Appendix

Complete likelihood for the Jolly-Seber model with tag loss

The complete likelihood for the Jolly-Seber model with tag loss assuming no possibility of loss of capture and assuming homogeneous survival, capture, and tag retention probabilities is given below.

$$
\begin{aligned}
L = \binom{N}{n_{\text{obs}}} \left\{ \sum_{j=0}^{k-1} b_j (1-p) \chi_{(0,j+1,0)} \right\}^{(N-n_{\text{obs}})} \times \left\{ 1 - \sum_{j=0}^{k-1} b_j (1-p) \chi_{(0,j+1,0)} \right\}^{n_{\text{obs}}} \times \\
\binom{n_{\text{obs}}}{n_{\omega_1}, n_{\omega_2}, ..., n_{\omega_m}} \prod_{i=1}^{m} \left[\psi_{f_i} T_d \left\{ \prod_{j=f_i}^{l_i} p^{w*_{ij}} (1-p)^{(1-w*_{ij})} \right\} \left\{ \prod_{j=f_i}^{l_i-1} \phi \right\} \times \right. \\
\left. \prod_{d=1}^{2} \left\{ \left(\prod_{j=f_i}^{l_{id}-1} \lambda \right) \left(1 - \prod_{j=l_{id}}^{q_{id}-1} \lambda \right)^{I(l_{id} \neq l_i)} \right\} \times \chi_{f_i, l_i, nt_{l_i}} \right]^{n_{\omega_i}} \times \\
\left\{ 1 - \sum_{j=0}^{k-1} b_j (1-p) \chi_{(0,j+1,0)} \right\}^{-n_{\text{obs}}}
\end{aligned}
$$

Survival Estimates

Figure A1: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.

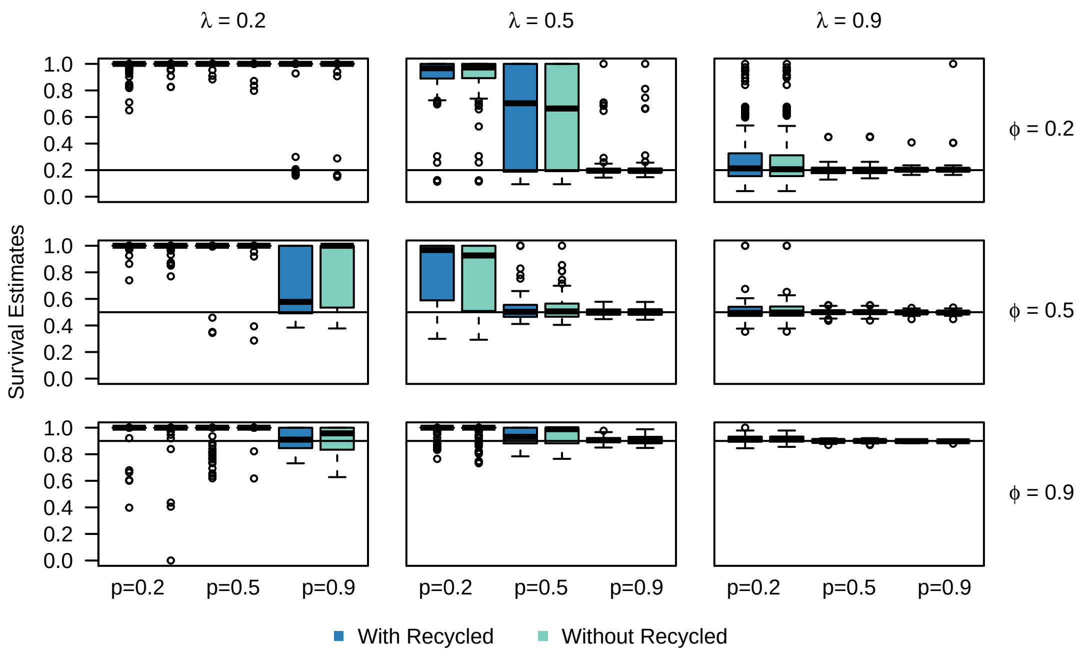


Figure A2: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.

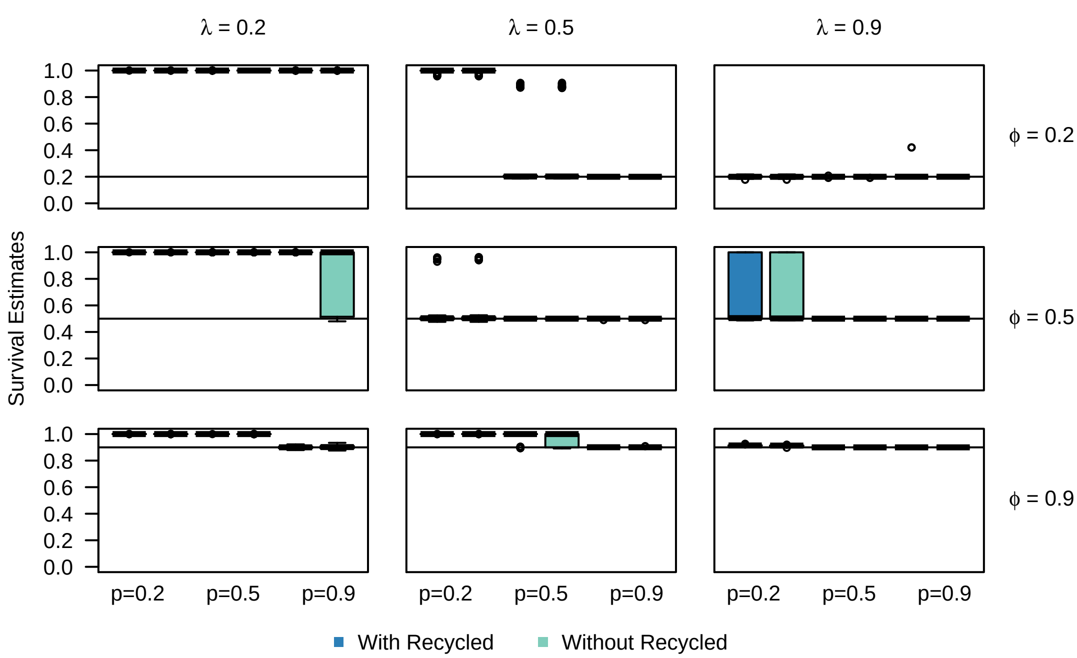


Figure A3: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.

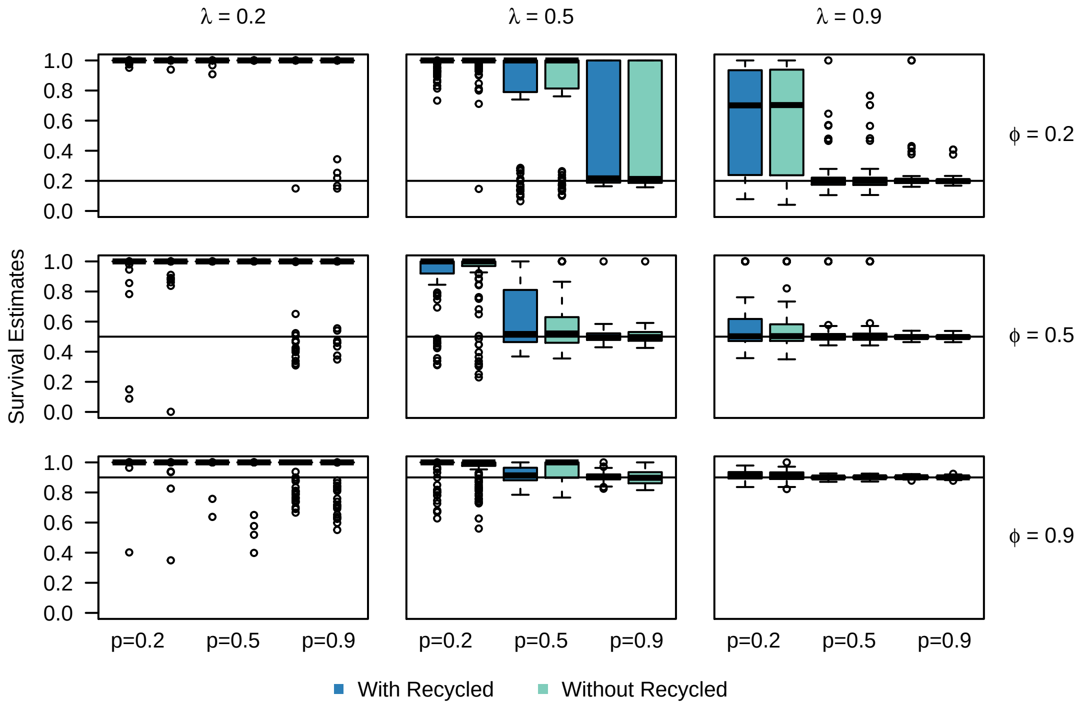


Figure A4: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.

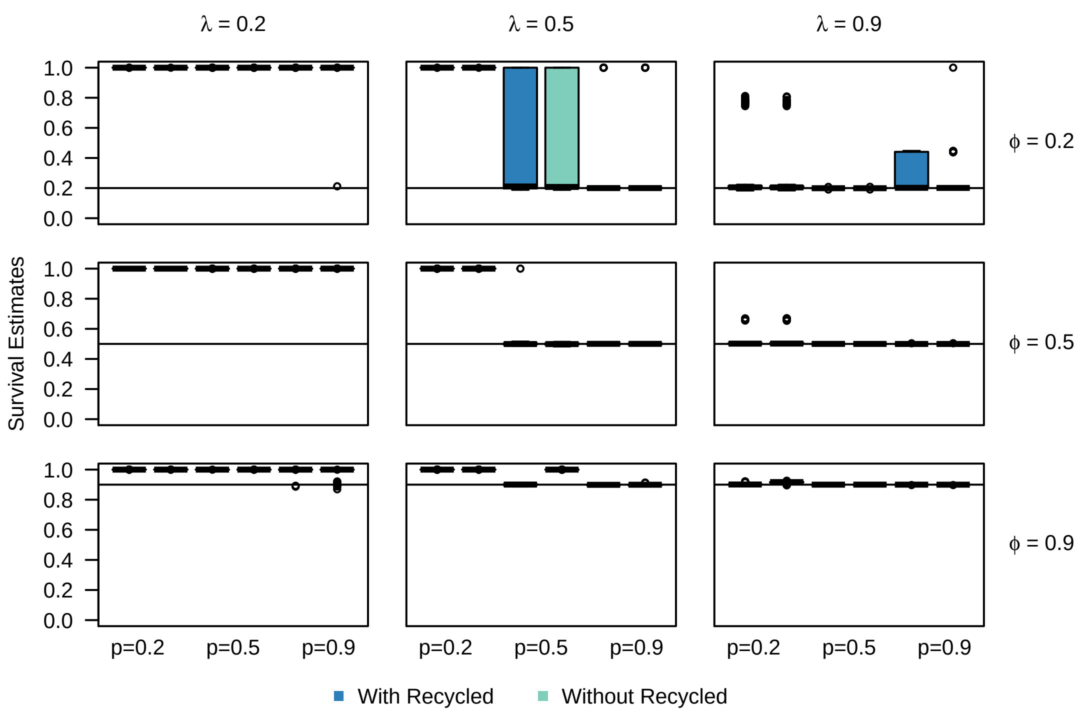


FIGURE A5: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 5 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.

