Factors affecting adult body condition in the endangered northern rockhopper penguin

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Table S1 GLM results for body condition (SMI) of adults northern rockhopper penguins modelled as a function of sex, stage, day of the year (yday) and year (yr), Reference values are female, *moulting* stage and year 1994,

	Estimate	SE	t value	P
(Intercept)	4837,63	34,72	139,33	**< 0,001**
sex (male)	67,52	18,24	3,70	**< 0,001**
Stage	3266,54	106,71	30,61	**< 0,001**
yr,1995	67,65	38,00	1,78	0,075
yr,1996	-97,34	31,69	-3,07	**< 0,01**
yr,1997	-505,72	29,17	-17,34	**< 0,001**
yr,1998	-210,67	29,35	-7,18	**< 0,001**
yr,1999	-175,35	29,88	-5,87	**< 0,001**
yr,2000	-355,77	29,08	-12,24	**< 0,001**
yr,2001	-186,93	29,17	-6,41	**< 0,001**
yr,2003	68,36	29,95	2,28	0,023
yr,2004	-192,87	30,41	-6,34	**< 0,001**
yr,2005	-274,56	32,99	-8,32	**< 0,001**
yr,2006	-146,79	32,07	-4,58	**< 0,001**
yr,2007	63,81	32,27	1,98	**< 0,05**
yr,2008	-222,92	33,21	-6,71	**< 0,001**
yr,2009	-70,73	27,82	-2,54	**< 0,05**
yr,2010	-362,50	31,76	-11,41	**< 0,001**
yr,2011	-260,52	28,86	-9,03	**< 0,001**
yr,2012	-244,93	28,43	-8,62	**< 0,001**
yr,2013	-294,82	28,88	-10,21	**< 0,001**
yr,2014	-151,27	30,03	-5,04	**< 0,001**
yr,2015	-66,59	29,76	-2,24	**< 0,05**
yr,2016	-74,00	29,82	-2,48	**< 0,01**
yday	-20,16	0,57	-35,31	**< 0,001**
sex,stage	-349,84	23,25	-15,05	**< 0,001**

Table S2 Overview of models compared for model selection using forward stepwise approach. Model formula, deviance explained and AIC are indicated. yday: day of the year, SSTa: sea surface temperature anomaly, SAM: Southern Annular Mode, SIOD: Subtropical Indian Ocean Dipole. Models selected are indicated in bold.

Stage	Sex	Model	r^2	Deviance explained (%)	AIC
Breeding	Female	SMI ~ 1	0	0	22583,24
		SMI ~ s(yday)	0,459	46,2	21652,01
		SMI ~ s(SSTa, k = 3)	0,039	4	22524,57
		SMI ~ s(SMA, k = 3)	0,004	0,493	22579,33
		SMI ~ s(SIOD, k = 3)	0,008	0,966	22572,26
		SMI ~ s(yday)+s(SSTa, k = 3)	0,478	48,1	21597,46
		SMI ~ s(yday)+s(SAM, k = 3)	0,46	46,4	21650,14
		SMI ~ s(yday)+s(SIOD, k = 3)	0,472	47,5	21617,28
		SMI ~ s(yday)+s(SSTa, k = 3)+s(SAM, k = 3)	0,481	48,4	21592,47
		SMI ~ s(yday)+s(SSTa, k = 3)+s(SIOD, k = 3)	**0,485**	**48,9**	**21577,56**
		SMI ~ s(yday)+s(SSTa, k = 3)+s(SIOD, k = 3)+s(SAM, k = 3)	0,487	49,1	21576,85
Breeding	Male	SMI ~ 1	0	0	30870,16
		SMI ~ s(yday)	0,353	35,5	29959,24
		SMI ~ s(SSTa, k = 3)	0,006	0,723	30858,05
		SMI ~ s(SAM, k = 3)	0,123	12,4	30595,43
		SMI ~ s(SIOD, k = 3)	0,045	4,57	30773,45
		SMI ~ s(yday)+s(SSTa, k = 3)	0,404	40,6	29787,84
		SMI ~ s(yday)+s(SAM, k = 3)	0,421	42,3	29723,29
		SMI ~ s(yday)+s(SIOD, k = 3)	0,368	37	29911,45
		SMI ~ s(yday)+ s(SAM, k = 3)+ s(SSTa, k = 3)	0,443	44,5	29645,52
		SMI ~ s(yday)+ s(SAM, k = 3)+ s(SIOD, k = 3)	0,453	45,5	29606,07
		SMI ~ s(yday)+ s(SAM, k = 3)+ s(SIOD, k = 3)+ s(SSTa, k = 3)	**0,466**	**46,8**	**29555,33**

