

## Responses to Questions from the Panel, 6 November 2014

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### Summary

Responses are provided to as many of the Panel's questions as time has permitted. As regards their questions related to a number of variants of the GLM approaches used in MARAM/IWS/DEC14/Peng/B4 (now updated in Peng/B13), speaking broadly it would seem that these variants make little difference to the results reported in those papers and their implications..

### Background

This document provides responses to questions from the International Review Panel to the extent that time and resources have made possible by the 24 November deadline. For the reader's ease of reference, appropriate extracts from the Panel's questions and subsequent clarifications are reproduced in *red italics*.

### Panel questions and responses

- 1. It would be helpful for both parties to formulate analyses as a test of formal hypotheses. This will help the Panel interpret analyses, understand positions, and identify differences as well as common ground. There are several response variables that can be analysed separately and also together (MANOVA or similar). The main factors would be closure status and island, but other factors can also be considered (adjacent catch levels, estimates of local biomass).*

The fundamental question (hypothesis) being addressed is what is the direction and extent to which pelagic fishing in the neighbourhood of penguin breeding colonies impacts the penguins' dynamics, and in particular their reproductive success. Given that some seven years ago the data available were inadequate to provide a clear answer to this question, the idea of an experiment to increase the contrast in catches around the islands to enhance estimation ability was put forward. However, before instituting this experiment it was necessary to determine its power to detect the effects of interest, because there was agreement that the experiment would not be seen as practical to undertake if it would need, say, more than two decades to yield definitive results. This led to agreement to an initial feasibility study to estimate the residual variance necessary to conduct such power analyses.

Thus the primary points at issue here do NOT involve testing alternative hypotheses *per se* (see Item 14 of MARAM/IES/DEC14/Peng/B10). Rather they relate to determination of whether the feasibility study has achieved its objective of providing reasonably reliable estimates of residual variance for the various response variables available, and consideration of the results from the power analyses that followed from those estimates.

Our results pertinent to these issues are reported in MARAM/IWS/DEC14/Peng/B12, and their implications in MARAM/IWS/DEC14/Peng/B2. These lead us to conclude that the objective of the feasibility study has been met, but further that even without proceeding now to a full experiment, results already obtained are sufficient to provide a basis for recommendations as regards closures around the four islands considered in the feasibility study.

Thus to our mind the issue here is not best model selection, but rather the consideration in combination of

- i) robust indications across a wide range of GLM analyses of the likely direction of the effect of fishing around islands on indices of penguin reproductive success, and
- ii) inferences concerning the impact of anchovy abundance on reproductive success at Dassen Island and Robben Island provided by a model of Robben Island penguin population dynamics (probably the strongest component of all the evidence) and the “river model” of the anchovy recruitment process – see documents MARAM/IWS/DEC14/Peng/B3a and MARAM/IWS/DEC14/Peng/B5, and the summary of their implications in MARAM/IWS/DEC14/Peng/2.

This last document details the island-specific nature of certain of our conclusions.

We have commented upon and run some analyses regarding the use of closure as a covariate in the GLM analyses (see Item 15 of MARAM/IWS/DEC14/Peng/B10, Peng/B12 and Peng/B13). These comments and results all point to such usage being inferior to the usage instead of catch.

- 2. *It would be helpful to have basic summary statistics (annual means and SDs) of the response data presented in relation to the factors of analysis (closure status, local fish catch, available fish biomass). The Panel is looking for bar plots w/ SE bars across closure status & island of all the response metrics (not catch)*

We understand that Richard Sherley is providing these.

- 3. *As background for Panel members not familiar with African penguins or local ecosystems, and to help understand the “energetics” of the situation, tables or summaries of the following information would be helpful (noting that some of this information is already available in various papers already distributed, but it would be helpful to have it synthesized – averages for the recent period would be fine):*
  - a. *penguin population abundance (and biomass) around the islands and for the whole population (if available)*
  - b. *degree of movement / migration for penguins*
  - c. *penguin per capita consumption and total population consumption of these two and related fish (relevant to penguin diet)*
  - d. *landings of these two and related fish, both around the island and at stock level*
- 4. *Again as background, any papers or information summarising energy budget / food web modelling in relation to penguins.*  
*Clarification: We are not looking for extra work here, just pointers to existing information (but possibly including material not already circulated that is in the peer reviewed literature).*

