

Supplementary figures

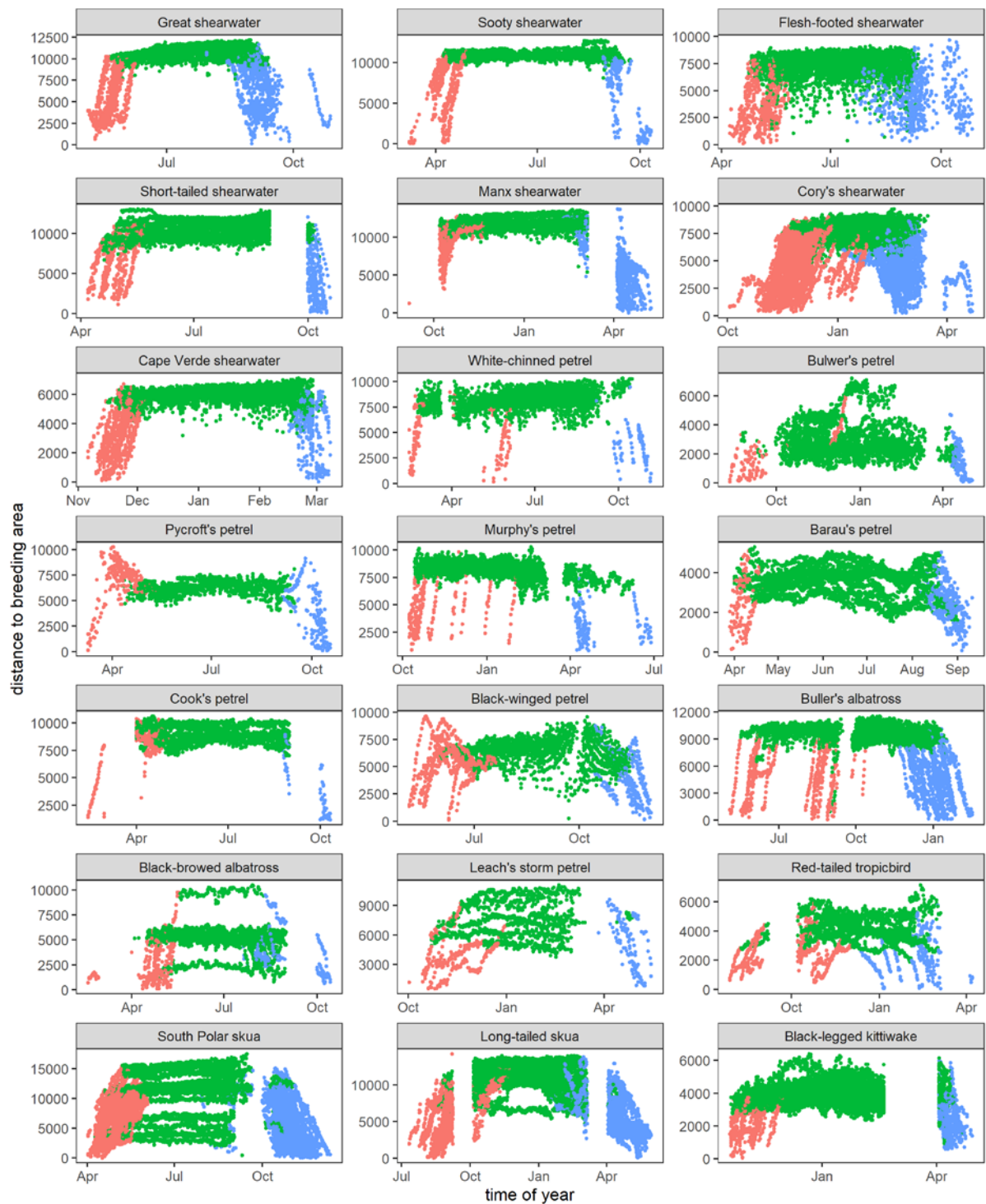


Figure S1. Time series of distance to the breeding areas for each species. Colours show the separation between the different migratory phases (salmon: outward migration, green: non-breeding period, blue: return migration). While all individuals of each species are combined on this figure, separation between migratory phases was done separately for each individual. This explains why different migratory phases might overlap in time within a species. Gaps are due to unreliable latitude data around the equinoxes.

