

# Web-based Supplementary Materials for The Effect of Recycled Individuals in the Jolly-Seber Tag Loss Model

## Web Appendix A: The Jolly-Seber Tag Loss Model

### Assumptions

Assumptions of the JSTL model with constant survival, capture, and tag retention probabilities and time-varying entry probabilities are as follows:

- The effect of recycled individuals is negligible
- All individuals (marked and unmarked) are equally catchable, and that capture probabilities for all individuals are the same for all individuals at all sample time
- All individuals (marked and unmarked) have equal survival probabilities between all sample times
- All individuals have equal entry (birth or immigration) probabilities, but entry probabilities can vary between sample times
- All marked individuals have equal tag retention probabilities between all sample times
- For double-tagged individuals, tag loss is independent between tags
- There is independence across all individuals
- The sampling period is relatively short compared to the interval between sampling times

### Notation

We use the following notation to describe the statistics or model parameters discussed in this study.

- $k =$  number of sample times
- $n_{\text{obs}} =$  the total number of individuals captured with no tags and treated as new individuals; when no recycling is present,  $n_{\text{obs}}$  is the number of unique individuals observed throughout the study
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- $p =$  the probability that an individual is recaptured at a sample time given that the individual was alive at the previous sample time
- $\phi =$  the probability that an individual survives and remain in the population between a sample time and the next sample time
- $b_j =$  the probability that an individual enters the system between sample times  $j$  and  $j + 1$ .  $j = 0, 1, \dots, k - 1$ .  $b_0$  is the expected fraction of individuals alive just prior to the first sample time.
- $v =$  the probability that an individual captured will be lost on capture
- $T_d =$  the probability that an individual is marked with  $d$  tags. Note that the probability of marking with a single tag is one minus the probability of marking with a double tag:  $T_1 = 1 - T_2$
- $\lambda =$  the probability that an individual captured will retain its tag between time periods given that it remains alive
- $N =$  super-population size, the total number of individuals ever present in population and available for capture during the study

*Functions of Parameters:*

- $b_{j*} =$  the expected fraction of the population remaining to enter the population that enters between sample times  $j$  and  $j + 1$ ,  $j = 0, 1, \dots, k - 1$ .
- $$b_{j*} = \begin{cases} b_0 & \text{if } j = 0 \\ b_j / \sum_{u=j}^{k-1} b_u & \text{if } j = 1, \dots, k - 1 \\ 1 & \text{if } j = k - 1 \end{cases}$$
- $B_j =$  net births; the number of individuals who enter the population after sample time  $j$  and survive to sample time  $j + 1$ ;  $j = 0, 1, \dots, k - 1$ .  $B_0$  is the number of individuals alive just before the first sample time. Note that  $E(B_j|N) = Nb_j$ .
- $\chi_{(f_i, l_i, nt)} =$  the probability that the individual with capture history  $i$  is first seen at  $f_i$  and not seen after sample time  $l_i$ , with  $nt$  tags. This is a recursive function of  $\phi$ ,  $p$ , and  $\lambda$ . If  $f_i = 0$ , this indicates individuals not yet captured but alive at time  $l_i$ .
- For individuals not yet captured:
- $$\chi_{(0, j, 0)} = \begin{cases} 1 - \phi + \phi(1 - p)\chi_{(0, j+1, 0)} & \text{if } j < k \\ 1 & \text{if } j = k \end{cases}$$
- For single tagged individuals:
- $$\chi_{(f_i, j, 1)} = \begin{cases} 1 - \phi + \phi(1 - p)\lambda\chi_{(f_i, j+1, 1)} + \phi(1 - \lambda) & \text{if } j < k \\ 1 & \text{if } j = k \end{cases}$$
- For double tagged individuals:
- $$\chi_{(f_i, j, 2)} = \begin{cases} 1 - \phi + \phi(1 - p)\lambda^2\chi_{(f_i, j+1, 2)} + \phi(1 - \lambda)^2 + 2\phi(1 - p)\lambda(1 - \lambda)\chi_{(f_i, j+1, 1)} & \text{if } j < k \\ 1 & \text{if } j = k \end{cases}$$
- $\psi_j =$  probability that an individual enters the population, is still alive and is not seen before time  $j$ ;  $j = 1, 2, \dots, k$
- $N_j =$  population size at time  $j$ .  $E(N_1|N) = B_0$ ,  $E(N_{j+1}|N) = (N_j - N_j p v)\phi + B_j$ , which is the number of individuals that survive from time  $j$  minus the number lost on capture plus the number of births.

## Complete Likelihood

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

$$L = \binom{N}{n_{\text{obs}}} \left\{ \sum_{j=0}^{k-1} b_j (1 - p) \chi_{(0, j+1, 0)} \right\}^{(N - n_{\text{obs}})} \times \left\{ 1 - \sum_{j=0}^{k-1} b_j (1 - p) \chi_{(0, j+1, 0)} \right\}^{n_{\text{obs}}} \times$$

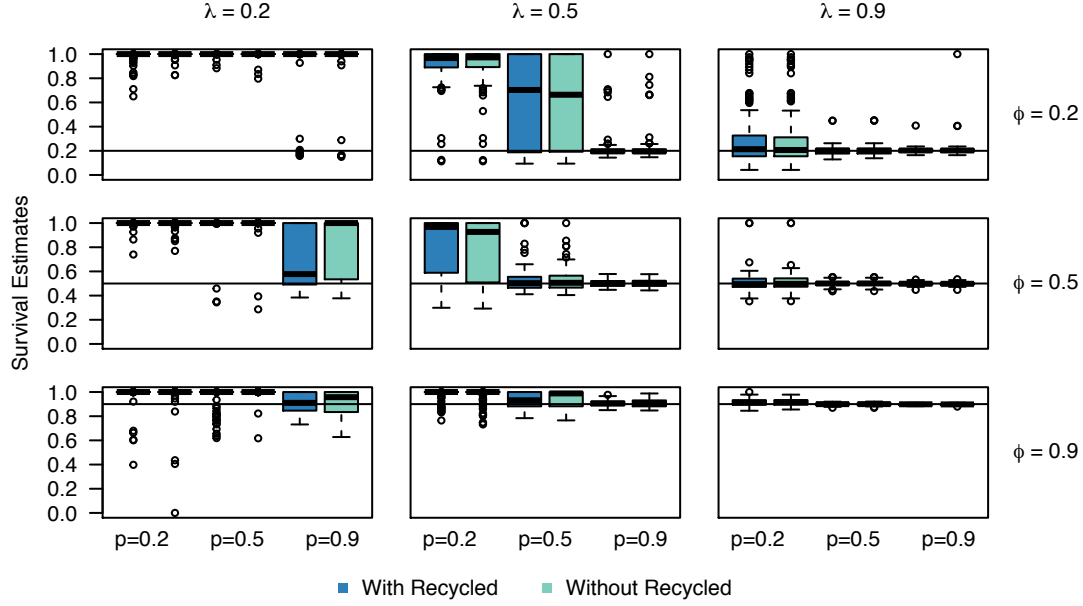
$$\left( \binom{n_{\text{obs}}}{n_{\omega_1}, n_{\omega_2}, \dots, n_{\omega_m}} \right) \prod_{i=1}^m \left[ \psi_{f_i} T_d \left\{ \prod_{j=f_i}^{l_i} p^{w_{*ij}} (1 - p)^{(1 - w_{*ij})} \right\} \left\{ \prod_{j=f_i}^{l_i-1} \phi \right\} \times \right.$$

$$\left. \prod_{d=1}^2 \left\{ \left( \prod_{j=f_i}^{l_{id}-1} \lambda \right) \left( 1 - \prod_{j=l_{id}}^{q_{id}-1} \lambda \right)^{I(l_{id} \neq l_i)} \right\} \times \chi_{f_i, l_i, nt_{l_i}} \right]^{n_{\omega_i}} \times$$

$$\left\{ 1 - \sum_{j=0}^{k-1} b_j (1 - p) \chi_{(0, j+1, 0)} \right\}^{-n_{\text{obs}}}$$

## Survival Estimates

N=1000, T=1

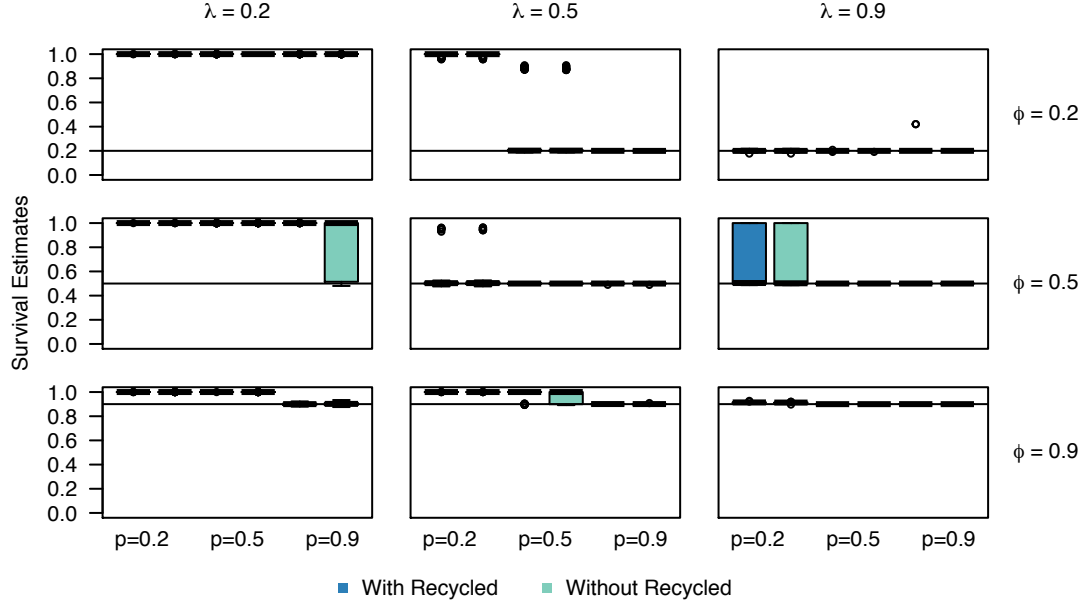


WEB FIGURE 1: Boxplots of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag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

WEB TABLE 1: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0066  | 0.0064 | 0.0066  | 0.0064 | 0.0069    | 0.0066   |
| 0.9    | 0.9 | 0.5       | 0.0334  | 0.0241 | 0.0327  | 0.0243 | 0.0337    | 0.0249   |
| 0.9    | 0.9 | 0.2       | 0.0796  | 0.0620 | 0.0926  | 0.0792 | 0.0941    | 0.0797   |
| 0.9    | 0.5 | 0.9       | 0.0095  | 0.0093 | 0.0097  | 0.0093 | 0.0096    | 0.0093   |
| 0.9    | 0.5 | 0.5       | 0.0286  | 0.0332 | 0.0683  | 0.0622 | 0.0801    | 0.0691   |
| 0.9    | 0.5 | 0.2       | 0.0039  | 0.0336 | 0.0420  | 0.0939 | 0.1032    | 0.1107   |
| 0.9    | 0.2 | 0.9       | 0.0224  | 0.0224 | 0.0249  | 0.0274 | 0.0291    | 0.0305   |
| 0.9    | 0.2 | 0.5       | 0.0213  | 0.0180 | 0.0620  | 0.0483 | 0.0963    | 0.0944   |
| 0.9    | 0.2 | 0.2       | 0.0114  | 0.0150 | 0.1290  | 0.0929 | 0.1487    | 0.1214   |
| 0.5    | 0.9 | 0.9       | 0.0138  | 0.0137 | 0.0132  | 0.0129 | 0.0132    | 0.0129   |
| 0.5    | 0.9 | 0.5       | 0.0307  | 0.0277 | 0.0317  | 0.0299 | 0.0318    | 0.0298   |
| 0.5    | 0.9 | 0.2       | 0.0544  | 0.0699 | 0.2501  | 0.2416 | 0.3815    | 0.3098   |
| 0.5    | 0.5 | 0.9       | 0.0212  | 0.0211 | 0.0217  | 0.0218 | 0.0216    | 0.0217   |
| 0.5    | 0.5 | 0.5       | 0.0554  | 0.0511 | 0.0969  | 0.1099 | 0.1002    | 0.1130   |
| 0.5    | 0.5 | 0.2       | 0.0059  | 0.0100 | 0.0934  | 0.1059 | 0.4943    | 0.4928   |
| 0.5    | 0.2 | 0.9       | 0.0465  | 0.0465 | 0.0870  | 0.0871 | 0.0880    | 0.0875   |
| 0.5    | 0.2 | 0.5       | 0.0651  | 0.0630 | 0.2466  | 0.2362 | 0.3861    | 0.3940   |
| 0.5    | 0.2 | 0.2       | 0.0135  | 0.0076 | 0.0334  | 0.0303 | 0.4929    | 0.4955   |
| 0.2    | 0.9 | 0.9       | 0.0147  | 0.0147 | 0.0857  | 0.0257 | 0.0865    | 0.0260   |
| 0.2    | 0.9 | 0.5       | 0.0264  | 0.0254 | 0.1393  | 0.1262 | 0.1420    | 0.1280   |
| 0.2    | 0.9 | 0.2       | 0.0058  | 0.0071 | 0.1597  | 0.2061 | 0.7824    | 0.7709   |
| 0.2    | 0.5 | 0.9       | 0.0310  | 0.0308 | 0.0507  | 0.0448 | 0.0508    | 0.0446   |
| 0.2    | 0.5 | 0.5       | 0.0481  | 0.0500 | 0.3683  | 0.3729 | 0.5306    | 0.5476   |
| 0.2    | 0.5 | 0.2       | 0.0039  | 0.0042 | 0.0289  | 0.0154 | 0.7955    | 0.7976   |
| 0.2    | 0.2 | 0.9       | 0.0692  | 0.0701 | 0.2481  | 0.2485 | 0.2661    | 0.2682   |
| 0.2    | 0.2 | 0.5       | 0.0586  | 0.0677 | 0.1722  | 0.1681 | 0.7256    | 0.7278   |
| 0.2    | 0.2 | 0.2       | 0.0086  | 0.0213 | 0.0266  | 0.0563 | 0.7951    | 0.7848   |

N=100000, T=1

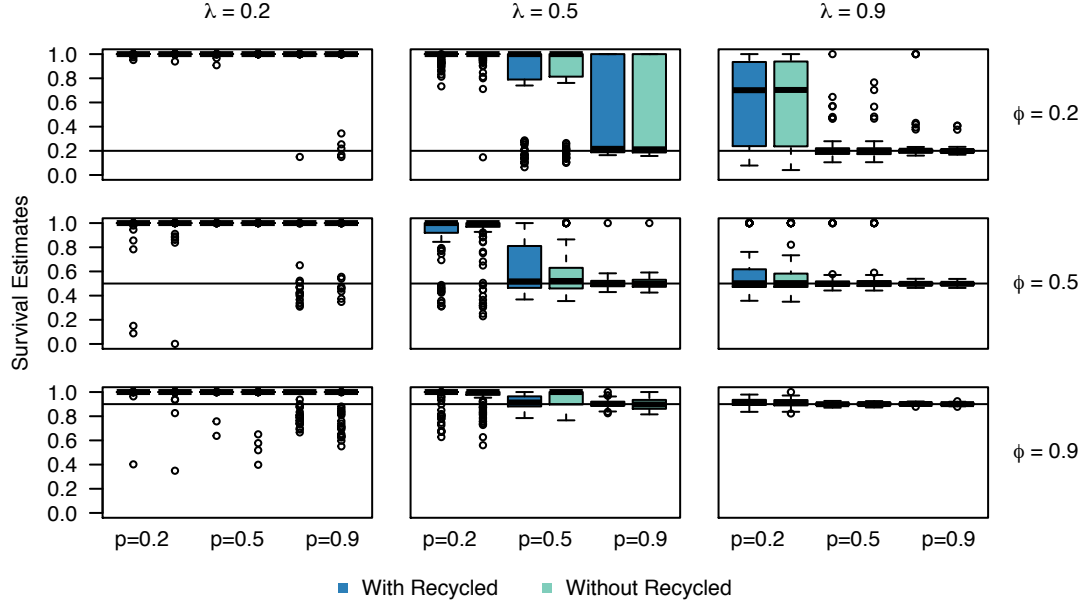


WEB FIGURE 2: Boxplots of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\phi$  used to simulate the data for each model.