Of comments of this nature in the Peng/B series which we have circulated, the only one that comes particularly to mind is that in MARAM/IWS/DEC14/Peng/B3b, lines 468-477. This is to the effect that the annual food requirements by penguins over recent years constitute only about 0.5% of the average annual loss to natural mortality of sardine and anchovy. Hence, taken together with the fact that anchovy in particular are not stationary around Dassen and Robben Islands, but rather part of an annual movement of recruits from the north southwards to the Agulhas Bank, it is clear that the impact of consumption by penguins at these islands on the abundances of these fish populations will be negligible.

- 5. *Specifically for paper B4 (in order of priority):*

In cases where more estimable parameter values are suggested than already considered in existing models, would it be enough to state only that minimal improvement in log-likelihood was

obtained where this turns out to be the case, with further results given only when it wasn't. *Agreed.*

*Please note that the most important request: to include closure status as a covariate in the analysis.*

This has been done in MARAM/IWS/DEC14/Peng/B12 as an alternative to catch. There is insufficient information content in the data to include both together as covariates in these GLMs.

*a. Is there an island effect on  $\sigma(\text{eps})$ ?*

This has been explored for the same subset of response variables and methods as considered in MARAM/IWS/DEC14/Peng/B15, and for catches within 10 nm of the islands, except that method (i) (fixed year effects) was not pursued as the estimation evidenced multimodality between trying to choose parameter values to set either the one or the other very low. For both methods (iii) and (iv), making  $\sigma(\text{eps})$  island dependent was not AIC justified except for the chick condition response variable. However the resultant differences in the estimates of the fishing effect parameter  $\lambda$  were minor for that variable except in a single case – that for sardine catches for Robben Island, for which the estimate changed from negative to positive.

*b. Consider random year-effects on  $\lambda$ ?*

Time proved to be insufficient for this to be explored.

*c. What is the effect of weighting response data by sample size or variance (presuming such data are made available). How does  $\sigma(\text{eps})$  compare to (average) measurement error CVs?*

The effects of taking sample size into account when weighting the annual means input to the GLM analyses are explored and reported upon in MARAM/IWS/DEC14/Peng/B15. This makes little difference to results for estimates of  $\lambda$  in the great majority of cases.

*d. Would it be possible to analyse impact of biomass as an alternative to catch?*

Time proved to be insufficient for this to be explored.

*e. Equation 2, consider island-specific  $\mu$  and scaling biomass. The suggestion is to divide biomass by mean biomass.*

The possibility of island-specific  $\mu$  values is pertinent to methods (iii) and (iv) only. This proved not to be AIC justified for method (iv) for all the islands and scenarios considered. For method (iii) there were some instances of such justification for Dassen and Robben Islands (but not for Bird and St Croix Islands) for chick growth, foraging path length and foraging trip duration, mainly for results where sardine was included in the catch. For Dassen Island there were only two instances (both barely so) of a change in the sign of the  $\lambda$  estimate. For Robben Island the magnitudes of such changes were larger, with two from positive to negative for chick growth, and three in the reverse direction for foraging path length.

- f. Some lambdas are set to +/-0.1 for the power analysis. What would it take to identify this for all indicators (for comparison)?*

The results for this are shown in Tables 1 and 2, which include comparable results under the original basis to set effect sizes (from MARAM/IWS/DEC14/Peng/B12, Table A.4) where the two sets differ. Such differences are generally fairly small, and as might be expected all in the direction of increasing the expected period to obtain a statistically significant result.

- g. How was the likelihood profile 95% CIS for sigma(eps) derived?*

The likelihood profile for fixed effects models follows very straightforwardly as the maximum value of the log likelihood for any given  $\sigma$  value corresponds to values of the other parameters which remain unchanged from their MLEs, resulting in a single closed form equation relating the log likelihood to  $\sigma$ , i.e. of the form:

$$-\ln L = n \ln \sigma + X/(2\sigma^2) \quad \text{where } X \text{ is independent of } \sigma.$$

For random effects models, this same approach has been used, but is an approximation through making the tacit assumption that the estimate of the variance of the random effects does not change as  $\sigma$  is varied to provide the profile.

