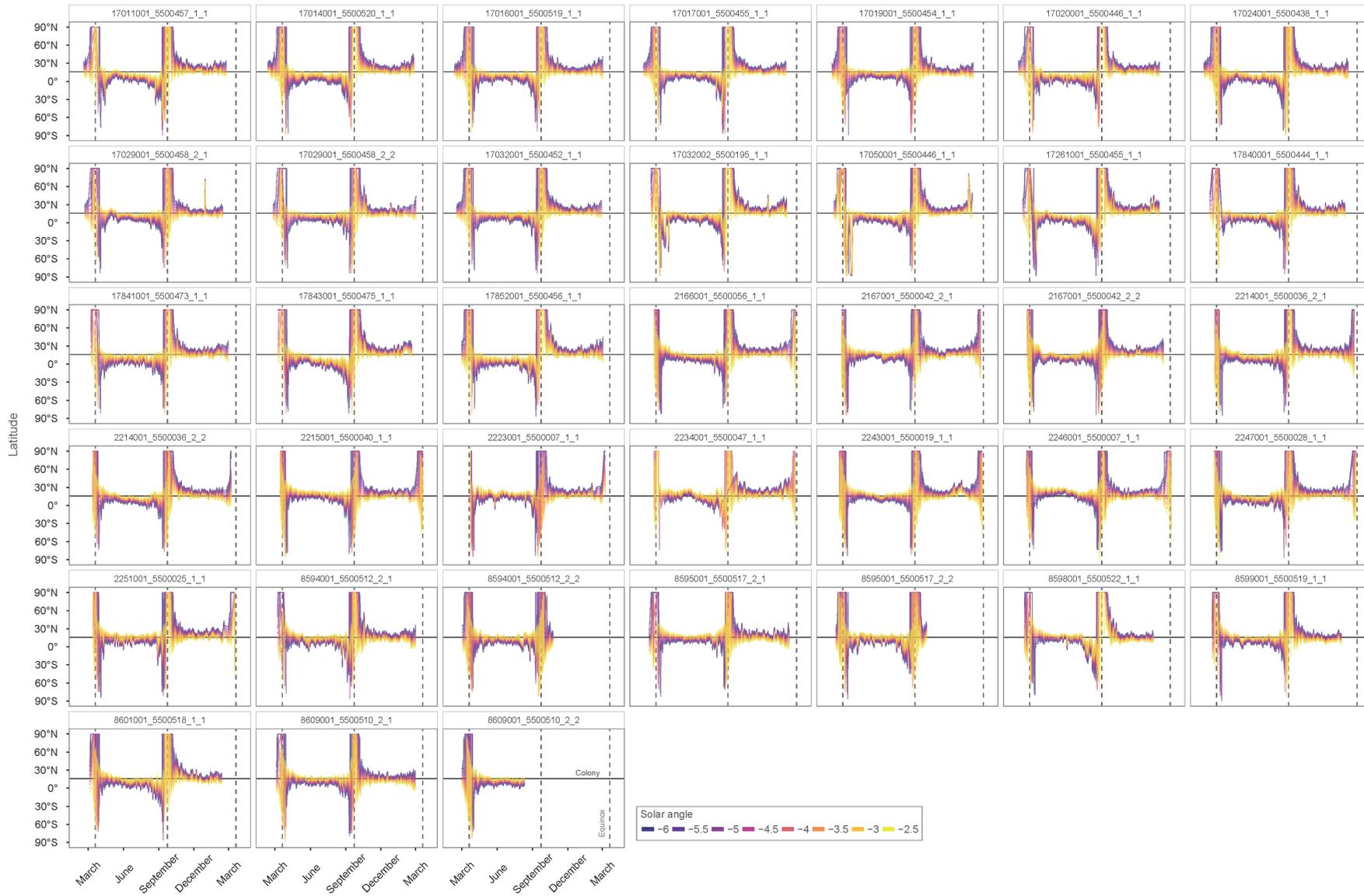


Fig. S1. Effect of equinoxes (red dashed lines) on estimation of latitude positions (using threshold method) of Boyd's shearwater tracked by geolocators in Cape Verde Islands from 2007 – 2012. Horizontal black line refers to mean latitude of two colonies (Ilhéu Raso and Ilhéu de Cima). Positions of all 38 unfiltered tracks are pooled together.