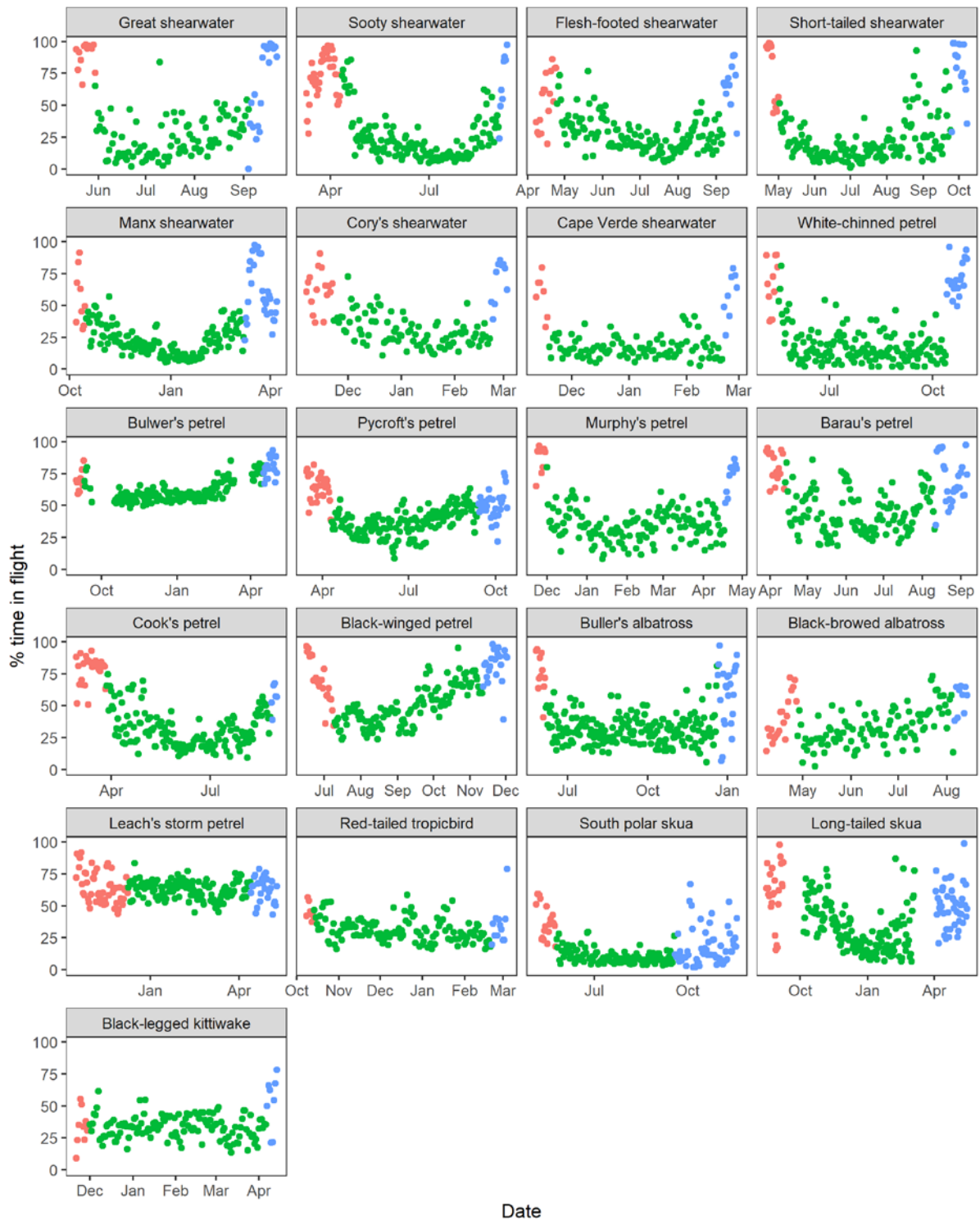


Figure S2. Time series of percentage of time spent in flight of an individual taken at random within each species. Colours show the separation between the different migratory phases, as in Fig. S1.