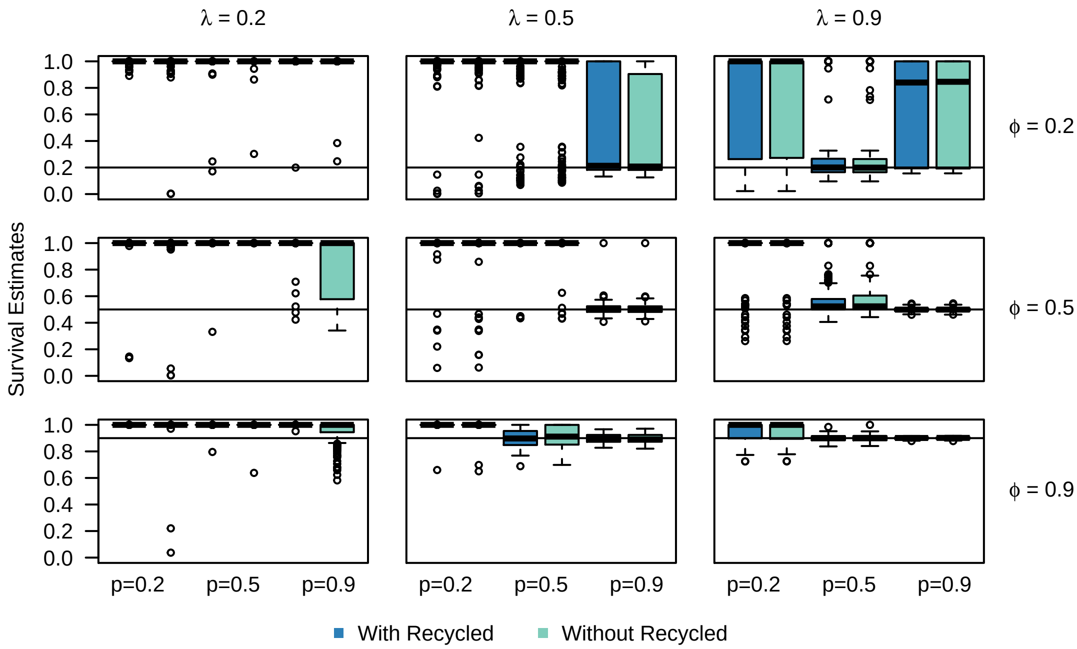
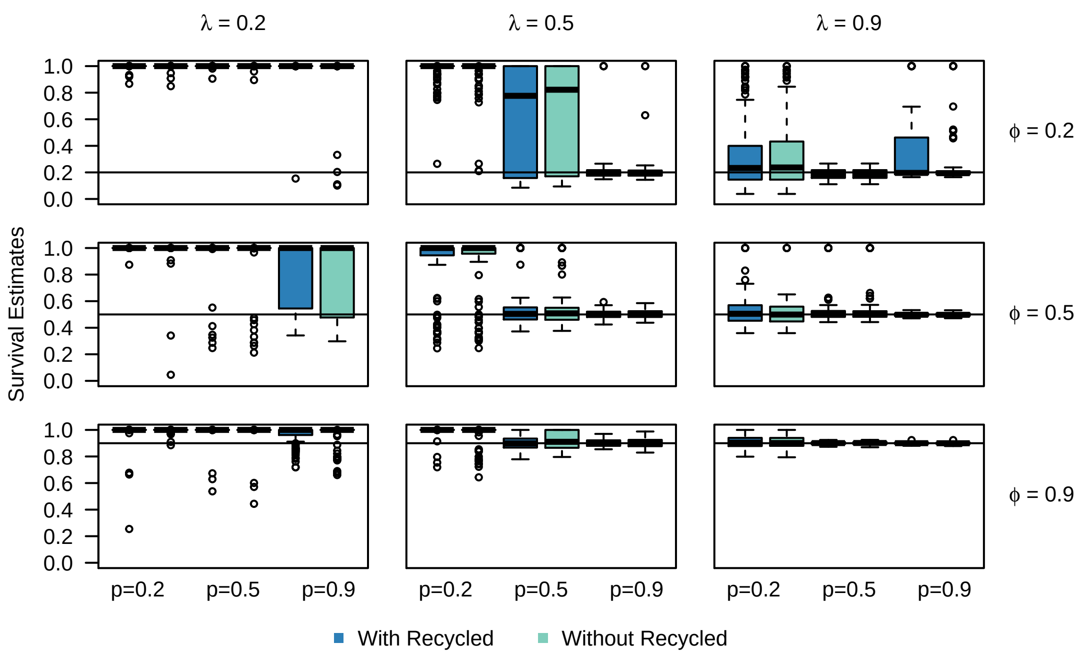


FIGURE A6: Boxplots of survival estimates ($\hat{\phi}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 7 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of ϕ used to simulate the data for each model.



Capture Estimates

Figure A7: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.

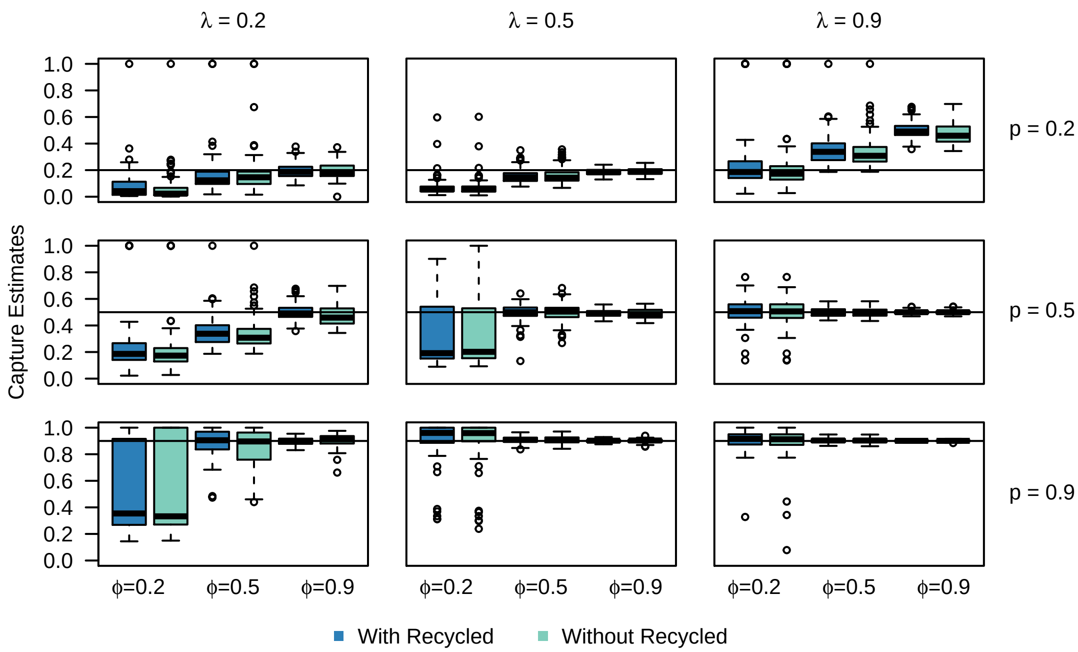


Figure A8: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.

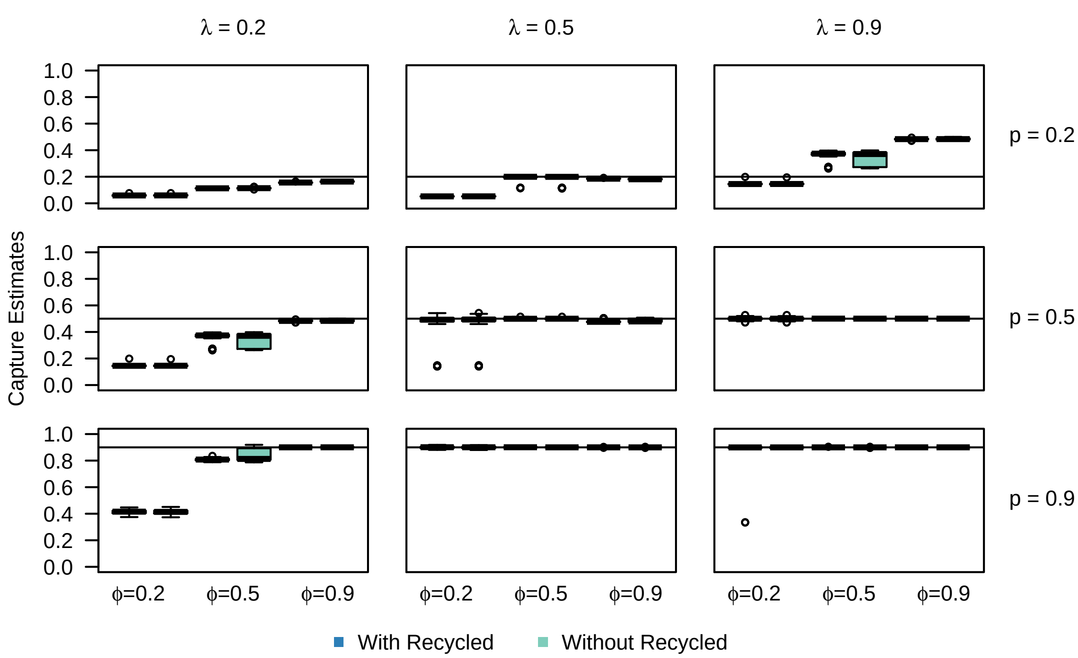


Figure A9: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.

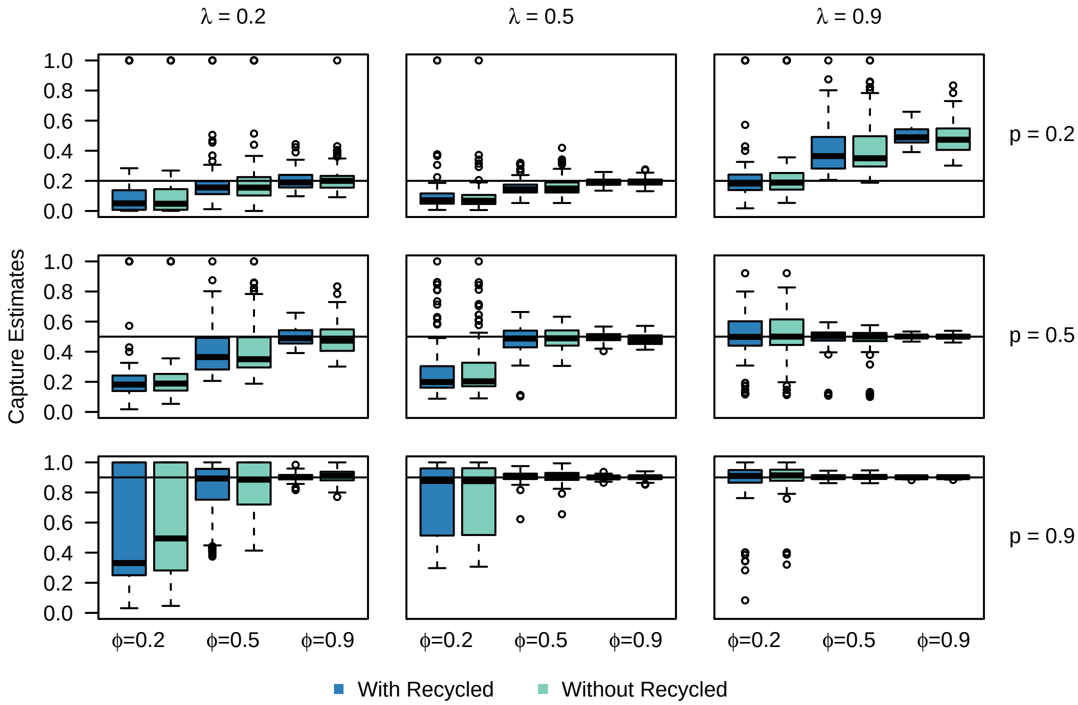


Figure A10: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.

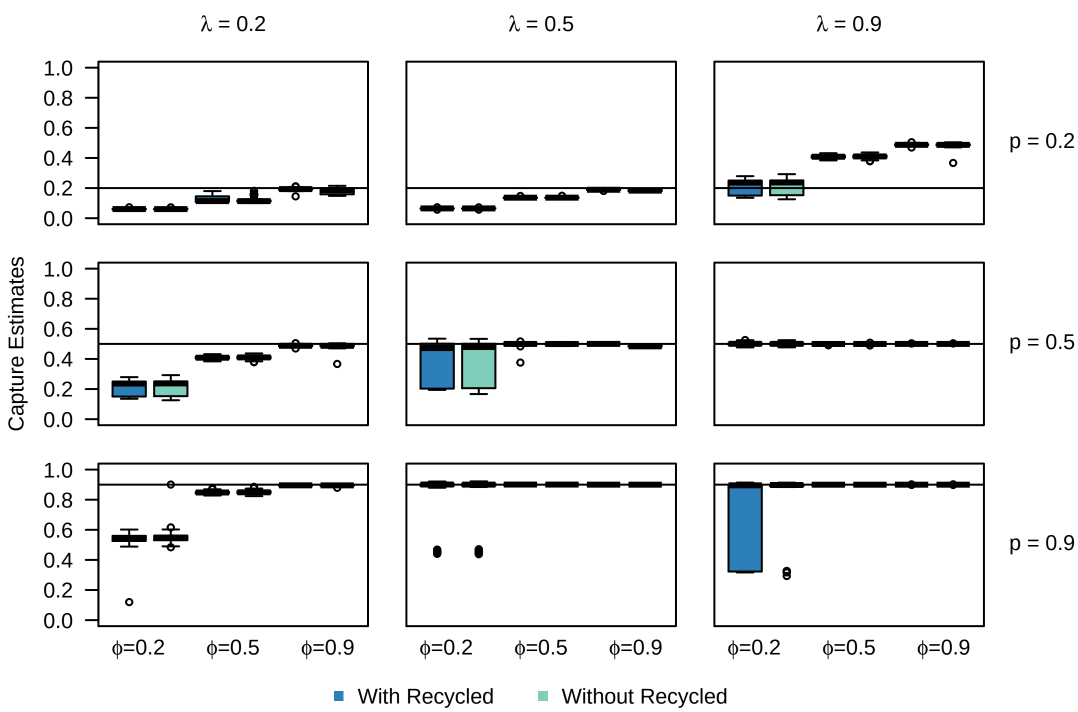


FIGURE A11: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 5 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.

