Taking Account of Sample Size in the GLM Analyses of the Response Variable Data from the Island Closure Feasibility Study

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Abstract

Two approaches are used to examine the impact of taking sample size into account in GLM analyses to estimate the fishing effect parameter λ. In the first the variance of each mean value input to the analyses is disaggregated into separate contributions reflecting process error (taken to be constant) and observation error (taken to be inversely proportional to sample size). The second simpler approach merely omits values for which the sample size was very low. The implications are evaluated for the majority of the scenarios considered and methods applied in earlier analyses which did not account explicitly for sample size. The pattern of results when sample size is taken into account is clear and consistent: broadly speaking results do not change much in the great majority of cases, and in particular the substantial preponderance of positive to negative estimates of the fishing effect parameter λ remains.

Background

MARAM/IWS/DEC14/Peng/A1 and Peng/A2 criticised GLM analyses of response variable data from the island closure feasibility study for using only unweighted annual means without consideration of their precision. Responses to these criticisms are provided in MARAM/IWS/DEC14/Peng/B13, and include pointing out that information regarding that precision was not amongst the data agreed to be made available for the analyses for presentation to the Panel, which are listed in MARAM/IWS/DEC14/Peng/C1. However, following circulation of MARAM/IWS/DEC14/Peng/A1 and Peng/A2, an offer was made to provide us with some data related to this precision. We requested sample size for its simplicity and greater "robustness" compared to standard error, because the latter can sometimes be misleading as standard error is itself an estimate often with a large associated variance, and so can indicate high precision despite sample size being rather low. The sample size data subsequently made available and used in the analyses of this document are listed in MARAM/IWS/DEC14/Peng/C4.

Methods

Taking sample size into account in the GLMs is not straightforward because factors other than sampling variance, which are often termed process error, must also impact the variance associated with the observed value of the response variable, and these will be independent of the sample size (N). The approach used has been to assume that that the variance associated with the annual mean for each response variable is the combination of two components:

i) a process error term of constant standard deviation σ_0, and

ii) a sampling error term with standard deviation $\sigma_1/\sqrt{N}$ where σ_1 is a constant.

Hence the overall variance associated with an annual mean for a response variable is:

$$\sigma^2 = \sigma_0^2 + \sigma_1^2/N \quad (1)$$

For the analyses of this document, "With *N*" results are those which use equation (1), whereas those labelled "Without *N*" set $\sigma^2 = \sigma_0^2$ and are accordingly identical to those reported in MARAM/IWS/DEC14/Peng/B4 and MARAM/IWS/DEC14/Peng/B12 which are based on unweighted means.

Initial analyses indicated that the data available contained insufficient information content to admit the free estimation of both σ_0 and σ_1. Accordingly "With *N*" runs were conducted with fixed values input for σ_0, the process error which must be present at some level (this consequently prevents sample size weighting leading to unduly large weights being accorded to means based on very large numbers of data). Two input values for σ_0 were chosen for each response variable considered, with a view towards such values in most cases reflecting about 10% and 20% of the standard deviation (i.e. about 1% and 4% respectively of the variance) of the data when accounting for an island effect only and omitting consideration of catch or closure.

Another simpler way to take sample size concerns into account is to exclude values for which the sample size is very low. This is the case for foraging path length and duration for Dassen Island for 2003 and 2009, for each of which the mean is based on three samples only. The impact of doing so is checked for catches within a 10 nm radius of the islands only, given limited time.

Results

Results have been provided for only four of the six response variables considered for Dassen and Robben Islands, corresponding to the more straightforward of the sets of data available for analysis. The reasons are time limitations, and the fact that the variance options of interest were not available in the statistics package used for the original GLM analyses, so that recoding the computations from scratch in ADMB was required. Again for reasons of time, it was not possible to code the random year effects analysis option, so that results are presented for only methods (i) – fixed year effects, (iii) – spawner biomass used as a covariate, and (iv) – recruit biomass used as a covariate, where those biomass estimates refer to results from surveys. The respective results are shown in Tables 1-3. Note that these tables include values for σ_0 when accounting for an island effect only, and also of the minimum value of the standard error attributed to any mean value input ($\sqrt{\sigma_0^2+\sigma_1^2/N_{max}}$) to check that none is receiving unduly high relative weighting.