- h. Show model selection results / residual diagnostics for some key models.*

In effectively all cases, the time series are very short, so that many conventional diagnostic plots would hardly be informative. What has been done therefore is to plot the observed response variable values against year for a few cases, showing also each's average value plotted as a horizontal straight line, and also on that plot to show the time series of corresponding values predicted by the GLM in question. Figure 1 shows these plots for Dassen Island and for Robben Island for each of the six response variables considered for model (iii) (spawner biomass as a covariate) and the case where catches correspond to the combination of sardine and anchovy within 10 nm. The same applies for the Bird Island and St Croix Island catches, except that there the catch involves sardine only.

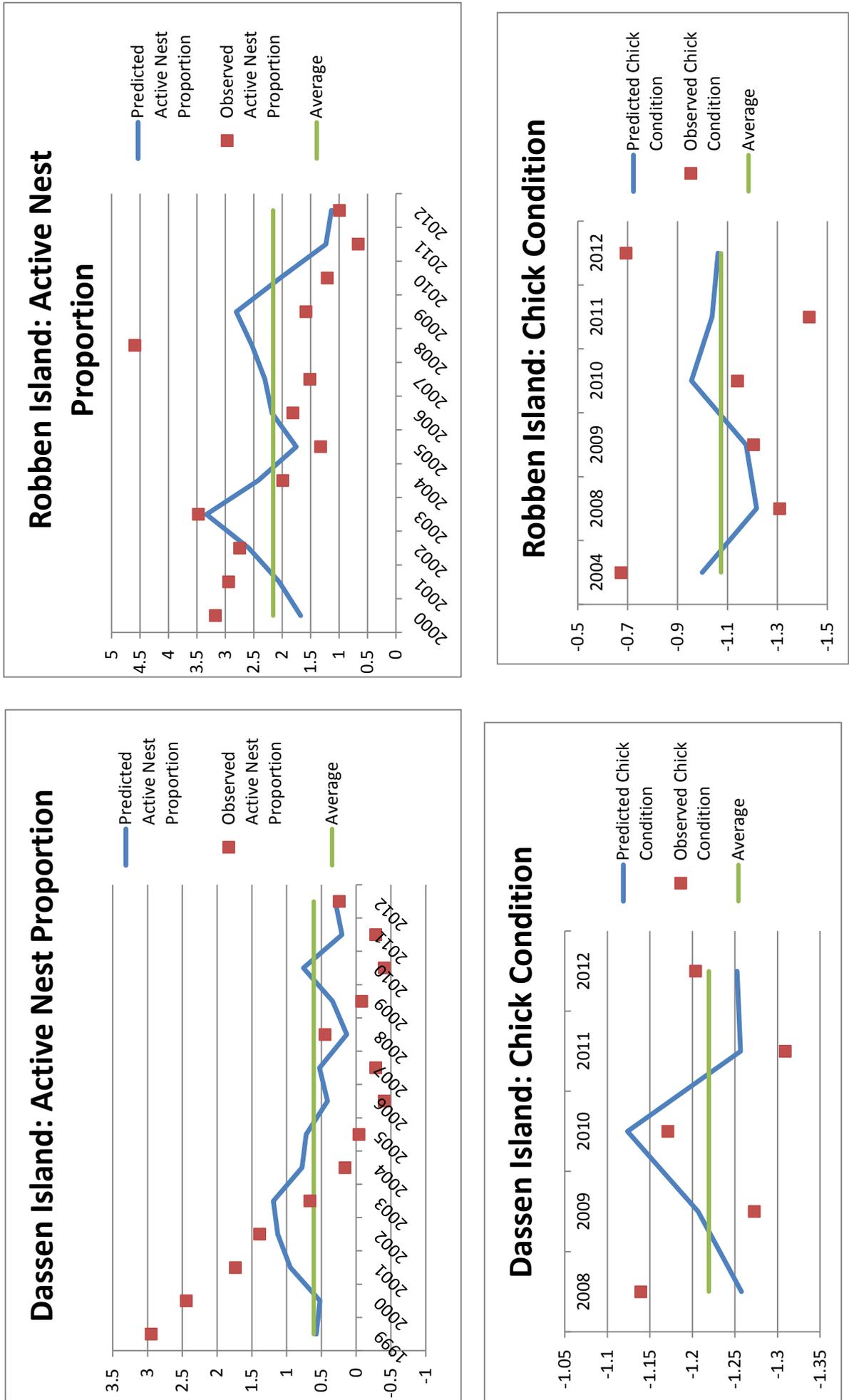
Table 1: The number of additional years' data required to detect a fishing effect significant at the 5% level with **95%** probability is given for each of Dassen and Robben islands for the **updated datasets**, where the true values of  $\lambda$  are assumed to be the random effects model-estimates. **If a model-estimated  $\lambda$  value is negative (i.e.  $\lambda < 0.1$ ) then  $\lambda = -0.1$  and similarly, if a model-estimated  $\lambda$  value is positive (i.e.  $\lambda > 0.1$ ) then  $\lambda = +0.1$ .** This is assumed for the effect size. A value of 0 indicates that the existing estimate of  $\lambda$  is already significant at the 5% level. C/O indicates future alternating periods of three years of the area being closed and open to fishing; O indicates the area is always open in the future. The values shown in parenthesis are the results for the original choices for effect sizes that were reported in Table A.4 of MARAM/IWS/DEC14/Peng/B12: these are shown only where the outcomes from the two sets of analyses differ.