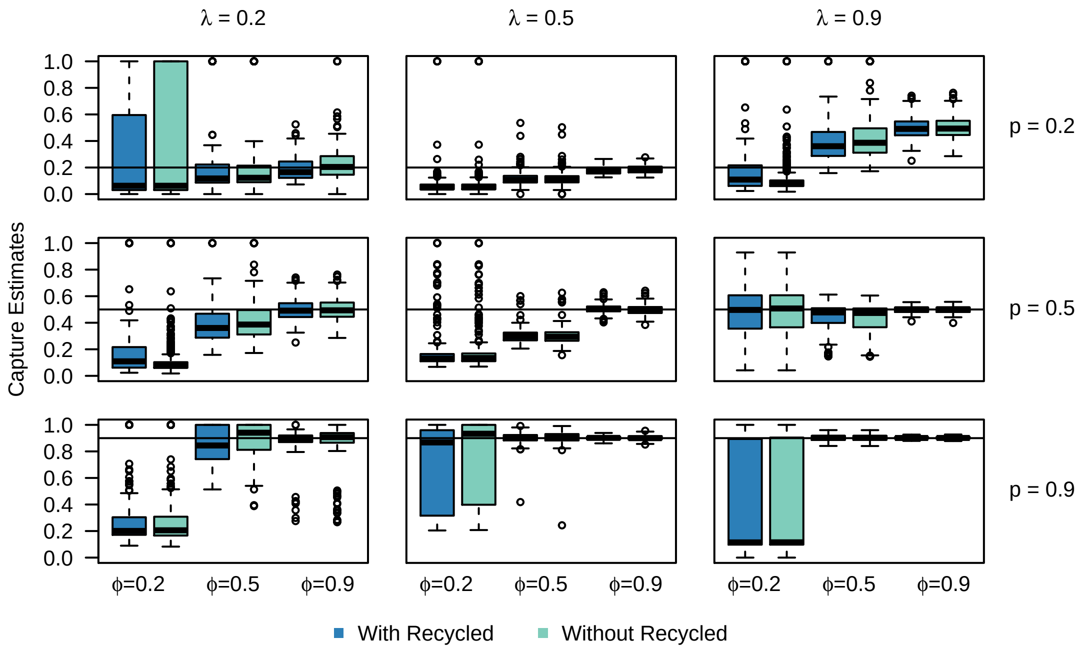
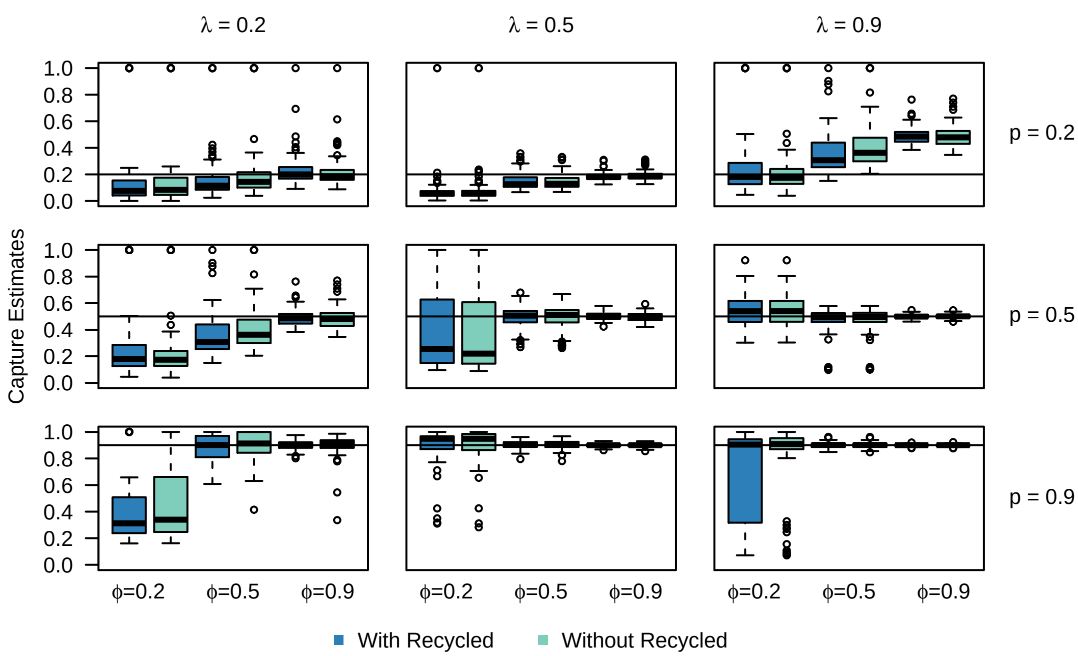


FIGURE A12: Boxplots of capture estimates ($\hat{p}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 7 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of p used to simulate the data for each model.



Tag Retention Estimates

FIGURE A13: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.

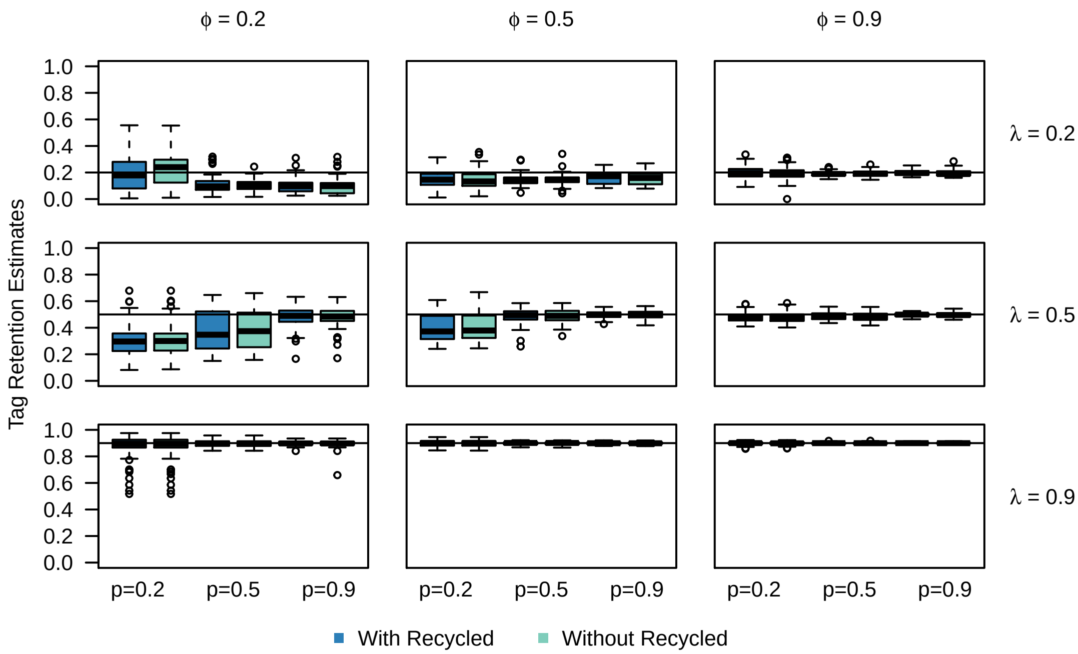


FIGURE A26: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.

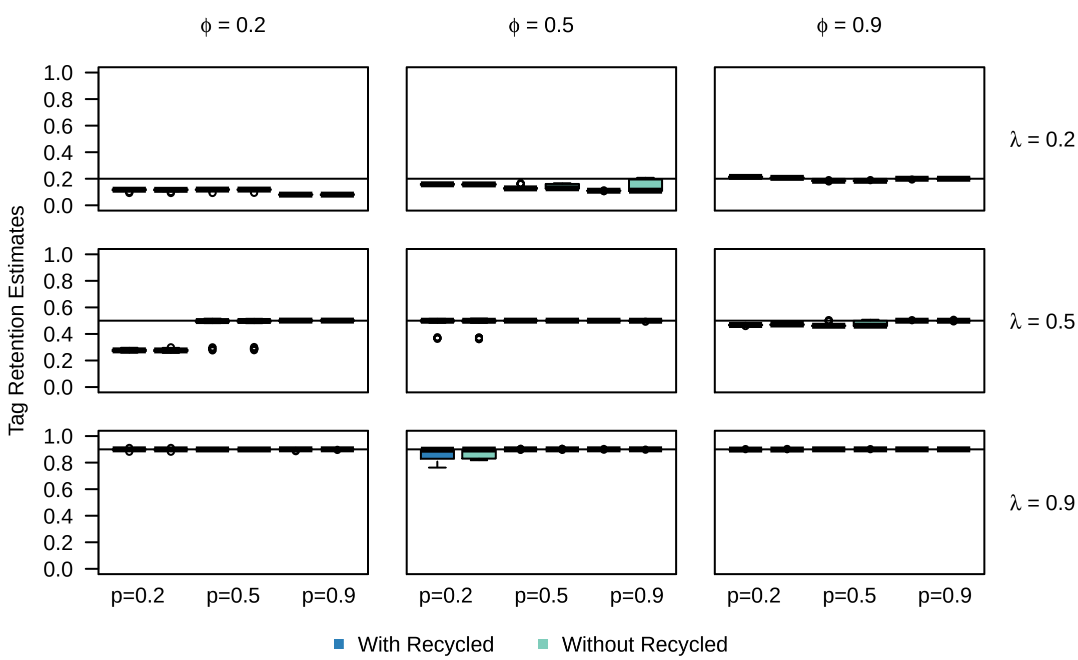


Figure A15: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.

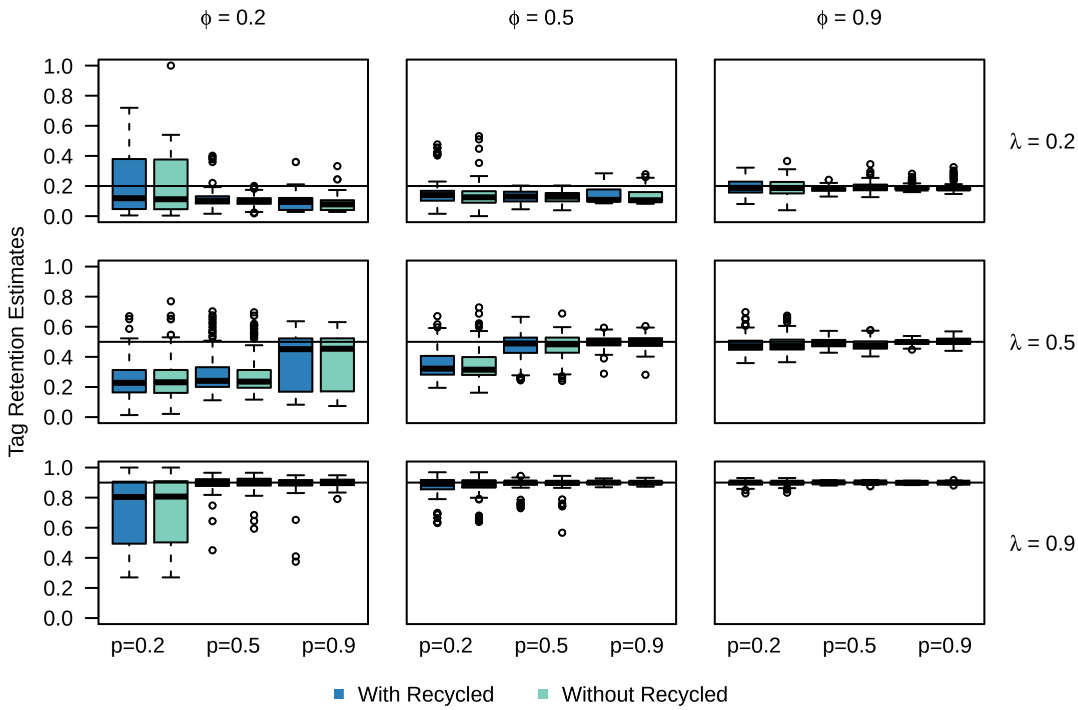


Figure A16: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.

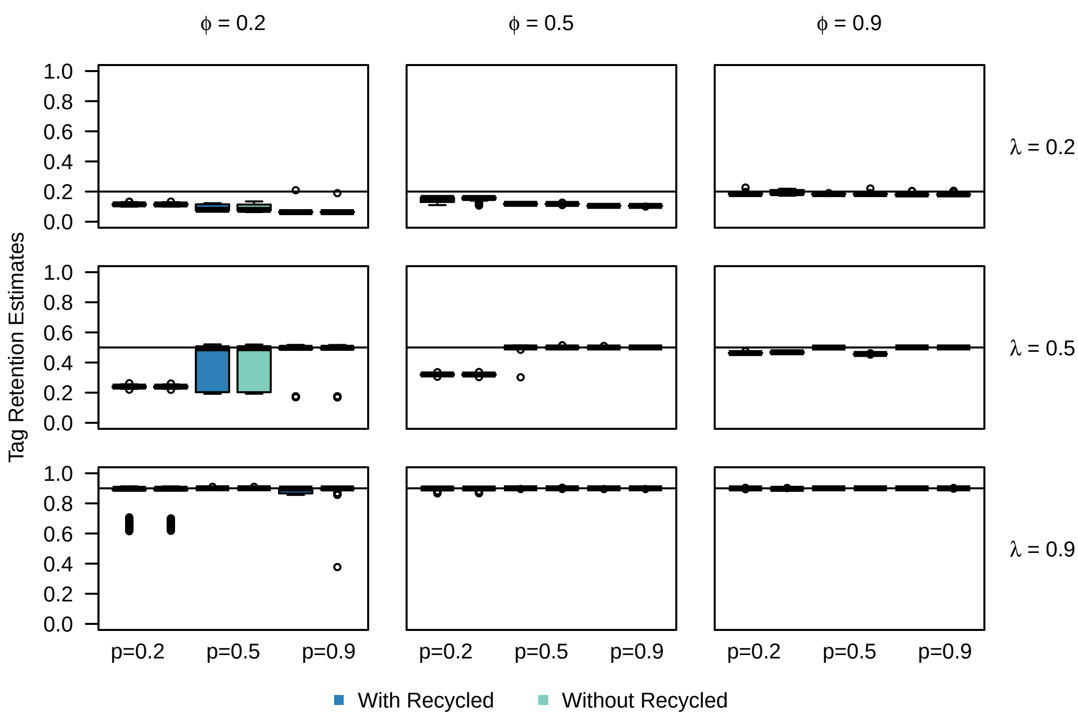


Figure A17: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 5 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.