WEB TABLE 2: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0007  | 0.0006 | 0.0006  | 0.0006 | 0.0006    | 0.0006   |
| 0.9    | 0.9 | 0.5       | 0.0032  | 0.0024 | 0.0031  | 0.0023 | 0.0031    | 0.0024   |
| 0.9    | 0.9 | 0.2       | 0.0138  | 0.0083 | 0.0136  | 0.0088 | 0.0135    | 0.0087   |
| 0.9    | 0.5 | 0.9       | 0.0009  | 0.0009 | 0.0009  | 0.0009 | 0.0009    | 0.0009   |
| 0.9    | 0.5 | 0.5       | 0.0048  | 0.0039 | 0.0510  | 0.0342 | 0.0742    | 0.0933   |
| 0.9    | 0.5 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.1000    | 0.1000   |
| 0.9    | 0.2 | 0.9       | 0.0022  | 0.0022 | 0.0027  | 0.0025 | 0.0132    | 0.0144   |
| 0.9    | 0.2 | 0.5       | 0.0001  | 0.0000 | 0.0000  | 0.0000 | 0.1000    | 0.1000   |
| 0.9    | 0.2 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.1000    | 0.1000   |
| 0.5    | 0.9 | 0.9       | 0.0014  | 0.0014 | 0.0014  | 0.0014 | 0.0014    | 0.0014   |
| 0.5    | 0.9 | 0.5       | 0.0030  | 0.0028 | 0.0032  | 0.0028 | 0.0032    | 0.0028   |
| 0.5    | 0.9 | 0.2       | 0.0100  | 0.0000 | 0.2228  | 0.0000 | 0.4272    | 0.5000   |
| 0.5    | 0.5 | 0.9       | 0.0021  | 0.0021 | 0.0021  | 0.0021 | 0.0021    | 0.0021   |
| 0.5    | 0.5 | 0.5       | 0.0054  | 0.0051 | 0.0055  | 0.0056 | 0.0054    | 0.0056   |
| 0.5    | 0.5 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.5    | 0.2 | 0.9       | 0.0033  | 0.0028 | 0.2351  | 0.2479 | 0.2829    | 0.3202   |
| 0.5    | 0.2 | 0.5       | 0.0123  | 0.0120 | 0.1297  | 0.1157 | 0.1357    | 0.1197   |
| 0.5    | 0.2 | 0.2       | 0.0001  | 0.0001 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.2    | 0.9 | 0.9       | 0.0015  | 0.0015 | 0.0014  | 0.0311 | 0.0014    | 0.0312   |
| 0.2    | 0.9 | 0.5       | 0.0025  | 0.0024 | 0.0026  | 0.0025 | 0.0026    | 0.0026   |
| 0.2    | 0.9 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.8000    | 0.8000   |
| 0.2    | 0.5 | 0.9       | 0.0031  | 0.0031 | 0.0032  | 0.0032 | 0.0032    | 0.0032   |
| 0.2    | 0.5 | 0.5       | 0.0064  | 0.0065 | 0.2382  | 0.2703 | 0.2556    | 0.2988   |
| 0.2    | 0.5 | 0.2       | 0.0002  | 0.0001 | 0.0000  | 0.0000 | 0.8000    | 0.8000   |
| 0.2    | 0.2 | 0.9       | 0.0074  | 0.0074 | 0.0074  | 0.0074 | 0.0073    | 0.0073   |
| 0.2    | 0.2 | 0.5       | 0.0070  | 0.0065 | 0.0117  | 0.0109 | 0.7946    | 0.7953   |
| 0.2    | 0.2 | 0.2       | 0.0002  | 0.0002 | 0.0000  | 0.0000 | 0.8000    | 0.8000   |

N=1000, T=0.5

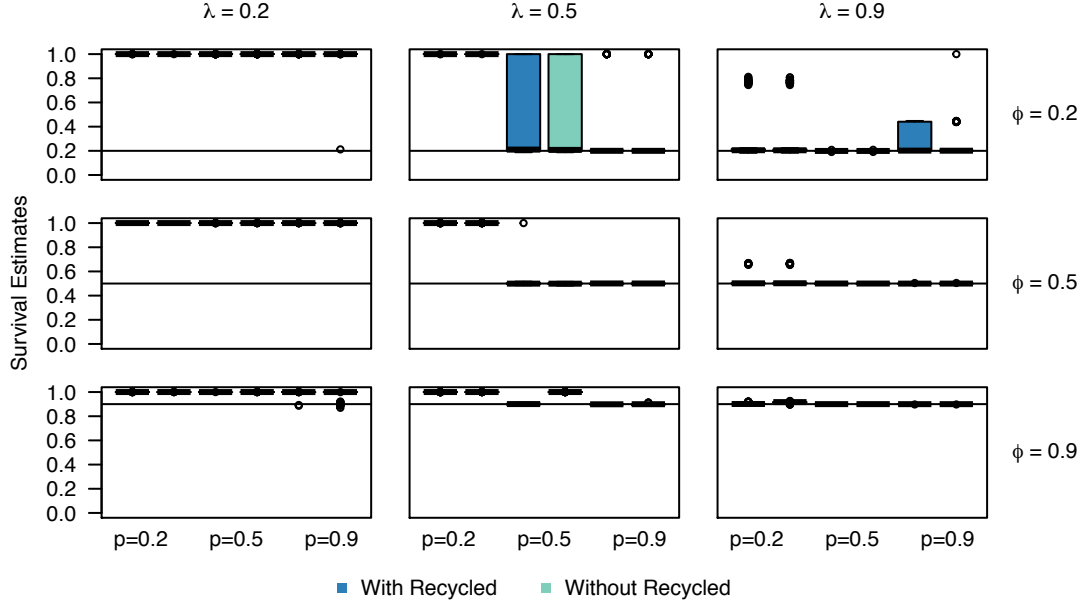


WEB FIGURE 3: Boxplots of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\phi$  used to simulate the data for each model.

WEB TABLE 3: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0082  | 0.0077 | 0.0085  | 0.0080 | 0.0085    | 0.0081   |
| 0.9    | 0.9 | 0.5       | 0.0459  | 0.0319 | 0.0458  | 0.0311 | 0.0456    | 0.0312   |
| 0.9    | 0.9 | 0.2       | 0.0294  | 0.0389 | 0.1177  | 0.0939 | 0.1262    | 0.1069   |
| 0.9    | 0.5 | 0.9       | 0.0115  | 0.0111 | 0.0109  | 0.0110 | 0.0109    | 0.0110   |
| 0.9    | 0.5 | 0.5       | 0.0257  | 0.0462 | 0.0725  | 0.0589 | 0.0888    | 0.0611   |
| 0.9    | 0.5 | 0.2       | 0.0063  | 0.0044 | 0.0932  | 0.0434 | 0.1234    | 0.1034   |
| 0.9    | 0.2 | 0.9       | 0.0256  | 0.0256 | 0.0312  | 0.0307 | 0.0332    | 0.0335   |
| 0.9    | 0.2 | 0.5       | 0.0311  | 0.0233 | 0.0916  | 0.0935 | 0.1063    | 0.1106   |
| 0.9    | 0.2 | 0.2       | 0.0066  | 0.0041 | 0.0676  | 0.0599 | 0.1128    | 0.1110   |
| 0.5    | 0.9 | 0.9       | 0.0151  | 0.0148 | 0.0164  | 0.0160 | 0.0164    | 0.0160   |
| 0.5    | 0.9 | 0.5       | 0.0410  | 0.0361 | 0.0646  | 0.0615 | 0.0645    | 0.0614   |
| 0.5    | 0.9 | 0.2       | 0.0109  | 0.0203 | 0.1496  | 0.2041 | 0.4801    | 0.4628   |
| 0.5    | 0.5 | 0.9       | 0.0215  | 0.0215 | 0.1396  | 0.1227 | 0.1437    | 0.1249   |
| 0.5    | 0.5 | 0.5       | 0.0693  | 0.0534 | 0.1787  | 0.2249 | 0.1971    | 0.2548   |
| 0.5    | 0.5 | 0.2       | 0.0004  | 0.0003 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.5    | 0.2 | 0.9       | 0.0468  | 0.0459 | 0.1756  | 0.1849 | 0.1891    | 0.2002   |
| 0.5    | 0.2 | 0.5       | 0.0390  | 0.0376 | 0.2110  | 0.1979 | 0.4543    | 0.4481   |
| 0.5    | 0.2 | 0.2       | 0.0094  | 0.0104 | 0.1031  | 0.1262 | 0.4945    | 0.4942   |
| 0.2    | 0.9 | 0.9       | 0.0158  | 0.0154 | 0.0371  | 0.1430 | 0.0371    | 0.1453   |
| 0.2    | 0.9 | 0.5       | 0.0303  | 0.0251 | 0.3840  | 0.3924 | 0.4876    | 0.5078   |
| 0.2    | 0.9 | 0.2       | 0.0073  | 0.0008 | 0.1702  | 0.0851 | 0.7799    | 0.7960   |
| 0.2    | 0.5 | 0.9       | 0.0326  | 0.0325 | 0.0976  | 0.1181 | 0.0982    | 0.1197   |
| 0.2    | 0.5 | 0.5       | 0.0405  | 0.0348 | 0.3305  | 0.3247 | 0.6892    | 0.6895   |
| 0.2    | 0.5 | 0.2       | 0.0008  | 0.0027 | 0.0000  | 0.0097 | 0.8000    | 0.7988   |
| 0.2    | 0.2 | 0.9       | 0.0644  | 0.0661 | 0.3416  | 0.3369 | 0.5360    | 0.5223   |
| 0.2    | 0.2 | 0.5       | 0.0273  | 0.0278 | 0.0952  | 0.0455 | 0.7811    | 0.7839   |
| 0.2    | 0.2 | 0.2       | 0.0009  | 0.0028 | 0.0061  | 0.0057 | 0.7994    | 0.7991   |

N=100000, T=0.5

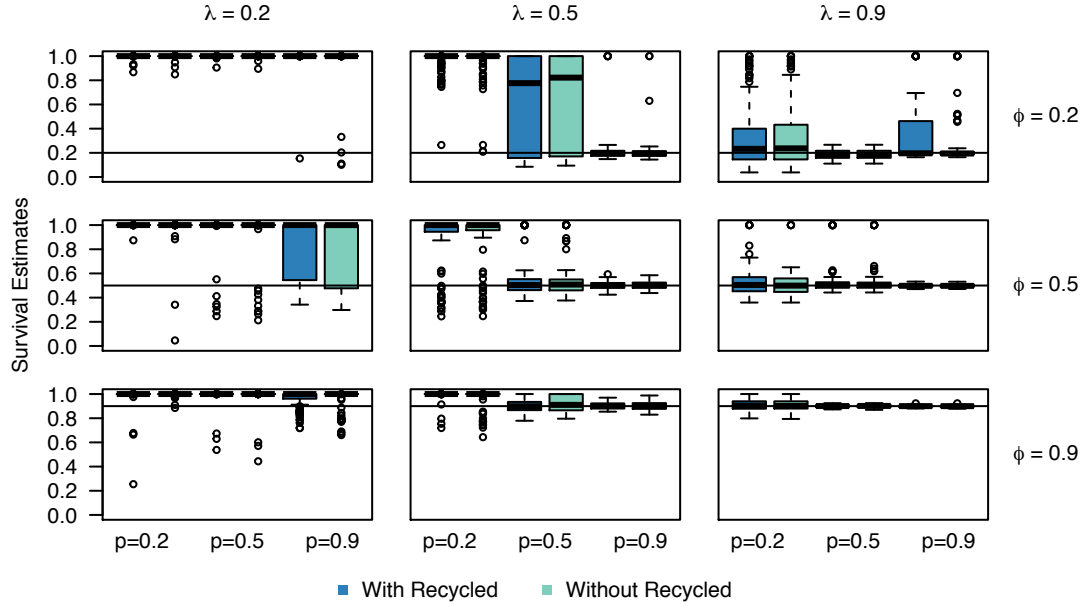


WEB FIGURE 4: Boxplots of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\phi$  used to simulate the data for each model.

WEB TABLE 4: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of survival estimates ( $\hat{\phi}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

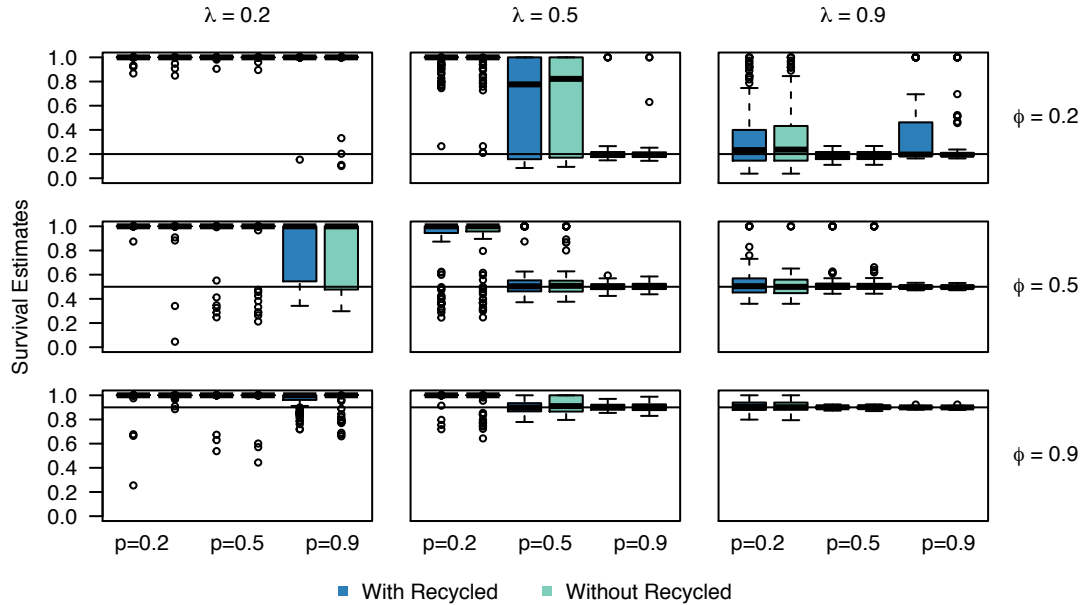
| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0008  | 0.0008 | 0.0009  | 0.0009 | 0.0009    | 0.0009   |
| 0.9    | 0.9 | 0.5       | 0.0045  | 0.0032 | 0.0052  | 0.0033 | 0.0052    | 0.0034   |
| 0.9    | 0.9 | 0.2       | 0.0179  | 0.0073 | 0.0343  | 0.0155 | 0.0932    | 0.0988   |
| 0.9    | 0.5 | 0.9       | 0.0012  | 0.0011 | 0.0010  | 0.0010 | 0.0010    | 0.0010   |
| 0.9    | 0.5 | 0.5       | 0.0000  | 0.0055 | 0.0000  | 0.0052 | 0.1000    | 0.0052   |
| 0.9    | 0.5 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0001 | 0.1000    | 0.0999   |
| 0.9    | 0.2 | 0.9       | 0.0026  | 0.0026 | 0.0055  | 0.0060 | 0.0165    | 0.0064   |
| 0.9    | 0.2 | 0.5       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.1000    | 0.1000   |
| 0.9    | 0.2 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.1000    | 0.1000   |
| 0.5    | 0.9 | 0.9       | 0.0015  | 0.0015 | 0.0014  | 0.0014 | 0.0014    | 0.0014   |
| 0.5    | 0.9 | 0.5       | 0.0041  | 0.0036 | 0.0041  | 0.0037 | 0.0041    | 0.0037   |
| 0.5    | 0.9 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.5    | 0.5 | 0.9       | 0.0023  | 0.0023 | 0.0020  | 0.0020 | 0.0020    | 0.0020   |
| 0.5    | 0.5 | 0.5       | 0.0068  | 0.0064 | 0.0068  | 0.0510 | 0.0068    | 0.0509   |
| 0.5    | 0.5 | 0.2       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.5    | 0.2 | 0.9       | 0.0052  | 0.0051 | 0.0566  | 0.0442 | 0.0612    | 0.0463   |
| 0.5    | 0.2 | 0.5       | 0.0000  | 0.0000 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.5    | 0.2 | 0.2       | 0.0002  | 0.0002 | 0.0000  | 0.0000 | 0.5000    | 0.5000   |
| 0.2    | 0.9 | 0.9       | 0.0018  | 0.0020 | 0.1240  | 0.1154 | 0.1367    | 0.1414   |
| 0.2    | 0.9 | 0.5       | 0.0031  | 0.0029 | 0.2704  | 0.2871 | 0.2885    | 0.3098   |
| 0.2    | 0.9 | 0.2       | 0.0005  | 0.0000 | 0.0788  | 0.0000 | 0.7960    | 0.8000   |
| 0.2    | 0.5 | 0.9       | 0.0033  | 0.0033 | 0.0032  | 0.0032 | 0.0033    | 0.0032   |
| 0.2    | 0.5 | 0.5       | 0.0064  | 0.0063 | 0.3971  | 0.4020 | 0.5184    | 0.5484   |
| 0.2    | 0.5 | 0.2       | 0.0001  | 0.0001 | 0.0000  | 0.0000 | 0.8000    | 0.8000   |
| 0.2    | 0.2 | 0.9       | 0.0085  | 0.0086 | 0.2210  | 0.2344 | 0.2438    | 0.2634   |
| 0.2    | 0.2 | 0.5       | 0.0007  | 0.0007 | 0.0001  | 0.0001 | 0.7999    | 0.7999   |
| 0.2    | 0.2 | 0.2       | 0.0003  | 0.0003 | 0.0000  | 0.0000 | 0.8000    | 0.8000   |

