The following supplement accompanies the article

'Stepping stone' pattern in Pacific Arctic tern migration reveals the importance of upwelling areas

Aly McKnight[1,*], Andrew J. Allyn[2], David C. Duffy[3], David B. Irons[1]

[1]**US Fish and Wildlife Service, Anchorage, Alaska 99503, USA**
[2]**Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, Massachusetts 01003, USA**
[3]**Pacific Cooperative Studies Unit, Department of Botany, University of Hawai'i Manoa, Honolulu, Hawaii 96822, USA**

*Email: aly.mcknight@gmail.com

Marine Ecology Progress Series 491: 253–264 (2013)

Supplement. Summary tables, figures, and statistical results

Table S1. General summary information for Arctic terns tagged with geolocation devices in Prince William Sound, Alaska in July 2007, including last useable data date, colony departure date, number of dates with useable position data post-filtering, date of arrival within wintering region, and approximate date ranges of attendance within the identified stopover regions. na: bird was not recorded in the specified region; nd: geolocator failed prior to possible arrival in region

	BIRDS					
	6212	**6217**	**6219**	**6222**	**6227**	**6228**
Date of last useable data	2 Dec	22 Feb	28 Feb	28 Feb	17 Oct	2 Jun
Total no. of useable position dates	78	129	147	89	49	160
No. of days with 24 h light	14	3	2	84	0	35
Depart colony region	24 Jul	27 Jul	31 Jul	15 Aug	7 Aug	27 Jul
California Current stopover	31 Jul – 31 Aug[a]	3 Aug – 20 Aug	4 Aug – 15 Aug	20 Aug – 28 Aug	11 Aug – 21 Aug	3 Aug – 10 Aug
Northern Humboldt stopover	10 Oct[a] – 24 Oct	30 Aug – ?[a]	27 Aug – 31 Aug[a]	10 Oct[a] – 27 Oct	30 Aug – ?[a]	23 Aug – 30 Aug
Southern Humboldt stopover	na	10 Oct[a] – 11 Oct	na	30 Oct – 4 Nov	na	10 Oct[a] – 16 Oct
Patagonia stopover	na	15 Oct – 14 Nov	12 Oct – 17 Nov	7 Nov – 17 Nov	11 Oct – 16 Oct	20 Oct – 12 Nov
Arrive in wintering region	na	17 Nov	23 Nov	<26 Nov[b]	nd	15 Nov

[a]Overlap with equinox filter period
[b]Uncertain timing due to transition filtering