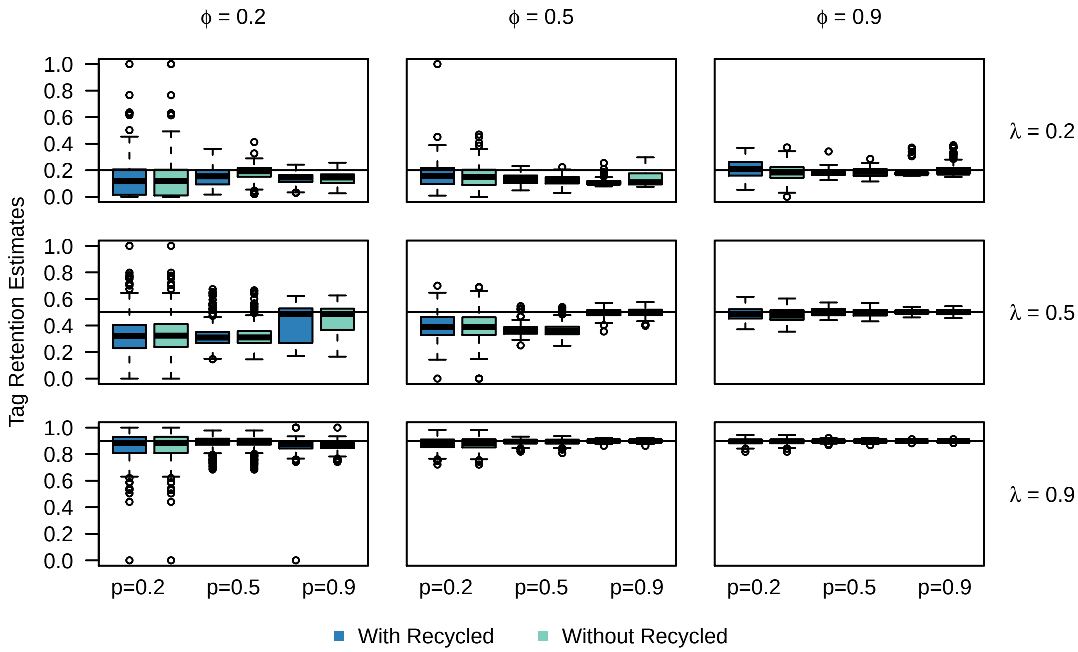
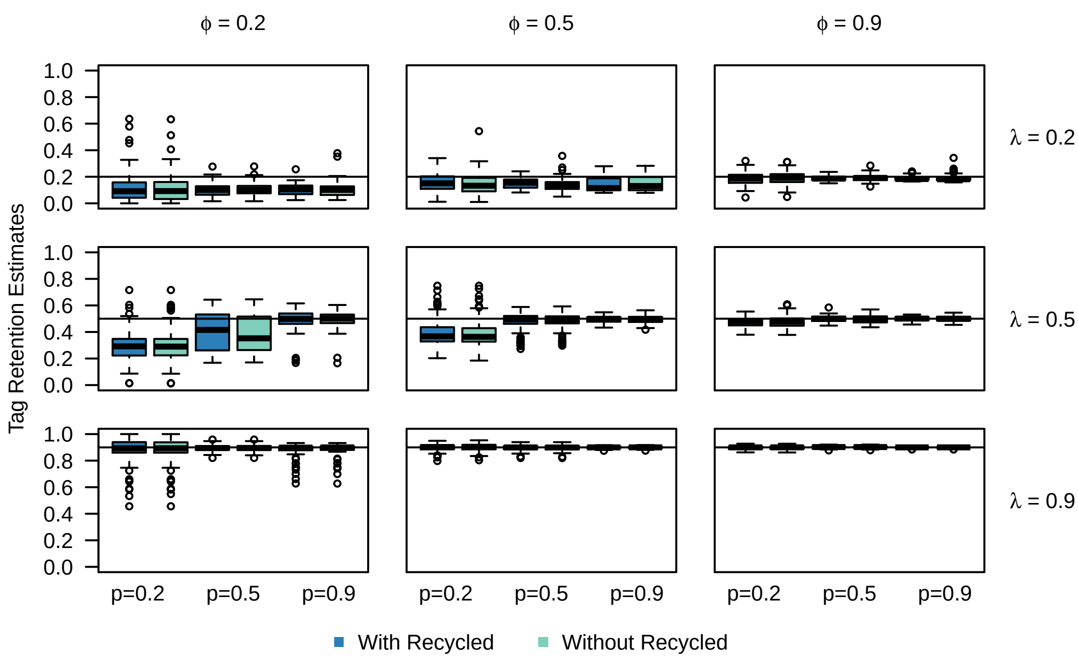


Figure A18: Boxplots of tag retention estimates ($\hat{\lambda}$) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 7 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of λ used to simulate the data for each model.



Super-Population Size Estimates

FIGURE A19: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.

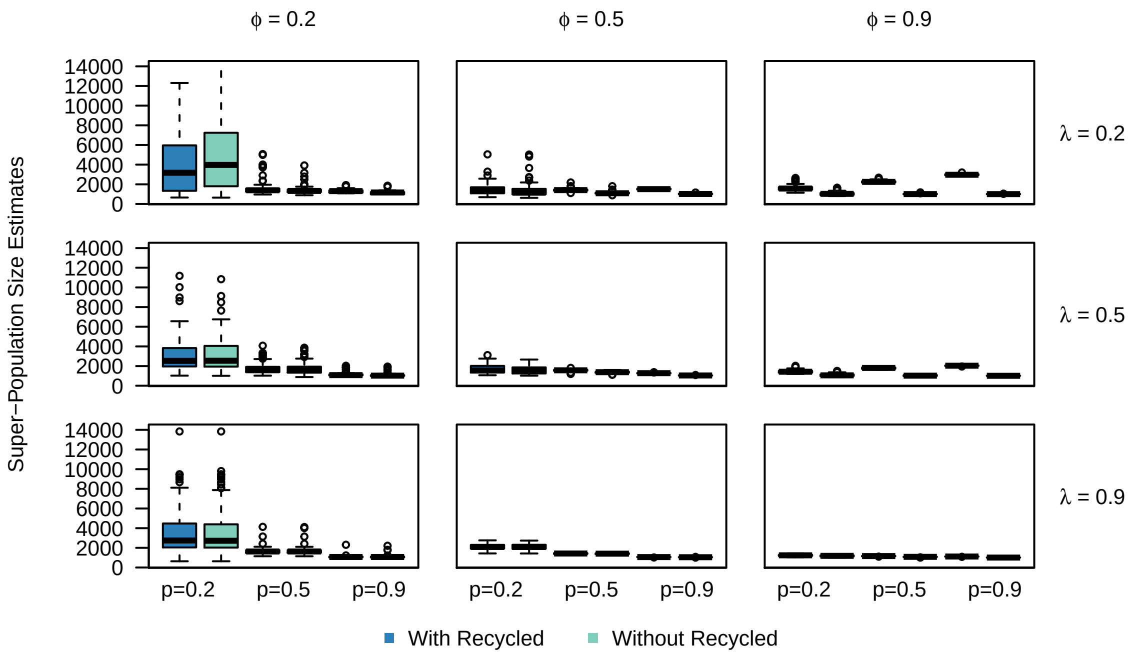


FIGURE A20: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 1$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.

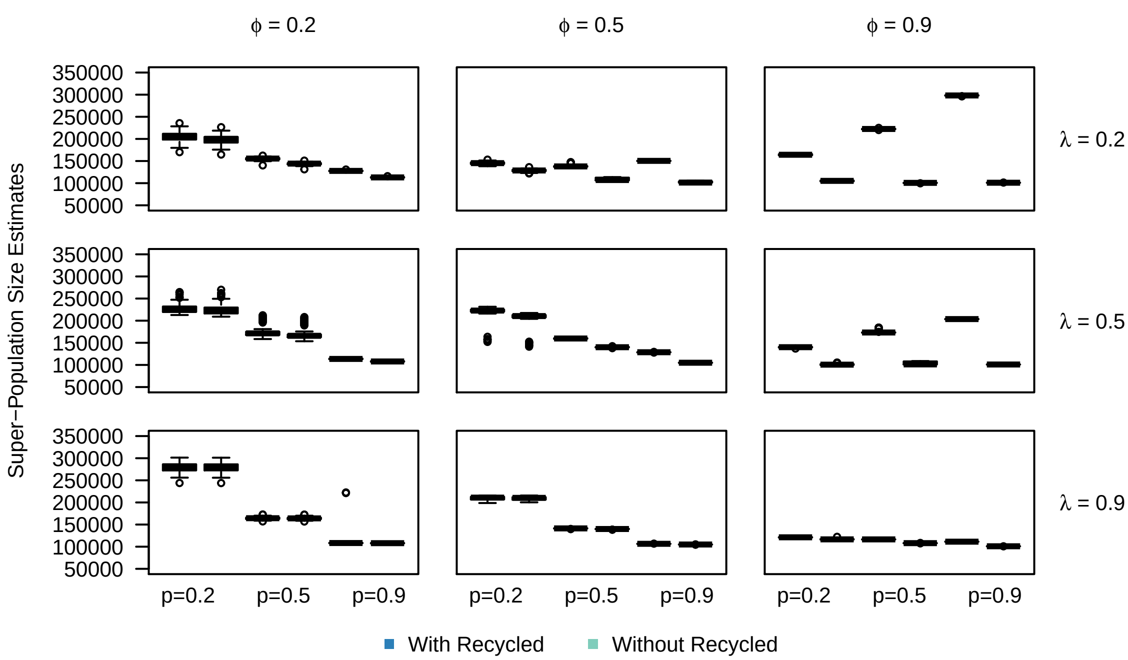


FIGURE A21: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.

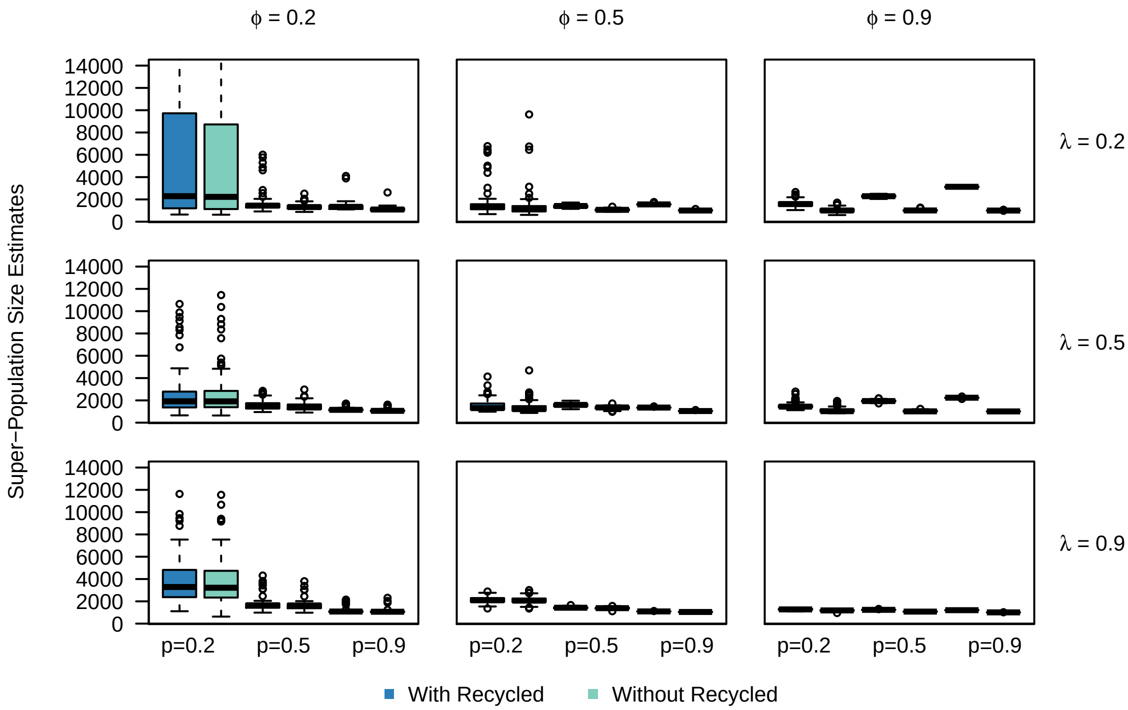


FIGURE A22: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with $T_2 = 0.5$ with 10 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.