$N=1000$ ,  $T=1$ ,  $t=5$



WEB FIGURE 5: 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  $\phi$  used to simulate the data for each model.

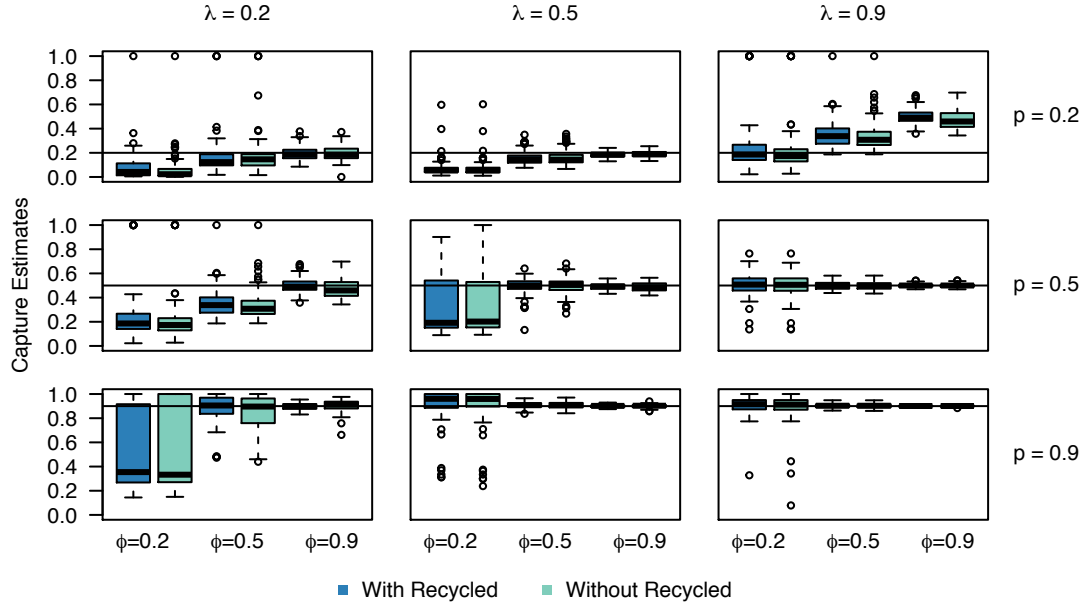
$N=1000$ ,  $T=1$ ,  $t=7$



WEB FIGURE 6: 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  $\phi$  used to simulate the data for each model.

## Capture Estimates

$N=1000$ ,  $T=1$



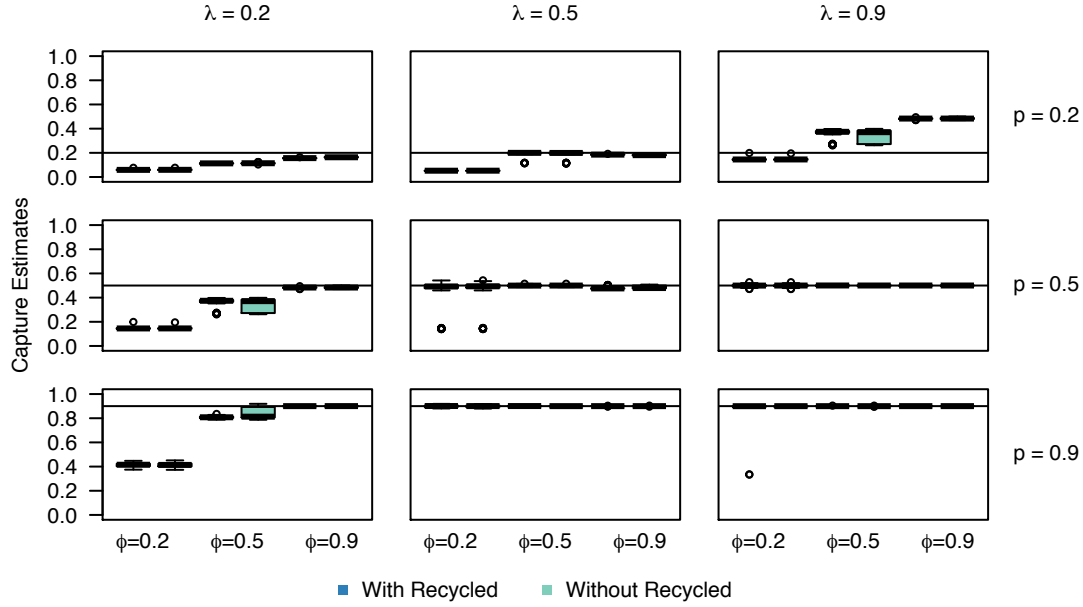
WEB FIGURE 7: Boxplots of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $p$  used to simulate the data for each model.

WEB TABLE 5: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0066  | 0.0065 | 0.0063  | 0.0060 | 0.0063    | 0.0060   |
| 0.9    | 0.9 | 0.5       | 0.0139  | 0.0106 | 0.0147  | 0.0116 | 0.0146    | 0.0116   |
| 0.9    | 0.9 | 0.2       | 0.0374  | 0.0245 | 0.0484  | 0.0251 | 0.0484    | 0.0251   |
| 0.9    | 0.5 | 0.9       | 0.0131  | 0.0129 | 0.0151  | 0.0148 | 0.0150    | 0.0147   |
| 0.9    | 0.5 | 0.5       | 0.0251  | 0.0213 | 0.0343  | 0.0269 | 0.0365    | 0.0283   |
| 0.9    | 0.5 | 0.2       | 0.0574  | 0.0470 | 0.0746  | 0.0590 | 0.0793    | 0.0587   |
| 0.9    | 0.2 | 0.9       | 0.0147  | 0.0147 | 0.0167  | 0.0178 | 0.0180    | 0.0186   |
| 0.9    | 0.2 | 0.5       | 0.0227  | 0.0203 | 0.0250  | 0.0225 | 0.0267    | 0.0260   |
| 0.9    | 0.2 | 0.2       | 0.0528  | 0.0470 | 0.0588  | 0.0514 | 0.0587    | 0.0515   |
| 0.5    | 0.9 | 0.9       | 0.0167  | 0.0166 | 0.0172  | 0.0172 | 0.0174    | 0.0173   |
| 0.5    | 0.9 | 0.5       | 0.0275  | 0.0251 | 0.0262  | 0.0256 | 0.0270    | 0.0264   |
| 0.5    | 0.9 | 0.2       | 0.0592  | 0.0570 | 0.1815  | 0.1119 | 0.1974    | 0.1128   |
| 0.5    | 0.5 | 0.9       | 0.0323  | 0.0322 | 0.0331  | 0.0329 | 0.0330    | 0.0328   |
| 0.5    | 0.5 | 0.5       | 0.0526  | 0.0498 | 0.0665  | 0.0680 | 0.0662    | 0.0678   |
| 0.5    | 0.5 | 0.2       | 0.0717  | 0.0696 | 0.1207  | 0.1175 | 0.1979    | 0.1852   |
| 0.5    | 0.2 | 0.9       | 0.0339  | 0.0342 | 0.0462  | 0.0457 | 0.0459    | 0.0455   |
| 0.5    | 0.2 | 0.5       | 0.0385  | 0.0357 | 0.0631  | 0.0562 | 0.0730    | 0.0709   |
| 0.5    | 0.2 | 0.2       | 0.0621  | 0.0536 | 0.1698  | 0.1628 | 0.1704    | 0.1650   |
| 0.2    | 0.9 | 0.9       | 0.0426  | 0.0428 | 0.1209  | 0.0769 | 0.1205    | 0.0768   |
| 0.2    | 0.9 | 0.5       | 0.0467  | 0.0489 | 0.1644  | 0.1473 | 0.1636    | 0.1466   |
| 0.2    | 0.9 | 0.2       | 0.0673  | 0.0785 | 0.3190  | 0.3079 | 0.5023    | 0.4954   |
| 0.2    | 0.5 | 0.9       | 0.0916  | 0.0926 | 0.0997  | 0.0952 | 0.0992    | 0.0951   |
| 0.2    | 0.5 | 0.5       | 0.0795  | 0.0789 | 0.2462  | 0.2420 | 0.2888    | 0.2873   |
| 0.2    | 0.5 | 0.2       | 0.0626  | 0.0655 | 0.2080  | 0.2367 | 0.3364    | 0.3405   |
| 0.2    | 0.2 | 0.9       | 0.0912  | 0.0895 | 0.2011  | 0.2017 | 0.2021    | 0.2023   |
| 0.2    | 0.2 | 0.5       | 0.0310  | 0.0318 | 0.0714  | 0.0716 | 0.1487    | 0.1480   |
| 0.2    | 0.2 | 0.2       | 0.0266  | 0.0384 | 0.1145  | 0.1184 | 0.1792    | 0.1698   |



$N=100000$ ,  $T=1$

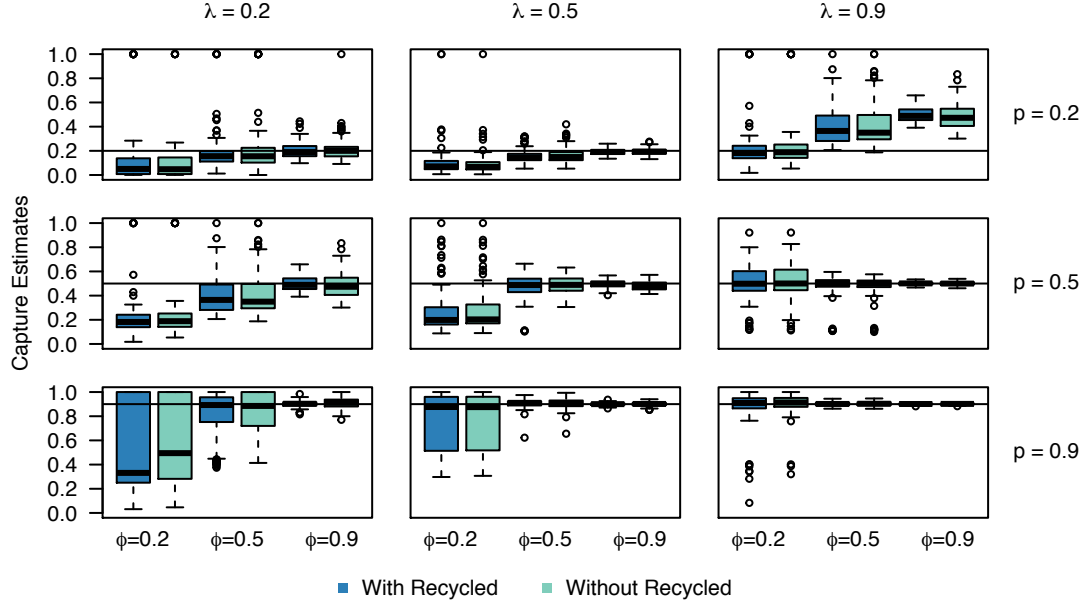


WEB FIGURE 8: Boxplots of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $p$  used to simulate the data for each model.