Response	Fish	Area	Dassen		Robben	
			C/O	O	C/O	O
Chick condition	Sardine	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	0
	Anchovy	10 nmi	> 20 (15)	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20
	Total	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20
Active nest proportion	Sardine	10 nmi	0	0	0	0
		20 nmi	-	0	-	0
		30 nmi	-	0	-	0
	Anchovy	10 nmi	> 20	> 20	0	0
		20 nmi	-	> 20	-	0
		30 nmi	-	> 20	-	0
	Total	10 nmi	> 20	> 20	0	0
		20 nmi	-	0	-	0
		30 nmi	-	0	-	0
Fledging success	Sardine	10 nmi	> 20	> 20	0	0
		20 nmi	-	> 20	-	0
		30 nmi	-	> 20	-	0
	Anchovy	10 nmi	16	14 (13)	> 20	> 20
		20 nmi	-	> 20 (18)	-	> 20
		30 nmi	-	11 (4)	-	> 20 (17)
	Total	10 nmi	> 20 (14)	> 20 (10)	> 20	> 20
		20 nmi	-	> 20 (10)	-	> 20
		30 nmi	-	> 20	-	> 20
Chick growth	Sardine	10 nmi	0	0	0	0
		20 nmi	-	0	-	0
		30 nmi	-	0	-	0
	Anchovy	10 nmi	1	> 20	1	> 20
		20 nmi	-	0	-	17 (12)
		30 nmi	-	0	-	> 20
	Total	10 nmi	1	> 20	1	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20
Foraging path length	Sardine	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20
	Anchovy	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20 (13)
	Total	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20 (20)
		30 nmi	-	> 20	-	0
Foraging trip duration	Sardine	10 nmi	0	0	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20
	Anchovy	10 nmi	0	0	> 20	> 20
		20 nmi	-	> 20	-	> 20 (20)
		30 nmi	-	> 20	-	0
	Total	10 nmi	0	0	> 20	> 20
		20 nmi	-	> 20	-	> 20 (19)
		30 nmi	-	> 20	-	0