A Latitude



B Longitude

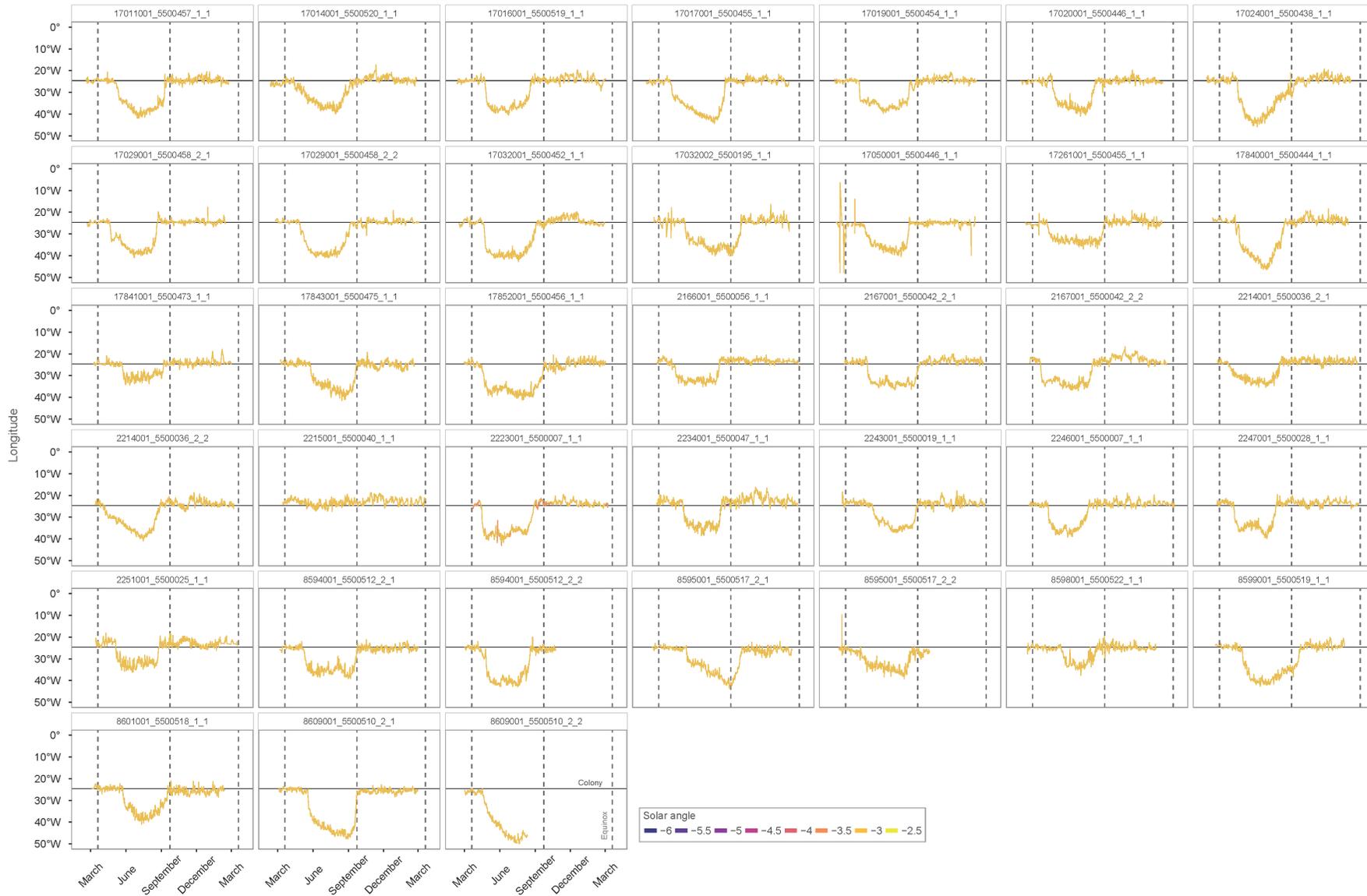


Fig. S2. Effect of equinoxes and solar angle on position estimations (using threshold method) of Boyd's shearwater tracked by geolocators in Cape Verde Islands from 2007 – 2012, for (A) latitude and (B) longitude. Horizontal black line refers to mean position of two colonies (Ilhéu Raso and Ilhéu de Cima), vertical dashed lines refer to spring (March) and autumnal (September) equinoxes. Figure visualize inherent systematic error of geolocation method, where latitude position can be more accurately estimated during solstices and at high latitudes, but more problematic during the equinox period and around the equator due to the little variation in day length (Hill 1994). Furthermore, the error in latitude is not constant and is over- or underestimated depending on the proximity to vernal/autumnal equinox, hemisphere and mismatch between light threshold value and solar angle used for analysis (Lisovski et al. 2012).

Starts on the day of deployment and ends on the day of retrieval of the logger (or when logger stopped collecting data).