Results of note are indicated in various ways in Tables 1 to 3, where focus is restricted to cases where taking account of the sample size does lead to a better fit in likelihood terms. This is always the case for the active nest proportion for methods (i) and (iv) (though not at all for method (iii)), but seldom otherwise. The focus is on whether the estimate of the fishing effect parameter λ changes to a meaningful extent is these cases. Unsurprisingly this is most frequently the case for method (i), where the variance of estimates is higher because of the lesser numbers of degrees of freedom, and a total of 11 changes by more than 0.2

are evident from the 72 comparisons in Table 1. This drops to 6 for method (iv), and to none for method (iii). These results must also be seen in the context that a change of 0.2 is generally less than the standard errors of the original "Without *N*" estimates (see Table A.2 of MARAM/IWS/DEC14/Peng/B12). Probably of more importance (particularly in the context of the interpretation placed on these λ estimates in MARAM/IWS/DEC14/Peng/B2 and Peng/B12) is whether taking account of the sample size leads to a change in the sign of the λ estimates. This occurs on four occasions for method (i) (three positive to negative, and one negative to positive), and on one only for each of the other two methods (both positive to negative).

If the low sample size data points for the foraging response variables for Dassen Island are omitted from the "Without *N*" computations, the pattern is similar to that above, with a greater number of "meaningful" changes in the λ estimates for method (i) than for the other two methods. Specifically there are four changes of sign for method (i) (three positive to negative, and one negative to positive), one for method (iii) (positive to negative), and none for method (iv)..

Conclusions

Admittedly time constraints have precluded checking for all the response variables and methods of GLM analysis used in MARAM/IWS/DEC14/Peng/B12, but more than 50% of these have been examined, and the pattern of results is clear and consistent. This is that if sample size is taken into account in these analyses, broadly speaking results do not change much in the great majority of cases, and in particular the substantial preponderance of positive to negative estimates of the fishing effect parameter λ remains.

Table 1: Results for **fixed year effects**, both for the exclusion and inclusion of sample size N. Note that for the case where sample size is included, σ_0 is fixed, and results are given for two σ_0 values. Cells highlighted in grey indicate that the λ value has changed sign when including sample size. The single star superscript marks a change in λ of greater than 0.1, while a double star superscript marks a change in λ of greater than 0.2. Note that the highlighting and superscripts are only shown for cases where the inclusion of the sample size improves the likelihood.

