Appendix B: Simulation methods and results

Focusing our efforts on the closed population mark-recapture model M_t (Otis et al. 1978), we examined the performance of analysis methods under several different sampling scenarios. We generated data using different combinations of underlying abundance (N), detection probability (p), and bilateral encounter probabilities (δ^L, δ^R, δ^B) for $T = 5$ occasions. For each scenario, we performed 100 simulations, to which we applied four estimation procedures: 1) inference based on Eq. 11 using the LRB data type; 2) inference based on Eq. 11 using the LR data type; 3) a "traditional" analysis using one side of the animal only (the side resulting in the highest number of observations was used); and 4) an analysis based on the likelihood formulation of Corkrey et al. (2008). To enable meaningful comparisons among estimation procedures, each was fit using MCMC with the same set of prior distributions (see Appendix A for further details). After a burn in of 5000 iterations, it required at most 30mins on a computer running 64-bit Windows 7 (3.4GHz Intel Core i7 processor, 16Gb RAM) to obtain chains of 25000 iterations for the LR and LRB analyses. For each scenario and estimator, we calculated proportional relative bias and coefficient of variation (CV). These quantities were calculated relative to the posterior mean, which is a commonly used point estimate in Bayesian analysis. We also calculated the 80% credible interval coverage for N (defined as the proportion of simulations for which the true parameter value falls within the 10th and 90th posterior sample quantiles).

We found both of the proposed integrated estimators and the one-sided estimator to be generally unbiased across all simulated scenarios with credible intervals for N having coverage rates that were close to nominal (Table B1). As expected among these estimators, the integrated models for the LRB and LR data types were more precise than the one-sided estimator. The inclusion of 'B' detections afforded relatively small gains in precision relative to the LR data type, and all three estimators performed similarly for the larger sample simulations with $N = 500$ and $p = 0.4$. The estimator based on Corkrey et al. (2008) was typically biased with poor coverage and low CV.

LITERATURE CITED

Corkrey, R., S. Brooks, D. Lusseau, K. Parsons, J. W. Durban, P. S. Hammond, and P. M. Thompson. 2008. A Bayesian capture-recapture population model with simultaneous estimation of heterogeneity. Journal of the American Statistical Association **103**:948–960.

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Table B1: Simulation results for abundance estimation assuming different combinations of underlying abundance (N), detection probability (p), and bilateral observation probabilities (δ^L and δ^R). Estimator performance is summarized by proportional relative bias ('bias'), coefficient of variation (CV), and 80% credible interval coverage (Cov). Subscripts on performance measures indicate the different estimators used, which included the methods developed in this paper for the LRB data type (1) and LR data type (2), traditional mark-recapture analysis using one side of the animal (3), and methods suggested by Corkrey et al. (2008) (4). One hundred simulations were performed at each design point.

N	p	δ^L	δ^R	bias_1	bias_2	bias_3	bias_4	Cov_1	Cov_2	Cov_3	Cov_4	CV_1	CV_2	CV_3	CV_4
100	0.2	0.2	0.2	-0.01	-0.02	-0.03	-0.24	0.75	0.72	0.77	0.00	0.12	0.12	0.14	0.04
100	0.2	0.4	0.4	-0.04	-0.05	-0.07	0.06	0.83	0.80	0.75	0.65	0.14	0.15	0.18	0.09
100	0.2	0.5	0.3	-0.02	-0.03	-0.06	0.13	0.80	0.79	0.72	0.49	0.15	0.16	0.18	0.10
100	0.4	0.2	0.2	0.00	0.00	0.00	-0.01	0.87	0.89	0.84	0.46	0.04	0.04	0.05	0.01
100	0.4	0.4	0.4	0.00	-0.01	-0.01	0.33	0.78	0.75	0.71	0.00	0.06	0.06	0.08	0.04
100	0.4	0.5	0.3	-0.01	-0.01	-0.01	0.36	0.80	0.83	0.82	0.00	0.06	0.06	0.07	0.04
500	0.2	0.2	0.2	0.01	0.01	0.00	-0.23	0.82	0.81	0.85	0.00	0.05	0.06	0.07	0.02
500	0.2	0.4	0.4	-0.01	-0.01	-0.01	0.11	0.84	0.84	0.80	0.15	0.07	0.07	0.09	0.04
500	0.2	0.5	0.3	-0.01	-0.01	-0.01	0.17	0.78	0.79	0.82	0.08	0.07	0.07	0.08	0.05
500	0.4	0.2	0.2	0.00	0.00	0.00	-0.02	0.75	0.67	0.73	0.30	0.02	0.02	0.02	0.01
500	0.4	0.4	0.4	0.00	0.00	0.00	0.33	0.81	0.82	0.78	0.00	0.03	0.03	0.04	0.02
500	0.4	0.5	0.3	0.01	0.00	0.01	0.39	0.80	0.76	0.83	0.00	0.03	0.03	0.03	0.02