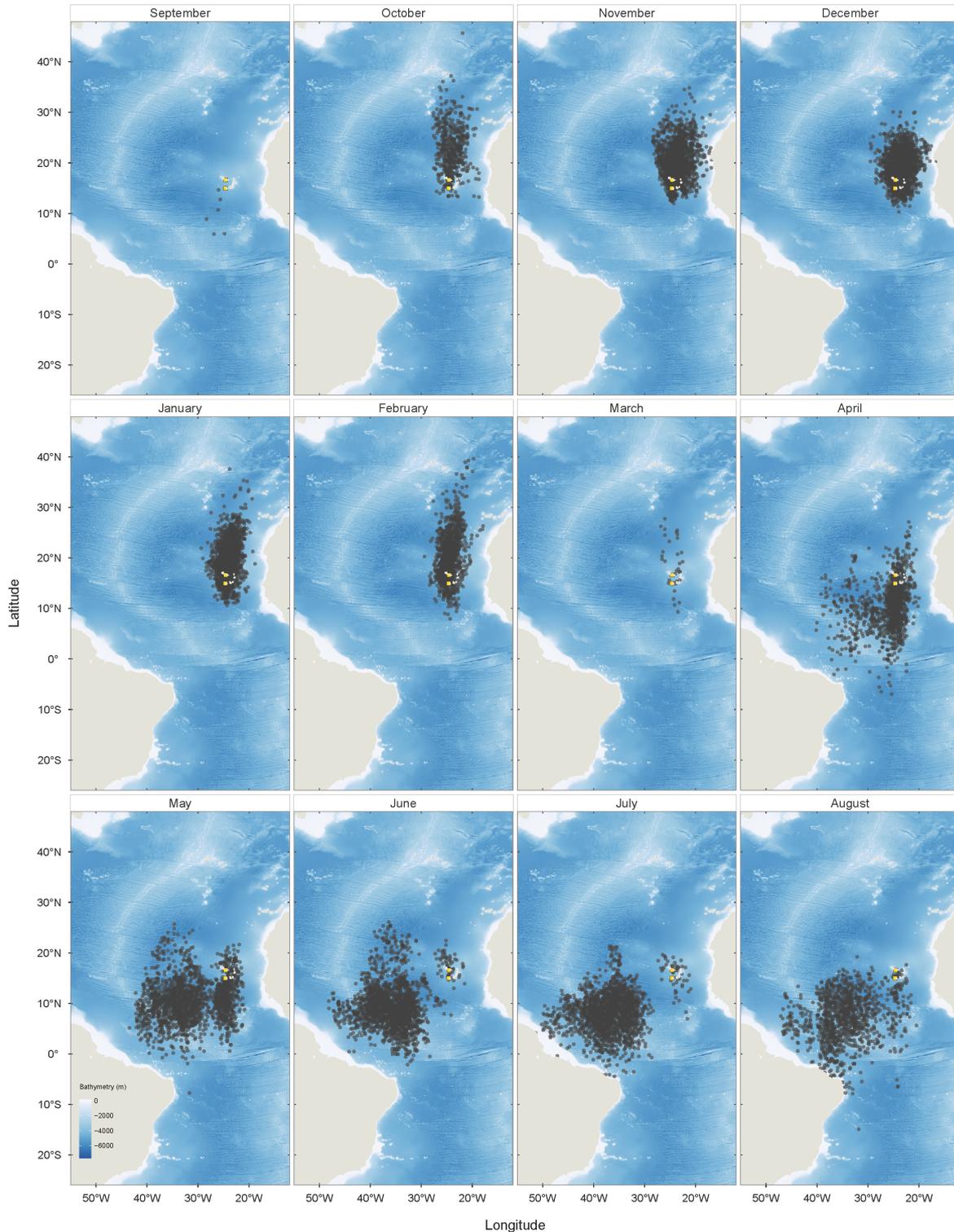


Fig. S3. Filtered monthly locations of Boyd's shearwaters ($n = 38$ tracks) tracked with geolocators on Cape Verde Islands (Ilhéu Raso and Ilhéu de Cima, marked as yellow squares) from 2007 – 2012, during their breeding (September – April) and non-breeding (May – August) period. The lack of locations in March and September is due to filtering process in which positions close to equinoxes were eliminated (see Methods). Bathymetry used as background.

