

**A NOTE ON THE EXTENT OF AUTOCORRELATION OF RESIDUALS IN THE GLM ANALYSES OF PENGUIN RESPONSE VARIABLES IN THE FEASIBILITY STUDY**

D.S. Butterworth and N. Moosa

MARAM, Department of Mathematics and Applied mathematics, University of Cape Town

One of the observations by the December 2014 IWS Panel on the penguin analyses presented in respect of the GLM analyses of penguin response variables was as follows:

“the observed residual patterns (some of the fits in MARAM/IWS/DEC14/Peng/B16 exhibit substantial serial correlation which needs to be reflected in the power calculations)”

This note examines this matter more systematically by estimating the autocorrelation in these residuals (Table 1) and also plotting the residuals themselves (Figure 1) and then the autocorrelation estimates (Figure 2) for the case of catches within a 10 nmi neighbourhood of the colony concerned, and either the combined sardine and anchovy catch (Robben and Dassen islands) or the sardine catch (St Croix and Bird islands).

The method used is coarse, in that the autocorrelation is estimated for the original residuals estimated, rather than in a joint estimation procedure, but is sufficient for the “ballparking” of the size of this effect that is intended here.

Figure 2 provides the most convenient summary of the results. Note that the error bars shown are only  $\pm 1$  se (Hessian-based), and so need to be mentally doubled in length to roughly identify statistically significant differences from zero. For St Croix and Bird islands there is no real evidence of significantly positive serial auto correlation (it is positive correlation that is of the most concern, as that would render previous inferences of statistically significant fishing effect parameter estimates in doubt). However for the Western Cape colonies, and particularly for Dassen island, though again few results differ significantly from zero, quite a number of the estimates themselves are large and positive.

Thus this systematic evaluation, albeit coarse, confirms the IWS Panel’s observation. Autocorrelation will need to be taken into account in power analyses. Given that it can be both positive and large, previous estimates of power will have been biased high, and longer periods than previously estimated will be needed to confirm statistically significant estimates of fishing effects.

**Table 1: Autocorrelation values for residuals in GLM model fits to penguin reproductive success indices**

	Random Model			Spawner Biomass			Recruit Biomass		
	AutoCorrelation ( $\rho$ )	Standard Error of $\rho$	Years (n)	AutoCorrelation ( $\rho$ )	Standard Error of $\rho$	Years (n)	AutoCorrelation ( $\rho$ )	Standard Error of $\rho$	Years (n)
<b>ROBBEN ISLAND</b>									
Chick Condition	-0.360	0.548	5	-0.328	0.622	5	-0.176	0.578	5
Active Nest Proportion	0.124	0.261	13	-0.047	0.257	13	-0.350	0.265	13
Fledging Success	0.572	0.251	12	0.183	0.287	12	0.532	0.258	12
Chick Growth	0.414	0.000	2	0.362	0.000	2	0.110	0.000	2
Foraging Path Length	-0.895	0.513	4	-0.632	0.553	4	-0.777	0.568	4
Foraging Trip Duration	-0.461	0.577	4	-0.403	0.515	4	-0.425	0.520	4
<b>DASSEN ISLAND</b>									
Chick Condition	-0.626	0.268	5	-0.202	0.340	5	-0.239	0.316	5
Active Nest Proportion	0.713	0.114	14	0.618	0.133	14	0.250	0.167	14
Fledging Success	0.501	0.319	5	0.356	0.314	5	0.501	0.307	5
Chick Growth	0.500	0.361	4	0.551	0.324	4	-0.012	0.608	4
Foraging Path Length	0.561	0.362	6	0.489	0.398	6	0.573	0.355	6
Foraging Trip Duration	-0.228	0.468	6	-0.342	0.509	6	-0.282	0.463	6
<b>ST CROIX ISLAND</b>									
Foraging Path Length	-0.362	0.419	6	-0.521	0.400	6	-0.300	0.411	6
Foraging Trip Duration	-0.698	0.331	6	-0.692	0.316	6	-0.718	0.263	6
<b>BIRD ISLAND</b>									
Foraging Path Length	-0.164	0.394	7	-0.007	0.402	7	-0.100	0.394	7
Foraging Trip Duration	0.070	0.546	7	0.278	0.504	7	-0.145	0.510	7