WEB TABLE 6: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0007  | 0.0006 | 0.0007  | 0.0007 | 0.0007    | 0.0007   |
| 0.9    | 0.9 | 0.5       | 0.0014  | 0.0011 | 0.0013  | 0.0011 | 0.0013    | 0.0011   |
| 0.9    | 0.9 | 0.2       | 0.0039  | 0.0025 | 0.0035  | 0.0023 | 0.0035    | 0.0023   |
| 0.9    | 0.5 | 0.9       | 0.0013  | 0.0013 | 0.0012  | 0.0012 | 0.0012    | 0.0012   |
| 0.9    | 0.5 | 0.5       | 0.0025  | 0.0020 | 0.0125  | 0.0090 | 0.0176    | 0.0228   |
| 0.9    | 0.5 | 0.2       | 0.0062  | 0.0045 | 0.0062  | 0.0045 | 0.0171    | 0.0172   |
| 0.9    | 0.2 | 0.9       | 0.0015  | 0.0015 | 0.0018  | 0.0016 | 0.0084    | 0.0091   |
| 0.9    | 0.2 | 0.5       | 0.0021  | 0.0020 | 0.0033  | 0.0020 | 0.0188    | 0.0147   |
| 0.9    | 0.2 | 0.2       | 0.0041  | 0.0032 | 0.0038  | 0.0028 | 0.0361    | 0.0441   |
| 0.5    | 0.9 | 0.9       | 0.0017  | 0.0017 | 0.0017  | 0.0017 | 0.0016    | 0.0017   |
| 0.5    | 0.9 | 0.5       | 0.0029  | 0.0026 | 0.0029  | 0.0027 | 0.0028    | 0.0027   |
| 0.5    | 0.9 | 0.2       | 0.0098  | 0.0089 | 0.0426  | 0.0084 | 0.0782    | 0.0925   |
| 0.5    | 0.5 | 0.9       | 0.0032  | 0.0032 | 0.0033  | 0.0033 | 0.0033    | 0.0033   |
| 0.5    | 0.5 | 0.5       | 0.0054  | 0.0051 | 0.0059  | 0.0057 | 0.0059    | 0.0057   |
| 0.5    | 0.5 | 0.2       | 0.0075  | 0.0074 | 0.0539  | 0.0433 | 0.1715    | 0.1502   |
| 0.5    | 0.2 | 0.9       | 0.0025  | 0.0022 | 0.0739  | 0.0781 | 0.0892    | 0.1011   |
| 0.5    | 0.2 | 0.5       | 0.0053  | 0.0052 | 0.0249  | 0.0220 | 0.0260    | 0.0228   |
| 0.5    | 0.2 | 0.2       | 0.0045  | 0.0043 | 0.0038  | 0.0035 | 0.0863    | 0.0871   |
| 0.2    | 0.9 | 0.9       | 0.0050  | 0.0050 | 0.0043  | 0.0796 | 0.0043    | 0.0801   |
| 0.2    | 0.9 | 0.5       | 0.0077  | 0.0075 | 0.0078  | 0.0078 | 0.0078    | 0.0077   |
| 0.2    | 0.9 | 0.2       | 0.0160  | 0.0151 | 0.0149  | 0.0136 | 0.4861    | 0.4862   |
| 0.2    | 0.5 | 0.9       | 0.0092  | 0.0092 | 0.0098  | 0.0098 | 0.0097    | 0.0097   |
| 0.2    | 0.5 | 0.5       | 0.0125  | 0.0118 | 0.1248  | 0.1411 | 0.1340    | 0.1561   |
| 0.2    | 0.5 | 0.2       | 0.0053  | 0.0051 | 0.0067  | 0.0068 | 0.3540    | 0.3544   |
| 0.2    | 0.2 | 0.9       | 0.0093  | 0.0092 | 0.0092  | 0.0092 | 0.0092    | 0.0092   |
| 0.2    | 0.2 | 0.5       | 0.0021  | 0.0021 | 0.0020  | 0.0019 | 0.1478    | 0.1479   |
| 0.2    | 0.2 | 0.2       | 0.0046  | 0.0045 | 0.0040  | 0.0040 | 0.1402    | 0.1403   |

$N=1000$ ,  $T=0.5$

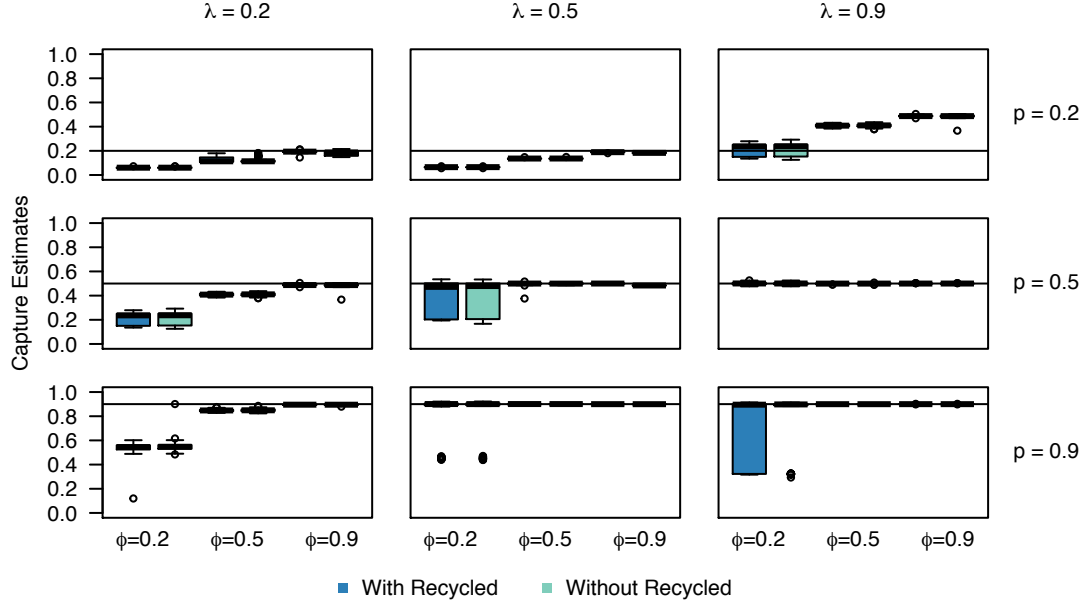


WEB FIGURE 9: Boxplots of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $p$  used to simulate the data for each model.

WEB TABLE 7: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0070  | 0.0066 | 0.0065  | 0.0063 | 0.0066    | 0.0063   |
| 0.9    | 0.9 | 0.5       | 0.0159  | 0.0115 | 0.0171  | 0.0118 | 0.0170    | 0.0118   |
| 0.9    | 0.9 | 0.2       | 0.0412  | 0.0269 | 0.0432  | 0.0272 | 0.0438    | 0.0271   |
| 0.9    | 0.5 | 0.9       | 0.0139  | 0.0134 | 0.0151  | 0.0140 | 0.0150    | 0.0140   |
| 0.9    | 0.5 | 0.5       | 0.0279  | 0.0239 | 0.0363  | 0.0290 | 0.0408    | 0.0291   |
| 0.9    | 0.5 | 0.2       | 0.0688  | 0.0549 | 0.1051  | 0.0602 | 0.1064    | 0.0599   |
| 0.9    | 0.2 | 0.9       | 0.0156  | 0.0152 | 0.0179  | 0.0170 | 0.0181    | 0.0175   |
| 0.9    | 0.2 | 0.5       | 0.0276  | 0.0247 | 0.0280  | 0.0244 | 0.0287    | 0.0256   |
| 0.9    | 0.2 | 0.2       | 0.0674  | 0.0622 | 0.1086  | 0.0699 | 0.1091    | 0.0696   |
| 0.5    | 0.9 | 0.9       | 0.0176  | 0.0173 | 0.0183  | 0.0178 | 0.0184    | 0.0179   |
| 0.5    | 0.9 | 0.5       | 0.0311  | 0.0277 | 0.0407  | 0.0397 | 0.0407    | 0.0398   |
| 0.5    | 0.9 | 0.2       | 0.0638  | 0.0612 | 0.2004  | 0.1960 | 0.2177    | 0.2129   |
| 0.5    | 0.5 | 0.9       | 0.0320  | 0.0321 | 0.1063  | 0.1001 | 0.1092    | 0.1015   |
| 0.5    | 0.5 | 0.5       | 0.0574  | 0.0520 | 0.0813  | 0.1080 | 0.0826    | 0.1120   |
| 0.5    | 0.5 | 0.2       | 0.1038  | 0.0960 | 0.1778  | 0.1638 | 0.1954    | 0.1866   |
| 0.5    | 0.2 | 0.9       | 0.0324  | 0.0318 | 0.0592  | 0.0613 | 0.0618    | 0.0646   |
| 0.5    | 0.2 | 0.5       | 0.0432  | 0.0399 | 0.0640  | 0.0555 | 0.0744    | 0.0710   |
| 0.5    | 0.2 | 0.2       | 0.0811  | 0.0812 | 0.2550  | 0.2047 | 0.2568    | 0.2037   |
| 0.2    | 0.9 | 0.9       | 0.0444  | 0.0437 | 0.1082  | 0.1639 | 0.1077    | 0.1654   |
| 0.2    | 0.9 | 0.5       | 0.0733  | 0.0723 | 0.2443  | 0.2453 | 0.2780    | 0.2848   |
| 0.2    | 0.9 | 0.2       | 0.0924  | 0.0772 | 0.3353  | 0.3400 | 0.4540    | 0.5007   |
| 0.2    | 0.5 | 0.9       | 0.0952  | 0.0935 | 0.1384  | 0.1450 | 0.1390    | 0.1445   |
| 0.2    | 0.5 | 0.5       | 0.0725  | 0.0707 | 0.1847  | 0.1933 | 0.2873    | 0.2928   |
| 0.2    | 0.5 | 0.2       | 0.0641  | 0.0659 | 0.2176  | 0.2122 | 0.3340    | 0.3404   |
| 0.2    | 0.2 | 0.9       | 0.0502  | 0.0511 | 0.1418  | 0.1057 | 0.1607    | 0.1355   |
| 0.2    | 0.2 | 0.5       | 0.0496  | 0.0484 | 0.1133  | 0.1435 | 0.1544    | 0.1723   |
| 0.2    | 0.2 | 0.2       | 0.0437  | 0.0381 | 0.2166  | 0.2775 | 0.2291    | 0.2801   |

$N=100000$ ,  $T=0.5$

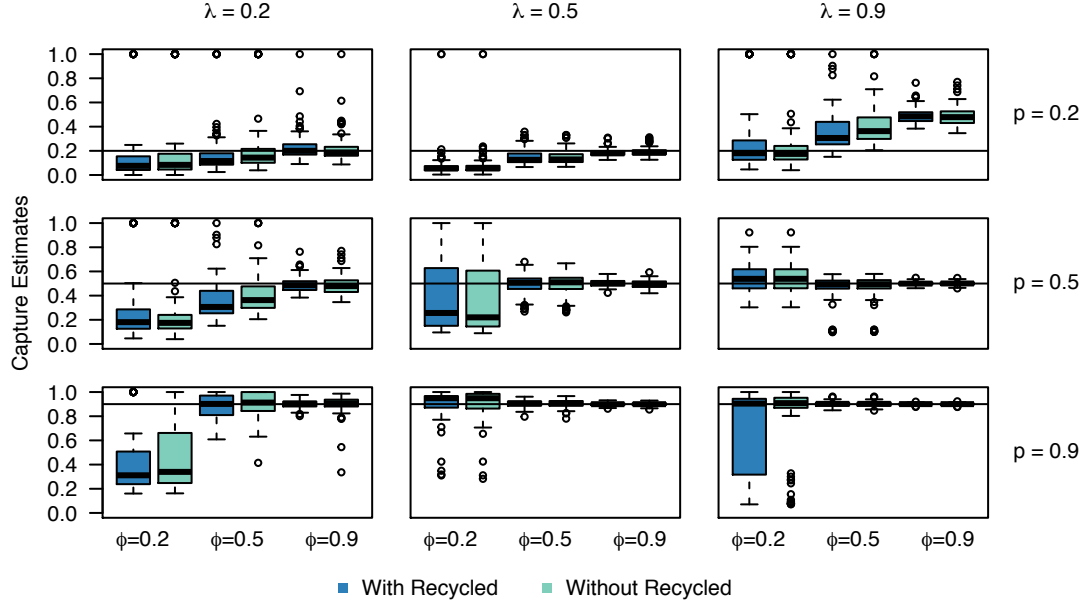


WEB FIGURE 10: Boxplots of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag 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.

WEB TABLE 8: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of capture estimates ( $\hat{p}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

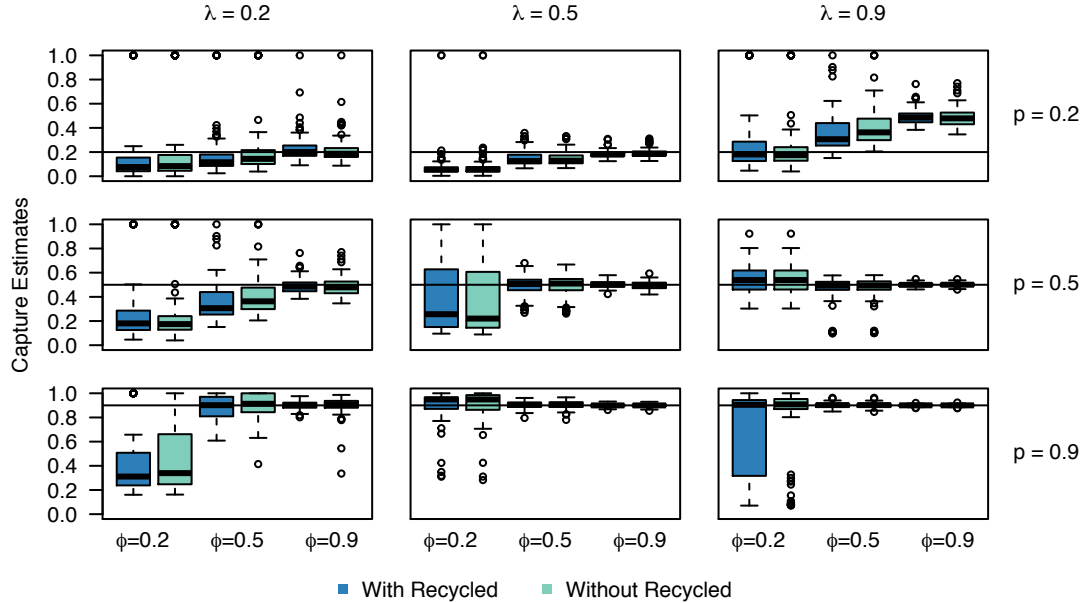
| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0007  | 0.0007 | 0.0007  | 0.0007 | 0.0007    | 0.0007   |
| 0.9    | 0.9 | 0.5       | 0.0016  | 0.0011 | 0.0016  | 0.0011 | 0.0016    | 0.0011   |
| 0.9    | 0.9 | 0.2       | 0.0046  | 0.0028 | 0.0048  | 0.0032 | 0.0068    | 0.0058   |
| 0.9    | 0.5 | 0.9       | 0.0014  | 0.0013 | 0.0013  | 0.0013 | 0.0013    | 0.0013   |
| 0.9    | 0.5 | 0.5       | 0.0028  | 0.0024 | 0.0028  | 0.0024 | 0.0161    | 0.0024   |
| 0.9    | 0.5 | 0.2       | 0.0074  | 0.0053 | 0.0141  | 0.0052 | 0.0193    | 0.0131   |
| 0.9    | 0.2 | 0.9       | 0.0015  | 0.0016 | 0.0032  | 0.0033 | 0.0092    | 0.0035   |
| 0.9    | 0.2 | 0.5       | 0.0025  | 0.0024 | 0.0050  | 0.0026 | 0.0166    | 0.0113   |
| 0.9    | 0.2 | 0.2       | 0.0060  | 0.0059 | 0.0195  | 0.0077 | 0.0283    | 0.0101   |
| 0.5    | 0.9 | 0.9       | 0.0018  | 0.0017 | 0.0018  | 0.0018 | 0.0018    | 0.0018   |
| 0.5    | 0.9 | 0.5       | 0.0032  | 0.0029 | 0.0029  | 0.0029 | 0.0029    | 0.0030   |
| 0.5    | 0.9 | 0.2       | 0.0112  | 0.0092 | 0.0114  | 0.0097 | 0.0518    | 0.0529   |
| 0.5    | 0.5 | 0.9       | 0.0034  | 0.0033 | 0.0032  | 0.0031 | 0.0032    | 0.0031   |
| 0.5    | 0.5 | 0.5       | 0.0061  | 0.0056 | 0.0061  | 0.0138 | 0.0061    | 0.0138   |
| 0.5    | 0.5 | 0.2       | 0.0121  | 0.0106 | 0.0109  | 0.0102 | 0.0908    | 0.0918   |
| 0.5    | 0.2 | 0.9       | 0.0034  | 0.0034 | 0.0261  | 0.0204 | 0.0281    | 0.0212   |
| 0.5    | 0.2 | 0.5       | 0.0036  | 0.0035 | 0.0036  | 0.0035 | 0.0638    | 0.0640   |
| 0.5    | 0.2 | 0.2       | 0.0061  | 0.0061 | 0.0188  | 0.0212 | 0.0815    | 0.0788   |
| 0.2    | 0.9 | 0.9       | 0.0048  | 0.0045 | 0.2409  | 0.2749 | 0.2716    | 0.3372   |
| 0.2    | 0.9 | 0.5       | 0.0088  | 0.0086 | 0.1520  | 0.1609 | 0.1613    | 0.1730   |
| 0.2    | 0.9 | 0.2       | 0.0279  | 0.0259 | 0.0436  | 0.0488 | 0.3536    | 0.3631   |
| 0.2    | 0.5 | 0.9       | 0.0096  | 0.0096 | 0.0097  | 0.0097 | 0.0097    | 0.0097   |
| 0.2    | 0.5 | 0.5       | 0.0116  | 0.0109 | 0.1466  | 0.1493 | 0.1926    | 0.2039   |
| 0.2    | 0.5 | 0.2       | 0.0134  | 0.0126 | 0.0485  | 0.0469 | 0.2877    | 0.2907   |
| 0.2    | 0.2 | 0.9       | 0.0081  | 0.0078 | 0.0616  | 0.0651 | 0.0680    | 0.0733   |
| 0.2    | 0.2 | 0.5       | 0.0032  | 0.0032 | 0.0028  | 0.0028 | 0.1350    | 0.1350   |
| 0.2    | 0.2 | 0.2       | 0.0054  | 0.0053 | 0.0043  | 0.0042 | 0.1393    | 0.1396   |

$N=1000, T=1, t=5$



WEB FIGURE 11: 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.