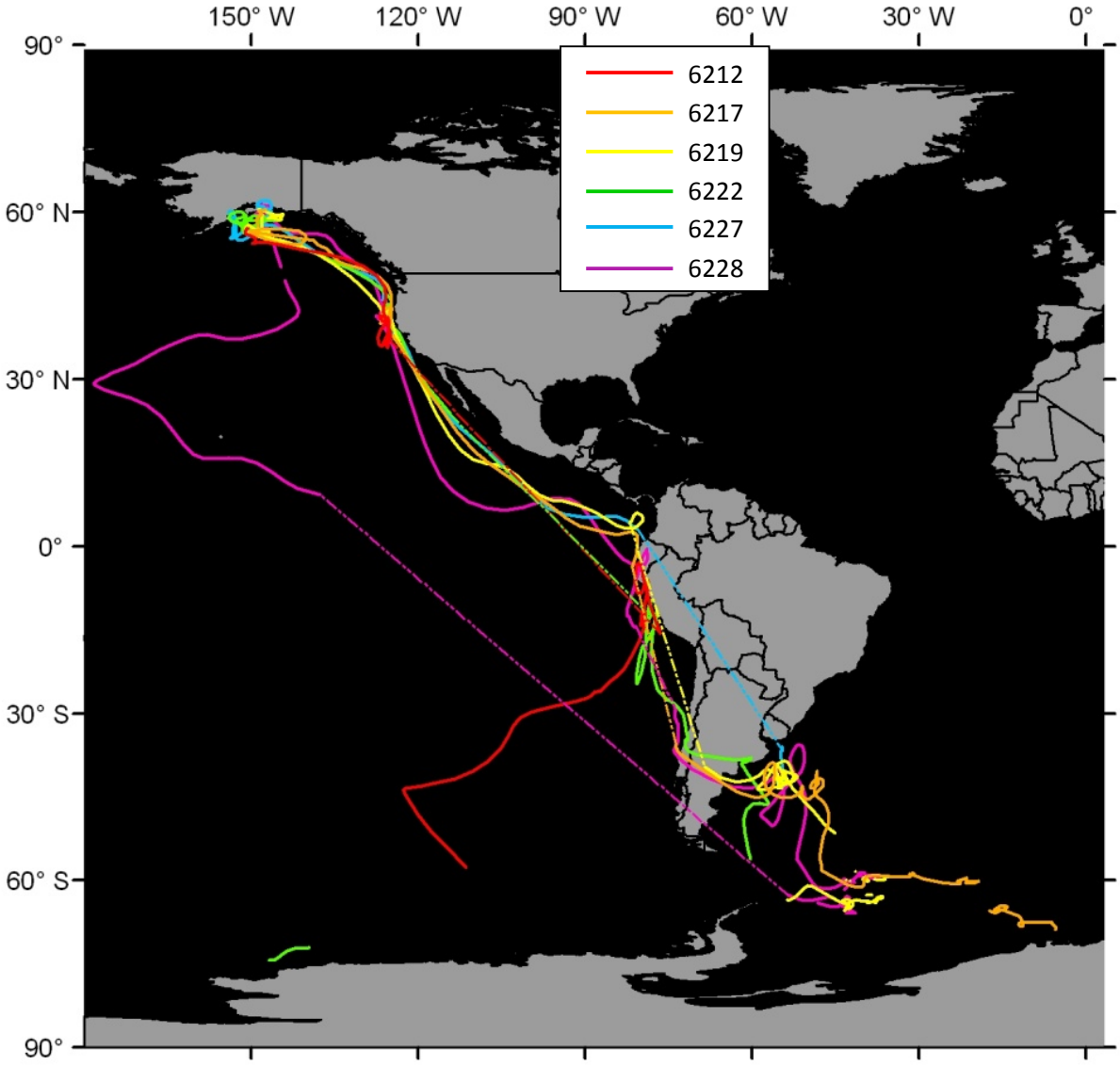

Fig. S1. Tracks of all 6 tagged Arctic terns determined through light geolocation for the entire deployment period. Tracks are color-coded by individual bird. Dotted lines indicate missing segments occurring around equinoxes. Only one bird (6228, purple, clockwise direction of travel) returned to the colony region with data collected over the entire round-trip migration; the rest of the devices suffered battery failure some time after the birds' arrival in the Southern Ocean

