Supplemental Material

Analysis S1. Sensitivity analyses for choice of priors used in the state-space model

A) Initial population size ($log(N_{est}[1])$)

- logN.est[1] ~ dnorm(mu, precision)

Table S1.1. Sensitivity analysis for prior A with different values for precision, keeping all other values constant

model	mu	precision	= s.d.	mean(N.est[1])	range(N.est[1])
1	8.5	0.35	0.21	5007	2603–8554
2	8.5	0.10	1.00	5011	2777–9404
3	8.5	0.01	4.00	5009	2825–9772
4	8.5	1.00	0.00	5004	2924–8550
5	8.5	10.0	1.00	4999	2848–8123

B) Mean growth rate ($\overline{\lambda}$)

- mean.r ~ dnorm(mu, precision)

Table S1.2. Sensitivity analysis for prior B with different values for precision, keeping all other values constant

model	mu	precision	= s.d.	mean(mean.r[1])	range(mean.r[1])
1	0	0.001	6.0	-0.0152	-0.5275–0.6054
2	0	0.010	4.0	-0.0152	-0.6150–0.5267
3	0	0.050	2.6	-0.0145	-0.5904–0.6198
4	0	0.100	2.0	-0.0153	-0.6115–0.7054
5	0	0.500	0.6	-0.0143	-0.5761–0.5821

C) Sigma of state process ($\sigma^2{}_\lambda$), and

D) Sigma of observation process ($\sigma^2{}_y$)

- sigma.proc ~ dunif(0, 10)
- sigma.obs ~ dunif(0, 10)

Table S1.3. Sensitivity analysis for priors C and D with different values for limits, keeping all other values constant

model	limits	variable	mean	range
1	0-10	sigma.proc	0.0528	0.0000–0.4122
1	0-10	sigma.obs	0.1463	0.0024–0.3117
2	0-1	sigma.proc	0.0543	0.0000–0.2917
2	0-1	sigma.obs	0.1457	0.0183–0.2885
3*	0-0.1	sigma.proc	0.0796	0.0095–0.1000
3*	0-0.1	sigma.obs	0.0947	0.0597–0.1000

*For model 3, chains push against upper boundary

E) Beta parameter (β_p)

- beta ~ dnorm(mu, precision)

Table S1.4. Sensitivity analysis for prior E with different values for precision, keeping all other values constant

model	mu	precision	= s.d.	mean(beta)	range(beta)
1	0	0.010	4.0	0.06603321	-1.280513–1.239738
2	0	0.100	2.0	0.06546704	-1.452994–1.479024
3	0	1.000	0.0	0.06436154	-1.168149–1.257884
4	0	10.00	-2.0	0.05124271	-0.930575–0.866530
5	0	1000	-4.0	0.01860346	-0.411313–0.374722
6	0	0.001	6.0	0.06589421	-1.626372–1.314486
7	0	5.000	-1.4	0.05630202	-1.018714–1.119940

Table S1. Annual number of breeding pairs and growth rate from 1984 to 2021 of Grey-headed Albatrosses breeding at Marion Island estimated by TRIM, a GAM, and a SSM with 95% confidence intervals.