Penguin response	Fish and Area		λ (Dassen)			λ (Robben)			σ_0			σ_1		-lnL			$\sqrt{\sigma_0^2+\sigma_1^2/N_{max}}$
			Without *N*	Δλ with *N*		Without *N*	Δλ with *N*		Without *N*	With *N*		With *N*		-lnL without *N*	Δ(-lnL) with *N*		
				σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	
		10	0.10	0.01	0.01	-0.11	-0.05	-0.05	0.10	0.04	0.02	2.46	2.59	-19.19	-0.47	-0.56	0.08
Chick condition	S	20	0.28	-0.06	-0.07	0.12	-0.08	-0.09	0.10	0.04	0.02	2.48	2.65	-19.69	0.22	0.21	0.08
Dassen *N* ϵ [397,1168]		30	0.42	-0.06	-0.08	0.49	-0.07	-0.08	0.08	0.04	0.02	2.10	2.34	-21.56	0.71	0.80	0.07
Robben *N* ϵ [393,947]		10	-0.67	0.00	0.00	0.34	0.00	0.02	0.03	0.04	0.02	0.00	0.78	-31.17	0.13	0.06	0.03
n: 11, *p*: 9, dof: 2	A	20	-0.36	0.03	0.04	-0.05	0.02	0.03	0.07	0.04	0.02	1.68	1.93	-23.03	0.25	0.25	0.06
σ_0 island effect only: 0.22		30	-0.97	0.08	0.11	-0.61	0.09	0.11	0.08	0.04	0.02	1.88	2.06	-21.71	-0.33	-0.44	0.06
		10	-0.80	0.00	-0.01	0.44	0.00	0.02	0.04	0.04	0.02	0.00	0.85	-30.4	0.02	-0.03	0.03
	T	20	-0.37	0.04	0.05	-0.04	0.02	0.02	0.08	0.04	0.02	1.95	2.15	-21.75	0.13	0.10	0.07
		30	-0.39	0.06	0.06	-0.04	0.08	0.09	0.10	0.04	0.02	2.36	2.48	-19.59	-0.50	-0.61	0.08
		10	0.96	-0.20**	-0.21**	0.71	-0.10*	-0.11*	0.37	0.10	0.05	22.00	22.12	-13.65	-7.17	-7.99	0.15
Active nest proportion	S	20	1.39	0.13*	0.13*	0.84	0.08	0.09	0.40	0.10	0.05	23.03	22.98	-11.58	-8.24	-9.10	0.15
Dassen *N* ϵ [2678,24901]		30	0.88	0.38**	0.39**	0.70	0.30**	0.31**	0.43	0.10	0.05	25.80	25.92	-9.7	-7.13	-7.74	0.17
Robben *N* ϵ [393,947]		10	0.15	-0.04	-0.04	1.02	0.08	0.09	0.28	0.10	0.05	17.59	18.06	-20.94	-4.99	-5.96	0.12
n: 27, *p*: 17, dof: 10	A	20	0.10	-0.05	-0.05	1.44	-0.07	-0.08	0.26	0.10	0.05	16.81	17.82	-23.61	-2.87	-3.50	0.12
σ_0 island effect only: 1.07		30	0.59	0.08	0.09	1.41	0.09	0.09	0.36	0.10	0.05	21.58	21.95	-14.4	-6.71	-7.40	0.15
		10	0.26	-0.06	-0.07	1.05	0.03	0.03	0.27	0.10	0.05	16.27	16.59	-22.1	-5.79	-7.05	0.12
	T	20	0.54	0.02	0.03	1.39	-0.23**	-0.25**	0.27	0.10	0.05	17.76	18.61	-22.19	-3.17	-3.83	0.13
		30	1.11	0.17*	0.19*	1.86	0.01	0.00	0.35	0.10	0.05	19.97	20.07	-15.27	-7.95	-8.95	0.14
		10	-0.24	0.04	0.06	-0.33	0.04	0.05	0.13	0.05	0.03	0.52	0.55	-21.08	1.87	1.97	0.10
Foraging path length	S	20	-0.80	0.28	0.32	-0.91	0.30	0.35	0.11	0.05	0.03	0.47	0.52	-23.03	3.01	3.25	0.09
Dassen *N* ϵ [3,37]		30	-0.63	0.37	0.42	-0.82	0.50	0.56	0.12	0.05	0.03	0.51	0.55	-21.91	2.72	2.85	0.10
Robben *N* ϵ [9,35]		10	-0.07	-0.14	-0.14	0.14	0.05	0.05	0.12	0.05	0.03	0.50	0.53	-21.2	1.58	1.61	0.09
n: 14, *p*: 11, dof: 3	A	20	-0.27	-0.04	-0.03	0.17	-0.02	-0.03	0.10	0.05	0.03	0.38	0.42	-23.84	1.17	1.26	0.08
σ_0 island effect only: 0.33		30	-0.74	-0.38**	-0.44**	-0.45	-0.47**	-0.56**	0.09	0.05	0.03	0.28	0.32	-25.79	-0.43	-0.63	0.06
		10	0.02	-0.17	-0.19	0.08	0.02	0.02	0.13	0.05	0.03	0.52	0.55	-20.99	1.69	1.71	0.09
	T	20	-0.21	-0.18	-0.19	0.08	-0.03	-0.03	0.12	0.05	0.03	0.41	0.44	-22.32	0.10	0.04	0.08
		30	-0.76	-0.62**	-0.70**	-0.65	-0.58**	-0.65**	0.11	0.05	0.03	0.33	0.34	-23.44	-1.80	-2.34	0.06
		10	0.31	-0.15	-0.15	0.36	-0.20	-0.20	0.14	0.05	0.03	0.54	0.56	-19.33	0.47	0.42	0.10
Foraging path duration	S	20	-0.55	0.21	0.24	-0.66	0.23	0.26	0.14	0.05	0.03	0.53	0.55	-19.72	0.60	0.60	0.10
Dassen *N* ϵ [3,37]		30	-0.66	0.38	0.42	-0.90	0.50	0.55	0.14	0.05	0.03	0.54	0.56	-19.93	0.99	1.00	0.10
Robben *N* ϵ [9,35]		10	0.07	-0.23	-0.24	0.27	0.10	0.10	0.12	0.05	0.03	0.47	0.50	-21.46	0.90	0.90	0.09
n: 14, *p*: 11, dof: 3	A	20	-0.04	-0.09	-0.09	0.45	-0.04	-0.05	0.10	0.05	0.03	0.37	0.40	-23.64	0.34	0.34	0.07
σ_0 island effect only: 0.25		30	-0.17	-0.40	-0.44	0.37	-0.56	-0.63	0.10	0.05	0.03	0.36	0.39	-23.92	0.12	0.03	0.07
		10	0.24	-0.24	-0.27	0.20	0.04	0.04	0.12	0.05	0.03	0.50	0.53	-21.35	1.65	1.67	0.09
	T	20	0.13	-0.26**	-0.28**	0.43	-0.07	-0.07	0.12	0.05	0.03	0.44	0.46	-21.23	-0.35	-0.49	0.08
		30	0.03	-0.80**	-0.87**	0.43	-0.86**	-0.94**	0.13	0.05	0.03	0.42	0.42	-20.76	-1.75	-2.11	0.08