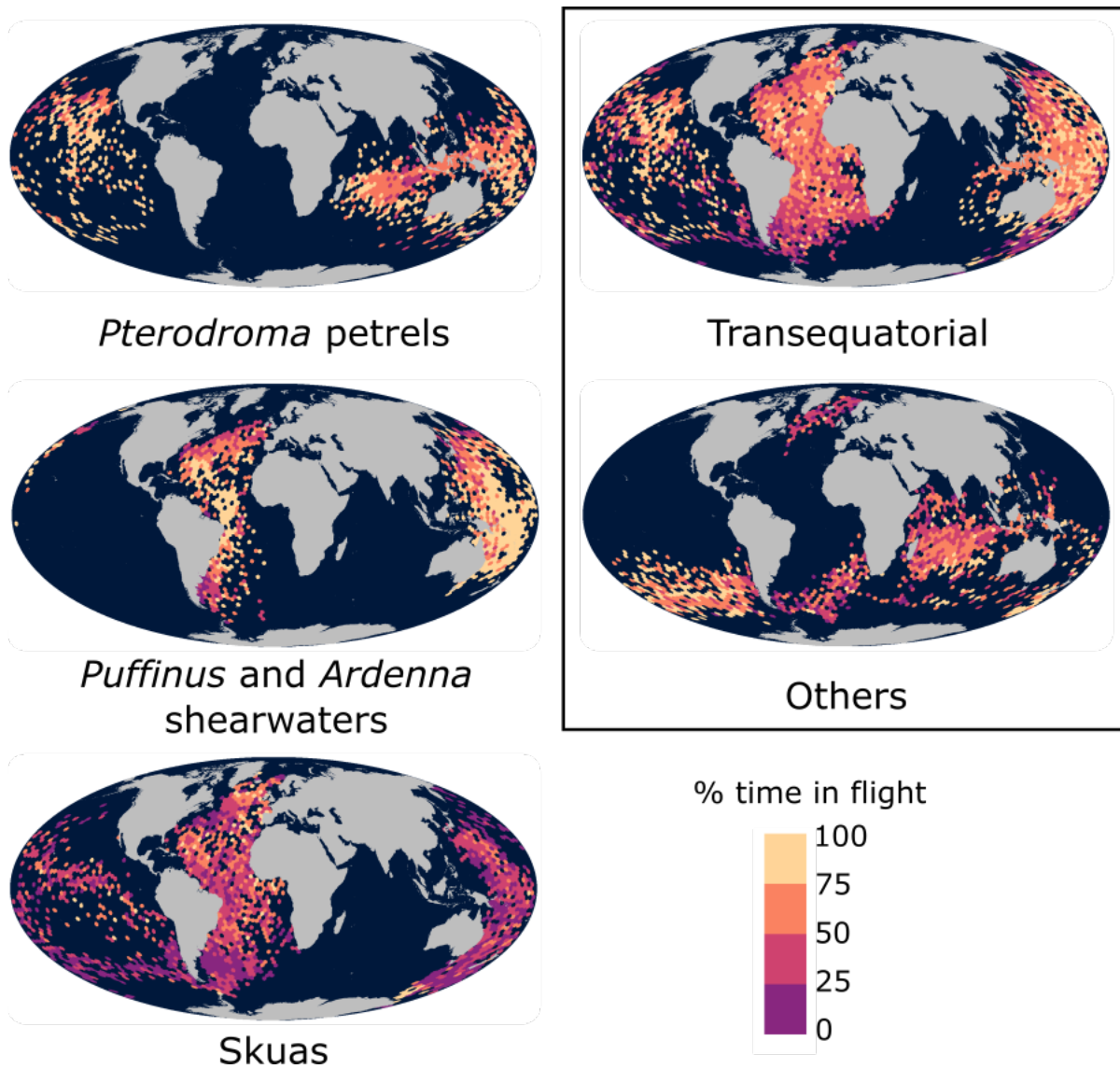


Figure S3. Proportion of time spent in flight during migration (outward and return), for non-transequatorial and transequatorial species, and a selection of example groups of species. Values correspond to averages across individuals, species, and hexagons (see methods).