Estimate (95% CI)	Year	TRIM	GAM	SSM
N breeding pairs	1984	4 921 (4 824–5 020)	4 877 (3 737–6 364)	5 084 (4 157–6 036)
	1985	4 921 (4 824–5 020)	4 927 (4 076–5 956)	5 151 (4 214–6 074)
	1986	4 921 (4 824–5 020)	4 990 (4 269–5 832)	5 211 (4 293–6 086)
	1987	4 921 (4 824–5 020)	5 079 (4 338–5 946)	5 272 (4 478–6 044)
	1988	5 037 (4 899–5 177)	5 207 (4 451–6 090)	5 380 (4 650–6 101)
	1989	5 741 (5 593–5 891)	5 378 (4 667–6 197)	5 532 (4 835–6 283)
	1990	5 481 (5 380–5 584)	5 587 (4 905–6 363)	5 647 (4 881–6 492)
	1991	5 233 (5 093–5 375)	5 821 (5 084–6 665)	5 756 (5 060–6 528)
	1992	6 500 (6 342–6 660)	6 065 (5 269–6 981)	5 973 (5 297–6 872)
	1993	7 452 (7 296–7 610)	6 307 (5 526–7 198)	6 136 (5 429–7 212)
	1994	6 232 (6 142–6 323)	6 535 (5 794–7 370)	6 118 (5 462–6 993)
	1995	5 211 (5 084–5 339)	6 733 (5 959–7 607)	6 112 (5 418–6 915)
	1996	6 600 (6 442–6 760)	6 872 (6 029–7 832)	6 290 (5 622–7 248)
	1997	7 671 (7 499–7 844)	6 910 (6 064–7 874)	6 448 (5 728–7 631)
	1998	7 728 (7 556–7 901)	6 811 (6 022–7 702)	6 460 (5 760–7 577)
	1999	5 622 (5 476–5 770)	6 569 (5 814–7 421)	6 306 (5 606–7 115)
	2000	6 757 (6 597–6 919)	6 227 (5 475–7 083)	6 298 (5 582–7 071)
	2001	6 229 (6 075–6 385)	5 871 (5 152–6 690)	6 210 (5 406–6 906)
	2002	5 005 (4 867–5 145)	5 600 (4 943–6 343)	6 093 (5 092–6 827)
	2003	5 691 (5 545–5 839)	5 496 (4 865–6 209)	6 127 (5 117–6 877)
	2004	4 459 (4 329–4 591)	5 615 (4 943–6 378)	6 165 (5 000–6 950)
	2005	6 647 (6 487–6 809)	5 969 (5 238–6 803)	6 478 (5 639–7 201)
	2006	7 344 (7 176–7 514)	6 522 (5 751–7 396)	6 750 (5 999–7 623)
	2007	7 162 (6 996–7 330)	7 163 (6 343–8 090)	6 934 (6 201–7 904)
	2008	7 857 (7 699–8 017)	7 721 (6 804–8 761)	7 111 (6 375–8 185)
	2009	7 561 (7 464–7 660)	8 022 (7 035–9 148)	7 202 (6 450–8 261)
	2010	7 276 (7 124–7 430)	7 995 (7 041–9 079)	7 252 (6 487–8 257)
	2011	7 965 (7 792–8 140)	7 714 (6 835–8 707)	7 329 (6 552–8 365)
	2012	6 709 (6 549–6 871)	7 352 (6 487–8 332)	7 314 (6 496–8 237)
	2013	8 838 (8 655–9 023)	7 078 (6 199–8 082)	7 420 (6 593–8 409)
	2014	5 725 (5 577–5 875)	6 999 (6 150–7 964)	7 297 (6 301–8 153)
	2015	8 541 (8 362–8 722)	7 138 (6 336–8 041)	7 471 (6 584–8 373)
	2016	5 710 (5 562–5 860)	7 445 (6 588–8 413)	7 437 (6 375–8 337)
	2017	8 709 (8 528–8 892)	7 810 (6 816–8 949)	7 725 (6 829–8 727)
	2018	7 722 (7 550–7 895)	8 102 (7 069–9 286)	7 845 (6 933–8 869)
	2019	8 330 (8 153–8 509)	8 230 (7 288–9 294)	8 191 (7 806–8 595)
	2020	8 397 (8 218–8 578)	8 192 (7 121–9 425)	8 102 (7 073–9 300)
	2021	7 953 (7 780–8 128)	8 064 (6 477–10 039)	8 170 (7 000–9 508)
Mean growth rate 1984–2021		1.31% (1.30–1.31%)	1.37% (1.24–1.50%)	1.29% (-0.77–3.58%)

Table S2. The results from TRIM model selection. Goodness-of-fit was assessed using the Pearson's Chi-squared (χ^2) statistic. Best fit models have the smallest χ^2 value and a large p-value (p > 0.05) and are shown here in bold.