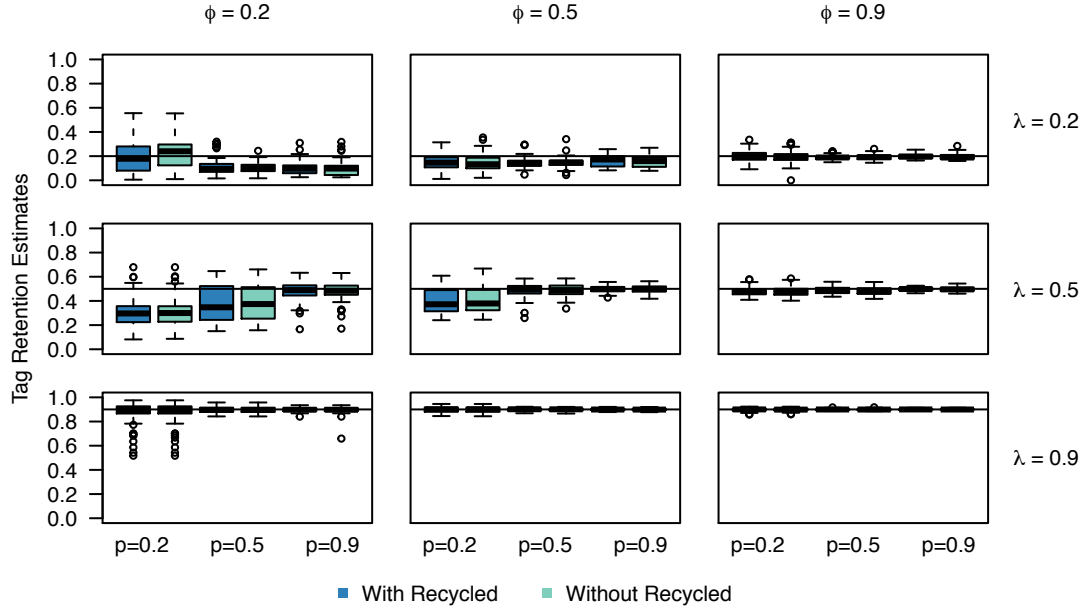
$N=1000, T=1, t=7$



WEB FIGURE 12: 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

N=1000, T=1

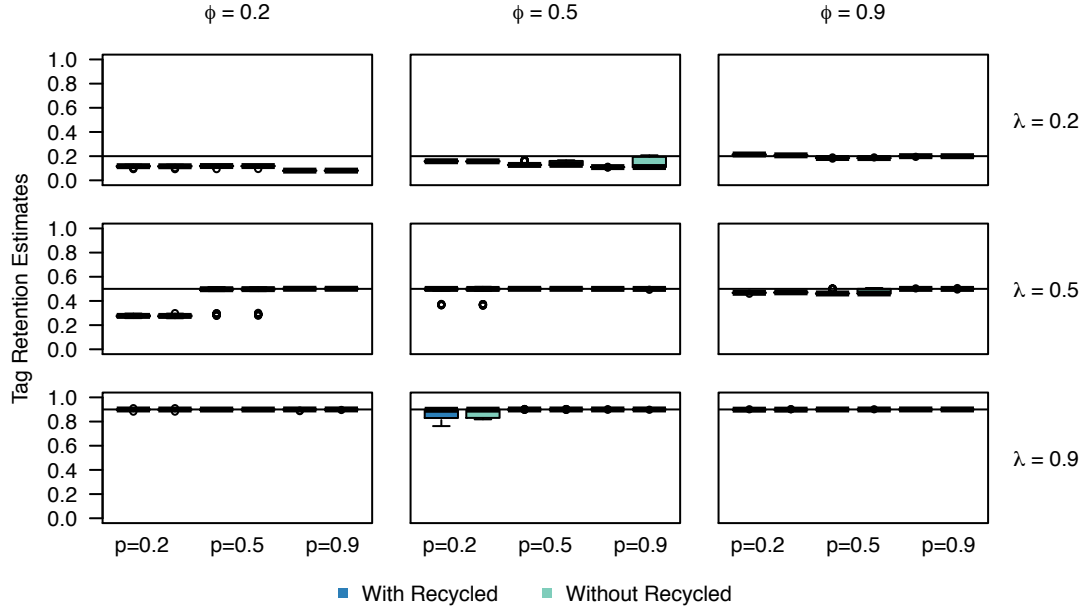


WEB FIGURE 13: Boxplots of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\lambda$  used to simulate the data for each model.

WEB TABLE 9: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0051  | 0.0049 | 0.0054  | 0.0054 | 0.0054    | 0.0054   |
| 0.9    | 0.9 | 0.5       | 0.0197  | 0.0143 | 0.0188  | 0.0142 | 0.0191    | 0.0144   |
| 0.9    | 0.9 | 0.2       | 0.0234  | 0.0152 | 0.0239  | 0.0184 | 0.0242    | 0.0184   |
| 0.9    | 0.5 | 0.9       | 0.0065  | 0.0063 | 0.0065  | 0.0061 | 0.0064    | 0.0061   |
| 0.9    | 0.5 | 0.5       | 0.0207  | 0.0184 | 0.0324  | 0.0291 | 0.0367    | 0.0314   |
| 0.9    | 0.5 | 0.2       | 0.0203  | 0.0178 | 0.0226  | 0.0187 | 0.0243    | 0.0210   |
| 0.9    | 0.2 | 0.9       | 0.0114  | 0.0113 | 0.0127  | 0.0129 | 0.0127    | 0.0130   |
| 0.9    | 0.2 | 0.5       | 0.0326  | 0.0297 | 0.0408  | 0.0349 | 0.0469    | 0.0417   |
| 0.9    | 0.2 | 0.2       | 0.0424  | 0.0386 | 0.0501  | 0.0439 | 0.0501    | 0.0437   |
| 0.5    | 0.9 | 0.9       | 0.0093  | 0.0092 | 0.0091  | 0.0091 | 0.0091    | 0.0091   |
| 0.5    | 0.9 | 0.5       | 0.0283  | 0.0256 | 0.0294  | 0.0273 | 0.0294    | 0.0272   |
| 0.5    | 0.9 | 0.2       | 0.0254  | 0.0260 | 0.0495  | 0.0478 | 0.0655    | 0.0597   |
| 0.5    | 0.5 | 0.9       | 0.0123  | 0.0122 | 0.0116  | 0.0115 | 0.0115    | 0.0115   |
| 0.5    | 0.5 | 0.5       | 0.0389  | 0.0363 | 0.0489  | 0.0511 | 0.0497    | 0.0517   |
| 0.5    | 0.5 | 0.2       | 0.0267  | 0.0250 | 0.0370  | 0.0371 | 0.0652    | 0.0680   |
| 0.5    | 0.2 | 0.9       | 0.0224  | 0.0223 | 0.0229  | 0.0224 | 0.0228    | 0.0223   |
| 0.5    | 0.2 | 0.5       | 0.0566  | 0.0551 | 0.1072  | 0.1040 | 0.1410    | 0.1421   |
| 0.5    | 0.2 | 0.2       | 0.0514  | 0.0480 | 0.0653  | 0.0597 | 0.0838    | 0.0784   |
| 0.2    | 0.9 | 0.9       | 0.0171  | 0.0170 | 0.0292  | 0.0165 | 0.0294    | 0.0165   |
| 0.2    | 0.9 | 0.5       | 0.0468  | 0.0457 | 0.0692  | 0.0673 | 0.0711    | 0.0686   |
| 0.2    | 0.9 | 0.2       | 0.0219  | 0.0234 | 0.0539  | 0.0521 | 0.1168    | 0.1139   |
| 0.2    | 0.5 | 0.9       | 0.0240  | 0.0240 | 0.0222  | 0.0220 | 0.0224    | 0.0222   |
| 0.2    | 0.5 | 0.5       | 0.0541  | 0.0526 | 0.1386  | 0.1432 | 0.1791    | 0.1866   |
| 0.2    | 0.5 | 0.2       | 0.0325  | 0.0323 | 0.0405  | 0.0639 | 0.1047    | 0.1109   |
| 0.2    | 0.2 | 0.9       | 0.0513  | 0.0517 | 0.0858  | 0.0857 | 0.0884    | 0.0885   |
| 0.2    | 0.2 | 0.5       | 0.0898  | 0.0899 | 0.1087  | 0.1069 | 0.2187    | 0.2229   |
| 0.2    | 0.2 | 0.2       | 0.0889  | 0.0824 | 0.1151  | 0.1192 | 0.1159    | 0.1194   |

$N=100000$ ,  $T=1$

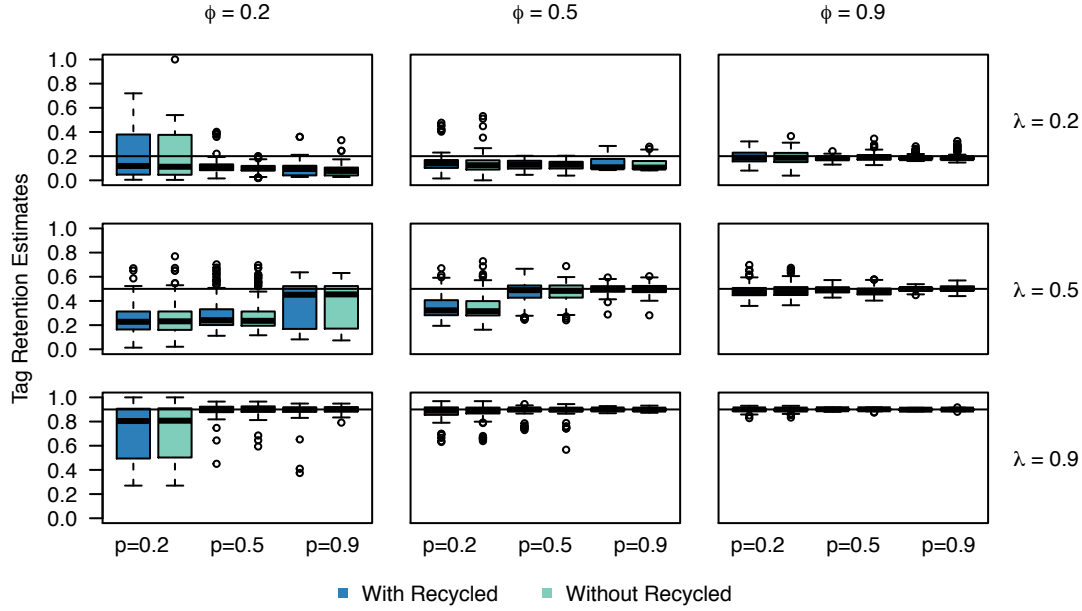


WEB FIGURE 14: Boxplots of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\lambda$  used to simulate the data for each model.

WEB TABLE 10: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0051  | 0.0049 | 0.0054  | 0.0054 | 0.0054    | 0.0054   |
| 0.9    | 0.9 | 0.5       | 0.0197  | 0.0143 | 0.0188  | 0.0142 | 0.0191    | 0.0144   |
| 0.9    | 0.9 | 0.2       | 0.0234  | 0.0152 | 0.0239  | 0.0184 | 0.0242    | 0.0184   |
| 0.9    | 0.5 | 0.9       | 0.0065  | 0.0063 | 0.0065  | 0.0061 | 0.0064    | 0.0061   |
| 0.9    | 0.5 | 0.5       | 0.0207  | 0.0184 | 0.0324  | 0.0291 | 0.0367    | 0.0314   |
| 0.9    | 0.5 | 0.2       | 0.0203  | 0.0178 | 0.0226  | 0.0187 | 0.0243    | 0.0210   |
| 0.9    | 0.2 | 0.9       | 0.0114  | 0.0113 | 0.0127  | 0.0129 | 0.0127    | 0.0130   |
| 0.9    | 0.2 | 0.5       | 0.0326  | 0.0297 | 0.0408  | 0.0349 | 0.0469    | 0.0417   |
| 0.9    | 0.2 | 0.2       | 0.0424  | 0.0386 | 0.0501  | 0.0439 | 0.0501    | 0.0437   |
| 0.5    | 0.9 | 0.9       | 0.0093  | 0.0092 | 0.0091  | 0.0091 | 0.0091    | 0.0091   |
| 0.5    | 0.9 | 0.5       | 0.0283  | 0.0256 | 0.0294  | 0.0273 | 0.0294    | 0.0272   |
| 0.5    | 0.9 | 0.2       | 0.0254  | 0.0260 | 0.0495  | 0.0478 | 0.0655    | 0.0597   |
| 0.5    | 0.5 | 0.9       | 0.0123  | 0.0122 | 0.0116  | 0.0115 | 0.0115    | 0.0115   |
| 0.5    | 0.5 | 0.5       | 0.0389  | 0.0363 | 0.0489  | 0.0511 | 0.0497    | 0.0517   |
| 0.5    | 0.5 | 0.2       | 0.0267  | 0.0250 | 0.0370  | 0.0371 | 0.0652    | 0.0680   |
| 0.5    | 0.2 | 0.9       | 0.0224  | 0.0223 | 0.0229  | 0.0224 | 0.0228    | 0.0223   |
| 0.5    | 0.2 | 0.5       | 0.0566  | 0.0551 | 0.1072  | 0.1040 | 0.1410    | 0.1421   |
| 0.5    | 0.2 | 0.2       | 0.0514  | 0.0480 | 0.0653  | 0.0597 | 0.0838    | 0.0784   |
| 0.2    | 0.9 | 0.9       | 0.0171  | 0.0170 | 0.0292  | 0.0165 | 0.0294    | 0.0165   |
| 0.2    | 0.9 | 0.5       | 0.0468  | 0.0457 | 0.0692  | 0.0673 | 0.0711    | 0.0686   |
| 0.2    | 0.9 | 0.2       | 0.0219  | 0.0234 | 0.0539  | 0.0521 | 0.1168    | 0.1139   |
| 0.2    | 0.5 | 0.9       | 0.0240  | 0.0240 | 0.0222  | 0.0220 | 0.0224    | 0.0222   |
| 0.2    | 0.5 | 0.5       | 0.0541  | 0.0526 | 0.1386  | 0.1432 | 0.1791    | 0.1866   |
| 0.2    | 0.5 | 0.2       | 0.0325  | 0.0323 | 0.0405  | 0.0639 | 0.1047    | 0.1109   |
| 0.2    | 0.2 | 0.9       | 0.0513  | 0.0517 | 0.0858  | 0.0857 | 0.0884    | 0.0885   |
| 0.2    | 0.2 | 0.5       | 0.0898  | 0.0899 | 0.1087  | 0.1069 | 0.2187    | 0.2229   |
| 0.2    | 0.2 | 0.2       | 0.0889  | 0.0824 | 0.1151  | 0.1192 | 0.1159    | 0.1194   |

$N=1000, T=0.5$

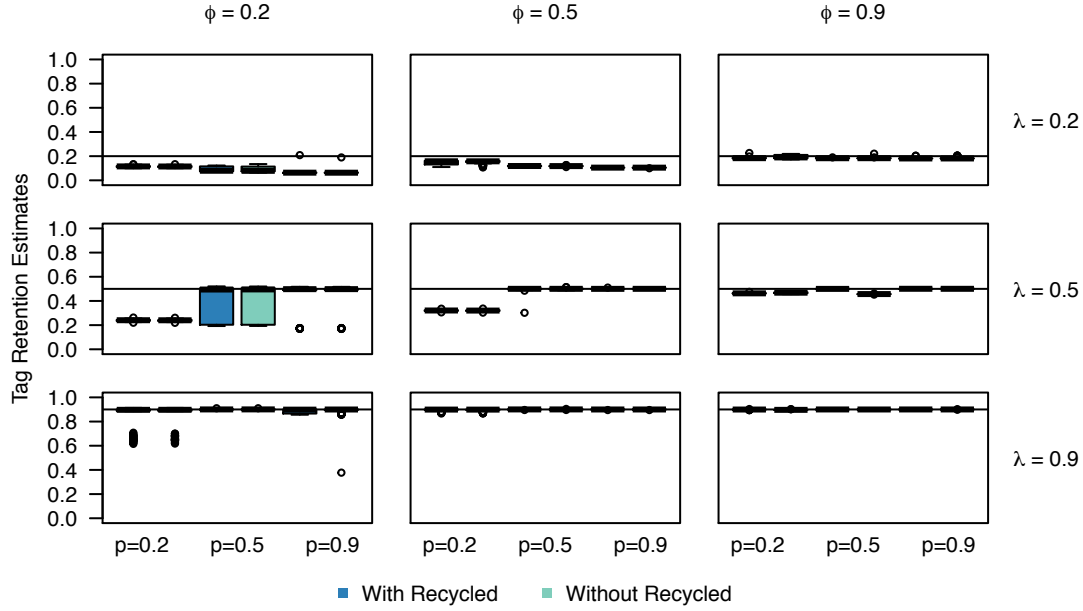


WEB FIGURE 15: Boxplots of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\lambda$  used to simulate the data for each model.