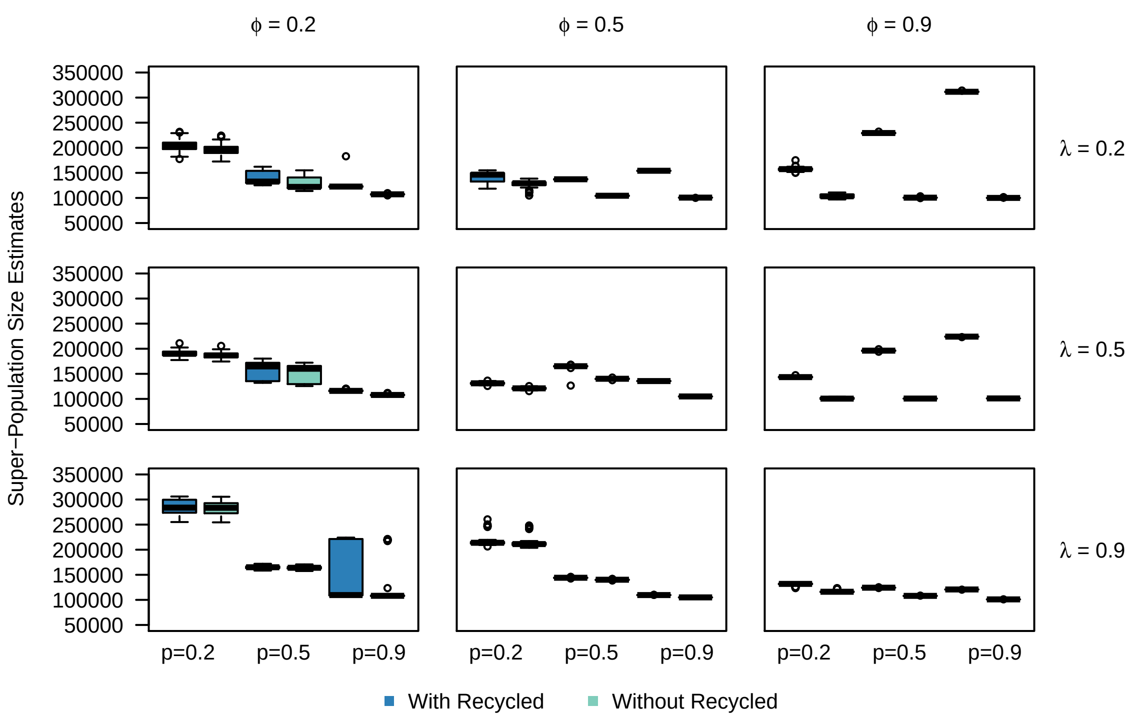


FIGURE A23: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 5 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.

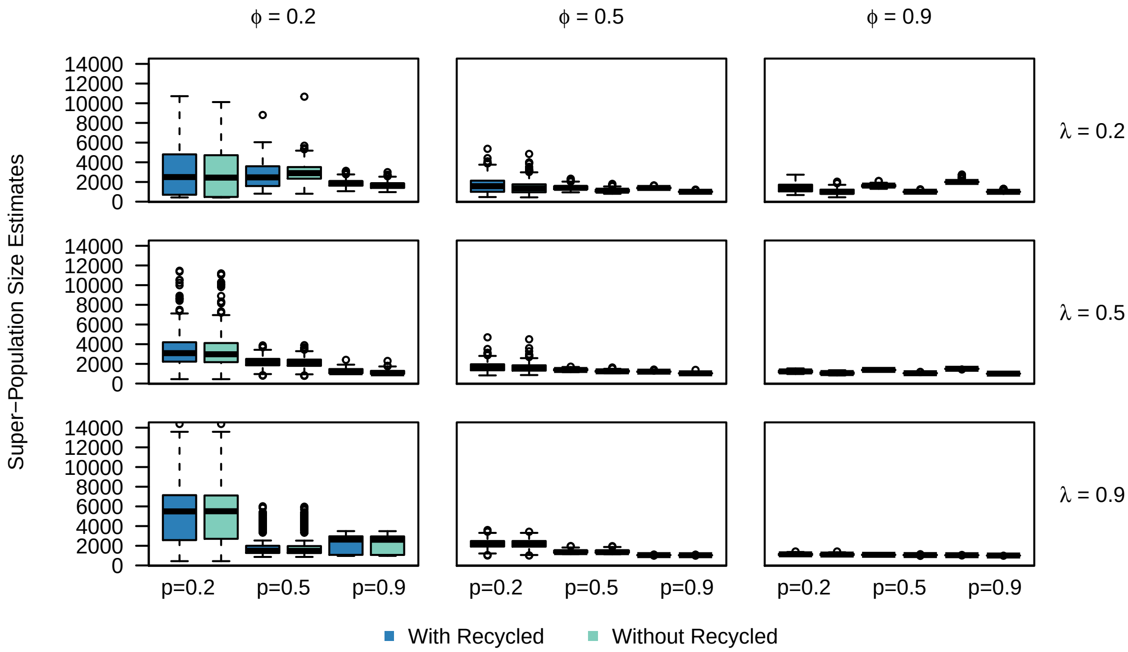
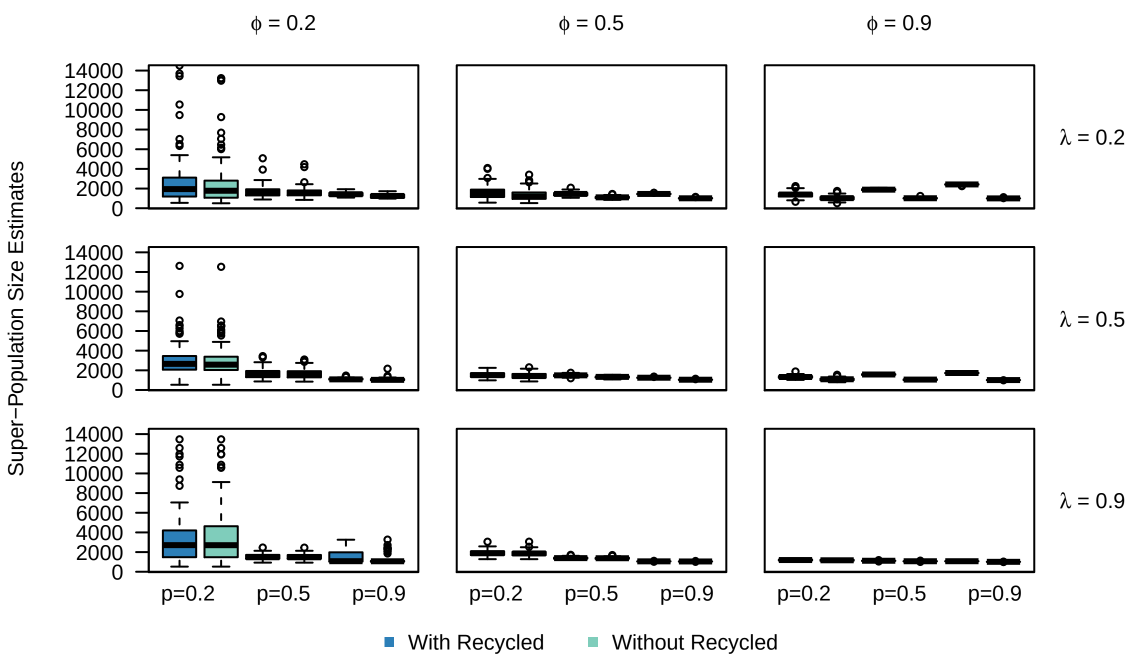


FIGURE A24: Boxplots of super-population size estimates (N) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with $T_2 = 1$ for 7 time periods for varying survival ($\phi = 0.2, 0.5, 0.9$), capture ($p = 0.2, 0.5, 0.9$), and tag retention ($\lambda = 0.2, 0.5, 0.9$) probabilities. The black line indicates the true value of N used to simulate the data for each model.



Abundance Estimates

FIGURE A25: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 10 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

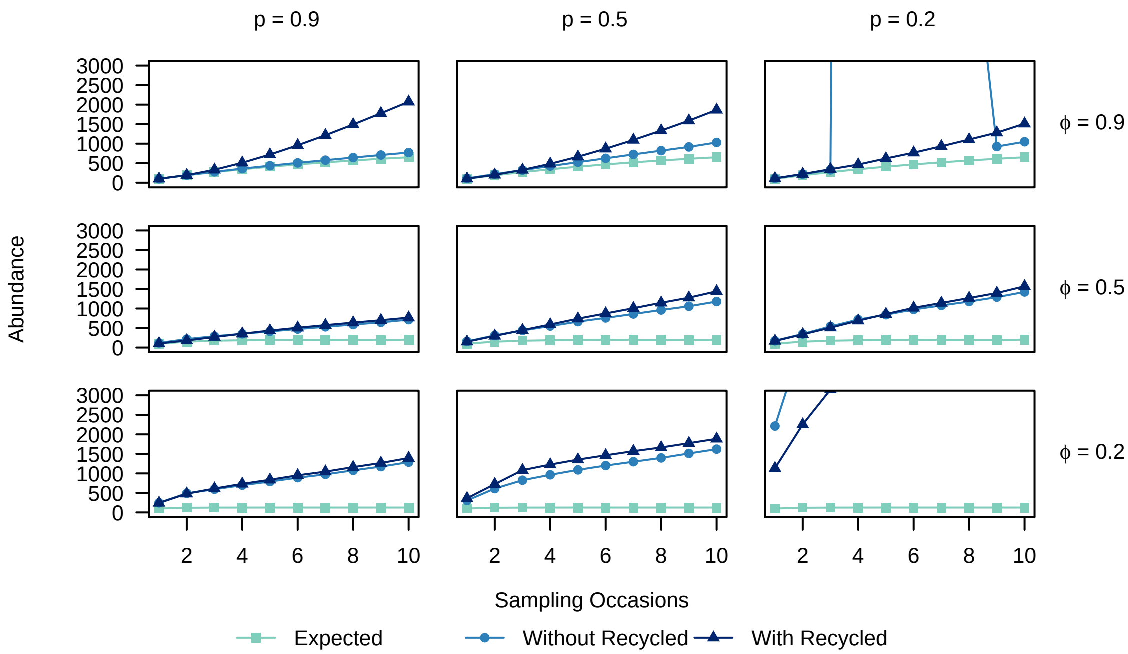


FIGURE A26: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 1$ with 10 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

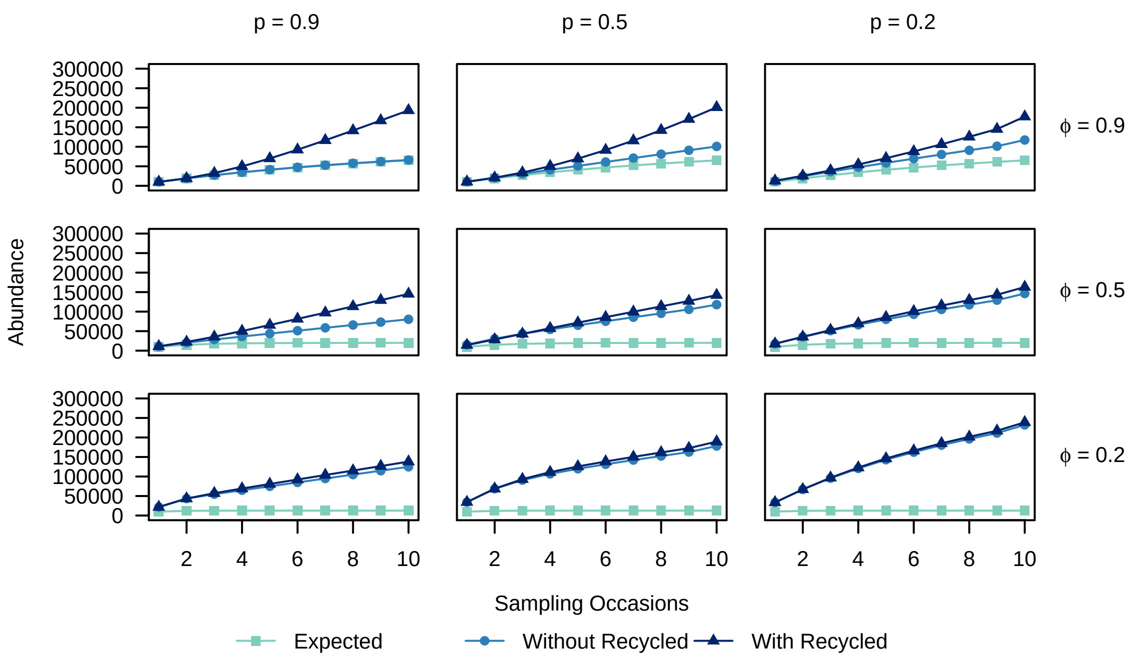


FIGURE A27: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 0.5$ with 10 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