Moulting	Female	SMI ~ 1	0	0	8684,516
		SMI ~ s(y.day)	0,257	26,9	8523,427
		SMI ~ s(SAM, k = 3)	0,004	0,548	8683,38
		SMI ~ s(SIOD, k = 3)	0,066	6,95	8647,263
		SMI ~ s(y.day)+s(SMA_ETE1, k = 3)	0,269	28,3	8515,792
		SMI ~ s(y.day)+s(siod_moy1_ETE_t, k = 3)	0,303	31,6	8488,342
		SMI ~ s(y.day)+s(siod_moy1_ETE_t, k = 3)+s(SMA_ETE1, k = 3)	**0,313**	**32,8**	**8481,769**
Moulting	Male	SMI ~ 1	0	0	12167,41
		SMI ~ s(y.day)	0,224	23,2	11972,68
		SMI ~ s(SMA, k = 3)	0,012	1,33	12158,69
		SMI ~ s(SIOD, k = 3)	0,032	3,47	12142,9
		SMI ~ s(y.day)+s(SMA_ETE1, k = 3)	0,232	24,2	11966,26
		SMI ~ s(y.day)+s(siod_moy1_ETE_t, k = 3)	0,268	27,7	11927,01
		SMI ~ s(yday)+s(SIOD, k = 3)+s(SMA, k = 3)	**0,292**	**30,2**	**11901,87**

Table S3 Overview of alternative models for *moulting* (excluding a single very early session, day of the year=23) compared for model selection using forward stepwise approach. Model formula, deviance explained and AIC are indicated. yday: day of the year, SAM: Southern Annular Mode, SIOD: Subtropical Indian Ocean Dipole. Models selected are indicated in bold.

Stage	Sex	Model	r^2	Deviance explained (%)	AIC
Moulting	Female	SMI ~ 1	0	0	8304,66
		SMI ~ s(y.day,k=2)	0,135	13,8	8227,49
		SMI ~ s(SAM, k = 3)	0,005	0,687	8302,89
		SMI ~ s(SIOD, k = 3)	0,061	6,42	8272,23
		SMI ~ s(y.day,k=2)+s(SMA_ETE1, k = 3)	0,146	15,2	8222,10
		SMI ~ s(y.day,k=2)+s(siod_moy1_ETE_t, k = 3)	0,237	24,2	8161,21
		SMI ~ s(y.day,k=2)+s(siod_moy1_ETE_t, k = 3)+s(SMA_ETE1, k = 3)	**0,244**	**25,2**	**8157,46**
Moulting	Male	SMI ~ 1	0	0	11507,11
		SMI ~ s(y.day,k=2)	0,169	17,1	11368,92
		SMI ~ s(SMA, k = 3)	0,014	1,55	11497,79
		SMI ~ s(SIOD, k = 3)	0,028	3,08	11487,20
		SMI ~ s(y.day,k=2)+s(SMA_ETE1, k = 3)	0,187	19,1	11354,04
		SMI ~ s(y.day,k=2)+s(siod_moy1_ETE_t, k = 3)	0,228	23,3	11314,17
		SMI ~ s(yday,k=2)+s(SIOD, k = 3)+s(SMA, k = 3)	**0,249**	**25,4**	**11296,16**

Table S4 Results of the GAM modelling body condition of female northern rockhopper penguins during the *breeding* stage, N = 1529 observations, yday: day of the year, SSTa: sea surface temperature anomaly, SIOD: Subtropical Indian Ocean Dipole. The model explained 49% of the deviance.