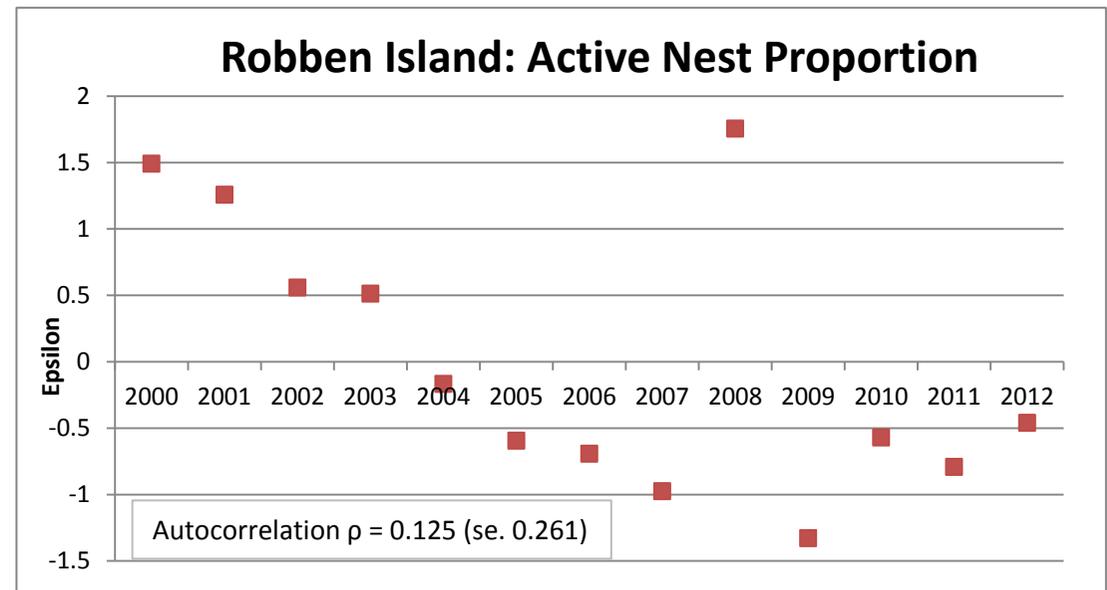
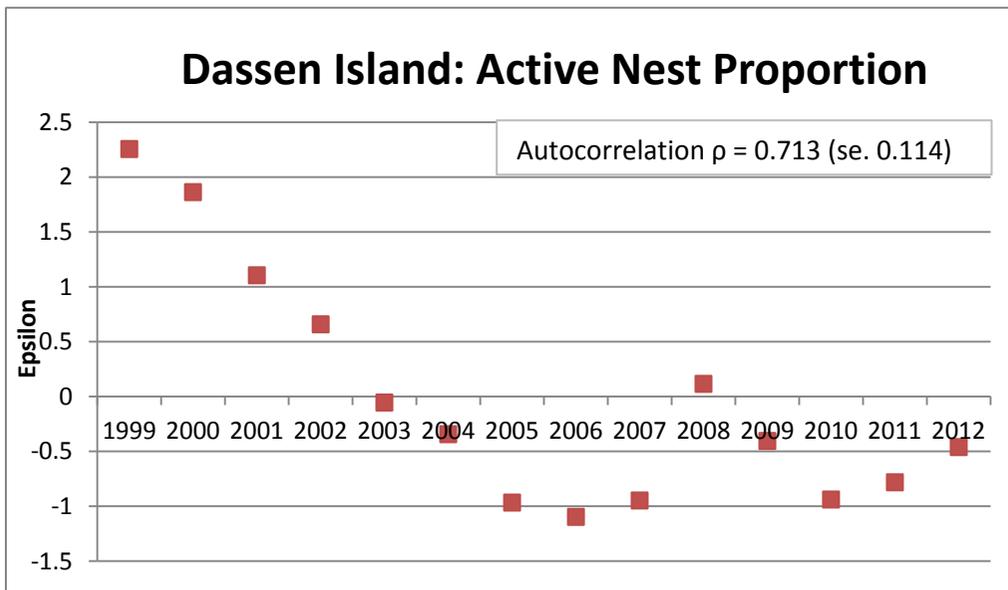
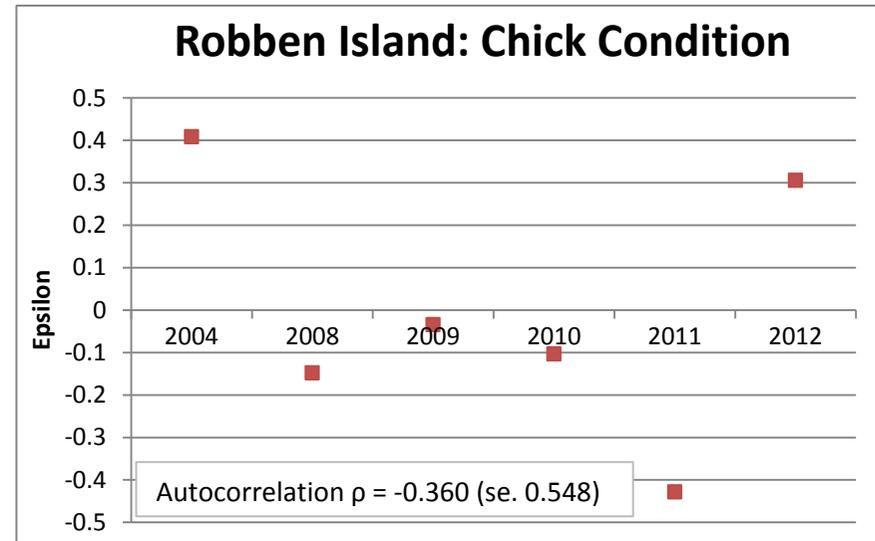
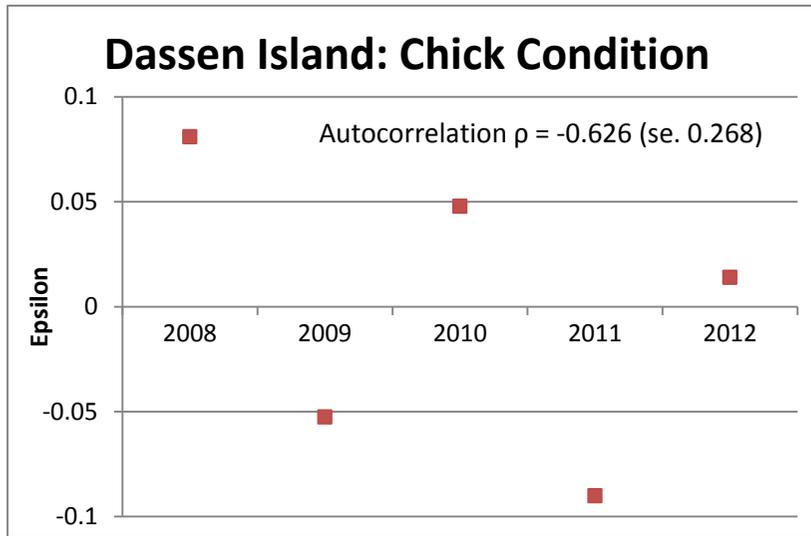


Figure 1: Plots of residuals for fits of random effects models for different measures of penguin reproductive success