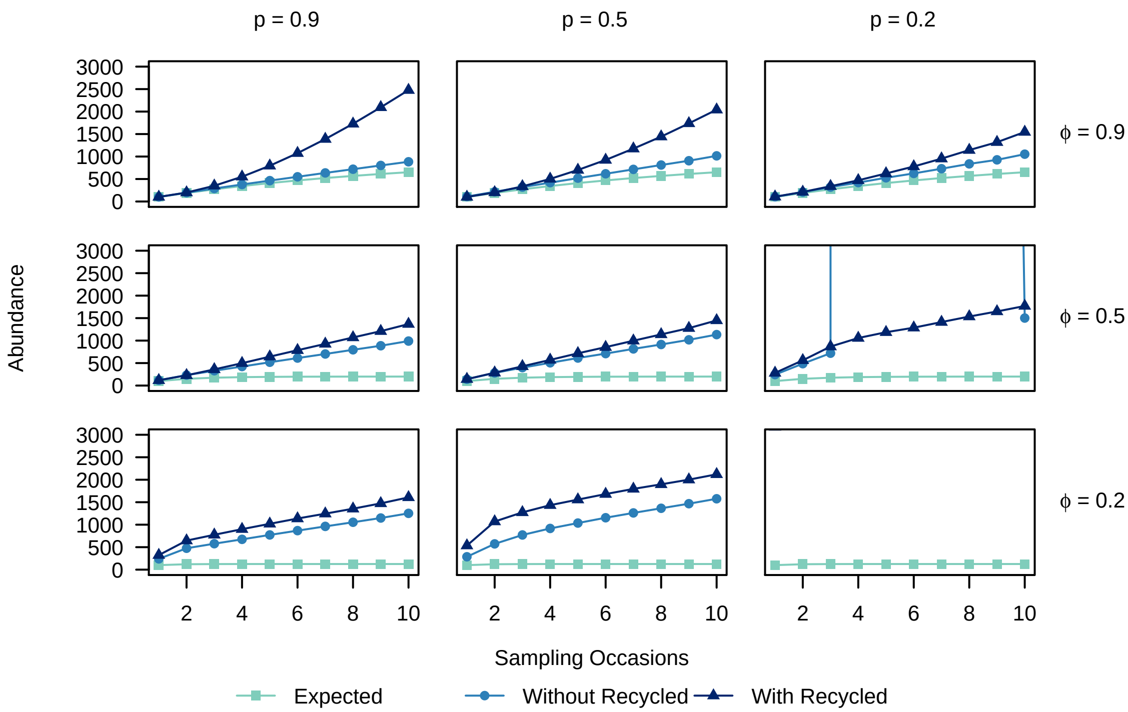


FIGURE A28: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 0.5$ with 10 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

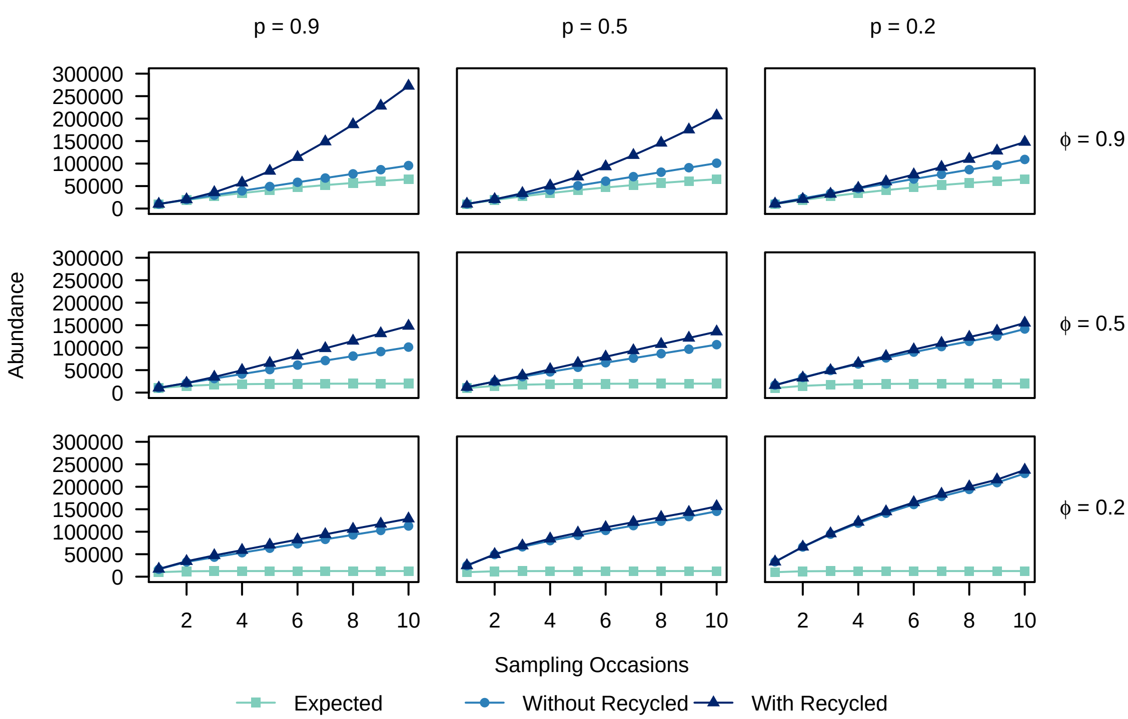


Figure A29: Mean abundance estimates (N_j's) for each sample time ($k = 5$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 5 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

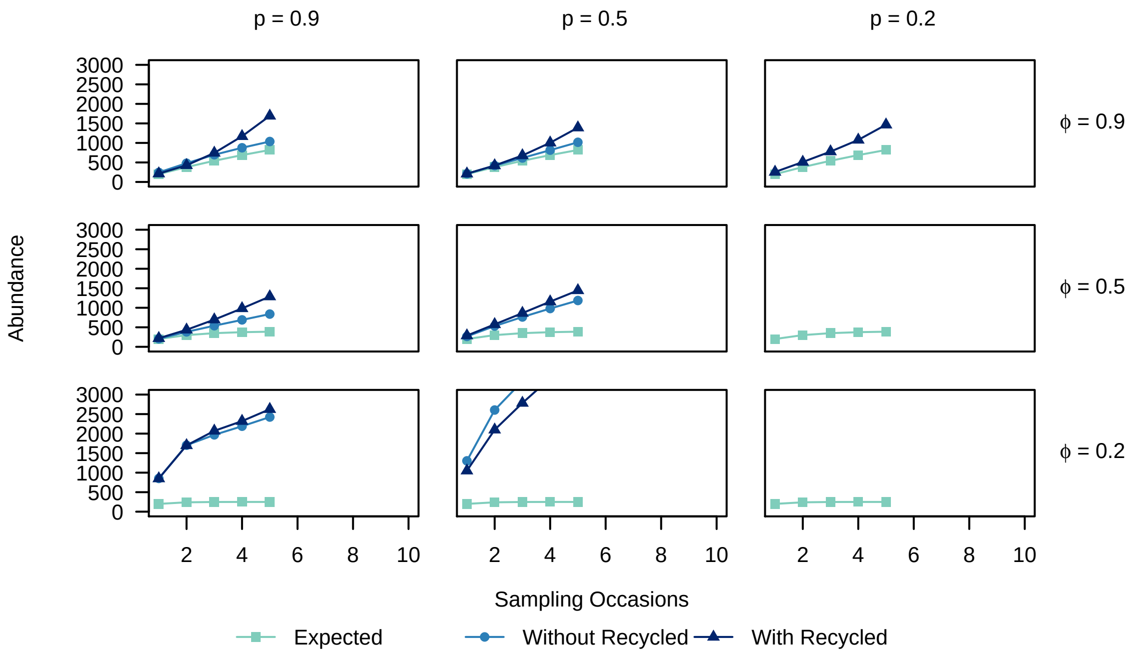


Figure A30: Mean abundance estimates (N_j's) for each sample time ($k = 7$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 7 time periods for low tag retention ($\lambda = 0.2$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

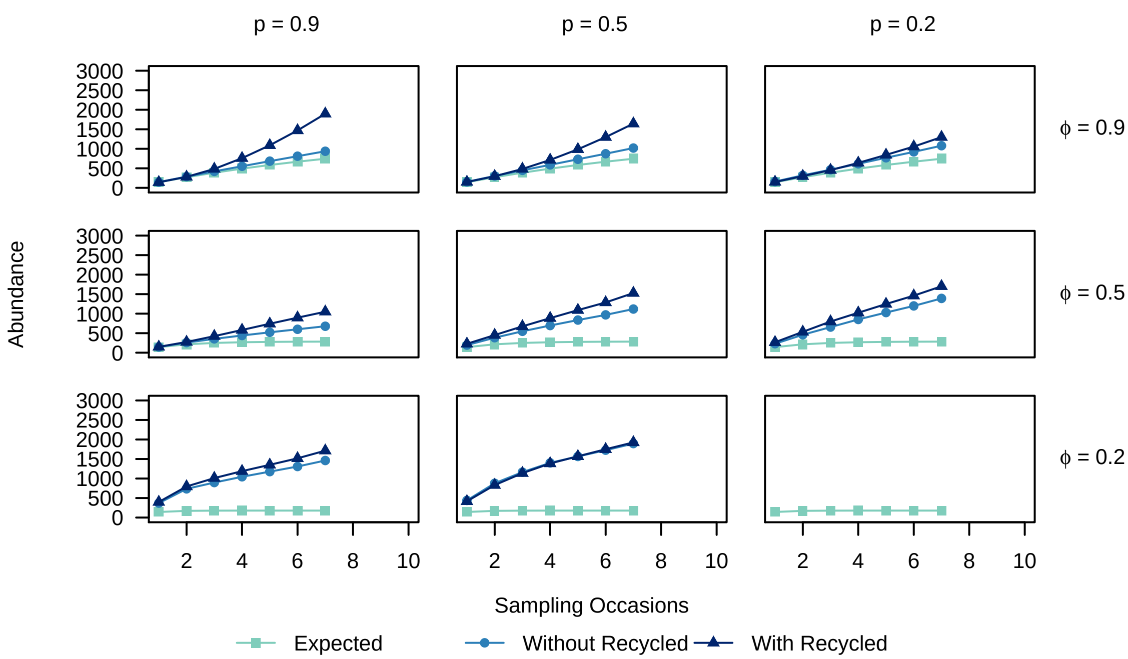


FIGURE A31: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 10 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

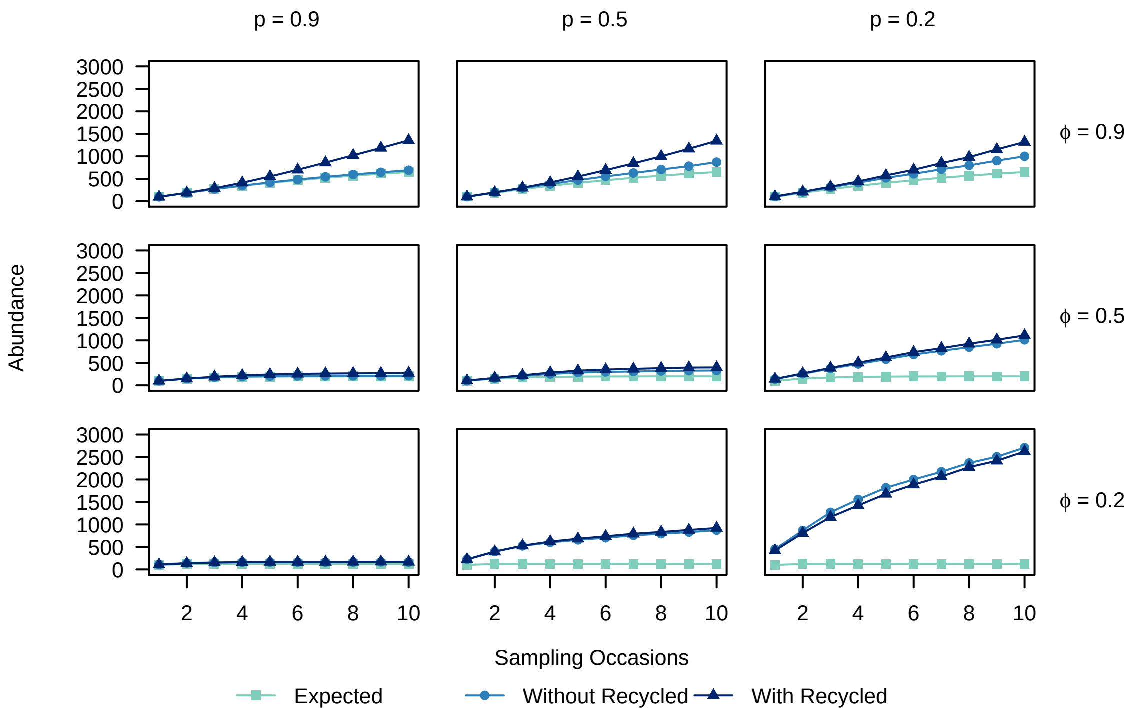


FIGURE A32: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 1$ with 10 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