Variable	Smoother edf	F-test	P value	Estimate (SE)
Intercept				3341,21 (7,14)
yday	7,22	161,48	<0,001	
SSTa	1,98	25,77	<0,001	
SIOD	1,10	18,52	<0,001	

Table S5 Results of the GAM modelling body condition of male northern rockhopper penguins during the *breeding* stage, N = 2108 observations, yday: day of the year, SSTa: sea surface temperature anomaly, SAM: Southern Annular Mode, SIOD: Subtropical Indian Ocean Dipole. The model explained 47% of the deviance.

Variable	Smoother edf	F-test	P value	Estimate (SE)
Intercept				3399,16 (5,82)
yday	4,49	198,14	<0,001	
SSTa	1,00	52,74	<0,001	
SAM	1,98	81,60	<0,001	
SIOD	1,00	96,65	<0,001	

Table S6 Results of the GAM modelling body condition of female northern rockhopper penguins during the *moulting* stage, N = 571 observations, yday: day of the year , SAM: Southern Annular Mode, SIOD: Subtropical Indian Ocean Dipole. The model explained 33% of the deviance.

Variable	Smoother edf	F-test	P value	Estimate (SE)
Intercept				3802,4 (16,8)
yday	8,23	24,27	<0,001	
SAM	1,92	5,37	<0,01	
SIOD	1,84	16,64	<0,001	

Table S7 Results of the GAM explaining body condition of male northern rockhopper penguins during the *moulting* stage, N = 803 observations, yday: day of the year, SAM: Southern Annular Mode, SIOD: Subtropical Indian Ocean Dipole. The model explained 30% of the deviance.

Variable	Smoother edf	F-test	P value	Estimate (SE)
Intercept				3866,00 (14,00)
yday	7,58	32,37	<0,001	
SAM	1,97	14,30	<0,001	
SIOD	1,97	38,52	<0,001	

Table S8 Results of the GAM modelling breeding success northern rockhopper penguins, N = 15 observations, SMI_fem: body condition of female during *breeding*, SMI_mal: body condition of male during *breeding*, SSTa_preb: sea surface temperature anomaly during the pre-breeding, SSTa_incub: sea surface temperature anomaly during the incubating, SAM: Southern Annular Mode.

Variable	Smoother edf	F-test	P value	Estimate (SE)
Intercept				0,31 (0,07)
SMI_fem	1,00	0,38	0,558	
SMI_mal	1,68	1,71	0,186	
SSTa_preb	1,00	0,03	0,860	
SSTa_incub	1,68	0,89	0,392	
SAM	1,00	0,00	0,975	