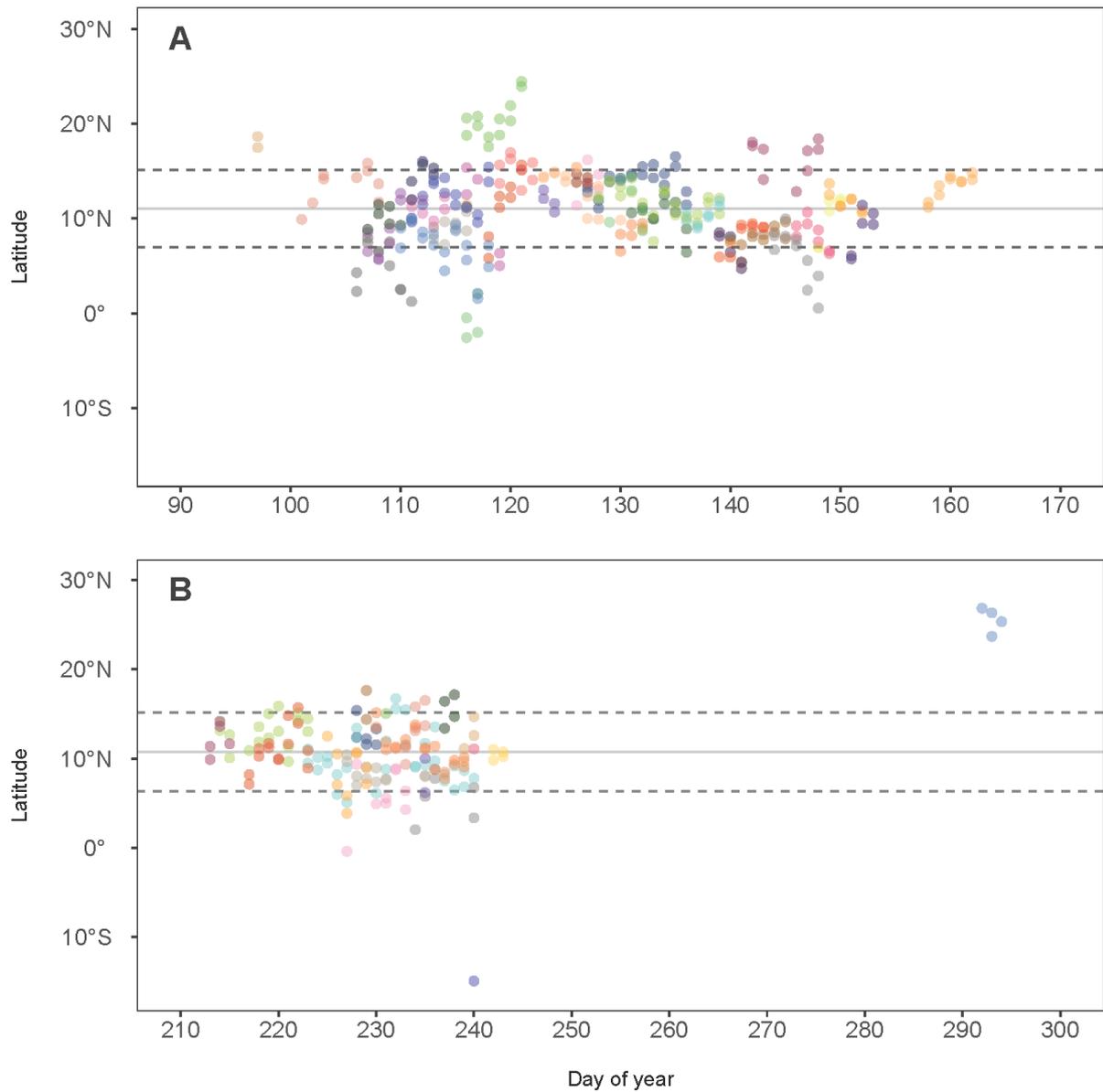


Fig. S4. Migratory corridors of Boyd's shearwaters tracked with geolocators from 2007 – 2012. All filtered latitudinal positions (see Methods) of (A) postnuptial migration ranged between 2°S and 24°N ($n = 36$), as a migratory corridor we defined a range between mean ± 1 SD of those positions, resulting in corridor between 7° – 15°N. (B) Prenuptial migration positions ranged between 15°S and 27°N ($n = 20$), resulting in corridor between 6° and 15°N, which overlapped with postnuptial corridor. Solid and dashed lines represent mean ± 1 SD, respectively. Colours refer to different individuals, the same colour does not imply the same individual in (A) and (B).

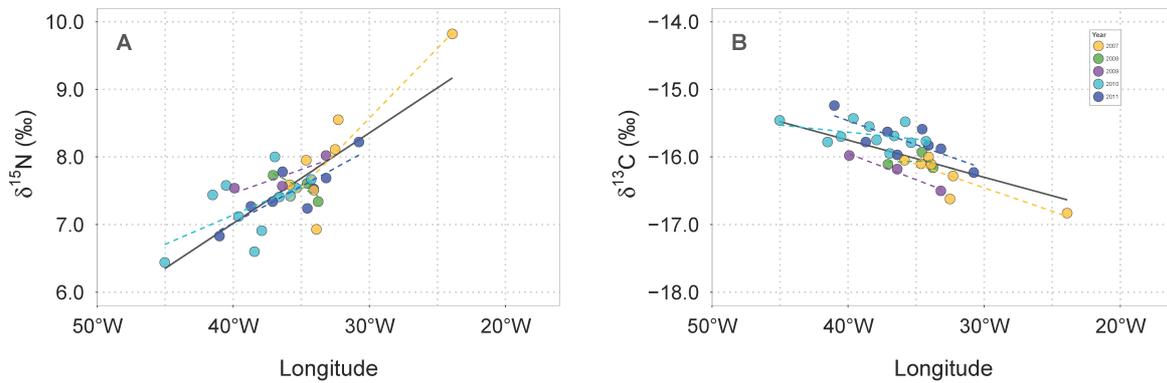


Fig S5. Relation between the (a) $\delta^{15}\text{N}$ and (b) $\delta^{13}\text{C}$ values of 8th secondary feather (S8) of Boyd's shearwaters tracked with geolocators ($n=32$, 2007-2012) and the longitude of the centroid, reflecting the area exploited during the non-breeding season (May-August). Points represent individual centroids of 50 % kernel utilization distribution during the non-breeding. Dark grey line refers to intercept and slope for fixed factor of linear mixed model (longitude as fixed factor, with year and individual as random, see Results and Fig. 5a-b) for all years pooled together. Dashed lines (coloured by year) refer to intercept and slope of simple linear regression of isotopic values and longitude to visualize that general pattern is maintained over years.