WEB TABLE 11: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0069  | 0.0064 | 0.0067  | 0.0062 | 0.0067    | 0.0063   |
| 0.9    | 0.9 | 0.5       | 0.0268  | 0.0185 | 0.0262  | 0.0178 | 0.0262    | 0.0179   |
| 0.9    | 0.9 | 0.2       | 0.0186  | 0.0118 | 0.0346  | 0.0229 | 0.0352    | 0.0247   |
| 0.9    | 0.5 | 0.9       | 0.0087  | 0.0083 | 0.0081  | 0.0084 | 0.0080    | 0.0084   |
| 0.9    | 0.5 | 0.5       | 0.0242  | 0.0256 | 0.0392  | 0.0282 | 0.0429    | 0.0288   |
| 0.9    | 0.5 | 0.2       | 0.0253  | 0.0177 | 0.0345  | 0.0192 | 0.0350    | 0.0270   |
| 0.9    | 0.2 | 0.9       | 0.0157  | 0.0156 | 0.0168  | 0.0172 | 0.0169    | 0.0174   |
| 0.9    | 0.2 | 0.5       | 0.0421  | 0.0370 | 0.0602  | 0.0584 | 0.0617    | 0.0604   |
| 0.9    | 0.2 | 0.2       | 0.0498  | 0.0452 | 0.0538  | 0.0492 | 0.0547    | 0.0499   |
| 0.5    | 0.9 | 0.9       | 0.0129  | 0.0126 | 0.0130  | 0.0128 | 0.0130    | 0.0128   |
| 0.5    | 0.9 | 0.5       | 0.0387  | 0.0342 | 0.0446  | 0.0420 | 0.0445    | 0.0418   |
| 0.5    | 0.9 | 0.2       | 0.0170  | 0.0172 | 0.0432  | 0.0508 | 0.0867    | 0.0835   |
| 0.5    | 0.5 | 0.9       | 0.0172  | 0.0170 | 0.0519  | 0.0379 | 0.0532    | 0.0387   |
| 0.5    | 0.5 | 0.5       | 0.0510  | 0.0435 | 0.0865  | 0.0964 | 0.0922    | 0.1040   |
| 0.5    | 0.5 | 0.2       | 0.0277  | 0.0253 | 0.0372  | 0.0385 | 0.0839    | 0.0812   |
| 0.5    | 0.2 | 0.9       | 0.0340  | 0.0340 | 0.0696  | 0.0659 | 0.0731    | 0.0699   |
| 0.5    | 0.2 | 0.5       | 0.0627  | 0.0623 | 0.1117  | 0.1002 | 0.1838    | 0.1766   |
| 0.5    | 0.2 | 0.2       | 0.0563  | 0.0597 | 0.0885  | 0.0909 | 0.1092    | 0.1024   |
| 0.2    | 0.9 | 0.9       | 0.0240  | 0.0241 | 0.0269  | 0.0792 | 0.0268    | 0.0801   |
| 0.2    | 0.9 | 0.5       | 0.0510  | 0.0477 | 0.1798  | 0.1830 | 0.2166    | 0.2237   |
| 0.2    | 0.9 | 0.2       | 0.0252  | 0.0219 | 0.0497  | 0.0564 | 0.1273    | 0.1229   |
| 0.2    | 0.5 | 0.9       | 0.0340  | 0.0341 | 0.0554  | 0.0625 | 0.0555    | 0.0629   |
| 0.2    | 0.5 | 0.5       | 0.0545  | 0.0537 | 0.1572  | 0.1479 | 0.2558    | 0.2533   |
| 0.2    | 0.5 | 0.2       | 0.0346  | 0.0360 | 0.0376  | 0.0723 | 0.1056    | 0.1104   |
| 0.2    | 0.2 | 0.9       | 0.0897  | 0.0907 | 0.2184  | 0.2189 | 0.2911    | 0.2890   |
| 0.2    | 0.2 | 0.5       | 0.0930  | 0.0911 | 0.1403  | 0.1252 | 0.2771    | 0.2813   |
| 0.2    | 0.2 | 0.2       | 0.0855  | 0.0907 | 0.1852  | 0.1774 | 0.1843    | 0.1766   |

N=100000, T=0.5



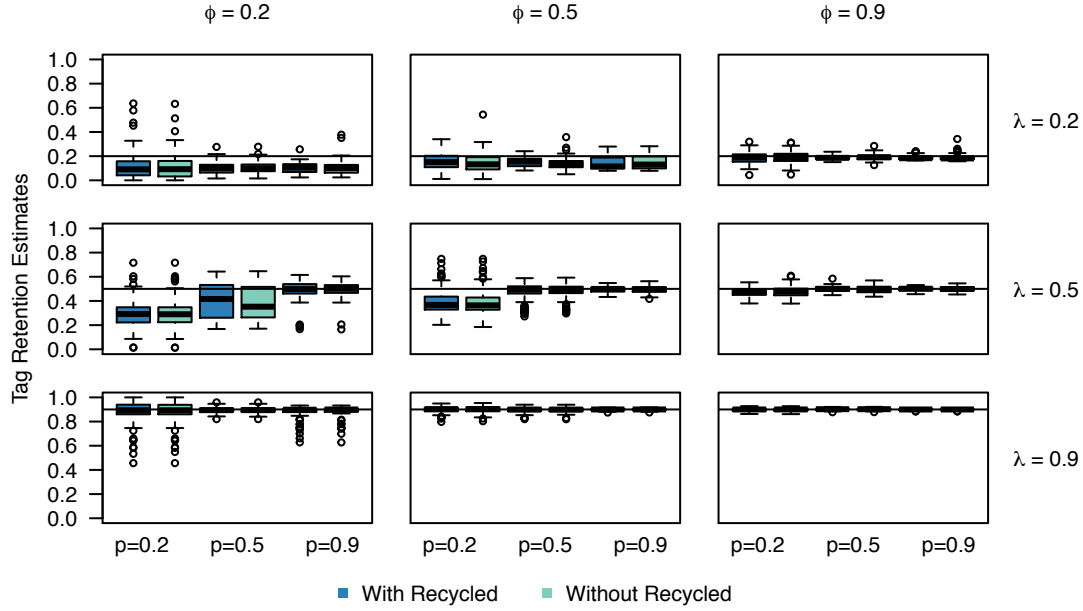
WEB FIGURE 16: Boxplots of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and tag retention ( $\lambda = 0.2, 0.5, 0.9$ ) probabilities. The black line indicates the true value of  $\lambda$  used to simulate the data for each model.

WEB TABLE 12: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of tag retention estimates ( $\hat{\lambda}$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 0.0007  | 0.0006 | 0.0007  | 0.0006 | 0.0007    | 0.0006   |
| 0.9    | 0.9 | 0.5       | 0.0027  | 0.0019 | 0.0028  | 0.0019 | 0.0028    | 0.0020   |
| 0.9    | 0.9 | 0.2       | 0.0016  | 0.0008 | 0.0064  | 0.0033 | 0.0177    | 0.0190   |
| 0.9    | 0.5 | 0.9       | 0.0009  | 0.0008 | 0.0008  | 0.0008 | 0.0008    | 0.0008   |
| 0.9    | 0.5 | 0.5       | 0.0017  | 0.0029 | 0.0018  | 0.0026 | 0.0431    | 0.0026   |
| 0.9    | 0.5 | 0.2       | 0.0024  | 0.0017 | 0.0045  | 0.0017 | 0.0171    | 0.0169   |
| 0.9    | 0.2 | 0.9       | 0.0016  | 0.0015 | 0.0019  | 0.0018 | 0.0035    | 0.0019   |
| 0.9    | 0.2 | 0.5       | 0.0036  | 0.0033 | 0.0054  | 0.0036 | 0.0330    | 0.0370   |
| 0.9    | 0.2 | 0.2       | 0.0052  | 0.0046 | 0.0148  | 0.0061 | 0.0155    | 0.0166   |
| 0.5    | 0.9 | 0.9       | 0.0013  | 0.0013 | 0.0013  | 0.0013 | 0.0013    | 0.0013   |
| 0.5    | 0.9 | 0.5       | 0.0039  | 0.0034 | 0.0038  | 0.0033 | 0.0038    | 0.0033   |
| 0.5    | 0.9 | 0.2       | 0.0014  | 0.0012 | 0.0014  | 0.0011 | 0.0951    | 0.0950   |
| 0.5    | 0.5 | 0.9       | 0.0017  | 0.0017 | 0.0016  | 0.0015 | 0.0016    | 0.0015   |
| 0.5    | 0.5 | 0.5       | 0.0054  | 0.0050 | 0.0053  | 0.0207 | 0.0053    | 0.0207   |
| 0.5    | 0.5 | 0.2       | 0.0031  | 0.0027 | 0.0029  | 0.0027 | 0.0819    | 0.0816   |
| 0.5    | 0.2 | 0.9       | 0.0032  | 0.0031 | 0.0093  | 0.0079 | 0.0101    | 0.0082   |
| 0.5    | 0.2 | 0.5       | 0.0056  | 0.0055 | 0.0053  | 0.0051 | 0.1794    | 0.1790   |
| 0.5    | 0.2 | 0.2       | 0.0064  | 0.0061 | 0.0151  | 0.0175 | 0.0504    | 0.0536   |
| 0.2    | 0.9 | 0.9       | 0.0026  | 0.0027 | 0.0537  | 0.0174 | 0.0550    | 0.0212   |
| 0.2    | 0.9 | 0.5       | 0.0060  | 0.0058 | 0.1104  | 0.1171 | 0.1182    | 0.1269   |
| 0.2    | 0.9 | 0.2       | 0.0031  | 0.0028 | 0.0129  | 0.0147 | 0.1360    | 0.1359   |
| 0.2    | 0.5 | 0.9       | 0.0033  | 0.0033 | 0.0032  | 0.0032 | 0.0032    | 0.0032   |
| 0.2    | 0.5 | 0.5       | 0.0072  | 0.0068 | 0.1502  | 0.1518 | 0.1932    | 0.2040   |
| 0.2    | 0.5 | 0.2       | 0.0046  | 0.0044 | 0.0200  | 0.0192 | 0.1130    | 0.1120   |
| 0.2    | 0.2 | 0.9       | 0.0080  | 0.0082 | 0.0922  | 0.0985 | 0.1018    | 0.1107   |
| 0.2    | 0.2 | 0.5       | 0.0090  | 0.0089 | 0.0075  | 0.0075 | 0.2603    | 0.2601   |
| 0.2    | 0.2 | 0.2       | 0.0092  | 0.0091 | 0.0070  | 0.0070 | 0.0854    | 0.0850   |

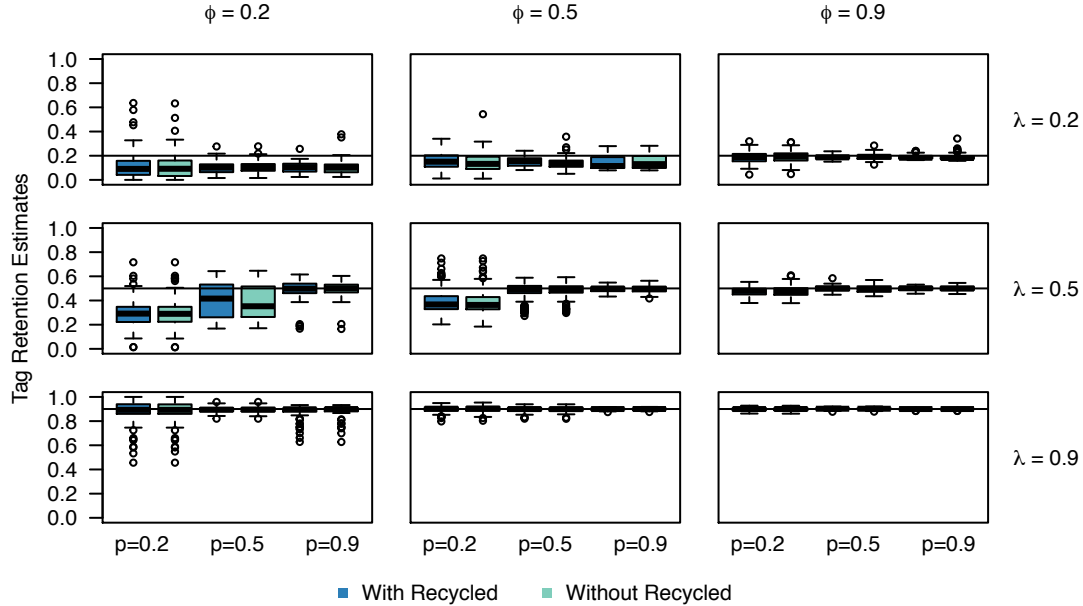


$N=1000, T=1, t=5$



WEB FIGURE 17: 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  $\lambda$  used to simulate the data for each model.