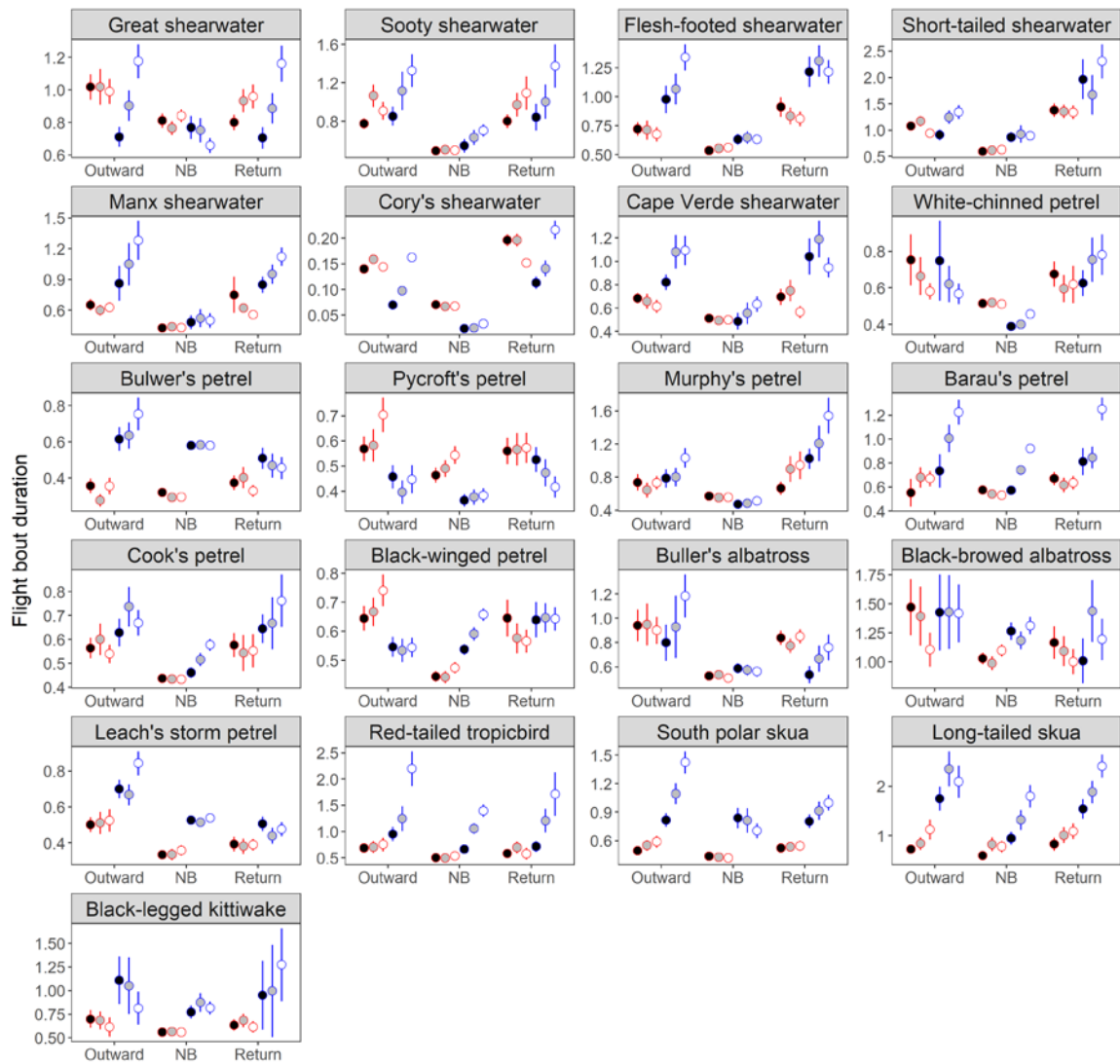


Figure S4. Effect of the moon (new moon: black dots, moon quarters: grey dots, full moon: white dots), migratory stages (outward migration, NB: non-breeding period, return migration) and day (in red) vs. night (in blue) on the duration of flight bouts in hours. Results are presented as mean \pm 95% CI across all individuals.