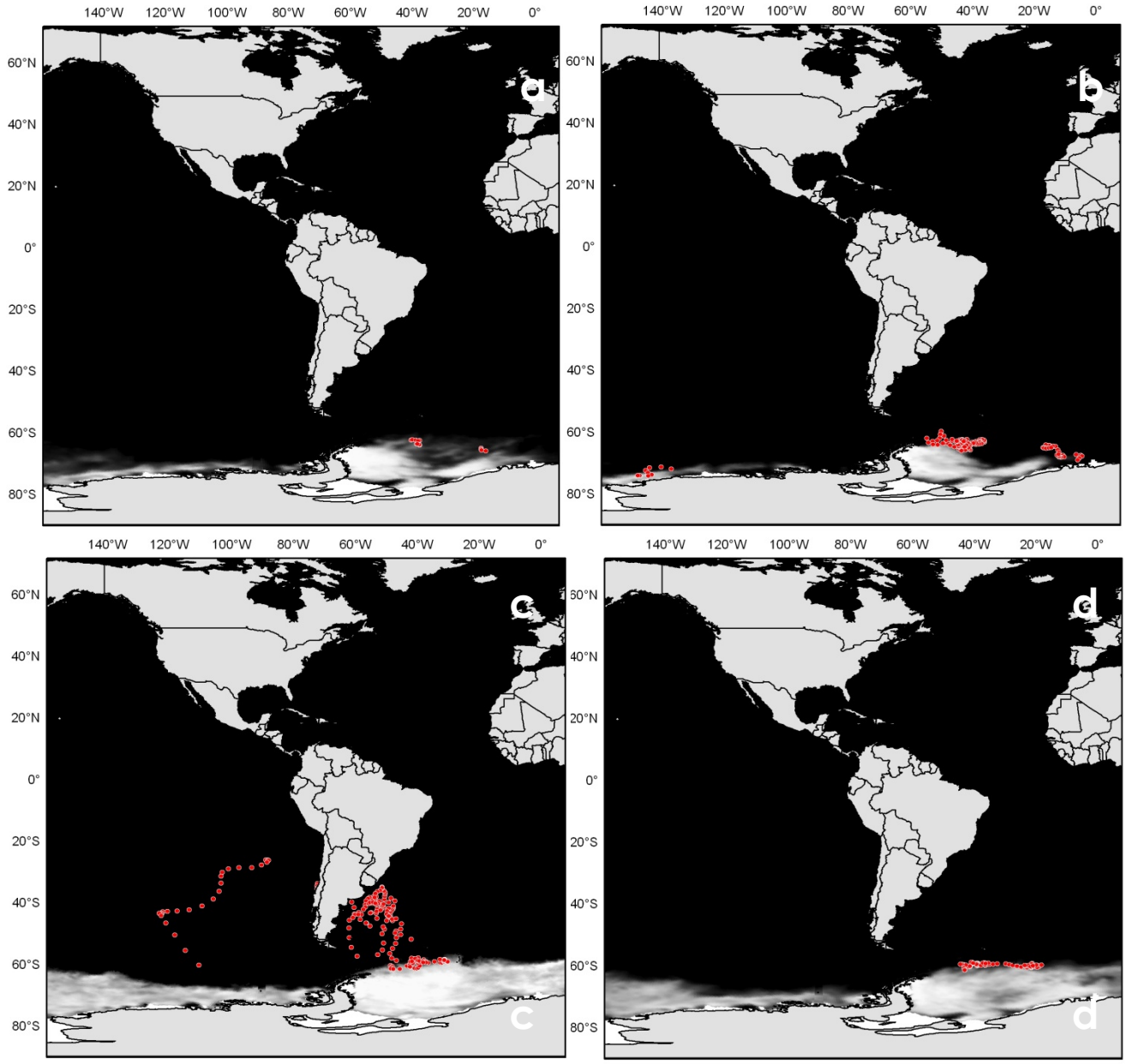

Fig. S2. All bird locations (red circles) overlaid on monthly Antarctic ice concentration data for (a) November (N = 4), (b) December (N = 3), (c) January (N = 2), and (d) February (N =3)

Table S2. Number of days each bird was located within staging areas vs. travel corridors, by month. Dates with unreliable position data are excluded, including all data from the month of September, which were unreliable due to latitudinal equinox error

Bird	August		October		November	
	Staging	Travel	Staging	Travel	Staging	Travel
6212	30	--	17	3	2	11
6217	19	11	16	6	22	5
6219	15	5	19	3	14	6
6222	20	10	20	2	12	5
6227	12	16	6	–	–	–
6228	14	16	16	6	22	3

Table S3. Results of linear effects model comparing the average hours per day spent in daytime/twilight foraging activity in staging areas versus traveling locations (by month) ± 95% confidence interval. Month = a fixed effect and 'bird' = a random effect. *denotes significant difference at $p < 0.05$

Month	**Staging areas (h d^{-1})**	**Travel corridors (h d^{-1})**	***F***	**p**
August	7.6 ± 0.4	4.4 ± 0.7	83.6	<0.001*
October	6.9 ± 0.5	5.7 ± 0.9	4.1	0.0442*
November	6.0 ± 0.6	6.1 ± 0.9	0.0	0.907