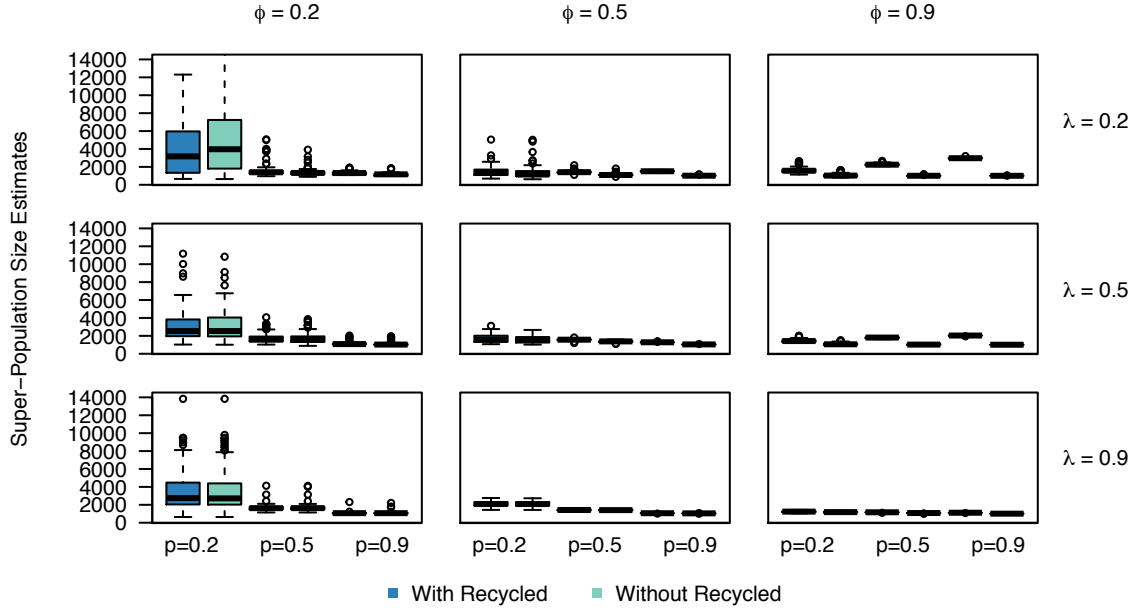
$N=1000, T=1, t=7$



WEB FIGURE 18: 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  $\lambda$  used to simulate the data for each model.

## Super-Population Size Estimates

$N=1000$ ,  $T=1$

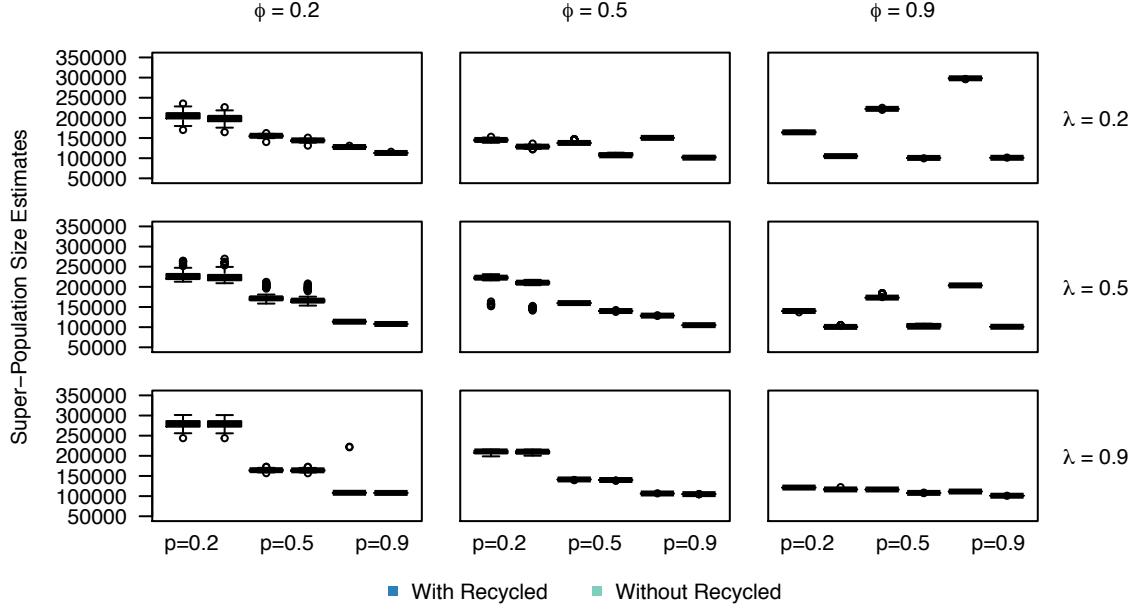


WEB FIGURE 19: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and 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.

WEB TABLE 13: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | $p$ | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R) | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|--------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 50.5    | 50.5   | 4.0     | 11.1   | 10.8      | 114.5    |
| 0.9    | 0.9 | 0.5       | 50.5    | 50.5   | 5.8     | 33.0   | 11.0      | 1037.9   |
| 0.9    | 0.9 | 0.2       | 49.6    | 49.6   | 10.5    | 75.8   | 12.0      | 1980.5   |
| 0.9    | 0.5 | 0.9       | 50.5    | 50.5   | 19.0    | 21.9   | 80.8      | 164.5    |
| 0.9    | 0.5 | 0.5       | 50.5    | 50.5   | 54.5    | 82.5   | 68.2      | 801.9    |
| 0.9    | 0.5 | 0.2       | 50.5    | 50.5   | 34.9    | 112.9  | 37.0      | 1266.4   |
| 0.9    | 0.2 | 0.9       | 49.8    | 49.8   | 74.2    | 80.3   | 192.9     | 245.4    |
| 0.9    | 0.2 | 0.5       | 50.5    | 50.5   | 130.0   | 160.7  | 156.0     | 477.6    |
| 0.9    | 0.2 | 0.2       | 49.6    | 50.5   | 173.7   | 290.1  | 179.3     | 687.8    |
| 0.5    | 0.9 | 0.9       | 50.5    | 50.5   | 12.0    | 12.7   | 49.1      | 64.7     |
| 0.5    | 0.9 | 0.5       | 50.5    | 50.5   | 16.9    | 28.4   | 48.0      | 284.1    |
| 0.5    | 0.9 | 0.2       | 49.6    | 49.6   | 34.7    | 57.0   | 44.2      | 527.3    |
| 0.5    | 0.5 | 0.9       | 50.5    | 50.5   | 61.6    | 61.6   | 411.9     | 424.5    |
| 0.5    | 0.5 | 0.5       | 50.4    | 50.4   | 85.0    | 95.9   | 388.2     | 576.5    |
| 0.5    | 0.5 | 0.2       | 50.5    | 50.5   | 108.7   | 132.5  | 157.8     | 443.4    |
| 0.5    | 0.2 | 0.9       | 49.4    | 49.4   | 276.4   | 273.7  | 1152.3    | 1149.4   |
| 0.5    | 0.2 | 0.5       | 50.5    | 50.5   | 417.9   | 445.8  | 723.5     | 816.6    |
| 0.5    | 0.2 | 0.2       | 49.4    | 49.4   | 710.4   | 587.7  | 801.9     | 760.4    |
| 0.2    | 0.9 | 0.9       | 50.5    | 50.5   | 158.2   | 132.9  | 184.1     | 156.7    |
| 0.2    | 0.9 | 0.5       | 50.8    | 50.5   | 176.7   | 165.7  | 194.4     | 214.2    |
| 0.2    | 0.9 | 0.2       | 50.3    | 50.3   | 161.5   | 164.5  | 226.2     | 346.0    |
| 0.2    | 0.5 | 0.9       | 50.5    | 50.5   | 426.7   | 362.3  | 815.9     | 763.0    |
| 0.2    | 0.5 | 0.5       | 50.5    | 50.5   | 624.0   | 582.9  | 973.6     | 954.5    |
| 0.2    | 0.5 | 0.2       | 50.5    | 50.5   | 423.4   | 784.3  | 583.8     | 993.3    |
| 0.2    | 0.2 | 0.9       | 50.5    | 50.5   | 2517.1  | 2485.1 | 3651.5    | 3662.1   |
| 0.2    | 0.2 | 0.5       | 50.1    | 50.1   | 1852.7  | 1877.8 | 2882.2    | 2866.4   |
| 0.2    | 0.2 | 0.2       | 49.1    | 49.1   | 8456.1  | 3760.5 | 9651.8    | 5001.5   |

$N=100000$ ,  $T=0.5$

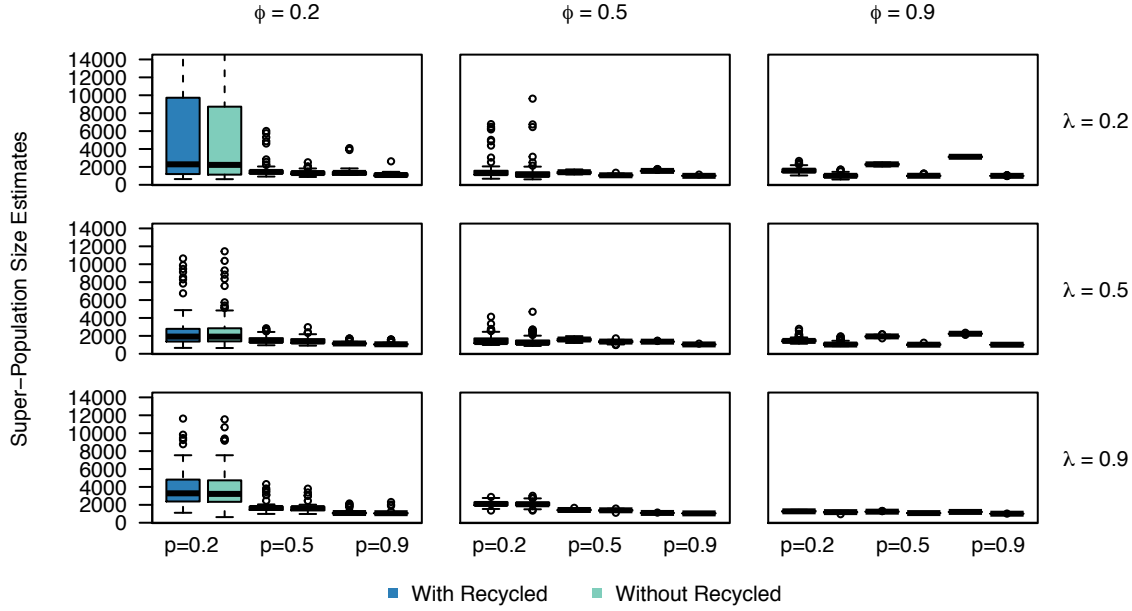


WEB FIGURE 20: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 1$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), 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.

WEB TABLE 14: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 1$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R)  | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|---------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 42.1    | 42.1   | 38.9    | 107.6   | 988.1     | 11361.8  |
| 0.9    | 0.9 | 0.5       | 37.8    | 37.8   | 48.3    | 355.4   | 982.7     | 103591.7 |
| 0.9    | 0.9 | 0.2       | 38.5    | 38.5   | 135.9   | 662.0   | 982.7     | 198249.4 |
| 0.9    | 0.5 | 0.9       | 37.9    | 37.9   | 175.4   | 211.2   | 7994.0    | 16488.3  |
| 0.9    | 0.5 | 0.5       | 37.9    | 37.9   | 3572.1  | 3521.2  | 5471.0    | 74619.3  |
| 0.9    | 0.5 | 0.2       | 41.4    | 41.4   | 296.0   | 800.3   | 712.4     | 122405.8 |
| 0.9    | 0.2 | 0.9       | 49.4    | 49.4   | 775.8   | 564.4   | 16686.3   | 21184.5  |
| 0.9    | 0.2 | 0.5       | 50.5    | 50.5   | 1545.3  | 993.9   | 1910.3    | 40081.3  |
| 0.9    | 0.2 | 0.2       | 50.5    | 50.5   | 1270.1  | 1737.6  | 5261.2    | 64349.6  |
| 0.5    | 0.9 | 0.9       | 50.5    | 50.5   | 109.5   | 117.8   | 4937.2    | 6525.9   |
| 0.5    | 0.9 | 0.5       | 50.5    | 50.5   | 173.4   | 267.0   | 4934.9    | 28655.8  |
| 0.5    | 0.9 | 0.2       | 37.3    | 37.3   | 1600.4  | 323.9   | 2719.0    | 50378.1  |
| 0.5    | 0.5 | 0.9       | 50.5    | 50.5   | 595.7   | 598.0   | 40018.0   | 41403.6  |
| 0.5    | 0.5 | 0.5       | 37.9    | 37.9   | 934.1   | 1019.7  | 40127.1   | 59803.7  |
| 0.5    | 0.5 | 0.2       | 38.1    | 38.1   | 3118.2  | 3462.6  | 9395.9    | 39297.7  |
| 0.5    | 0.2 | 0.9       | 48.9    | 48.9   | 3926.0  | 3936.0  | 109240.3  | 109983.6 |
| 0.5    | 0.2 | 0.5       | 42.1    | 42.1   | 18455.0 | 17443.4 | 106660.8  | 120015.2 |
| 0.5    | 0.2 | 0.2       | 50.5    | 50.5   | 2571.6  | 2768.5  | 28853.1   | 45396.0  |
| 0.2    | 0.9 | 0.9       | 37.9    | 37.9   | 428.2   | 15996.7 | 7973.9    | 19083.5  |
| 0.2    | 0.9 | 0.5       | 38.3    | 38.3   | 772.7   | 817.7   | 7954.7    | 13739.3  |
| 0.2    | 0.9 | 0.2       | 38.1    | 38.1   | 897.2   | 969.9   | 13086.8   | 27825.1  |
| 0.2    | 0.5 | 0.9       | 43.6    | 43.6   | 2729.4  | 2724.0  | 64215.6   | 64466.8  |
| 0.2    | 0.5 | 0.5       | 38.1    | 38.1   | 12500.3 | 14199.0 | 70108.9   | 77289.2  |
| 0.2    | 0.5 | 0.2       | 42.0    | 42.0   | 2572.1  | 2739.3  | 44049.6   | 55230.3  |
| 0.2    | 0.2 | 0.9       | 42.1    | 42.1   | 10707.4 | 10726.6 | 178913.1  | 179098.6 |
| 0.2    | 0.2 | 0.5       | 50.5    | 50.5   | 12705.6 | 11900.4 | 125943.1  | 128430.9 |
| 0.2    | 0.2 | 0.2       | 50.5    | 50.5   | 9921.4  | 10271.3 | 99244.6   | 105891.3 |

$N=1000$ ,  $T=0.5$

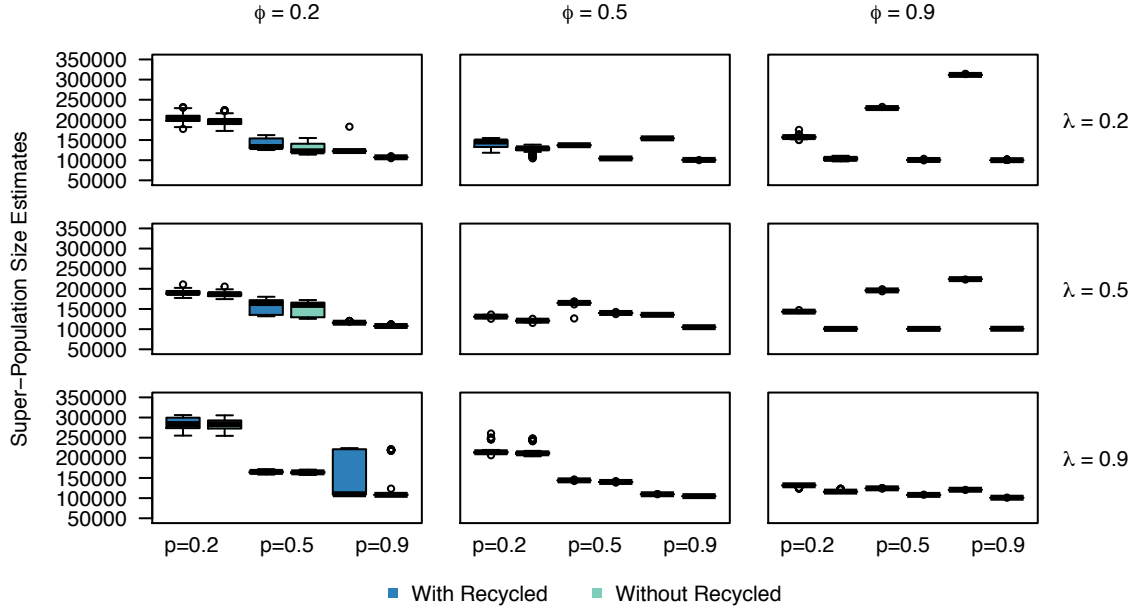


WEB FIGURE 21: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), 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.