Table 2: Results for year effects given by **spawner biomass**, both for the exclusion and inclusion of sample size N. Note that for the case where sample size is included, σ_0 is fixed, and results are given for two σ_0 values. Cells highlighted in grey indicate that the λ value has changed sign when including sample size. The single star superscript marks a change in λ of greater than 0.1, while a double star superscript marks a change in λ of greater than 0.2. Note that the highlighting and superscripts are only shown for cases where the inclusion of the sample size improves the likelihood.

Penguin response	Fish and Area		λ (Dassen)			λ (Robben)			σ_0			σ_1		-lnL			$\sqrt{\sigma_0^2+\sigma_1^2/N_{max}}$
			Without *N*	Δλ with *N*		Without *N*	Δλ with *N*		Without *N*	With *N*		With *N*		-lnL without *N*	Δ(-lnL) with *N*		
				σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	
		10	-0.07	0.01	0.01	-0.04	-0.11*	-0.11*	0.10	0.04	0.02	4.47	4.55	-19.19	-0.37	-0.40	0.13
Chick condition	S	20	-0.02	0.00	0.00	-0.01	-0.06	-0.06	0.10	0.04	0.02	4.62	4.70	-19.69	-0.18	-0.19	0.14
Dassen *N* ∈ [397,1168]		30	0.02	0.00	0.00	0.16	0.03	0.03	0.08	0.04	0.02	4.58	4.67	-21.56	-0.16	-0.17	0.14
Robben *N* ∈ [393,947]		10	0.01	0.03	0.03	-0.12	-0.09	-0.09	0.03	0.04	0.02	5.49	5.58	-31.17	0.10	0.11	0.16
n: 11, *p*: 5, dof: 6	A	20	0.06	0.00	0.00	-0.06	-0.15	-0.15	0.07	0.04	0.02	5.72	5.80	-23.03	0.28	0.29	0.17
σ_0 island effect only: 0.22		30	0.11	-0.02	-0.02	0.18	-0.14	-0.14	0.08	0.04	0.02	5.99	6.10	-21.71	1.18	1.21	0.18
		10	0.03	0.05	0.05	-0.14	-0.09	-0.10*	0.04	0.04	0.02	5.07	5.14	-30.40	-0.39	-0.42	0.15
	T	20	0.12	0.02	0.02	-0.07	-0.14	-0.15	0.08	0.04	0.02	5.48	5.56	-21.75	0.14	0.14	0.16
		30	0.25	0.02	0.02	0.34	-0.04	-0.04	0.10	0.04	0.02	5.39	5.51	-19.59	1.13	1.17	0.16
		10	0.29	-0.04	-0.04	0.16	0.01	0.01	0.37	0.10	0.05	87.72	88.63	-13.65	3.59	3.67	0.56
Active nest proportion	S	20	0.66	-0.04	-0.05	0.25	0.01	0.01	0.40	0.10	0.05	75.49	76.46	-11.58	1.71	1.80	0.49
Dassen *N* ∈ [2678,24901]		30	0.80	-0.07	-0.07	0.38	0.02	0.02	0.43	0.10	0.05	73.67	74.66	-9.70	1.39	1.49	0.48
Robben *N* ∈ [393,947]		10	0.04	-0.40	-0.40	0.69	-0.36	-0.36	0.28	0.10	0.05	97.43	98.10	-20.94	4.18	4.22	0.62