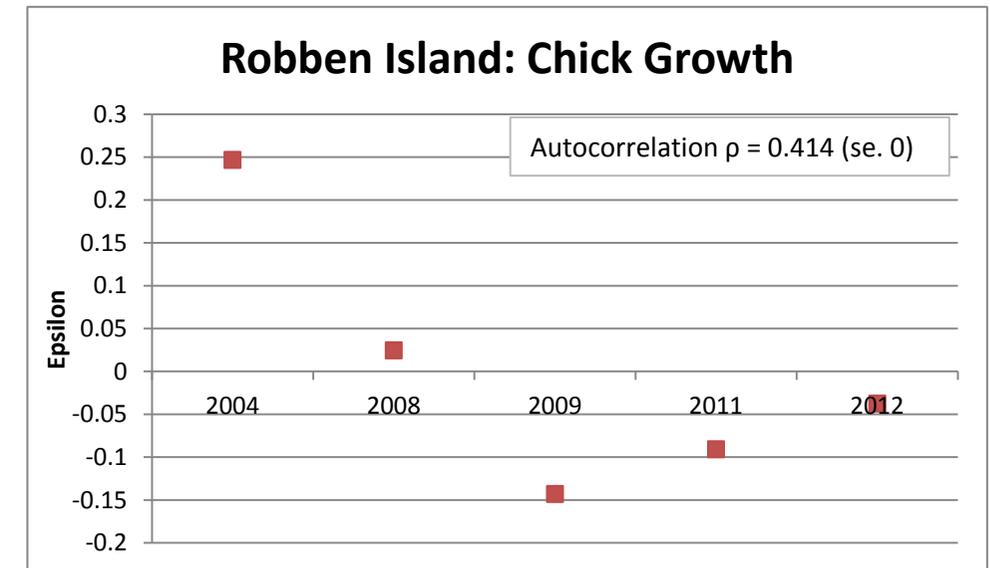
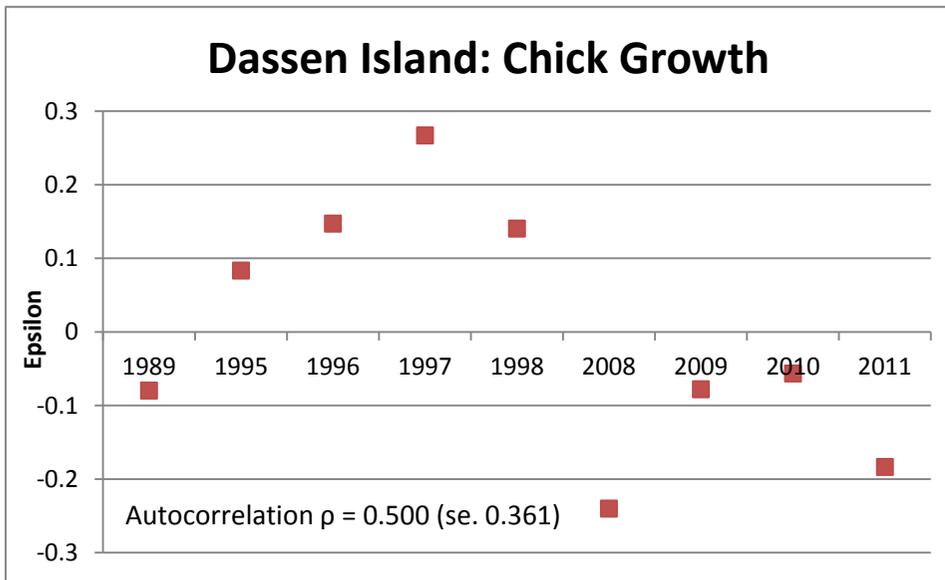
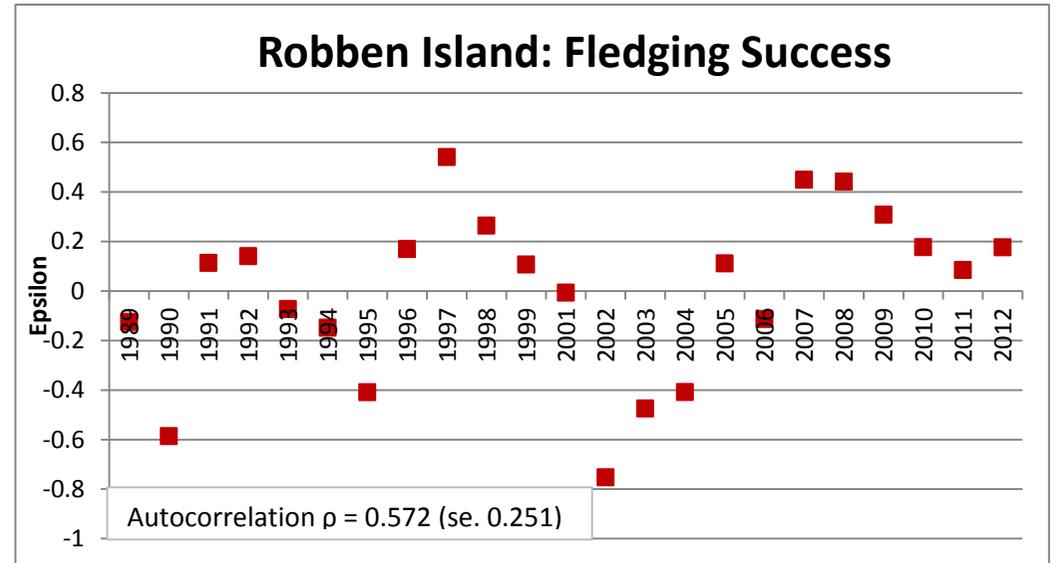
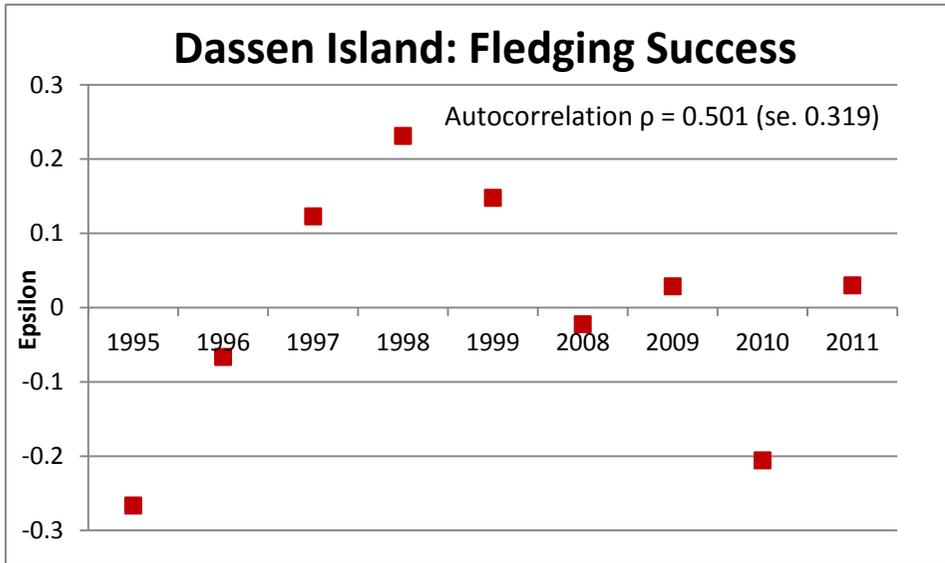


