

The following supplement accompanies the article

# Variability in trophic level and habitat use in response to environmental forcing: isotopic niche dynamics of breeding seabirds in the southeastern Bering Sea

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Marine Ecology Progress Series 593: 247–260 (2018)

**Table S1 Candidate models for carbon stable isotope signatures.** Models are listed in order of AIC<sub>c</sub> score.

Models, all with ID as random effect	k	n	AICc	ΔAICc	wi
PC1+Species+Season+Colony+PC1*Species+Season*Colony	11	1129	2776.95	0.00	1
PC1+Species+Colony+Season+PC1*Species	10	1129	2794.11	17.16	0
PC1+Species+Colony+Season+Species*Colony	10	1129	2804.50	27.54	0
PC1+Species+Colony+PC1*Species	9	1129	2806.33	29.37	0
Species+Colony+PC1+Species*Colony	9	1129	2818.89	41.93	0
PC1+Species+Season+Colony+PC1*Colony+Season*Species	11	1129	2827.57	50.62	0
PC1+Species+Colony+Season+Colony*Season	9	1129	2827.80	50.84	0
PC1+Species+Colony+Season+Species*Season	10	1129	2829.40	52.45	0
PC1+Species+Colony+Season+PC1*Season	9	1129	2843.62	66.66	0
PC1+Species+Colony+Season+PC1*Colony	9	1129	2845.01	68.05	0
PC1+Species+Colony+Season	8	1129	2847.39	70.44	0
PC1+Species+Colony+PC1*Colony	8	1129	2858.48	81.53	0
PC1+Season+Colony+PC1*Season	7	1129	2887.10	110.14	0
PC1+Season+Colony+PC1*Colony	7	1129	2889.12	112.16	0
Colony+Season+PC1+Colony*Season	6	1129	2890.39	113.44	0
PC1+Colony+PC1*Colony	6	1129	2906.08	129.12	0
PC1+Colony	5	1129	2907.23	130.27	0
Species+Colony+Season+Species*Colony	9	1129	2992.50	215.54	0
PC1+Species+Season+PC1*Species	9	1129	2996.08	219.13	0
Species+Colony+Species*Colony	8	1129	3001.40	224.44	0
PC1+Species+PC1*Species	8	1129	3003.15	226.20	0
Species+Season+PC1+Species*Season	9	1129	3012.65	235.70	0
Species+Season+Colony+Species*Season	9	1129	3019.55	242.59	0
Colony+Season+Species+Colony*Season	7	1129	3031.69	254.74	0
PC1+Season+Species+PC1*Season	8	1129	3036.21	259.26	0
Species+Colony	6	1129	3040.24	263.29	0
PC1+Species	6	1129	3043.47	266.52	0
PC1+Season	5	1129	3055.95	279.00	0
PC1+Season+PC1*Season	6	1129	3056.64	279.69	0
PC1	4	1129	3066.71	289.75	0
Colony+Season	5	1129	3075.59	298.63	0
Colony	4	1129	3087.00	310.05	0
Species+Season+Species*Season	8	1129	3144.15	367.20	0
Species+Season	6	1129	3161.31	384.35	0
Species	5	1129	3166.42	389.46	0
Season	4	1129	3185.67	408.72	0
null model	3	1129	3193.26	416.31	0

**Table S2 Candidate models for nitrogen stable isotope signatures.** Models are listed in order of AIC<sub>c</sub> score.