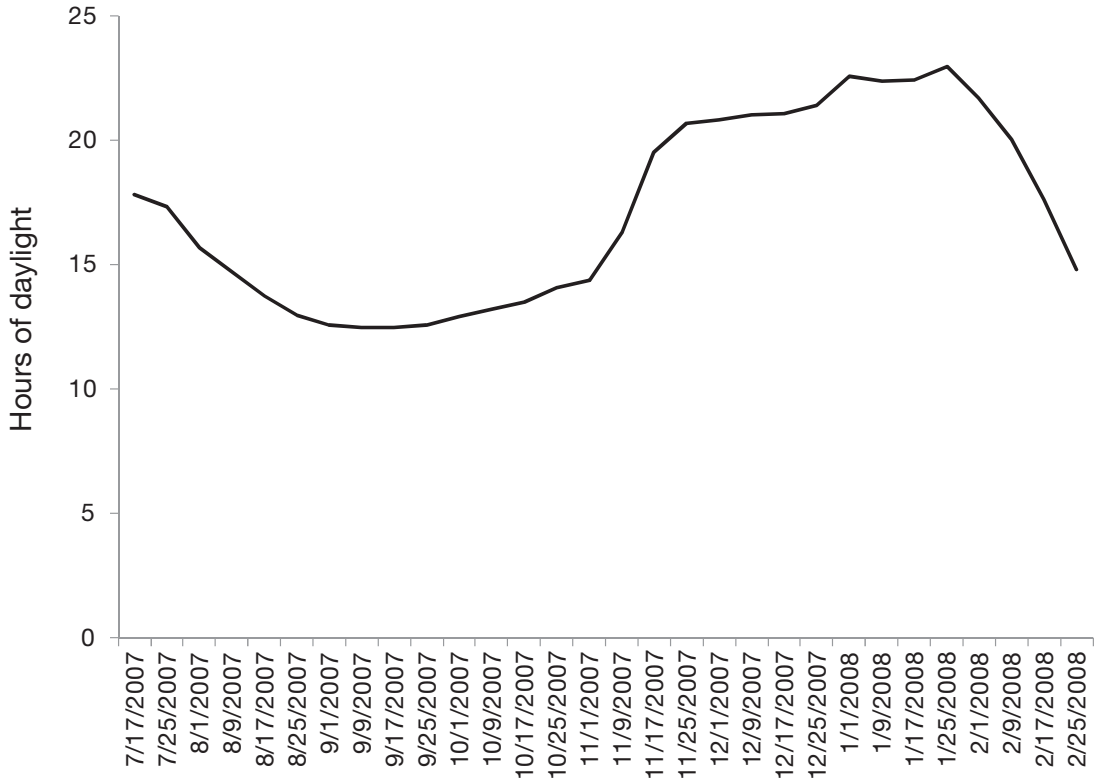

Fig. S3. Number of hours of daylight experienced by tagged Arctic terns by week, based on duration of full light recorded by geolocator tags. Values were first averaged over all birds for each day, then average daily values were averaged by week (July to mid-October: N = 6; mid-October to January: N = 5, February: N = 2). Dates are mm/dd/yy

Table S4. Results of linear effects model comparing the average hours per day spent in daytime/twilight foraging activity in staging areas versus traveling locations (by month) ± 95% confidence intervals. Month = a fixed effect and 'bird' = a random effect. Tukey's honest significance test results are also reported for months showing significant differences. *denotes significant difference at $p < 0.05$

Behavior	ANOVA	Month	Average h d^{-1}			Significant comparisons
Flying/standing						
	$F = 14.18$, $p < 0.0001$*					
		August	7.90	±	1.22	Aug < Nov, Dec, Jan ($p = 0.032$, $p \leq 0.001$, $p \leq 0.001$)
		September	6.21	±	0.75	Sep < Nov, Dec, Jan ($p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$)
		October	6.98	±	0.57	Oct < Nov, Dec, Jan ($p = 0.001$, $p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$)
		November	11.10	±	1.41	
		December	14.02	±	2.05	
		January	14.61	±	3.30	Jan > Feb ($p = 0.035$)
		February	10.42	±	4.81	
Foraging						
	$F = 0.934$, $p < 0.0478$*					
		August	5.69	±	1.24	None of the month-to-month comparisons were significant at the $\alpha = 0.05$ level
		September	6.00	±	0.71	
		October	6.14	±	0.57	
		November	5.67	±	0.96	
		December	5.39	±	0.97	
		January	5.12	±	1.50	
		February	4.38	±	1.91	
Floating						
	$F = 5.54$, $p < 0.0001$*					
		August	0.50	±	0.22	Aug > Oct, Nov, Dec, Jan, Feb ($p = 0.003$, $p = 0.004$, $p = 0.001$, $p = 0.002$, $p = 0.008$)
		September	0.35	±	0.19	
		October	0.13	±	0.07	
		November	0.12	±	0.07	
		December	0.04	±	0.07	
		January	0.03	±	0.03	
		February	0.05	±	0.05	

Table S5. Results of linear effects model comparing the average hours per day spent in daytime /twilight foraging activity in staging areas versus traveling locations (by month) ± 95% confidence interval. Month = a fixed effect and 'bird' = a random effect. Tukey's honest significance test results are also reported for months showing significant differences. *denotes significant difference at $p < 0.05$

Behavior	ANOVA	Month	Avg. min per bout			Significant comparisons
Flying/standing						
	$F = 23.13$, $p < 0.0001$*					
		August	40	±	7	Aug < Dec, Jan, Feb ($p \leq 0.001$, $p = 0.004$, $p \leq 0.001$)
		September	31	±	4	Sep < Nov, Dec, Jan, Feb ($p = 0.005$, $p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$)
		October	29	±	2	Oct < Aug, Nov, Dec, Jan, Feb ($p = 0.01$, $p < 0.001$, $p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$)
		November	45	±	7	Nov < Dec, Jan ($p = 0.007$, $p \leq 0.001$)
		December	60	±	4	
		January	66	±	9	
		February	57	±	4	
Foraging						
	$F = 2.833$, $p < 0.0175$*					
		August	28	±	4	None of the month-to-month comparisons were significant at the $\alpha = 0.05$ level
		September	29	±	3	
		October	29	±	2	
		November	24	±	4	
		December	23	±	4	
		January	21	±	4	
		February	26	±	4	