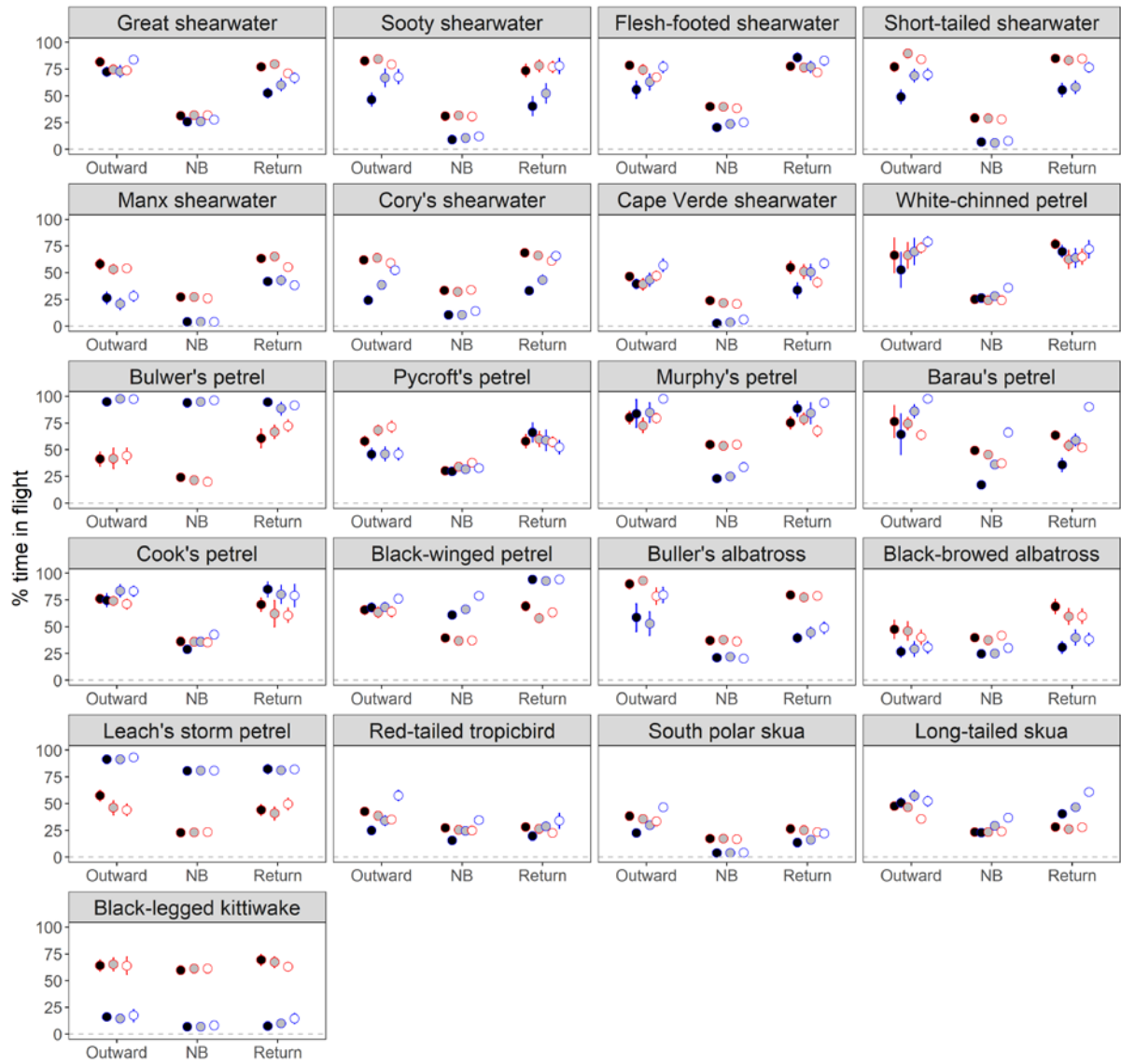


Figure S5. Effect of the moon (new moon: black dots, moon quarters: grey dots, full moon: white dots), migratory stages (outward migration, NB: non-breeding period, return migration) and day (in red) vs night (in blue) on the percentage of time spent in flight. Results are presented as mean \pm 95% CI.

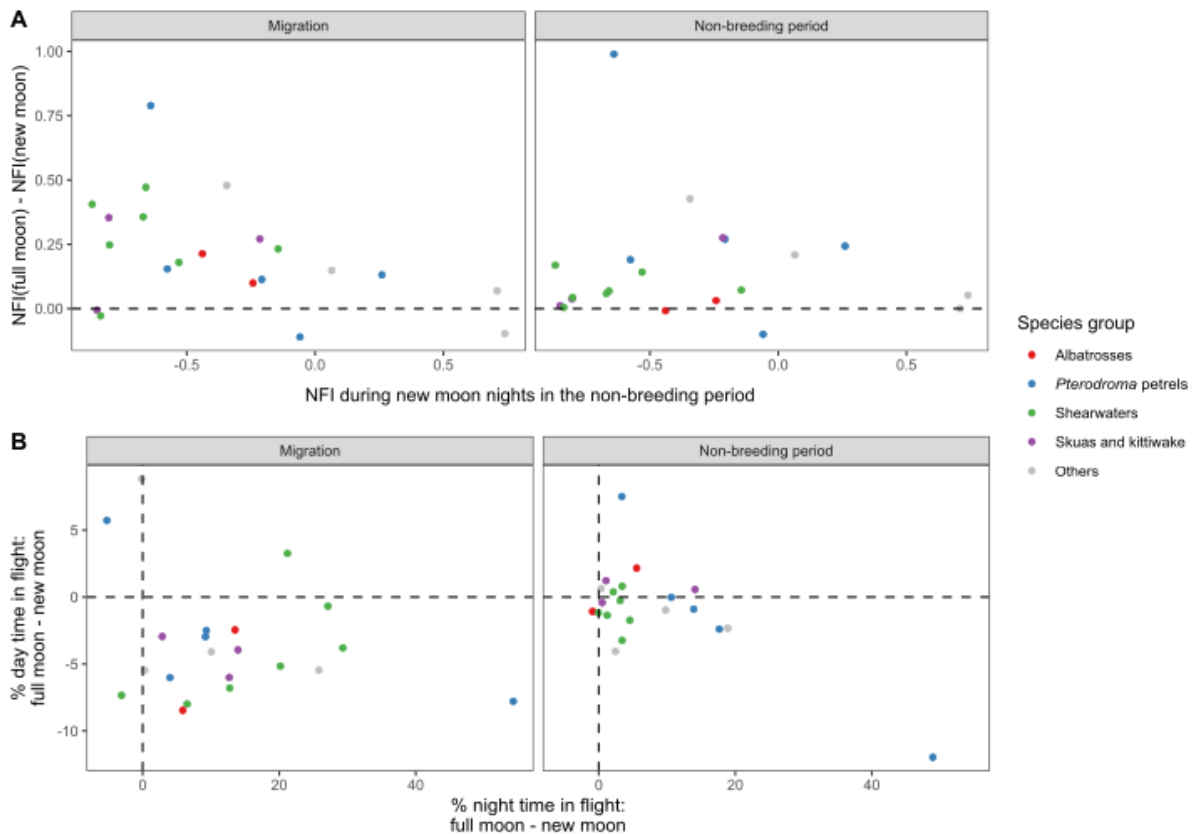


Figure S6. Effect of the moon on flight activity. A) Effect of the moon on nocturnality levels (measured using differences in the Night Flight Index – NFI) against *baseline* nocturnality (NFI during new moon nights in the non-breeding period); high values on the y-axis mean that the NFI increases markedly during full moon compared with new moon. B) Effect of the moon on flight activity during the day compared with during the night; points above the $x=0$ line represent species which increase their flight time in darkness during full moon, while points below the $y=0$ line represent species which decrease their flight time in daylight during full moon. All panels represent species averages across individuals and days within each moon phase and migratory stage. Migration panels represent averages of outward and return migrations.