Models, all with ID as random effect	k	n	AICc	ΔAICc	wi
PC1+Season+Species+Colony+PC1*Season+PC1*Species+Season*Species	13	1129	3984.43	0.00	0.990
Season+Species+Colony+Season*Species+Colony*Species+Season*Colony	12	1129	3993.95	9.53	0.010
PC1+Species+Season+Colony+PC1*Species+Season*Colony	11	1129	4024.56	40.14	0.000
PC1+Species+Season+Colony+Season*Colony+PC1*Species	11	1129	4024.56	40.14	0.000
PC1+Species+Season+Colony+PC1*Colony+Season*Species	11	1129	4029.59	45.16	0.000
Species+Colony+PC1+Species*Colony	9	1129	4030.14	45.71	0.000
PC1+Species+Colony+Season+Species*Colony	10	1129	4031.99	47.56	0.000
Species+Colony+Species*Colony	8	1129	4033.16	48.73	0.000
Species+Colony+Season+Species*Colony	9	1129	4034.96	50.53	0.000
PC1+Species+Colony+PC1*Species	9	1129	4035.76	51.33	0.000
PC1+Species+Colony+Season+PC1*Species	10	1129	4037.77	53.35	0.000
PC1+Species+Colony+Season+Species*Season	10	1129	4041.37	56.94	0.000
PC1+Species+Colony+Season+PC1*Season	9	1129	4042.23	57.81	0.000
Species+Season+Colony+Species*Season	9	1129	4044.82	60.39	0.000
PC1+Species+Colony+Season+Colony*Season	9	1129	4051.01	66.59	0.000
Colony+Season+Species+Colony*Season	8	1129	4053.48	69.05	0.000
PC1+Species+Colony+PC1*Colony	8	1129	4054.15	69.73	0.000
PC1+Species+Colony+Season+PC1*Colony	9	1129	4056.11	71.68	0.000
PC1+Species+Colony+Season	8	1129	4066.14	81.72	0.000
Species+Colony	6	1129	4067.17	82.74	0.000
PC1+Season+Colony+PC1*Season	7	1129	4081.67	97.24	0.000
Colony+Season+PC1+Colony*Season	7	1129	4092.72	108.29	0.000
PC1+Colony+PC1*Colony	6	1129	4095.73	111.30	0.000
Colony+Season+Colony*Season	6	1129	4097.70	113.27	0.000
PC1+Season+Colony+PC1*Colony	7	1129	4105.26	120.83	0.000
PC1+Colony	5	1129	4108.97	124.55	0.000
Colony	4	1129	4110.83	126.41	0.000
Colony+Season	5	1129	4330.06	345.63	0.000
Species+Season+Species*Season	8	1129	4331.93	347.50	0.000
Species+Season+PC1+Species*Season	9	1129	4332.69	348.26	0.000
PC1+Species+PC1*Species	8	1129	4334.22	349.80	0.000
PC1+Species+Season+PC1*Species	9	1129	4337.29	352.87	0.000
PC1+Season+Species+PC1*Season	8	1129	4347.65	363.23	0.000
Species	5	1129	4349.44	365.01	0.000
Species+Season	6	1129	4349.61	365.19	0.000
PC1+Species	6	1129	4378.95	394.52	0.000
PC1+Season+PC1*Season	6	1129	4390.14	405.72	0.000
null model	3	1129	4391.72	407.29	0.000
Season	4	1129	4392.07	407.65	0.000
PC1	4	1129	4393.64	409.22	0.000
PC1+Season	5	1129	4393.62	409.31	0.000

**Table S3 Parameters for the top performing δ<sup>13</sup>C model.** Abbreviations for species are common murres (COMU) and thick-billed murres (TBMU).

Fixed Effects	Slope	SE	df	t-value	p-value
Intercept	-19.59	0.09	1238.00	-210.88	< 0.0001
PC1	0.10	0.01	1356.70	6.85	< 0.0001
SpecisCOMU	0.26	0.05	1316.00	5.46	< 0.0001
Species TBMU	0.28	0.04	1306.00	6.62	< 0.0001
SeasonArrival	-0.47	0.09	540.70	-5.45	< 0.0001
Colony	0.37	0.06	1049.30	6.46	< 0.0001
PC1:SpeciesCOMU	0.12	0.02	1307.70	5.82	< 0.0001
PC1:SpeciesTBMU	-0.02	0.02	1372.70	-1.24	0.214
SeasonArrival:Colony	0.25	0.06	502.30	4.40	< 0.0001

**Table S4 Parameters for the top performing  $\delta^{15}\text{N}$  model.** Abbreviations include COMU (common murre) and TBMU (thick-billed murre).