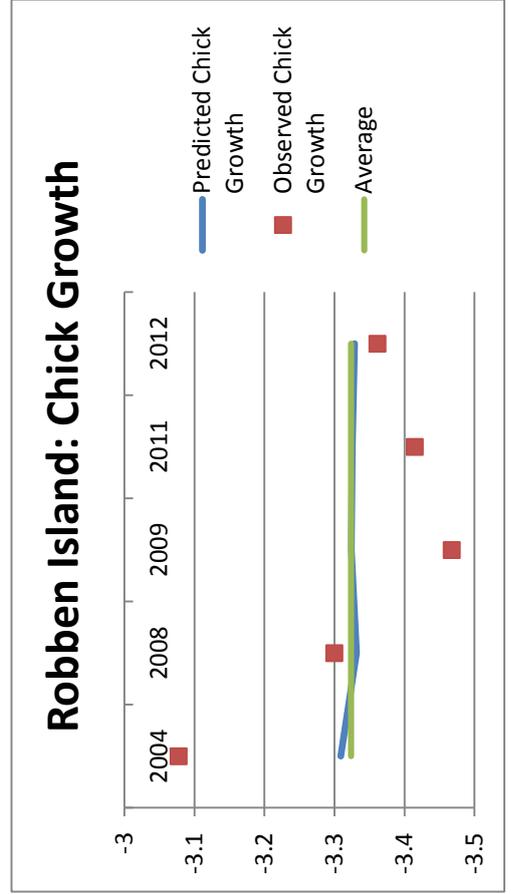
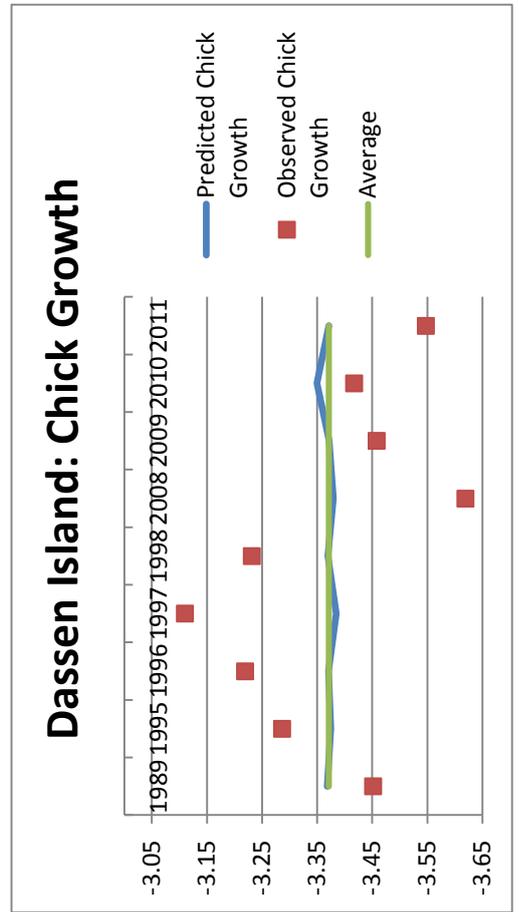
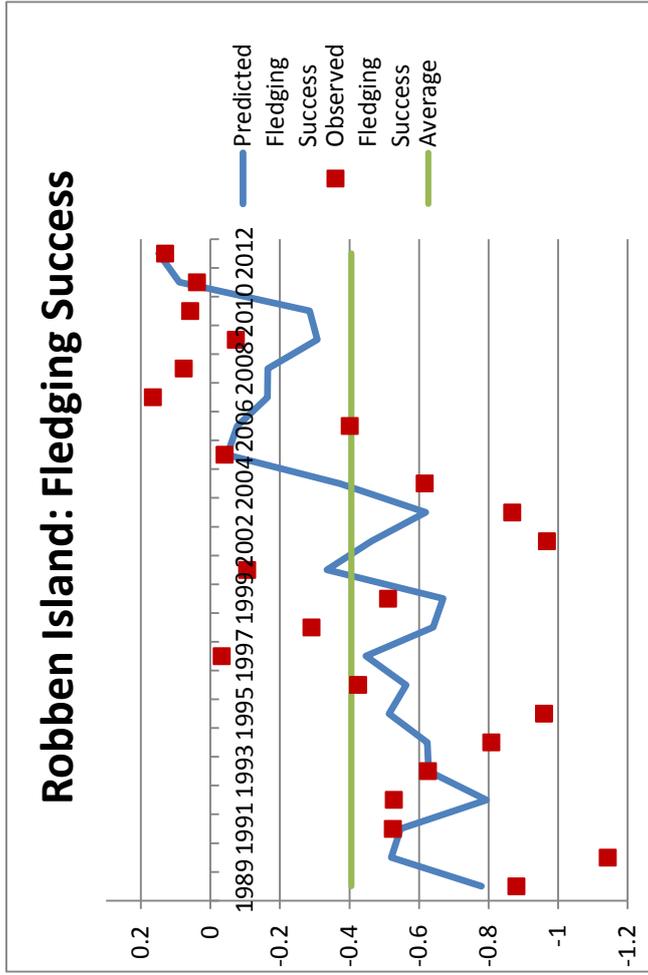
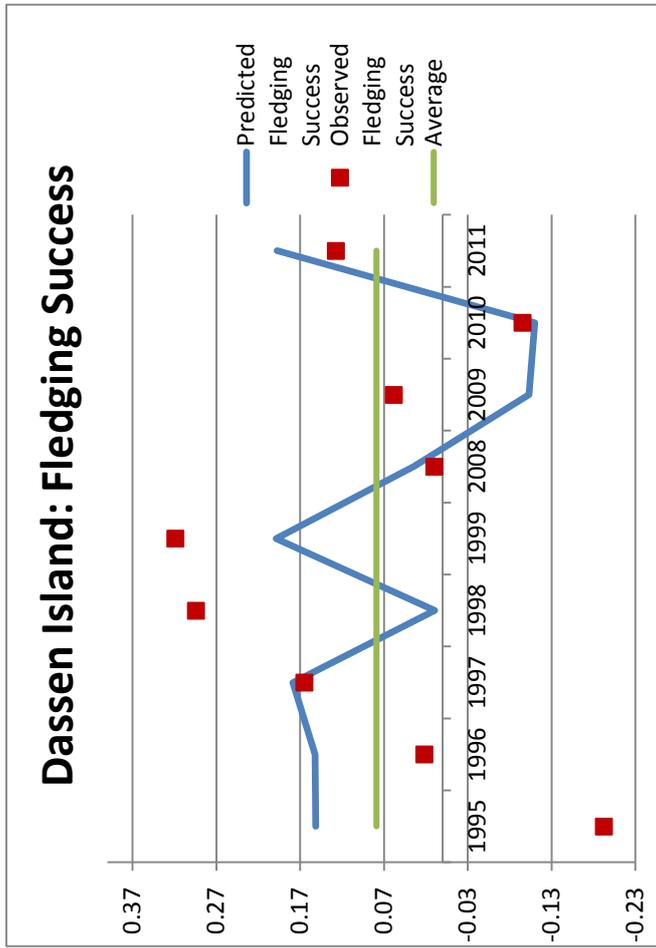
Table 2: The number of additional years' data required to detect a fishing effect significant at the 5% level with **95%** probability is given for each of Bird and StCroix islands for the **updated datasets**, where the true values of  $\lambda$  are assumed to be the random effects model-estimates. **If a model-estimated  $\lambda$  value is negative (i.e.  $\lambda < 0.1$ ) then  $\lambda = -0.1$  and similarly, if a model-estimated  $\lambda$  value is positive (i.e.  $\lambda > 0.1$ ) then  $\lambda = +0.1$ .** This is assumed for the effect size. A value of 0 indicates that the existing estimate of  $\lambda$  is already significant at the 5% level. C/O indicates future alternating periods of three years of the area being closed and open to fishing; O indicates the area is always open in the future. The values shown in parenthesis are the results for the original choices for effect sizes that were reported in Table A.4 of MARAM/IWS/DEC14/Peng/B12: these are shown only where the outcomes from the two sets of analyses differ.