n: 27, *p*: 5, dof: 22	A	20	0.77	-0.41	-0.42	1.10	-0.48	-0.48	0.26	0.10	0.05	97.47	98.20	-23.61	5.55	5.60	0.62
σ_0 island effect only: 1.07		30	0.93	-0.59	-0.60	0.67	-0.59	-0.59	0.36	0.10	0.05	98.61	99.31	-14.40	4.22	4.27	0.63
		10	0.31	-0.31	-0.31	0.73	-0.29	-0.29	0.27	0.10	0.05	95.11	95.87	-22.10	4.96	5.02	0.61
	T	20	1.44	0.09	0.09	1.25	-0.43	-0.43	0.27	0.10	0.05	84.17	85.05	-22.19	5.15	5.22	0.54
		30	2.06	0.10	0.10	1.29	-0.24	-0.24	0.35	0.10	0.05	79.70	80.56	-15.27	3.34	3.41	0.51
		10	-0.10	-0.09	-0.09	-0.12	-0.03	-0.03	0.13	0.05	0.03	0.87	0.90	-21.08	2.71	2.79	0.15
Foraging path length	S	20	-0.13	-0.12	-0.12	-0.12	-0.03	-0.03	0.11	0.05	0.03	0.85	0.88	-23.03	2.56	2.65	0.15
Dassen *N* ∈ [3,37]		30	-0.12	-0.10	-0.11	-0.13	-0.03	-0.04	0.12	0.05	0.03	0.86	0.89	-21.91	2.65	2.74	0.15
Robben *N* ∈ [9,35]		10	0.13	-0.14	-0.15	0.17	-0.09	-0.09	0.12	0.05	0.03	1.45	1.46	-21.20	3.74	3.78	0.24
n: 14, *p*: 5, dof: 9	A	20	0.27	-0.05	-0.06	0.33	0.04	0.04	0.10	0.05	0.03	1.34	1.36	-23.84	3.89	3.94	0.23
σ_0 island effect only: 0.33		30	0.15	-0.02	-0.02	0.53	0.03	0.03	0.09	0.05	0.03	1.27	1.29	-25.79	3.42	3.47	0.21
		10	0.11	0.00	0.00	0.13	-0.19	-0.20	0.13	0.05	0.03	1.29	1.31	-20.99	3.64	3.69	0.22
	T	20	0.17	0.04	0.04	0.31	-0.05	-0.05	0.12	0.05	0.03	1.23	1.25	-22.32	3.82	3.88	0.21
		30	0.09	0.01	0.01	0.51	0.05	0.05	0.11	0.05	0.03	1.15	1.17	-23.44	3.53	3.57	0.19
		10	0.08	-0.06	-0.07	0.07	-0.01	-0.01	0.14	0.05	0.03	0.84	0.86	-19.33	2.13	2.20	0.14
Foraging path duration	S	20	0.07	-0.12	-0.12	0.05	0.01	0.01	0.14	0.05	0.03	0.83	0.86	-19.72	1.78	1.83	0.14
Dassen *N* ∈ [3,37]		30	0.06	-0.12	-0.12	0.05	0.01	0.01	0.14	0.05	0.03	0.83	0.85	-19.93	1.73	1.78	0.14
Robben *N* ∈ [9,35]		10	0.39	-0.11	-0.12	0.12	-0.06	-0.07	0.12	0.05	0.03	0.77	0.80	-21.46	2.14	2.24	0.13
n: 14, *p*: 5, dof: 9	A	20	0.24	-0.14	-0.14	0.25	0.05	0.06	0.10	0.05	0.03	0.79	0.81	-23.64	0.49	0.51	0.14
σ_0 island effect only: 0.25		30	-0.03	-0.02	-0.01	0.41	0.02	0.02	0.10	0.05	0.03	0.71	0.73	-23.92	-1.08	-1.11	0.12
		10	0.40	-0.04	-0.05	0.15	-0.09	-0.10	0.12	0.05	0.03	0.73	0.77	-21.35	3.04	3.17	0.13
	T	20	0.24	-0.13	-0.13	0.28	0.04	0.04	0.12	0.05	0.03	0.79	0.81	-21.23	1.40	1.44	0.14
		30	0.07	-0.13*	-0.13*	0.43	0.08	0.09	0.13	0.05	0.03	0.70	0.72	-20.76	-0.45	-0.46	0.12