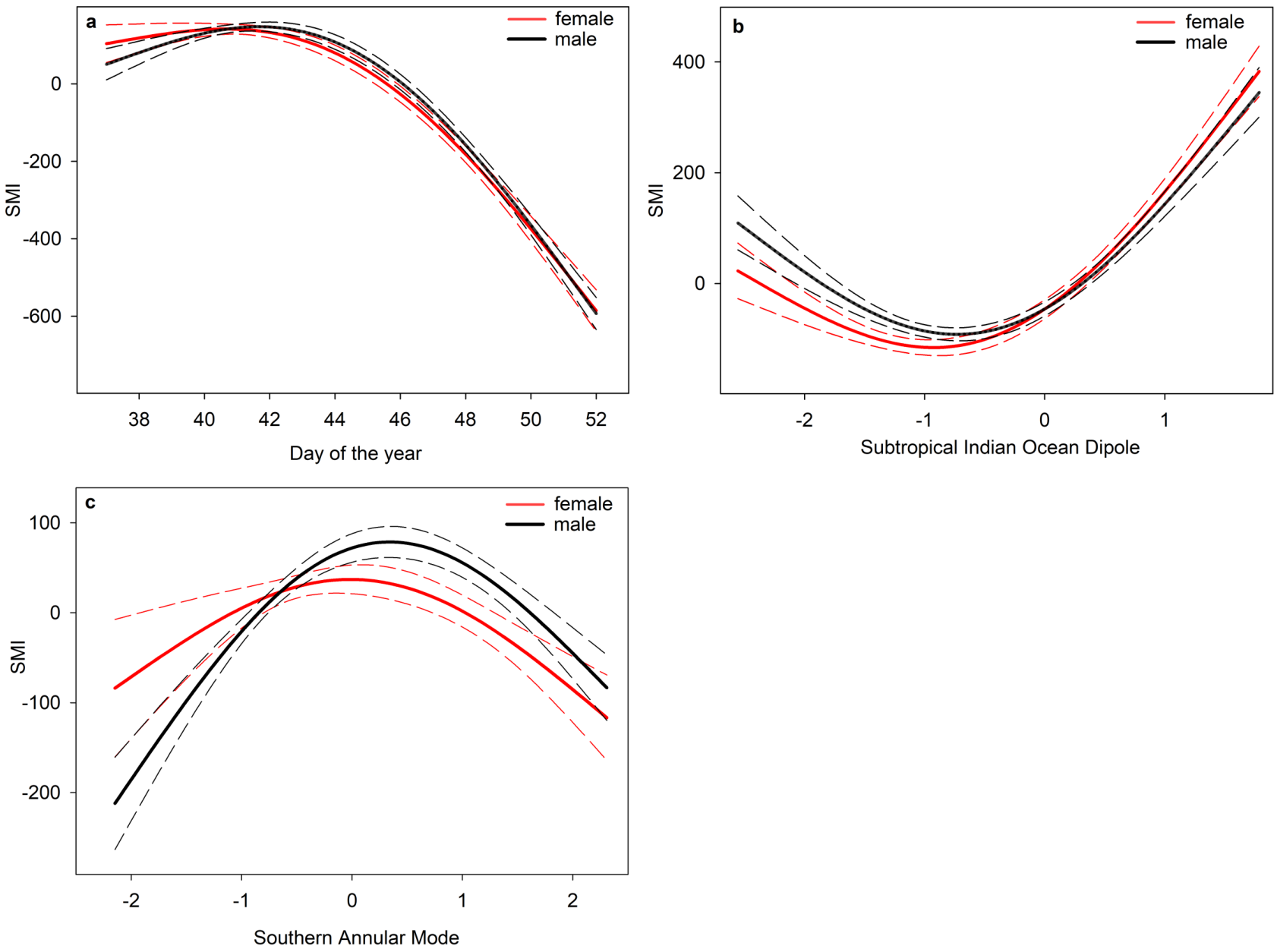
a
female
male
SMI
0
-200
-400
-600
38
40
42
44
46
48
50
52
Day of the year
b
female
male
SMI
400
200
0
-2
-1
0
1
Subtropical Indian Ocean Dipole
c
female
male
SMI
100
0
-100
-200
-2
-1
0
1
2
Southern Annular Mode

Figure S1. Estimated smoothing curves (with s.e.) for environmental covariates in relation to the body condition of northern rockhopper penguins during the *moulting* stage in females and males (excluding one very early session, day of the year=23) . Covariates considered were a) day of the year, b) Subtropical Indian Ocean Dipole and c) Southern Annular Mode.