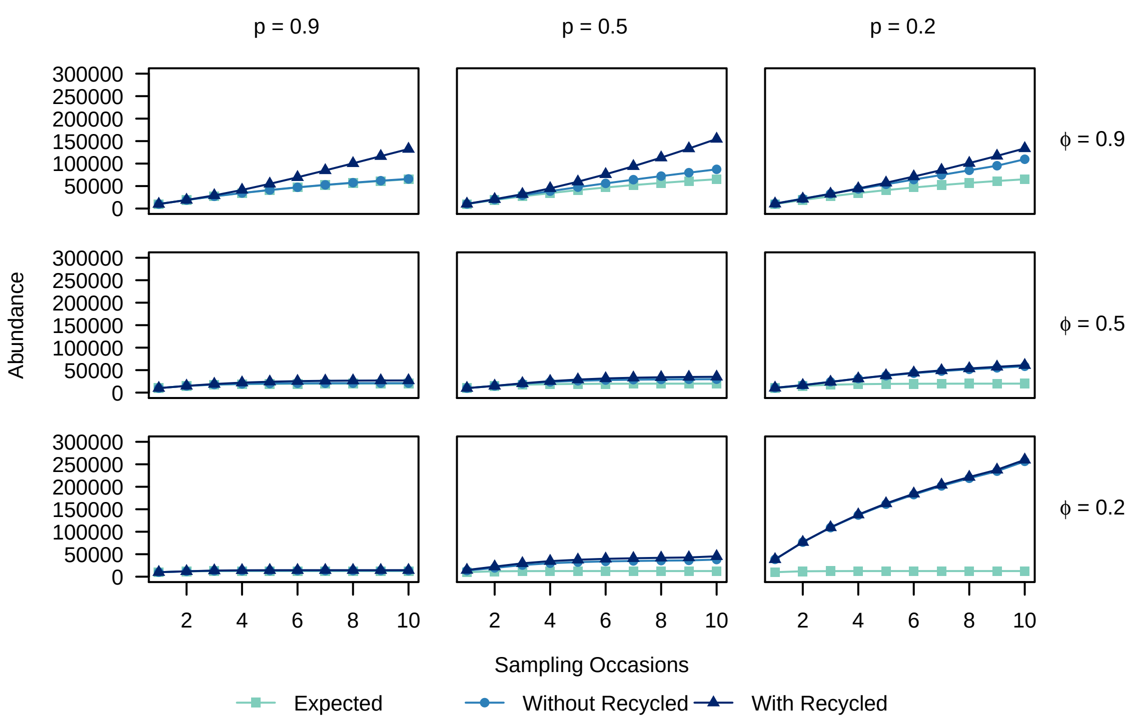


FIGURE A33: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 0.5$ with 10 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

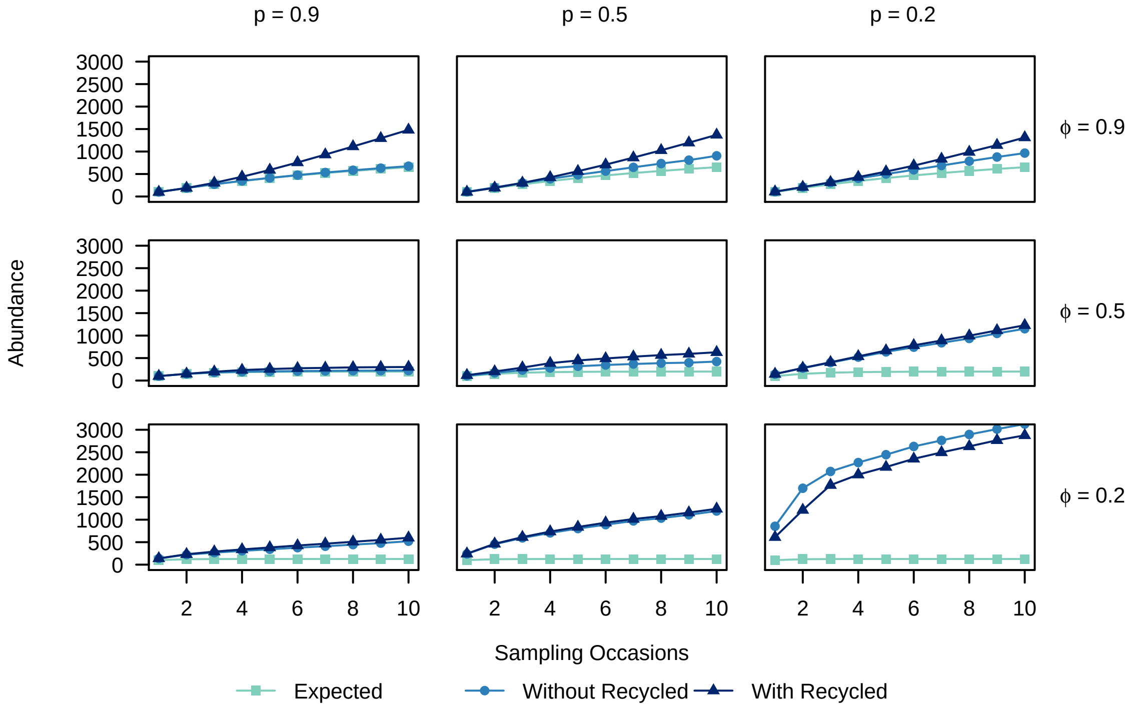


FIGURE A34: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 0.5$ with 10 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

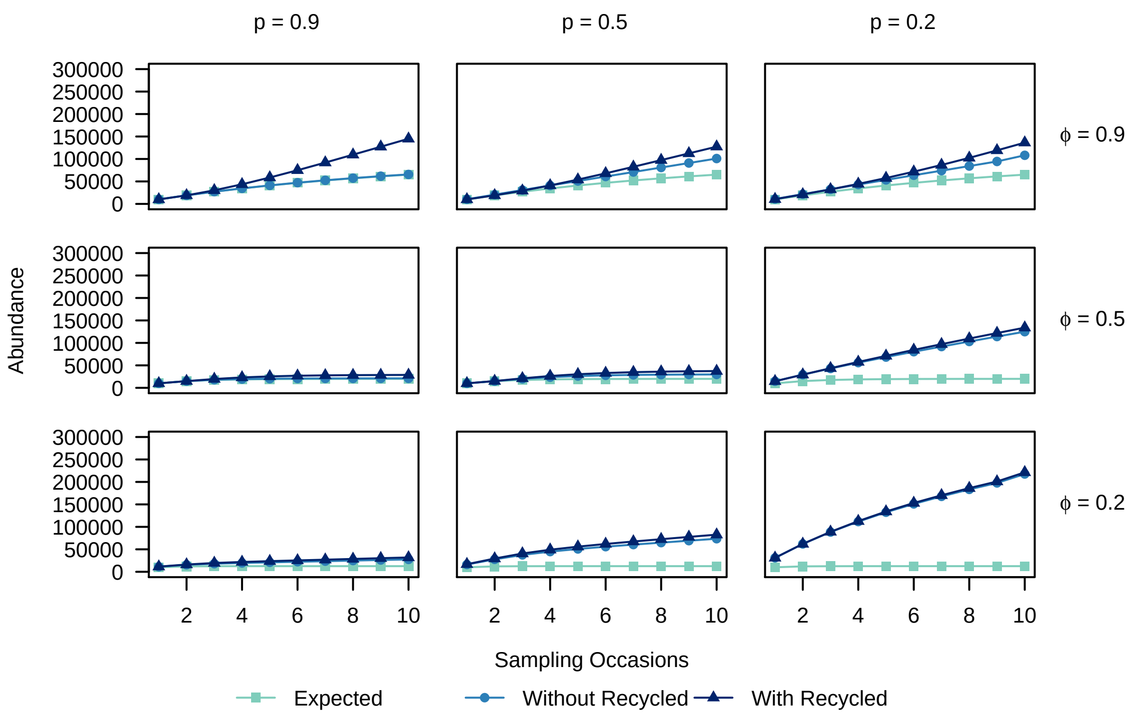


Figure A35: Mean abundance estimates (N_j's) for each sample time ($k = 5$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 5 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

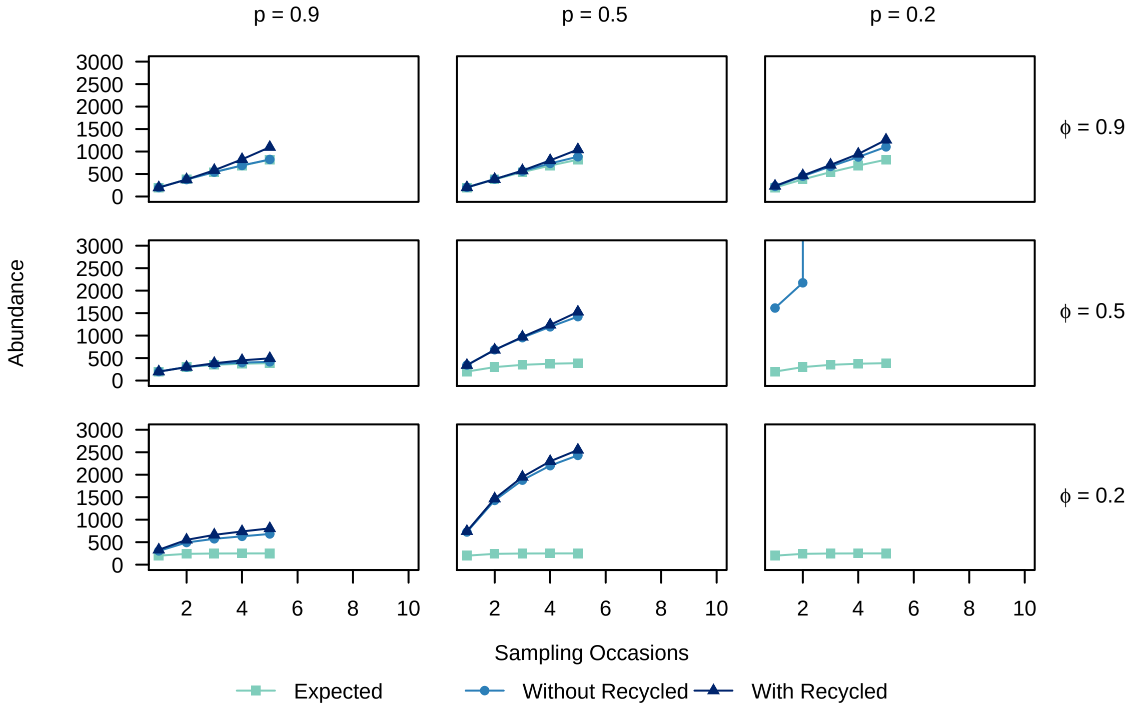


Figure A36: Mean abundance estimates (N_j's) for each sample time ($k = 7$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 7 time periods for medium tag retention ($\lambda = 0.5$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

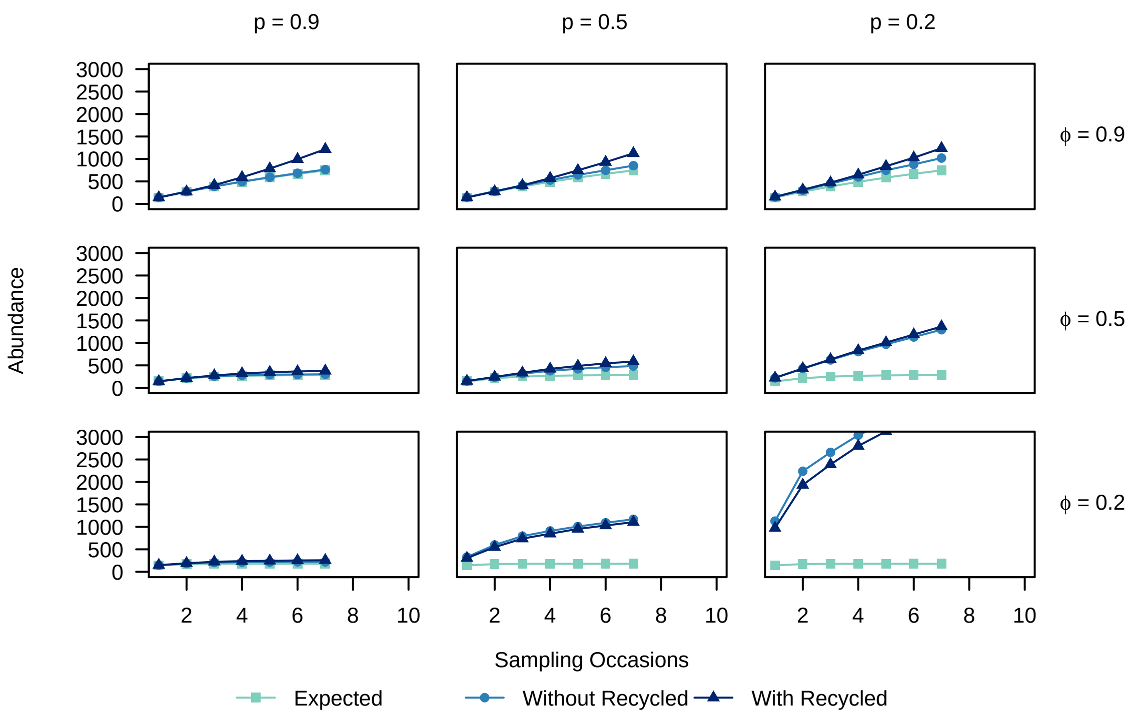


Figure A37: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 10 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