Figure 1 (contd): Plots of residuals for fits of random effects models for different measures of penguin reproductive success

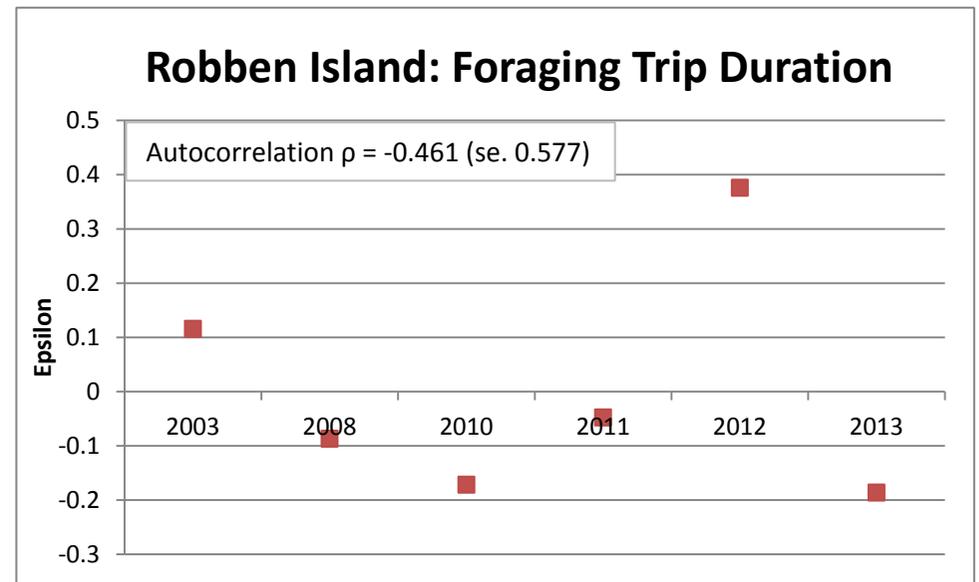
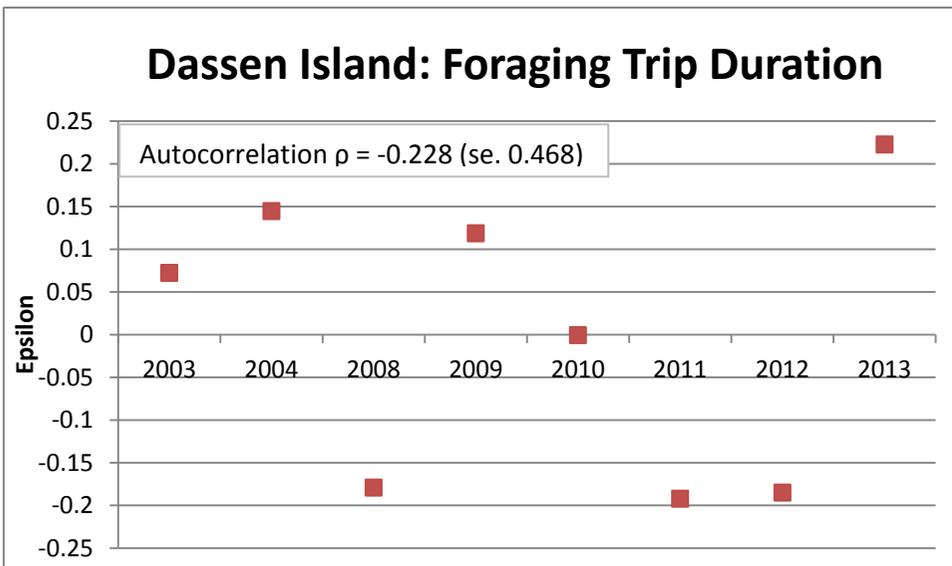
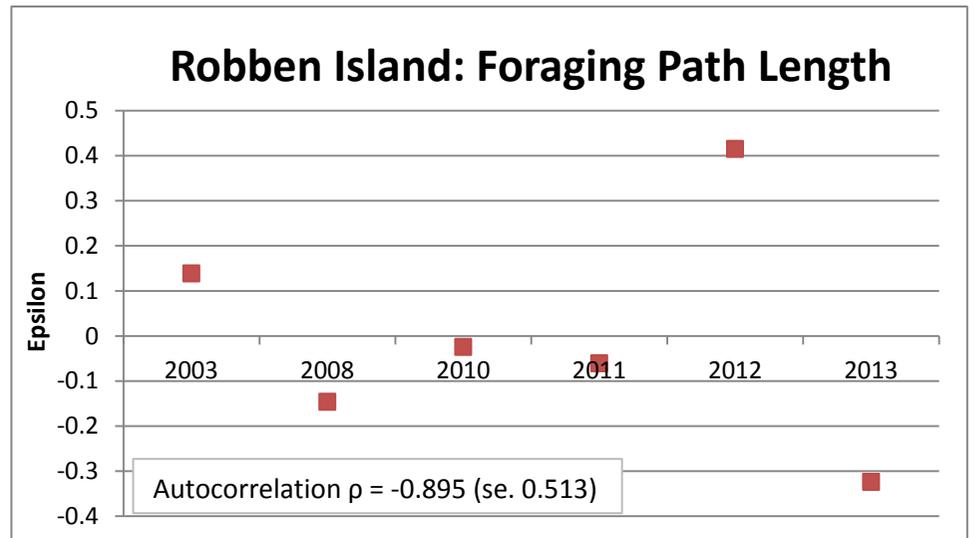
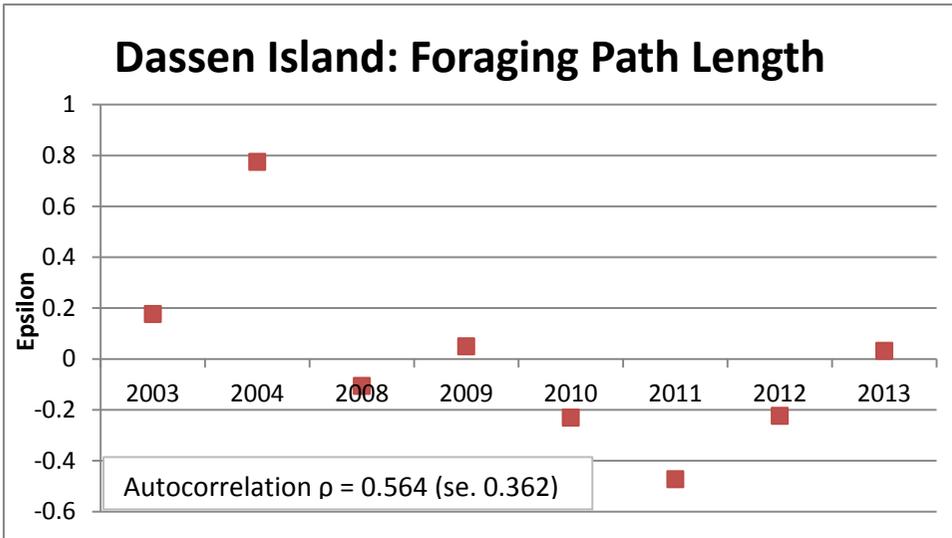