Supplementary tables

Table S1. List of study species and colony locations.

Latin name	Common name	Colony	Reference
<i>Ardenna gravis</i>	Great shearwater	Gough Island (40.35°S; 9.88°W)	
<i>Ardenna grisea</i>	Sooty shearwater	Kidney Island, Falkland Islands (51.62°S; 57.76°W)	(Hedd, Montevecchi, Otley, Phillips, & Fifield, 2012)
<i>Ardenna carneipes</i>	Flesh-footed shearwater	Lord Howe Island (31.53°S; 159.08°E)	
<i>Ardenna tenuirostris</i>	Short-tailed shearwater	Great Dog Island, Tasmania (40.15°S; 148.15°E)	
<i>Puffinus puffinus</i>	Manx shearwater	Skomer Island (51.74°N; 5.30° W)	(Guilford et al., 2009)
<i>Calonectris borealis</i>	Cory's shearwater	Selvagem Grande (30.15°N; 15.87°W)	
<i>Calonectris edwardsii</i>	Cape Verde shearwater	Curral Velho, Cape Verde (15.97°N; 22.79°W)	
		Raso, Cape Verde (16.61°N; 24.60°W)	
<i>Procellaria aequinoctialis</i>	White-chinned petrel	Antipodes Island (49.68°S; 178.8°E)	
<i>Bulweria bulwerii</i>	Bulwer's petrel	Selvagem Grande (30.15°N; 15.87°W)	
<i>Pterodroma pycrofti</i>	Pycroft's petrel	Great Mercury Island (36.58°S; 175.92°E)	(Rayner et al., 2016)
<i>Pterodroma ultima</i>	Murphy's petrel	Henderson Island, Pitcairn Islands (24.37°S; 128.33°W)	(Clay, Phillips, Manica, Jackson, & Brooke, 2017)
<i>Pterodroma baraui</i>	Barau's petrel	Reunion Island (21.12°S; 55.42°E)	(Pinet et al., 2011)
<i>Pterodroma cookii</i>	Cook's petrel	Little Barrier Island (36.19°S; 175.08°E)	(Rayner et al., 2008, 2011)
<i>Pterodroma nigripennis</i>	Black-winged petrel	Raoul Island, Kermadec Islands (29.27°S; 177.93°W)	Rayner unpublished Bird life tracking database
<i>Thalassarche bulleri</i>	Buller's albatross	North East Island, Snares (48.01°S; 166.6°E)	
<i>Thalassarche melanophris</i>	Black-browed albatross	Bird Island, South Georgia (54.00°S; 38.05°W)	

<i>Oceanodroma leucorhoa</i>	Leach's storm petrel	Baccalieu Island (48.12°N; 52.8°W)	April Hedd unpubl. data
<i>Phaethon rubricauda</i>	Red-tailed tropicbird	Nosy Ve, Madagascar (23.6°S; 43.61°E)	(Le Corre et al., 2012)
<i>Stercorarius maccormicki</i>	South polar skua	Pointe Géologie, Terre Adélie (66.67°S ; 140.02°E)	
		King George Island, South Shetland Islands (62.19°S; 58.95°W)	(Kopp et al., 2011)
<i>Stercorarius longicaudus</i>	Long-tailed skua	Karupelv Valley, Greenland (72.5°N; 24.0°W)	(van Bemmelen et al., 2017)
		Hochstetter Forland, Greenland (75.15°N; 19.67°W)	(Gilg et al., 2013; van Bemmelen et al., 2017)
		Ammarnäs, Sweden (66.00°N; 16.18°E)	(van Bemmelen et al., 2017)
		Kongsfjorden, Svalbard (78.90°N; 12.22°E)	(Gilg et al., 2013; van Bemmelen et al., 2017)
		Zackenberget, Greenland (74.48°N; 20.58°W)	(Gilg et al., 2013; van Bemmelen et al., 2017)
<i>Rissa tridactyla</i>	Black-legged kittiwake	Kongsfjorden, Svalbard (78.9°N; 12.22°E)	(Frederiksen et al., 2012)

Table S2: Samples sizes for each species, migratory period and moon phase. For scientific names, see Table 1.