Fixed Effects	Slope	SE	df	t-value	p-value
Intercept	12.31	0.12	1468.40	105.88	< 0.0001
PC1	0.06	0.03	1476.10	2.28	0.0227
SeasonArrival	0.15	0.09	953.60	1.61	0.1085
SpeciesCOMU	0.06	0.12	1421.40	0.48	0.6333
SpeciesTBMU	0.16	0.11	1428.00	1.46	0.1449
Colony	0.96	0.05	1209.40	18.93	< 0.0001
PC1:SeasonArrival	-0.12	0.02	1041.10	-5.11	< 0.0001
PC1:SpeciesCOMU	0.17	0.03	1223.90	5.58	< 0.0001
PC1:SpeciesTBMU	0.02	0.03	1269.20	0.82	0.41
SeasonArrival:SpeciesCOMU	0.22	0.14	969.00	1.60	0.1111
SeasonArrival:SpeciesTBMU	-0.49	0.12	1006.00	-4.04	< 0.0001

**Table S5 Layman’s metrics for the seabird group under cold and warm ocean conditions.** Reported are the mode and 50% and 95% credible intervals by island and season. Abbreviations are as follows: “TA” = total area, “dC” = range covered by  $\delta^{13}\text{C}$ , “dN” = range covered by  $\delta^{15}\text{N}$ , “Centroid” = distance to the centroid, “NNdist” = distance to the nearest neighbor, and “sdNNdist” = standard deviation of the nearest neighbor distance.

Credible Interval		TA		dC		dN		Centroid		NNdist		sdNNdist	
		Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm
St. George Arrival	upper 95%	0.103	0.361	0.594	1.050	0.795	1.567	0.353	0.716	0.465	0.839	0.308	0.696
	50%	0.036	0.250	0.432	0.853	0.623	1.387	0.291	0.642	0.356	0.732	0.147	0.539
	<b>mode</b>	<b>0.006</b>	<b>0.194</b>	<b>0.345</b>	<b>0.757</b>	<b>0.535</b>	<b>1.298</b>	<b>0.26</b>	<b>0.601</b>	<b>0.31</b>	<b>0.684</b>	<b>0.092</b>	<b>0.461</b>
	50%	0.002	0.141	0.260	0.653	0.449	1.194	0.230	0.561	0.262	0.626	0.014	0.353
	lower 95%	0.000	0.039	0.103	0.467	0.287	1.019	0.172	0.482	0.180	0.524	0.000	0.159
St. George Chick-rearing	upper 95%	0.329	0.168	0.893	1.331	1.232	1.137	0.573	0.621	0.826	0.730	0.362	0.559
	50%	0.132	0.054	0.577	1.014	0.929	0.816	0.428	0.494	0.578	0.562	0.130	0.360
	<b>mode</b>	<b>0.046</b>	<b>0.013</b>	<b>0.412</b>	<b>0.848</b>	<b>0.761</b>	<b>0.652</b>	<b>0.358</b>	<b>0.432</b>	<b>0.461</b>	<b>0.476</b>	<b>0.015</b>	<b>0.251</b>
	50%	0.017	0.002	0.255	0.683	0.609	0.485	0.298	0.365	0.359	0.402	0.004	0.114
	lower 95%	-0.024	0.000	0.042	0.354	0.307	0.190	0.194	0.247	0.207	0.267	-0.006	-0.011
St. Paul Arrival	upper 95%	0.113	0.0986	0.985	0.4998	0.3923	0.7549	0.4129	0.3312	0.4985	0.4607	0.4138	0.2447
	50%	0.04	0.0355	0.809	0.3053	0.2325	0.552	0.339	0.2464	0.3786	0.3197	0.3138	0.0838
	<b>mode</b>	<b>0.017</b>	<b>0.009</b>	<b>0.717</b>	<b>0.21</b>	<b>0.159</b>	<b>0.446</b>	<b>0.304</b>	<b>0.205</b>	<b>0.327</b>	<b>0.239</b>	<b>0.242</b>	<b>0.009</b>
	50%	0.0013	0.0022	0.628	0.13	0.0941	0.3368	0.2688	0.17	0.2823	0.1998	0.016	0.0024
	lower 95%	-0.002	-0.004	0.457	0.0226	0.0107	0.1383	0.2053	0.1095	0.2084	0.1209	0.0138	-0.004
St. Paul Chick-rearing	upper 95%	0.4128	0.2129	1.834	1.1522	1.9236	0.801	0.9085	0.523	1.1553	0.6955	0.749	0.3746
	50%	0.1645	0.0565	1.464	0.7849	1.5365	0.4719	0.7779	0.3688	0.9715	0.4596	0.435	0.1173
	<b>mode</b>	<b>0.052</b>	<b>0.005</b>	<b>1.278</b>	<b>0.591</b>	<b>1.339</b>	<b>0.318</b>	<b>0.709</b>	<b>0.277</b>	<b>0.889</b>	<b>0.355</b>	<b>0.222</b>	<b>0.016</b>
	50%	0.0147	0.0004	1.094	0.4029	1.1512	0.1954	0.6503	0.2211	0.7732	0.2609	0.1053	0.0023
	lower 95%	-0.021	0	0.725	0.0939	0.7793	0.0309	0.5285	0.1079	0.5812	0.1161	-0.022	-0.007