Figure 1 (contd): Plots of residuals for fits of random effects models for different measures of penguin reproductive success

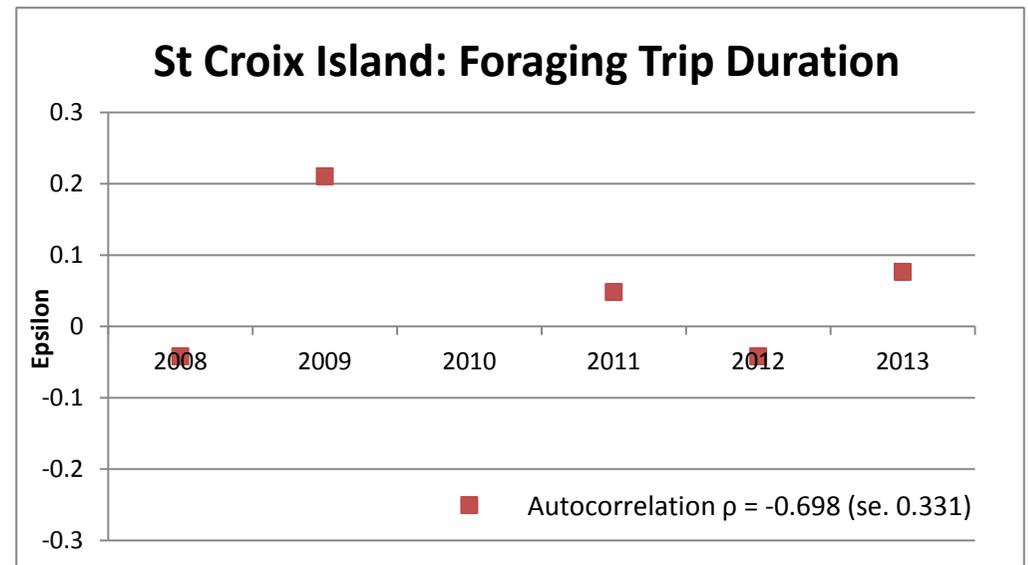
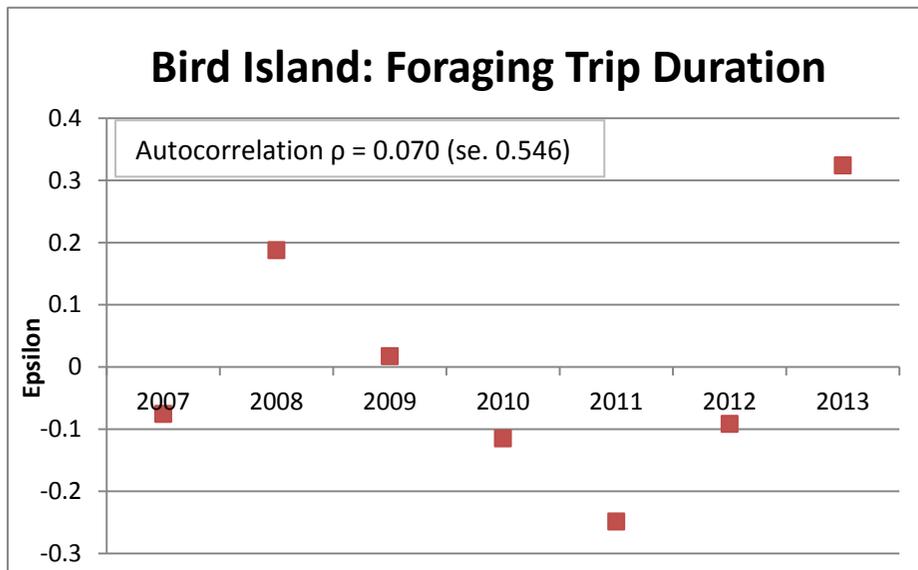
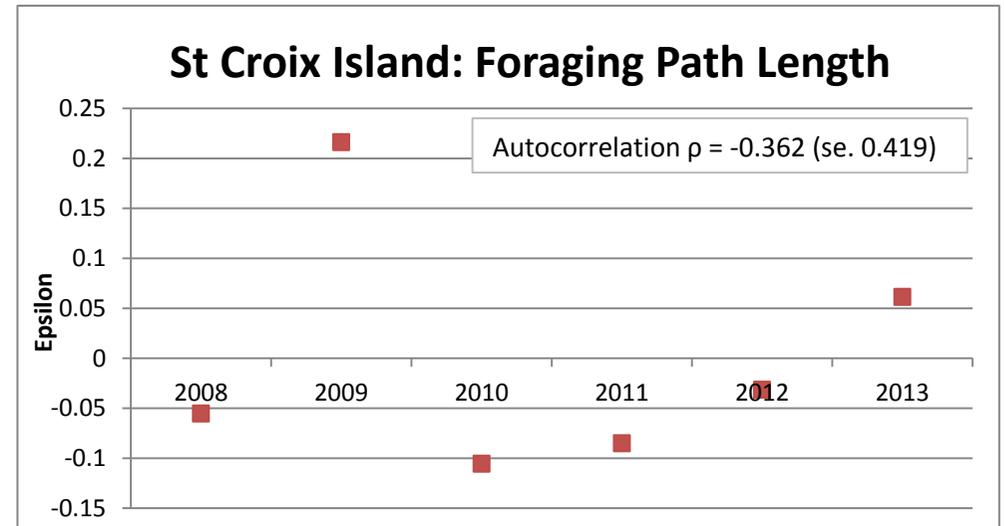
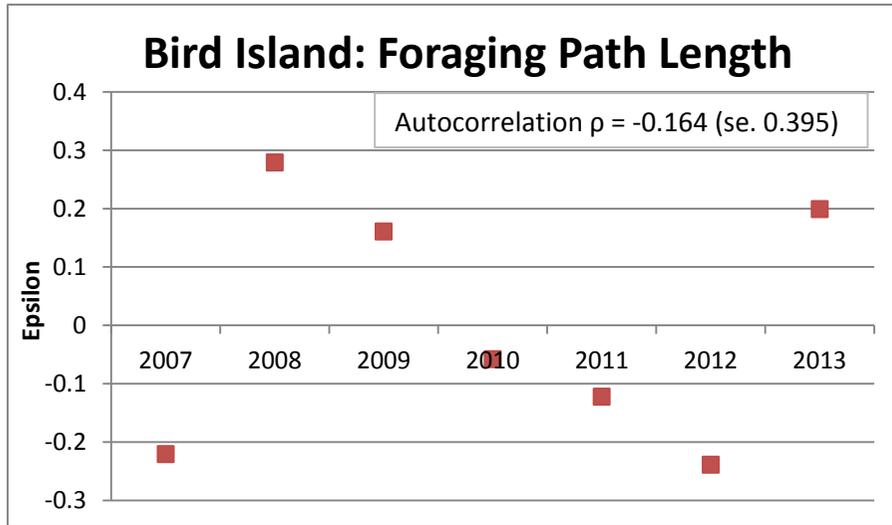