Table S1. a) Differences of least squares means and standard errors among sampled feathers (P1, S1, S8 and R6) of Boyd’s shearwater based on the linear mixed effects models (LMM) that included individual and year as random factors (see Results). P-values are adjusted using Bonferroni correction; significant differences are highlighted in bold. (b) Variance of random effects explained in models.

(a)

Feather	$\delta^{15}\text{N}$			$\delta^{13}\text{C}$		
	Estimate	SE	p-value	Estimate	SE	p-value
P1 - S1	1.146	0.158	< 0.001	-0.640	0.066	< 0.001
P1 - S8	1.183	0.158	< 0.001	-0.762	0.066	< 0.001
P1 - R6	0.247	0.158	0.719	-0.313	0.066	< 0.001
S1 - S8	0.037	0.158	1.000	-0.122	0.066	0.417
S1 - R6	-0.899	0.158	< 0.001	0.327	0.066	< 0.001
S8 - R6	-0.936	0.158	< 0.001	0.448	0.066	< 0.001

(b)

Random eff.	$\delta^{15}\text{N}$			$\delta^{13}\text{C}$		
	Variance	SD	%	Variance	SD	%
individual	0.322	0.567	39.31	0.029	0.171	20.20
year	0.100	0.317	12.24	0.045	0.213	31.26
residual	0.397	0.623	48.45	0.070	0.265	48.54

Table S2. (a) Model estimates and standard errors of linear mixed models (LMM) testing for spatial gradient in isotopic values of nitrogen and carbon of Boyd’s shearwaters breeding in Cape Verde Islands. The best-supported models (in bold, see Results and Table 3) include longitude as fixed factor. All models include individual and year as random factors. (b) Variance explained by random factors of best-supported longitudinal gradient model.

(a)

Model	Term	$\delta^{15}\text{N}$			$\delta^{13}\text{C}$		
		Estimate	SE	t-value	Estimate	SE	t-value
Long	(Intercept)	12.358	0.632	19.542	-17.941	0.373	-48.100
	longitude	0.133	0.018	7.612	-0.055	0.010	-5.398
Long + Lat	(Intercept)	12.531	0.739	16.946	-17.933	0.414	-43.314
	latitude	-0.008	0.020	-0.385	-0.001	0.011	-0.062
	longitude	0.136	0.019	7.358	-0.055	0.010	-5.224
Null	(Intercept)	7.604	0.153	49.597	-15.990	0.127	-126.377
Lat	(Intercept)	7.242	0.318	22.775	-15.888	0.186	-85.536
	latitude	0.038	0.031	1.229	-0.011	0.015	-0.715

(b)

Random effect	$\delta^{15}\text{N}$			$\delta^{13}\text{C}$		
	Estimate	SD	%	Estimate	SD	%
individual	0.103	0.322	69.26	0.000	0.321	0.00
year	0.000	0.000	0.00	0.036	0.000	53.38
residual	0.046	0.214	30.74	0.032	0.214	46.62

Literature Cited:

Hill RD, Braun MJ (2001) Geolocation by light level—The next step: Latitude. Electron Tagging Track Mar Fish:315–330

Lisovski S, Hewson CM, Klaassen RHG, Korner-Nievergelt F, Kristensen MW, Hahn S (2012) Geolocation by light: accuracy and precision affected by environmental factors. Methods Ecol Evol 3:603–612