Response	Fish	Area	Bird		StCroix	
			C/O	O	C/O	O
Foraging path length	Sardine	10 nmi	> 20	> 20	0	0
		20 nmi	-	> 20	-	0
		30 nmi	-	> 20	-	> 20 (19)
Foraging trip duration	Sardine	10 nmi	> 20	> 20	> 20	> 20
		20 nmi	-	> 20	-	> 20
		30 nmi	-	> 20	-	> 20

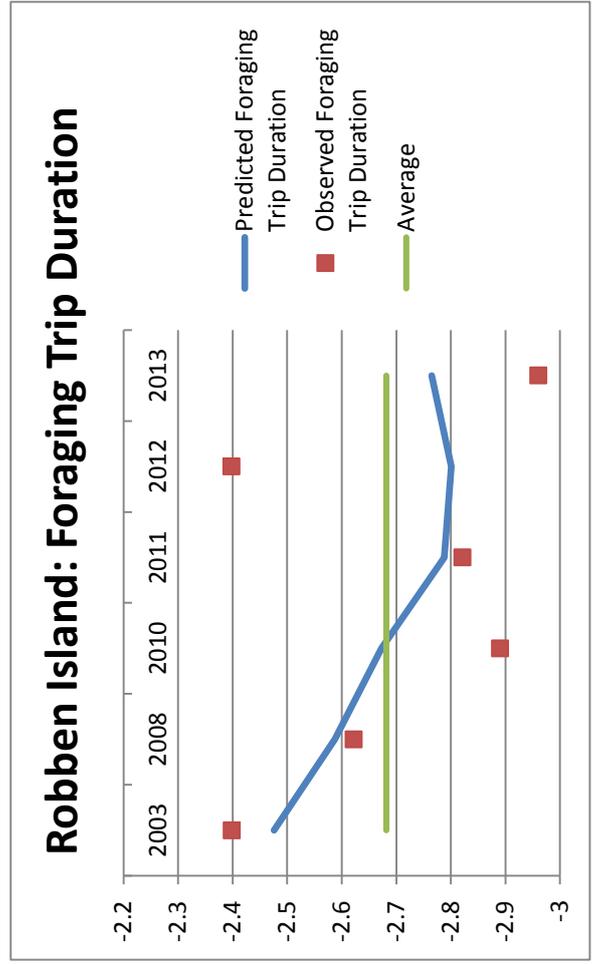
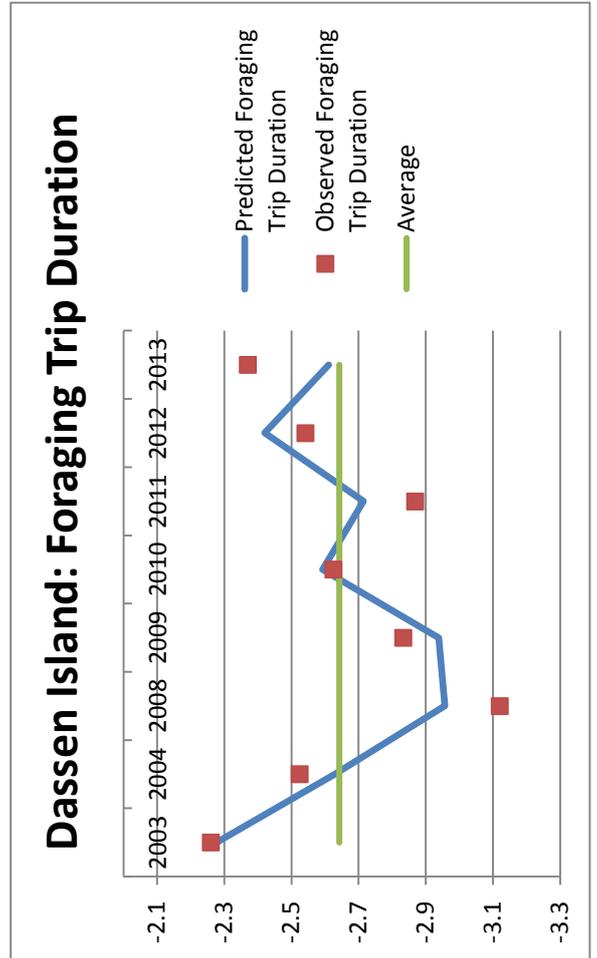
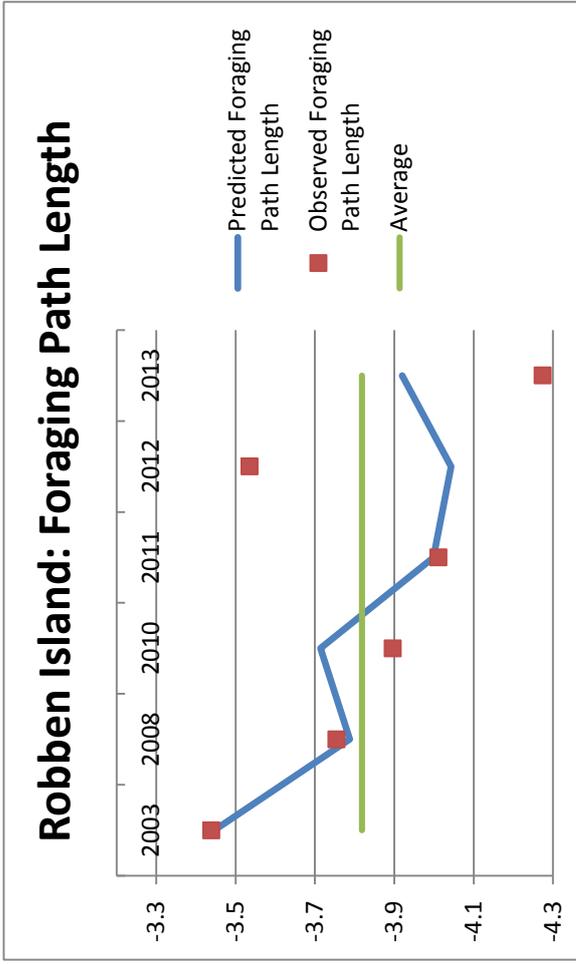
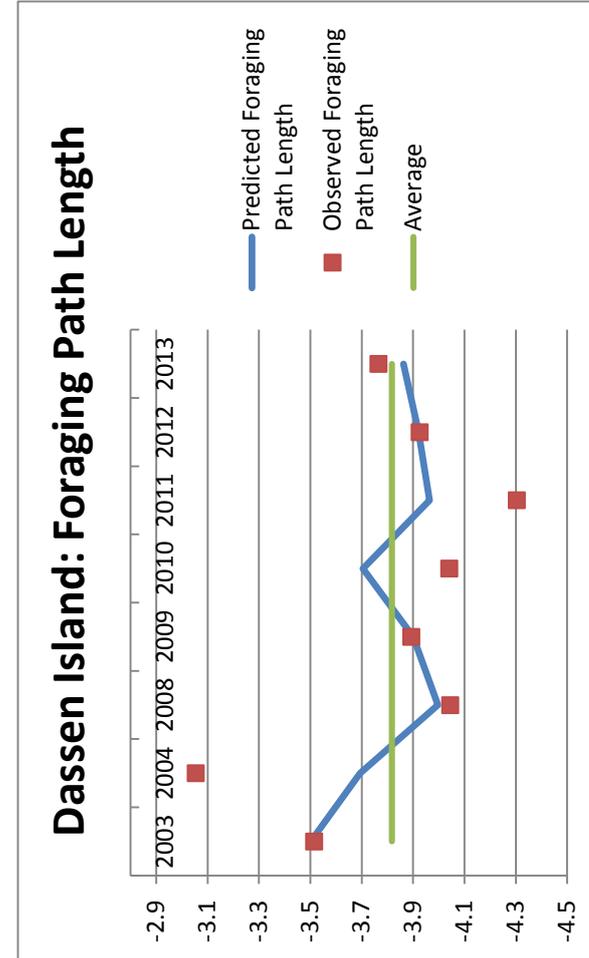
**Figure 1:** Comparisons of observed of predicted variables of  $\ln(F)$ , the transformed value of the response variable to which the GLM is fitted, for model (iii) (spawner biomass as a covariate). Results are shown for Dassen Island and for Robben Island for each of the six response variables considered and the case where catches correspond to the combination of sardine and anchovy within 10nm. The same applies for the Bird and St Croix Island catches, except that there the catch involves sardine only and there are only two response variables available for those islands.



**Figure 1 (contd):** Comparisons of observed of predicted variables of  $\ln(F)$ , the transformed value of the response variable to which the GLM is fitted, for model (iii) (spawner biomass as a covariate). Results are shown for Dassen Island and for Robben Island for each of the six response variables considered and the case where catches correspond to the combination of sardine and anchovy within 10nm. The same applies for the Bird and St Croix Island catches, except that there the catch involves sardine only and there are only two response variables available for those islands.



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