Figure 1 (contd): Plots of residuals for fits of random effects models for different measures of penguin reproductive success

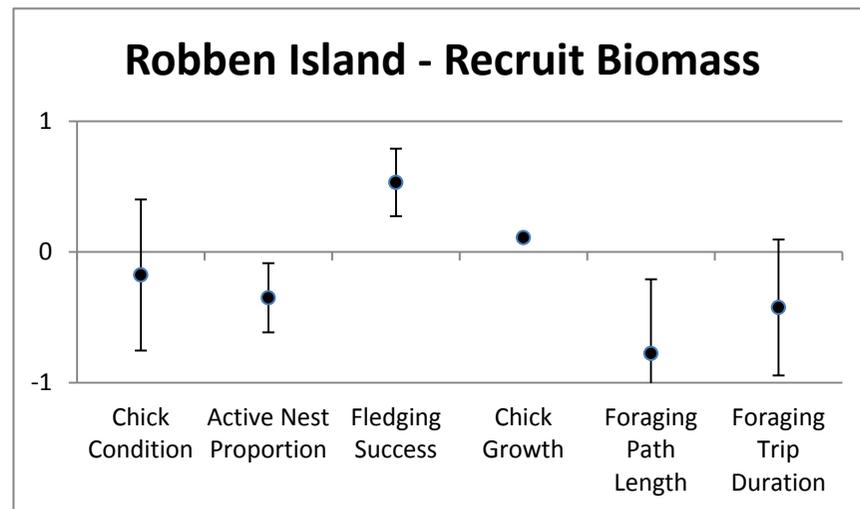