Table 3: Results for year effects given by **recruit biomass**, both for the exclusion and inclusion of sample size N. Note that for the case where sample size is included, σ_0 is fixed, and results are given for two σ_0 values. Cells highlighted in grey indicate that the λ value has changed sign when including sample size. The single star superscript marks a change in λ of greater than 0.1, while a double star superscript marks a change in λ of greater than 0.2. Note that the highlighting and superscripts are only shown for cases where the inclusion of the sample size improves the likelihood.

Penguin response	Fish and Area		λ (Dassen)			λ (Robben)			σ_0	σ_1				-lnL			$\sqrt{\sigma_0^2+\sigma_1^2/N_{max}}$
			Without *N*	Δλ with *N*		Without N	Δλ with *N*		Without *N*	With *N*		With *N*		-lnL without *N*	Δ(-lnL) with *N*		
				σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	σ_0 higher	σ_0 lower		σ_0 higher	σ_0 lower	
		10	-0.01	0.00	0.00	0.17	0.03	0.03	0.10	0.04	0.02	5.50	5.59	-19.19	0.46	0.47	0.16
Chick condition	S	20	0.07	-0.01	-0.01	0.34	0.08	0.08	0.10	0.04	0.02	5.24	5.32	-19.69	0.14	0.14	0.16
Dassen *N* ∈ [397,1168]		30	0.08	-0.02	-0.02	0.38	0.01	0.02	0.08	0.04	0.02	4.61	4.70	-21.56	-0.12	-0.13	0.14
Robben *N* ∈ [393,947]		10	0.01	0.00	0.00	-0.13	-0.06	-0.06	0.03	0.04	0.02	5.51	5.59	-31.17	0.17	0.18	0.16
n: 11, *p*: 5, dof: 6	A	20	0.06	0.00	0.00	-0.08	-0.11	-0.12	0.07	0.04	0.02	5.71	5.80	-23.03	0.29	0.30	0.17
σ_0 island effect only: 0.22		30	0.13	0.02	0.02	0.23	-0.07	-0.07	0.08	0.04	0.02	5.75	5.84	-21.71	0.86	0.88	0.17
		10	0.00	0.01	0.01	-0.12	-0.07	-0.07	0.04	0.04	0.02	5.53	5.61	-30.40	0.15	0.15	0.16
	T	20	0.07	0.00	0.00	-0.07	-0.13	-0.14	0.08	0.04	0.02	5.74	5.82	-21.75	0.31	0.32	0.17
		30	0.18	0.02	0.02	0.34	-0.07	-0.07	0.10	0.04	0.02	5.64	5.75	-19.59	1.07	1.10	0.17
		10	0.41	-0.12*	-0.12*	0.28	0.01	0.01	0.37	0.10	0.05	67.46	68.16	-13.65	-1.73	-1.69	0.43
Active nest proportion	S	20	0.68	-0.15*	-0.16*	0.29	-0.03	-0.03	0.40	0.10	0.05	61.63	62.39	-11.58	-2.69	-2.64	0.40
Dassen *N* ∈ [2678,24901]		30	0.77	-0.19*	-0.20**	0.39	-0.05	-0.05	0.43	0.10	0.05	62.07	62.84	-9.70	-2.44	-2.40	0.40
Robben *N* ∈ [393,947]		10	0.37	-0.13*	-0.13*	0.66	-0.09	-0.09	0.28	0.10	0.05	62.83	63.43	-20.94	-0.71	-0.70	0.41