Model	Counts used	1990 incl.?	Stepwise?	Has Covariate?	χ^2	df	p-value
A	Total	Yes	No	Yes	5787.00	30	0.00
B	Total	Yes	No	No	6199.52	34	0.00
C[a]	Total	Yes	Yes	Yes	-	-	-
D	Total	Yes	Yes	No	1529.87	20	0.00
E	Total	No	No	Yes	4230.21	29	0.00
F	Total	No	No	No	4680.68	33	0.00
G[a]	Total	No	Yes	Yes	-	-	-
H[b]	**Total**	**No**	**Yes**	**No**	**1.44**	**3**	**0.70**
I	Site Imputed	Yes	No	Yes	5767.64	30	0.00
J	Site Imputed	Yes	No	No	6170.62	34	0.00
K[a]	Site Imputed	Yes	Yes	Yes	-	-	-
L	Site Imputed	Yes	Yes	No	1530.78	20	0.00
M	Site Imputed	No	No	Yes	4211.19	29	0.00
N	Site Imputed	No	No	No	4650.35	33	0.00
O[a]	Site Imputed	No	Yes	Yes	-	-	-
P	**Site Imputed**	**No**	**Yes**	**No**	**1.44**	**3**	**0.70**

[a] All models which used a stepwise approach and had a covariate (C, G, K, O) did not run and therefore no results are available.

[b] Selected model.

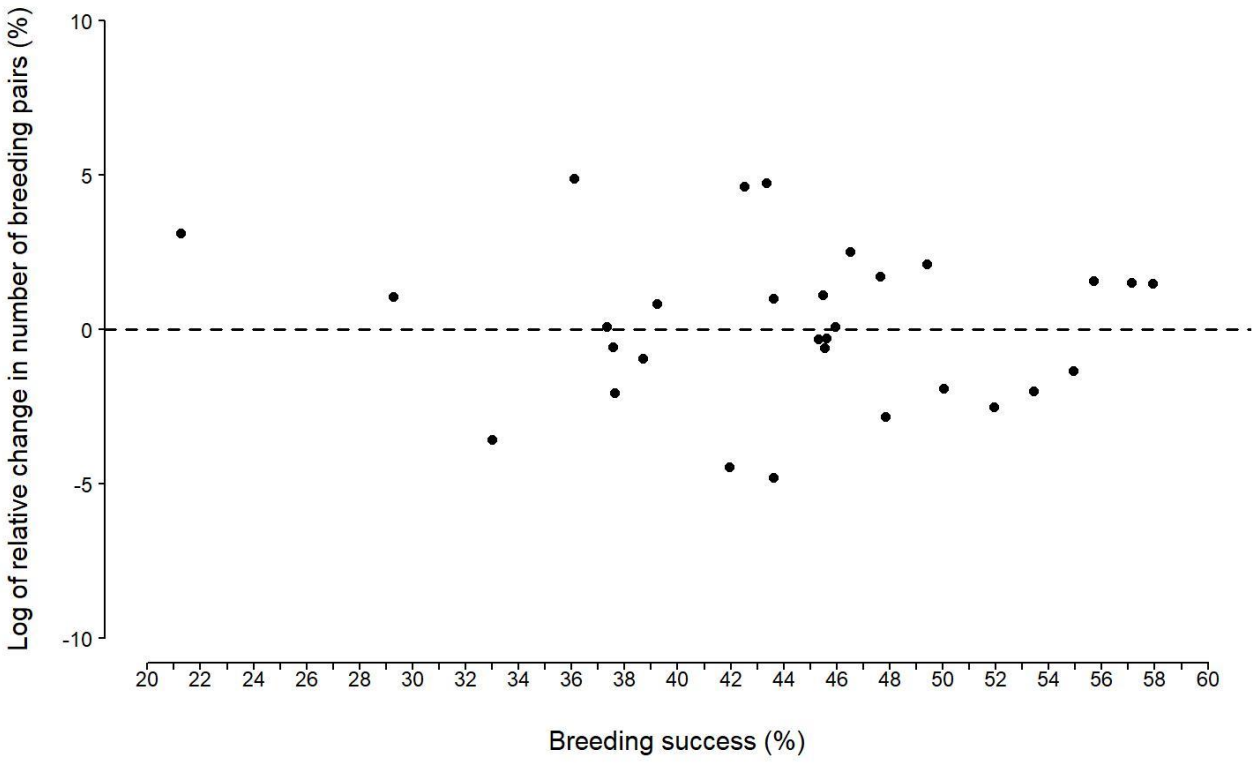

Figure S1. The relative change in the number of breeding pairs (from year t to t+1) on the log scale against the breeding success (in year t) per annum.