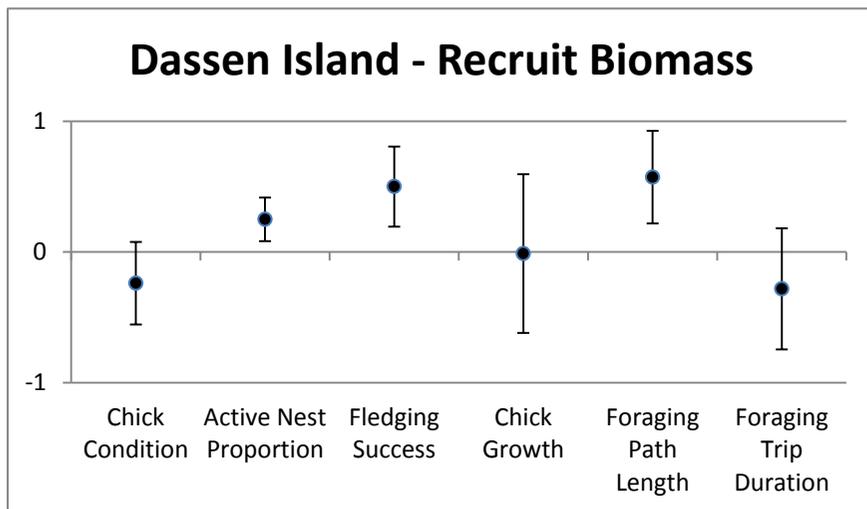
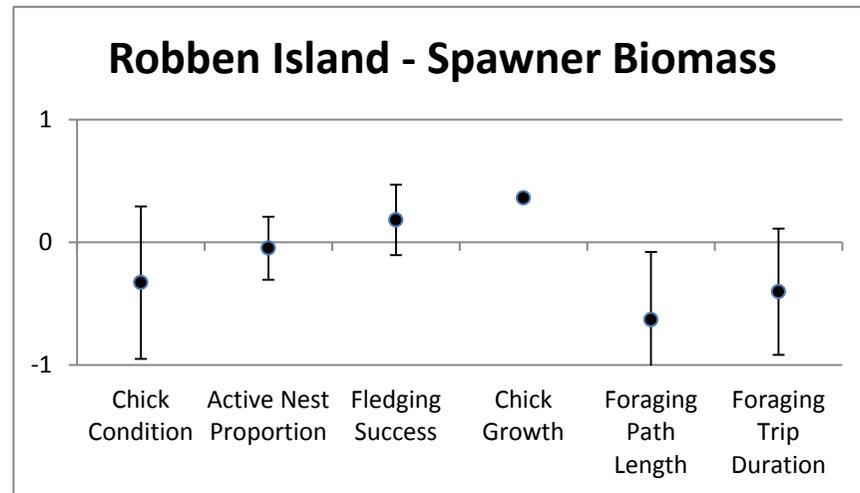
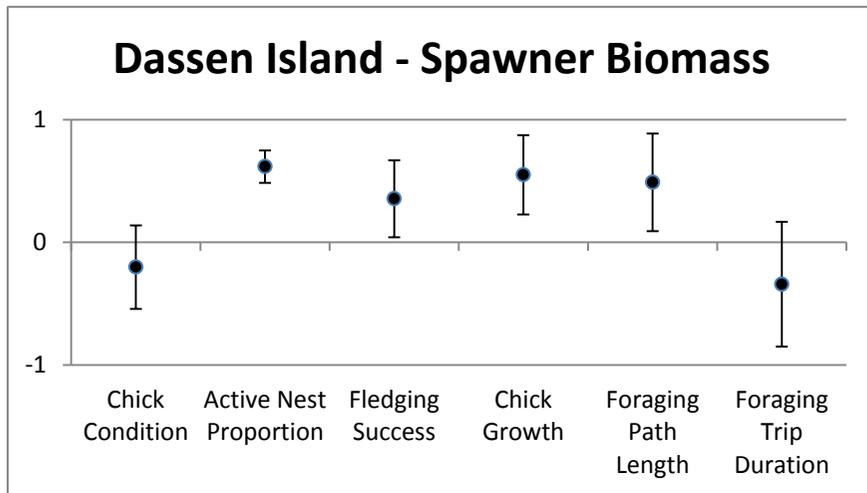
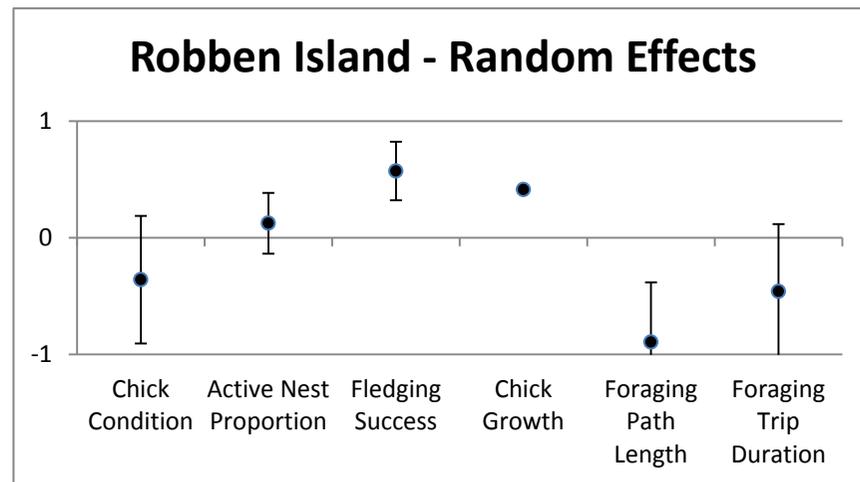
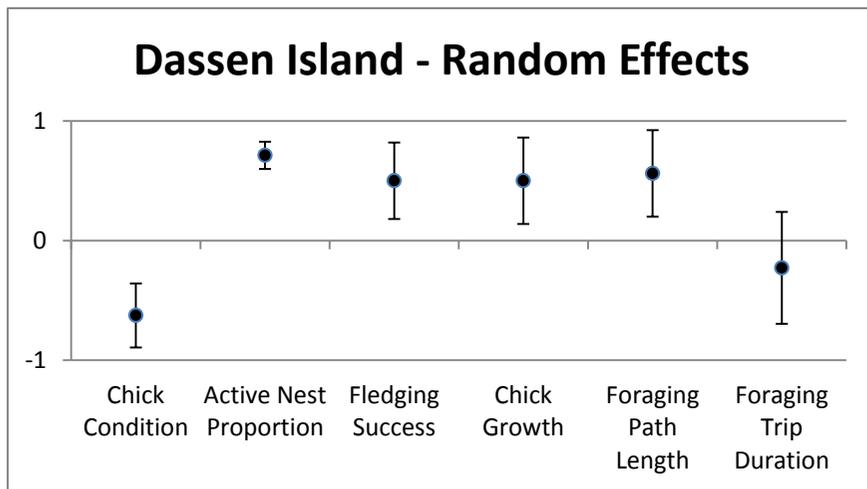