Common name	Trans-equatorial migrant?	Number of tracked individuals								
		Outward migration			Non-breeding period			Return migration		
		New moon	Quarters	Full moon	New moon	Quarters	Full moon	New moon	Quarters	Full moon
Great shearwater	Yes	26	28	24	29	29	29	24	26	23
Sooty shearwater	Yes	15	15	11	17	17	17	10	12	11
Flesh-footed shearwater	Yes	16	19	17	23	23	23	13	20	18
Short-tailed shearwater	Yes	29	36	30	39	39	39	28	37	35
Manx shearwater	Yes	21	26	21	29	29	29	28	27	25
Cory's shearwater	Yes	90	97	91	90	93	92	38	42	34
Cape Verde shearwater	Yes	24	25	22	36	36	36	18	20	23
White-chinned petrel	No	5	11	11	14	14	14	7	9	7
Bulwer's petrel	Yes	9	6	4	14	14	14	5	6	5
Pycroft's petrel	No	4	4	4	4	4	4	5	6	6
Murphy's petrel	Yes	8	8	9	15	15	16	5	8	7
Barau's petrel	No	3	9	11	13	13	13	10	10	12
Cook's petrel	Yes	9	8	8	11	11	11	5	4	4
Black-winged	Yes	8	9	8	10	10	10	10	10	10

petrel										
Buller's albatross	No	4	7	7	14	14	14	14	14	14
Black-browed albatross	No	11	13	13	21	21	21	7	14	11
Leach's storm petrel	Yes	6	5	4	6	6	6	6	6	6
Red-tailed tropicbird	No	12	12	10	12	12	12	11	10	9
South polar skua	Yes	56	56	56	56	56	56	55	55	55
Long-tailed skua	Yes	14	14	13	11	11	11	12	12	12
Black-legged kittiwake	No	20	19	11	32	32	32	18	26	17

Table S3: Flight increase during migration (ratio of % flight time during migration over % of flight time during the non-breeding period for each individual), latitudinal migratory range (absolute latitudinal difference between breeding area and the average latitude during the non-breeding period) and distance between breeding and non-breeding grounds (average distance to the breeding grounds across the non-breeding period).

Common name	Ratio of flight increase (mean \pm SD)	Latitudinal migratory range (mean \pm SD)	Distance between breeding and non-breeding grounds
Great shearwater	2.98 \pm 1.15	91 \pm 5 °	10,700 \pm 400 km
Sooty shearwater	3.48 \pm 0.78	98 \pm 2 °	11,000 \pm 200 km
Flesh-footed shearwater	2.45 \pm 0.71	63 \pm 5 °	7,400 \pm 600 km
Short-tailed shearwater	4.63 \pm 1.01	89 \pm 5 °	10,300 \pm 1,000 km
Manx shearwater	3.09 \pm 0.75	93 \pm 3 °	11,700 \pm 400 km
Cory's shearwater	2.40 \pm 0.78	63 \pm 4 °	7,900 \pm 500 km
Cape Verde shearwater	3.94 \pm 1.22	46 \pm 3 °	5,900 \pm 200 km
White-chinned petrel	2.51 \pm 0.86	18 \pm 6 °	8,400 \pm 600 km
Bulwer's petrel	1.25 \pm 0.11	25 \pm 13 °	3,200 \pm 1,300 km
Pycroft's petrel	1.72 \pm 0.16	43 \pm 2 °	6,300 \pm 300 km
Murphy's petrel	1.97 \pm 0.27	68 \pm 3 °	8,100 \pm 600 km
Barau's petrel	1.71 \pm 0.14	3 \pm 1 °	3,500 \pm 500 km
Cook's petrel	2.08 \pm 0.35	68 \pm 4 °	9,000 \pm 600 km
Black-winged petrel	1.39 \pm 0.14	54 \pm 5 °	6,300 \pm 600 km
Buller's albatross	2.45 \pm 0.72	18 \pm 5 °	9,400 \pm 500 km
Black-browed albatross	1.31 \pm 0.78	25 \pm 5 °	5,300 \pm 1,200 km
Leach's storm petrel	1.30 \pm 0.16	53 \pm 13 °	7,500 \pm 1,900 km
Red-tailed tropicbird	1.31 \pm 0.23	15 \pm 10 °	4,200 \pm 600 km
South polar skua	3.13 \pm 0.94	99 \pm 17 °	12,100 \pm 2,400 km
Long-tailed skua	1.89 \pm 0.28	98 \pm 11 °	11,100 \pm 1,200 km
Black-legged kittiwake	1.16 \pm 0.14	30 \pm 3 °	3,900 \pm 400 km

Table S4: Percentage of flying bouts longer than 24 h / percentage of time spent in bouts longer than 24 h (number of individuals involved). For scientific names, see Table 1.