n: 27, *p*: 5, dof: 22	A	20	0.85	-0.14*	-0.14*	1.00	-0.22**	-0.22**	0.26	0.10	0.05	59.81	60.48	-23.61	-0.36	-0.33	0.39
σ_0 island effect only: 1.07		30	0.89	-0.21**	-0.22**	0.70	-0.04	-0.04	0.36	0.10	0.05	62.76	63.36	-14.40	-1.42	-1.41	0.40
		10	0.48	-0.16*	-0.17*	0.93	-0.03	-0.03	0.27	0.10	0.05	56.55	57.14	-22.10	-1.76	-1.76	0.37
	T	20	1.12	-0.20**	-0.21**	1.32	-0.30**	-0.30**	0.27	0.10	0.05	51.82	52.63	-22.19	-0.88	-0.84	0.34
		30	1.50	-0.39**	-0.41**	1.43	-0.17*	-0.17*	0.35	0.10	0.05	52.18	53.01	-15.27	-2.31	-2.27	0.34
		10	0.09	0.01	0.01	0.15	-0.03	-0.03	0.13	0.05	0.03	1.39	1.41	-21.08	3.96	4.01	0.23
Foraging path length	S	20	0.07	-0.13	-0.14	0.17	-0.03	-0.03	0.11	0.05	0.03	1.39	1.41	-23.03	3.79	3.84	0.23
Dassen *N* ∈ [3,37]		30	0.08	-0.08	-0.08	0.19	-0.03	-0.03	0.12	0.05	0.03	1.39	1.41	-21.91	3.90	3.95	0.23
Robben *N* ∈ [9,35]		10	0.09	-0.14	-0.15	0.25	-0.08	-0.08	0.12	0.05	0.03	1.45	1.47	-21.20	3.65	3.69	0.24
n: 14, *p*: 5, dof: 9	A	20	0.24	-0.07	-0.07	0.44	0.09	0.09	0.10	0.05	0.03	1.33	1.35	-23.84	3.79	3.84	0.22
σ_0 island effect only: 0.33		30	0.16	-0.07	-0.07	0.61	0.01	0.01	0.09	0.05	0.03	1.28	1.30	-25.79	3.48	3.53	0.22
		10	0.15	-0.20	-0.20	0.28	-0.07	-0.08	0.13	0.05	0.03	1.43	1.45	-20.99	4.02	4.06	0.24
	T	20	0.23	-0.07	-0.07	0.47	0.05	0.06	0.12	0.05	0.03	1.33	1.35	-22.32	4.27	4.33	0.22
		30	0.18	-0.10	-0.10	0.66	0.06	0.06	0.11	0.05	0.03	1.25	1.27	-23.44	4.07	4.13	0.21
		10	0.12	-0.06	-0.07	0.12	-0.03	-0.03	0.14	0.05	0.03	0.84	0.87	-19.33	1.97	2.03	0.15
Foraging path duration	S	20	0.12	-0.14	-0.15	0.13	-0.03	-0.03	0.14	0.05	0.03	0.85	0.87	-19.72	1.47	1.51	0.15
Dassen *N* ∈ [3,37]		30	0.12	-0.14	-0.14	0.14	-0.03	-0.03	0.14	0.05	0.03	0.85	0.87	-19.93	1.42	1.46	0.15
Robben *N* ∈ [9,35]		10	0.36	-0.11	-0.11	0.16	-0.10	-0.10	0.12	0.05	0.03	0.77	0.80	-21.46	1.82	1.91	0.13
n: 14, *p*: 5, dof: 9	A	20	0.22	-0.11	-0.11	0.31	0.00	0.00	0.10	0.05	0.03	0.79	0.81	-23.64	0.64	0.67	0.14
σ_0 island effect only: 0.25		30	-0.02	-0.02	-0.01	0.46	-0.01	-0.01	0.10	0.05	0.03	0.70	0.72	-23.92	-0.98	-1.00	0.12
		10	0.41	-0.08	-0.09	0.19	-0.09	-0.10	0.12	0.05	0.03	0.75	0.78	-21.35	3.04	3.16	0.13
	T	20	0.26	-0.14	-0.14	0.33	-0.01	-0.01	0.12	0.05	0.03	0.79	0.81	-21.23	1.46	1.51	0.14
		30	0.11	-0.16*	-0.16*	0.49	0.03	0.04	0.13	0.05	0.03	0.69	0.71	-20.76	-0.49	-0.49	0.12