Figure 2: Plots of auto-correlation p estimates for various methods and models (error bars  $\pm 1$  se)

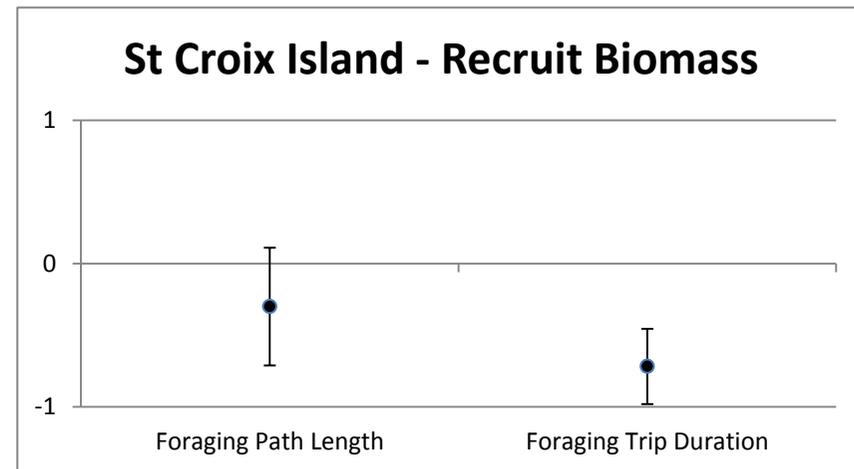
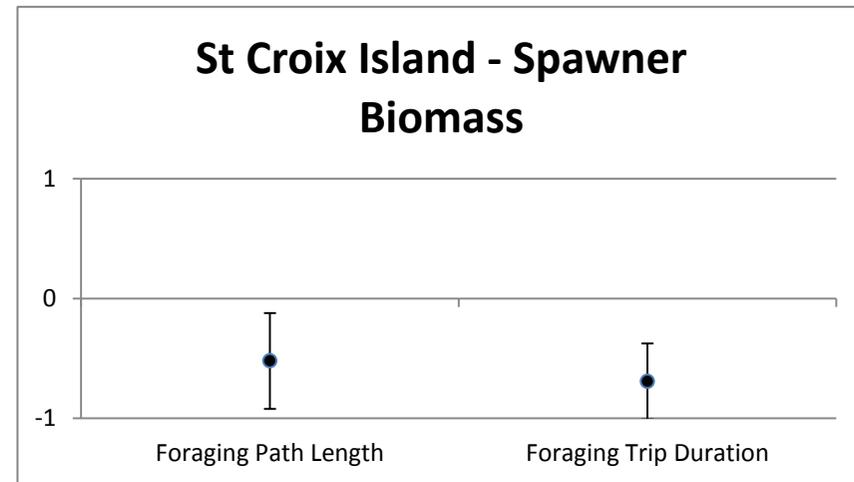
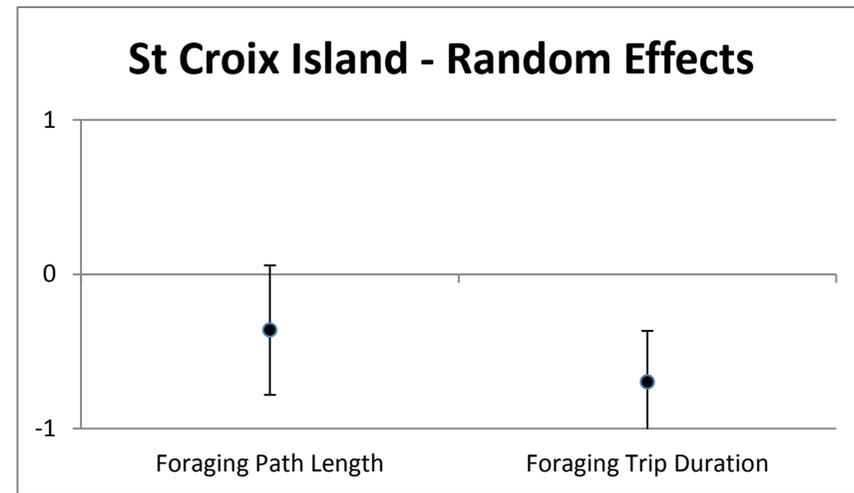
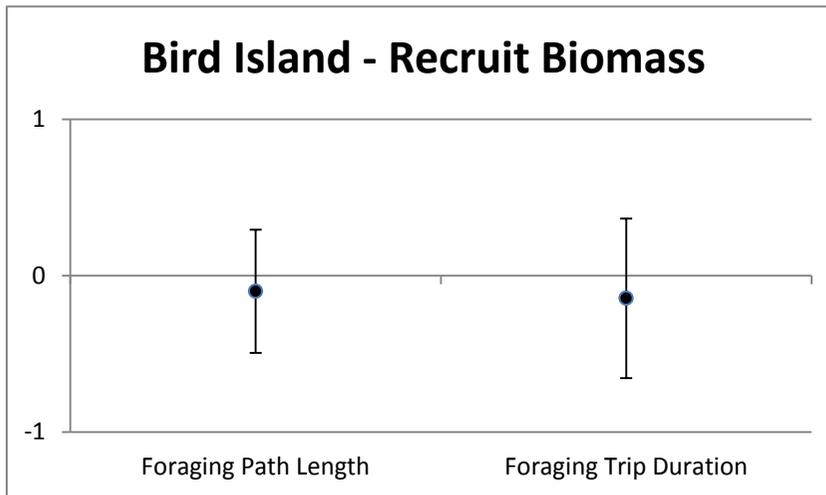
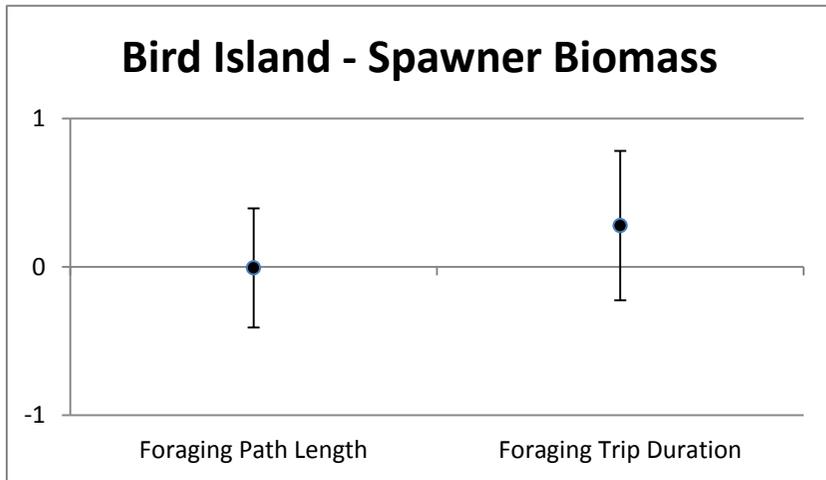
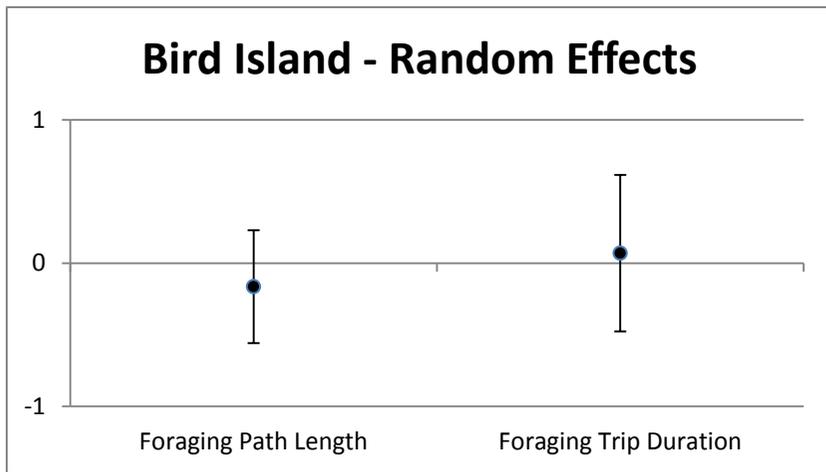


Figure 2 (contd): Plots of auto-correlation p estimates for various methods and models (error bars  $\pm 1$  se)