**Table S6 Bayesian calculated Standard Ellipse Areas for kittiwakes and murre.**  
 Reported are the modes and 50% and 95% credible intervals for “BLKI” black-legged kittiwakes, “COMU” common murre, and “TBMU” thick-billed murre.

Credible Interval		BLKI		COMU		TBMU	
		Cold	Warm	Cold	Warm	Cold	Warm
St. George Arrival	upper 95%	0.867	0.662	0.751	1.787	1.287	0.927
	50%	0.748	0.574	0.655	1.613	1.154	0.787
	<b>mode</b>	<b>0.693</b>	<b>0.534</b>	<b>0.606</b>	<b>1.527</b>	<b>1.088</b>	<b>0.722</b>
	50%	0.642	0.495	0.568	1.445	1.025	0.669
	lower 95%	0.555	0.431	0.495	1.298	0.918	0.575
St. George Chick-rearing	upper 95%	3.777	2.676	2.868	4.325	2.861	3.087
	50%	3.134	2.037	2.221	3.671	2.308	2.237
	<b>mode</b>	<b>2.864</b>	<b>1.774</b>	<b>1.939</b>	<b>3.887</b>	<b>2.074</b>	<b>1.922</b>
	50%	2.611	1.529	1.718	3.111	1.859	1.655
	lower 95%	2.204	1.148	1.355	2.644	1.504	1.247
St. Paul Arrival	upper 95%	1.367	0.901	0.538	1.935	1.904	1.403
	50%	1.132	0.770	0.472	1.659	1.682	1.162
	<b>mode</b>	<b>1.032</b>	<b>0.712</b>	<b>0.442</b>	<b>1.532</b>	<b>1.577</b>	<b>1.058</b>
	50%	0.937	0.660	0.411	1.412	1.474	0.962
	lower 95%	0.779	0.570	0.361	1.208	1.305	0.805
St. Paul Chick-rearing	upper 95%	3.299	1.768	3.904	1.961	3.776	5.855
	50%	2.353	1.347	3.123	1.513	3.007	4.287
	<b>mode</b>	<b>1.998</b>	<b>1.167</b>	<b>2.803</b>	<b>1.33</b>	<b>2.672</b>	<b>3.633</b>
	50%	1.700	1.019	2.514	1.162	2.394	3.135
	lower 95%	1.244	0.783	2.061	0.899	1.937	2.353