Common name	Outward migration	Return migration	Non-breeding period
Great shearwater	-	0.01% / 3.2% (1)	-
Sooty shearwater	-	-	-
Flesh-footed shearwater	-	-	-
Short-tailed shearwater	-	0.31% / 7.5% (14)	0.01% / 0.3% (1)
Manx shearwater	-	-	-
Cory's shearwater	-	-	-
Cape Verde shearwater	-	-	-
White-chinned petrel	-	-	-
Bulwer's petrel	-	-	-
Pycroft's petrel	-	-	-
Murphy's petrel	-	-	-
Barau's petrel	-	-	-
Cook's petrel	-	-	-
Black-winged petrel	-	-	-
Buller's albatross	-	-	-
Black-browed albatross	-	-	-
Leach's storm petrel	-	-	-
Red-tailed tropicbird	-	-	-
South polar skua	-	0.02% / 0.1% (1)	-
Long-tailed skua	-	-	-
Black-legged kittiwake	-	-	-

Table S5: Percentage of time spent in wet bouts > 1h, over a 24-h period. For scientific names, see Table 1.

Common name	Outward migration	Non-breeding period	Return migration
Great shearwater	50.0	62.7	52.7
Sooty shearwater	32.4	54.2	48.5
Flesh-footed shearwater	39.9	50.6	36.7
Short-tailed shearwater	44.3	53.9	44.5
Manx shearwater	49.5	48.9	51.3
Cory's shearwater	54.5	58.0	55.3
Cape Verde shearwater	74.5	82.6	73.3
White-chinned petrel	44.2	64.8	43.2
Bulwer's petrel	15.8	30.4	7.5
Pycroft's petrel	30.0	54.1	44.8
Murphy's petrel	23.0	59.4	35.4
Barau's petrel	40.0	48.3	46.4
Cook's petrel	20.8	34.0	29.2
Black-winged petrel	30.8	34.0	29.2
Buller's albatross	39.7	51.8	50.0
Black-browed albatross	78.3	84.0	84.6
Leach's storm petrel	31.7	49.5	47.7
Red-tailed tropicbird	53.5	58.5	68.5
South polar skua	55.2	70.7	69.1
Long-tailed skua	28.1	32.3	35.9
Black-legged kittiwake	57.3	46.2	42.7

Table S6. *Baseline* nocturnality (Night flight index during the non-breeding period) averaged across days and individuals simultaneously.

Latin name	Common name	<i>Baseline</i> nocturnality (mean \pm SD)
<i>Ardenna gravis</i>	Great shearwater	-0.1 \pm 0.6
<i>Ardenna grisea</i>	Sooty shearwater	-0.6 \pm 0.4
<i>Ardenna carneipes</i>	Flesh-footed shearwater	-0.5 \pm 0.4
<i>Ardenna tenuirostris</i>	Short-tailed shearwater	-0.8 \pm 0.3
<i>Puffinus puffinus</i>	Manx shearwater	-0.8 \pm 0.3
<i>Calonectris borealis</i>	Cory's shearwater	-0.6 \pm 0.4
<i>Calonectris edwardsii</i>	Cape Verde shearwater	-0.8 \pm 0.4
<i>Procellaria aequinoctialis</i>	White-chinned petrel	0.2 \pm 0.6
<i>Bulweria bulwerii</i>	Bulwer's petrel	0.8 \pm 0.2
<i>Pterodroma pycrofti</i>	Pycroft's petrel	-0.1 \pm 0.4
<i>Pterodroma ultima</i>	Murphy's petrel	-0.5 \pm 0.4
<i>Pterodroma barau</i>	Barau's petrel	-0.2 \pm 0.6
<i>Pterodroma cookii</i>	Cook's petrel	-0.1 \pm 0.5
<i>Pterodroma nigripennis</i>	Black-winged petrel	0.4 \pm 0.3
<i>Thalassarche bulleri</i>	Buller's albatross	-0.4 \pm 0.5
<i>Thalassarche melanophris</i>	Black-browed albatross	-0.2 \pm 0.6
<i>Oceanodroma leucorhoa</i>	Leach's storm petrel	0.7 \pm 0.2
<i>Phaethon rubricauda</i>	Red-tailed tropicbird	-0.1 \pm 0.5
<i>Stercorarius maccormicki</i>	South polar skua	-0.8 \pm 0.4
<i>Stercorarius longicaudus</i>	Long-tailed skua	-0.1 \pm 0.6
<i>Rissa tridactyla</i>	Black-legged kittiwake	-0.8 \pm 0.3

Table S7: Results of the following linear models: Moon effect ~ NFI during moonless nights, with Moon effect = $NFI_{\text{full moon}} - NFI_{\text{new moon}}$. Each data point corresponds to mean species values (across days then individuals).

Model I – migration				
	Estimate	Standard error	t-value	p-value
Intercept	0.160	0.048	3.32	0.003
Slope	-0.183	0.087	-2.09	0.048
Model II – non-breeding period				
	Estimate	Standard error	t-value	p-value
Intercept	0.146	0.056	2.59	0.017
Slope	-0.035	0.102	-0.34	0.733

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