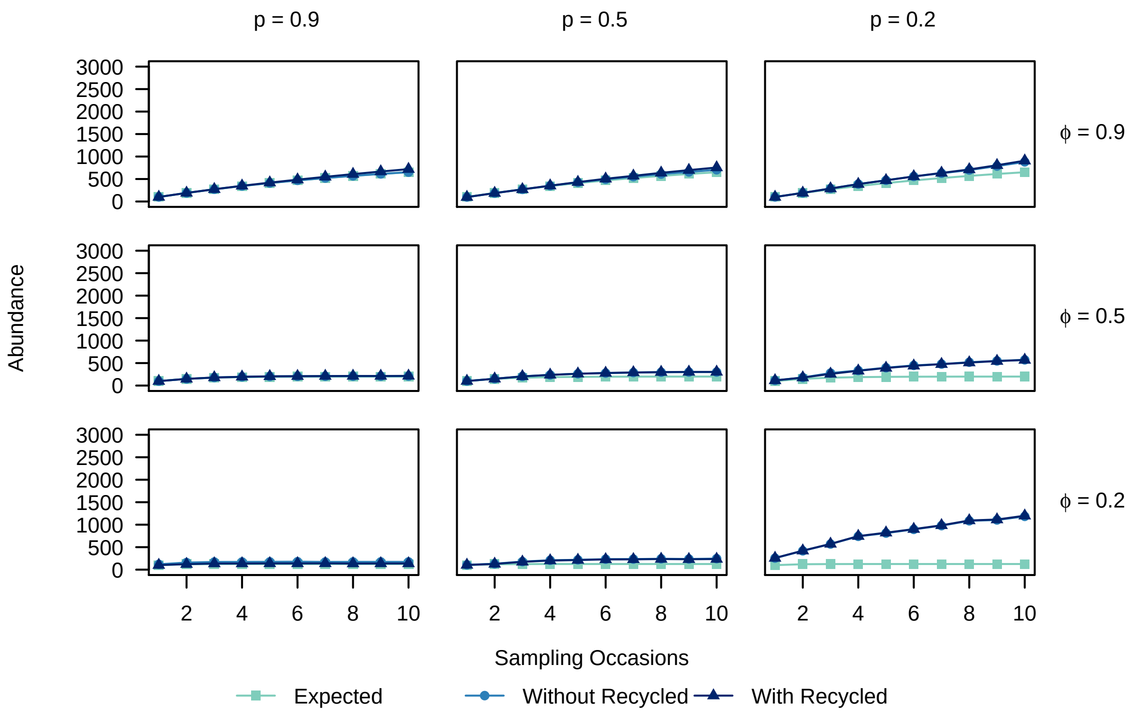


Figure A38: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 1$ with 10 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

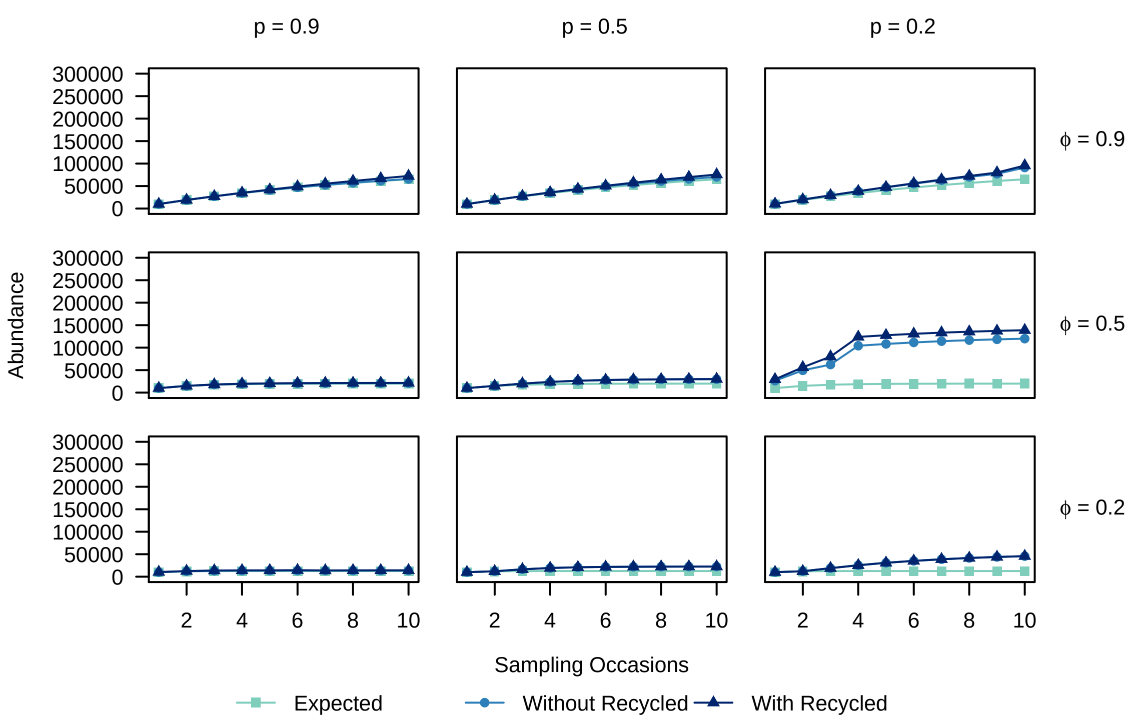


FIGURE A39: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 0.5$ with 10 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

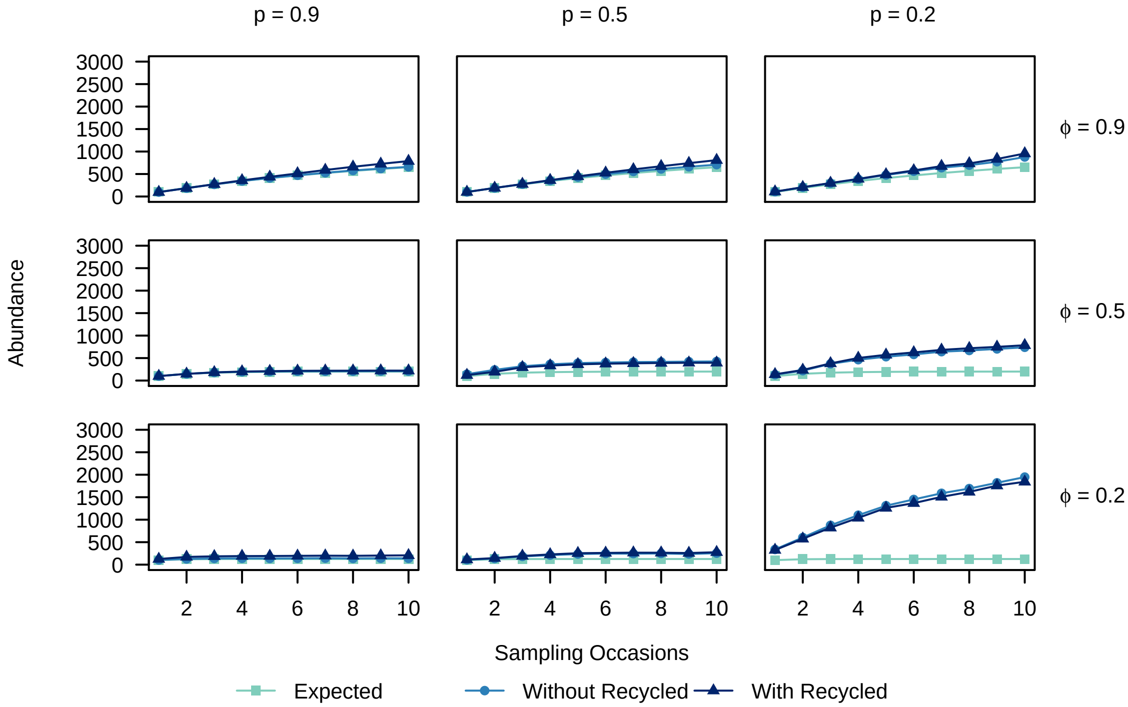


FIGURE A40: Mean abundance estimates (N_j's) for each sample time ($k = 10$) between analysis with and without recycled individuals with population size $N = 100000$ with $T_2 = 0.5$ with 10 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

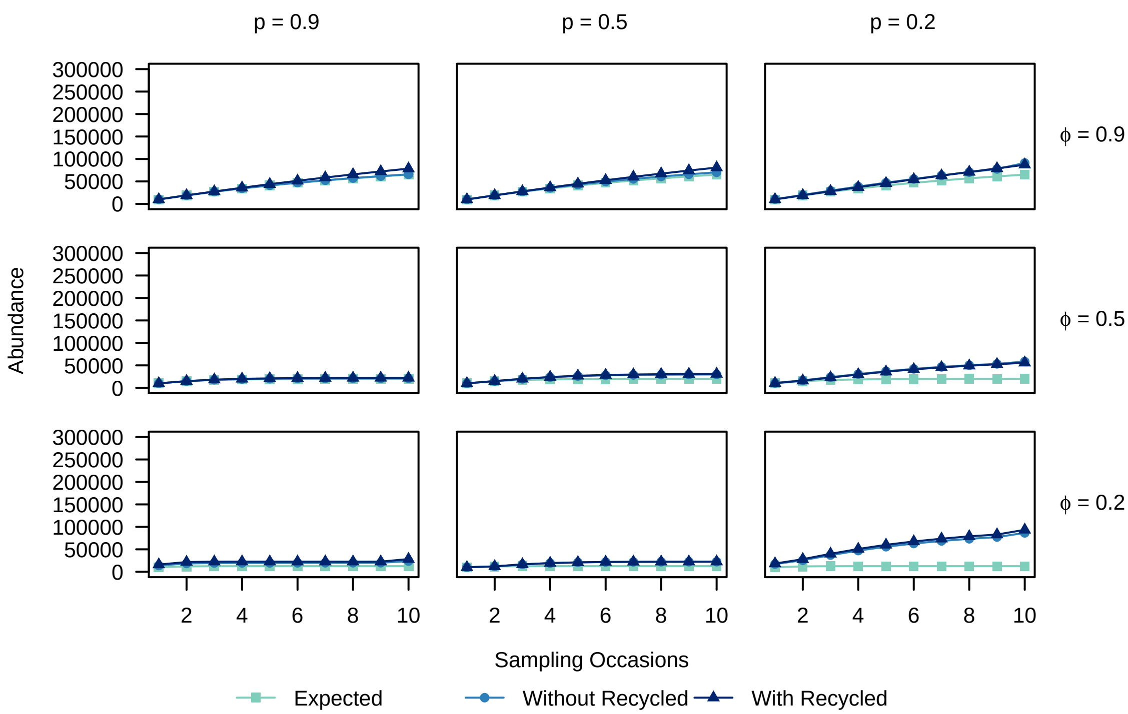


Figure A41: Mean abundance estimates (N_j's) for each sample time ($k = 5$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 5 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).

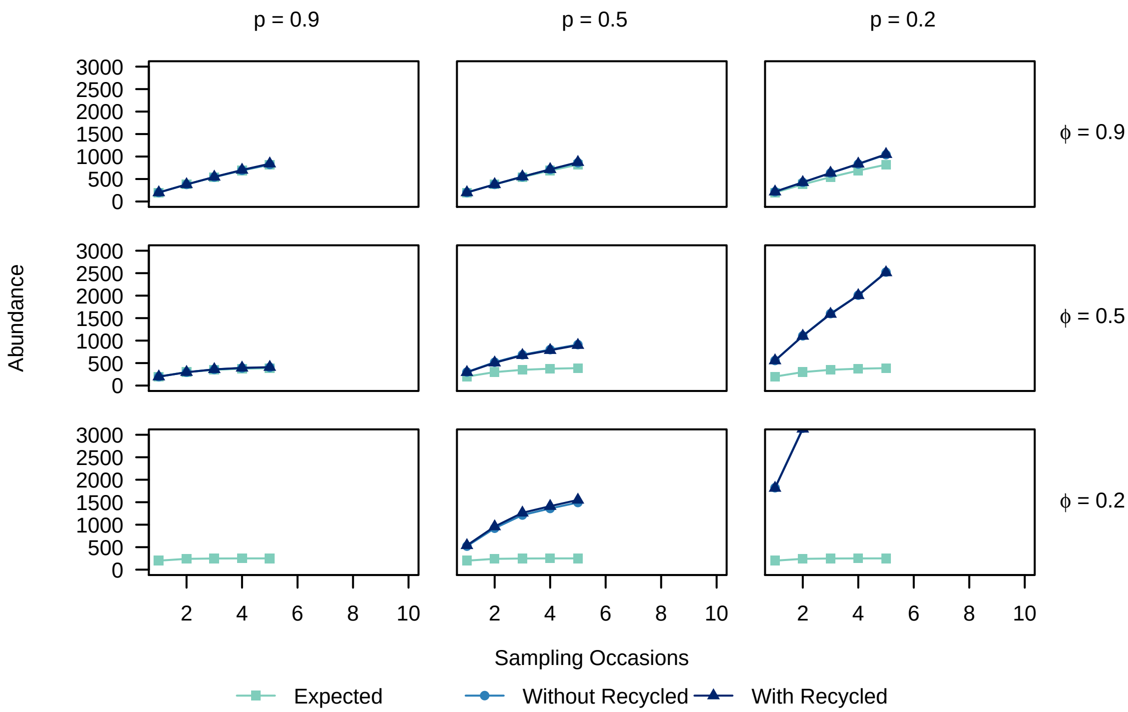


Figure A42: Mean abundance estimates (N_j's) for each sample time ($k = 7$) between analysis with and without recycled individuals with population size $N = 1000$ with $T_2 = 1$ with 5 time periods for high tag retention ($\lambda = 0.9$), varying survival probabilities ($\phi = 0.2, 0.5, 0.9$) and varying capture probabilities ($p = 0.2, 0.5, 0.9$).