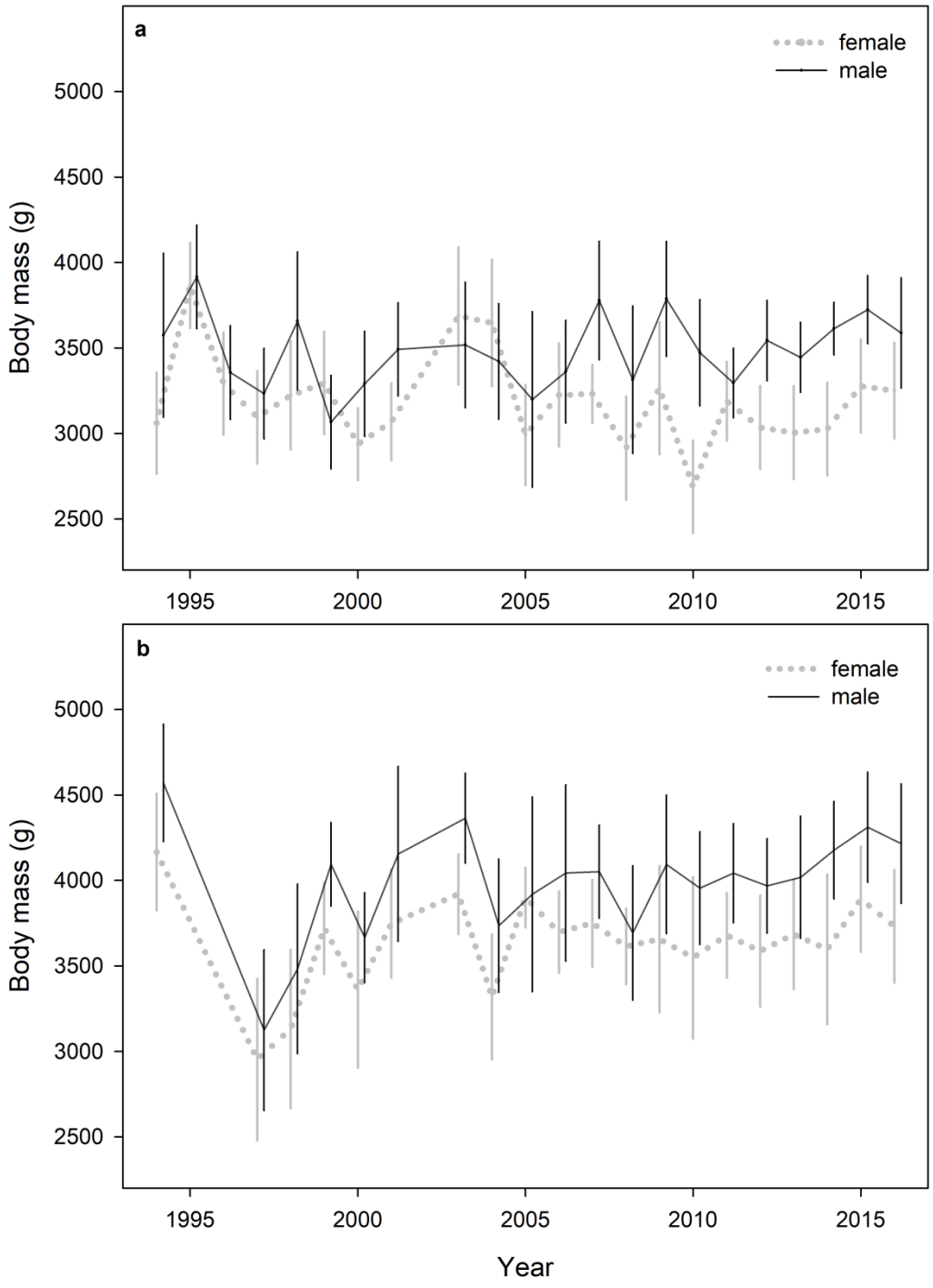

Figure S2. Body mass (g) in adult northern rockhopper penguins on Amsterdam Island from 1994 to 2016 during a) *breeding* stage and b) *moulting* stage in females (white) and males (black).