WEB TABLE 15: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R') | SD (R)  | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|---------|---------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 50.5    | 50.5   | 4.1     | 13.6    | 98990.4   | 98793.7  |
| 0.9    | 0.9 | 0.5       | 50.5    | 50.5   | 7.1     | 39.2    | 98990.7   | 97760.7  |
| 0.9    | 0.9 | 0.2       | 50.5    | 50.5   | 13.0    | 66.0    | 98996.6   | 96870.5  |
| 0.9    | 0.5 | 0.9       | 50.5    | 50.5   | 19.3    | 28.0    | 98920.9   | 98760.1  |
| 0.9    | 0.5 | 0.5       | 50.3    | 50.3   | 62.8    | 89.9    | 98963.0   | 98058.6  |
| 0.9    | 0.5 | 0.2       | 50.5    | 50.5   | 54.8    | 91.8    | 98984.5   | 97710.5  |
| 0.9    | 0.2 | 0.9       | 50.5    | 50.5   | 68.2    | 75.3    | 98813.8   | 98717.0  |
| 0.9    | 0.2 | 0.5       | 50.5    | 50.5   | 211.3   | 275.9   | 98886.7   | 98472.5  |
| 0.9    | 0.2 | 0.2       | 50.5    | 50.5   | 197.3   | 294.3   | 98961.1   | 98383.8  |
| 0.5    | 0.9 | 0.9       | 50.5    | 50.5   | 12.6    | 13.8    | 98952.5   | 98906.8  |
| 0.5    | 0.9 | 0.5       | 50.5    | 50.5   | 20.8    | 29.6    | 98955.0   | 98645.7  |
| 0.5    | 0.9 | 0.2       | 50.4    | 50.4   | 35.9    | 62.7    | 98981.0   | 98437.8  |
| 0.5    | 0.5 | 0.9       | 50.3    | 50.3   | 73.0    | 70.3    | 98608.8   | 98566.8  |
| 0.5    | 0.5 | 0.5       | 49.3    | 49.3   | 135.1   | 179.0   | 98657.1   | 98440.0  |
| 0.5    | 0.5 | 0.2       | 50.5    | 50.5   | 89.9    | 118.4   | 98932.9   | 98602.1  |
| 0.5    | 0.2 | 0.9       | 50.0    | 50.0   | 293.9   | 276.7   | 97899.1   | 97877.0  |
| 0.5    | 0.2 | 0.5       | 49.7    | 49.7   | 526.1   | 532.8   | 98627.1   | 98483.6  |
| 0.5    | 0.2 | 0.2       | 49.4    | 49.3   | 1206.1  | 1205.4  | 98637.9   | 98389.6  |
| 0.2    | 0.9 | 0.9       | 50.5    | 50.5   | 184.9   | 200.8   | 98901.6   | 98873.5  |
| 0.2    | 0.9 | 0.5       | 50.3    | 50.3   | 130.2   | 119.9   | 98908.3   | 98831.8  |
| 0.2    | 0.9 | 0.2       | 49.7    | 49.7   | 194.6   | 410.9   | 98872.1   | 98639.7  |
| 0.2    | 0.5 | 0.9       | 50.5    | 50.5   | 449.9   | 540.4   | 98331.1   | 98283.4  |
| 0.2    | 0.5 | 0.5       | 50.2    | 50.2   | 357.5   | 410.7   | 98531.2   | 98447.0  |
| 0.2    | 0.5 | 0.2       | 50.5    | 50.5   | 262.1   | 903.0   | 98660.0   | 98354.8  |
| 0.2    | 0.2 | 0.9       | 49.0    | 49.0   | 2151.8  | 2035.6  | 96164.6   | 96153.8  |
| 0.2    | 0.2 | 0.5       | 48.9    | 48.9   | 2042.4  | 2077.0  | 97454.8   | 97469.4  |
| 0.2    | 0.2 | 0.2       | 49.1    | 46.7   | 11541.5 | 11170.7 | 94078.0   | 93726.1  |

$N=100000$ ,  $T=0.5$

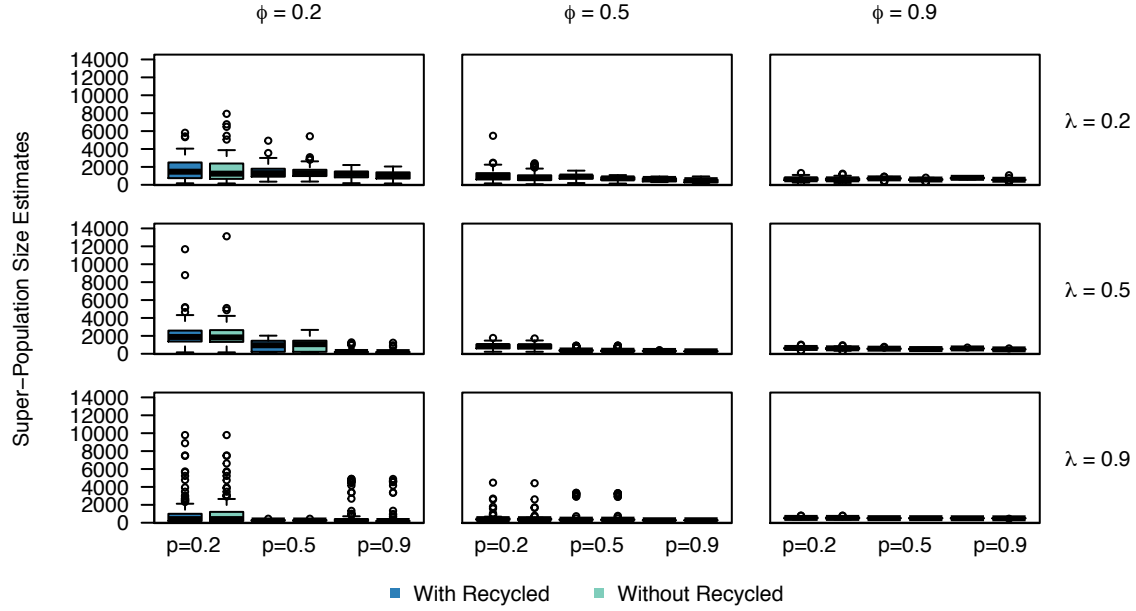


WEB FIGURE 22: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 100000 with  $T_2 = 0.5$  with 10 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), 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.

WEB TABLE 16: Standard Error (SE), Standard Deviation (SD), and Root Mean Squared Error (RMSE) of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed without (R') and with (R) the effect of recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for varying tag retention ( $\lambda = 0.2, 0.5, 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

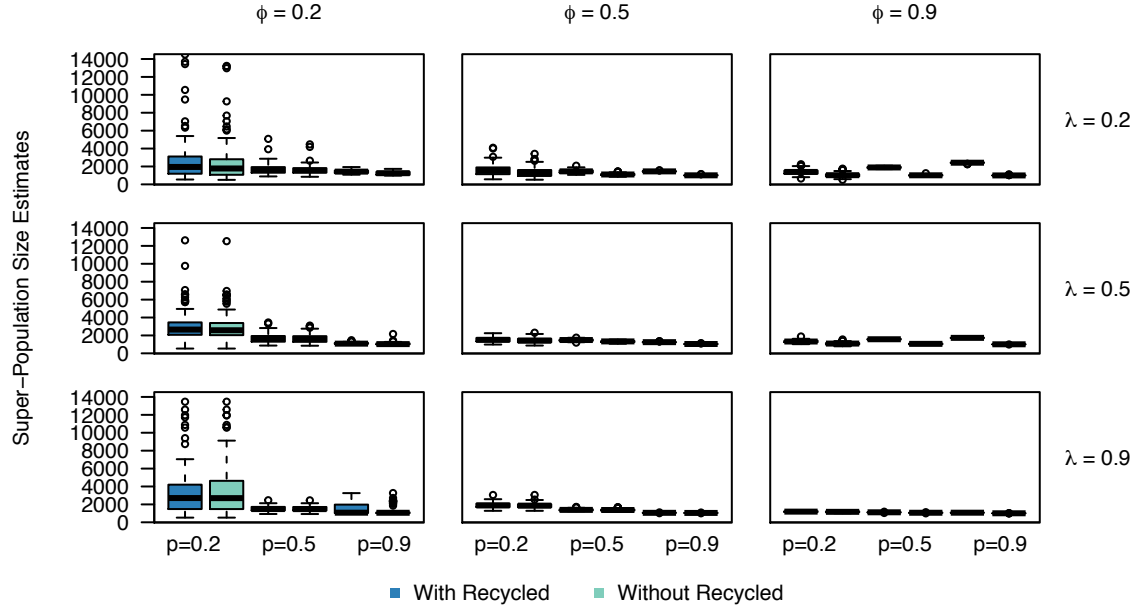
| $\phi$ | p   | $\lambda$ | SE (R') | SE (R) | SD (R')  | SD (R)   | RMSE (R') | RMSE (R) |
|--------|-----|-----------|---------|--------|----------|----------|-----------|----------|
| 0.9    | 0.9 | 0.9       | 50.5    | 50.5   | 38.2     | 154.8    | 996.5     | 20737.8  |
| 0.9    | 0.9 | 0.5       | 50.5    | 50.5   | 65.0     | 424.6    | 994.0     | 124165.7 |
| 0.9    | 0.9 | 0.2       | 50.5    | 50.5   | 332.4    | 698.0    | 384.3     | 211677.2 |
| 0.9    | 0.5 | 0.9       | 50.5    | 50.5   | 150.6    | 230.0    | 8000.3    | 24281.5  |
| 0.9    | 0.5 | 0.5       | 50.5    | 50.5   | 188.6    | 778.9    | 716.8     | 96173.9  |
| 0.9    | 0.5 | 0.2       | 50.5    | 50.5   | 429.5    | 836.9    | 674.7     | 129334.3 |
| 0.9    | 0.2 | 0.9       | 50.5    | 50.5   | 1869.8   | 2206.8   | 16707.2   | 31391.7  |
| 0.9    | 0.2 | 0.5       | 50.5    | 50.5   | 1359.9   | 1149.9   | 1675.6    | 43537.0  |
| 0.9    | 0.2 | 0.2       | 50.5    | 50.5   | 3394.6   | 3112.9   | 5123.0    | 57428.7  |
| 0.5    | 0.9 | 0.9       | 50.5    | 50.5   | 120.8    | 142.7    | 4955.3    | 9575.2   |
| 0.5    | 0.9 | 0.5       | 50.5    | 50.5   | 187.0    | 302.3    | 4914.5    | 35599.2  |
| 0.5    | 0.9 | 0.2       | 50.5    | 50.5   | 168.8    | 359.0    | 679.4     | 54183.0  |
| 0.5    | 0.5 | 0.9       | 50.5    | 50.5   | 542.8    | 560.4    | 40070.0   | 44111.9  |
| 0.5    | 0.5 | 0.5       | 50.7    | 50.7   | 1005.8   | 4079.9   | 40103.5   | 64909.0  |
| 0.5    | 0.5 | 0.2       | 50.5    | 50.5   | 669.8    | 911.8    | 4448.1    | 37200.1  |
| 0.5    | 0.2 | 0.9       | 50.5    | 50.5   | 12143.1  | 10053.7  | 116273.8  | 116900.2 |
| 0.5    | 0.2 | 0.5       | 50.5    | 50.5   | 1854.1   | 1903.6   | 21073.9   | 31154.4  |
| 0.5    | 0.2 | 0.2       | 50.5    | 50.5   | 7436.9   | 9739.0   | 27781.3   | 43358.6  |
| 0.2    | 0.9 | 0.9       | 50.5    | 50.5   | 45500.3  | 53655.2  | 55134.4   | 71471.1  |
| 0.2    | 0.9 | 0.5       | 49.5    | 49.5   | 1354.9   | 1518.0   | 8221.2    | 16562.5  |
| 0.2    | 0.9 | 0.2       | 50.5    | 50.5   | 863.1    | 6102.6   | 7316.1    | 24173.2  |
| 0.2    | 0.5 | 0.9       | 50.5    | 50.5   | 2644.7   | 2650.5   | 63982.9   | 65064.7  |
| 0.2    | 0.5 | 0.5       | 50.5    | 50.5   | 17928.4  | 18475.8  | 52981.9   | 57515.5  |
| 0.2    | 0.5 | 0.2       | 50.5    | 50.5   | 11448.1  | 11795.3  | 30061.5   | 40722.3  |
| 0.2    | 0.2 | 0.9       | 49.5    | 49.5   | 102582.5 | 108004.1 | 247997.3  | 257817.0 |
| 0.2    | 0.2 | 0.5       | 50.5    | 50.5   | 6004.5   | 6146.6   | 86974.2   | 90655.7  |
| 0.2    | 0.2 | 0.2       | 47.2    | 47.2   | 10566.9  | 10894.6  | 97248.1   | 104776.4 |

$N=1000$ ,  $T=1$ ,  $t=5$



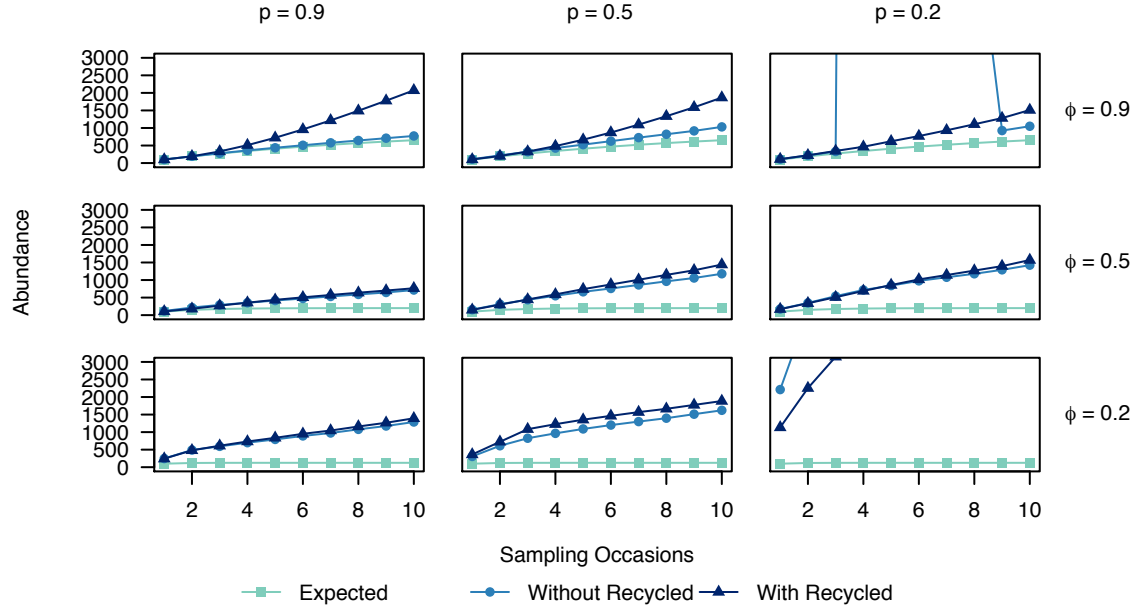
WEB FIGURE 23: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  for 5 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and 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.

$N=1000$ ,  $T=0.5$ ,  $t=7$

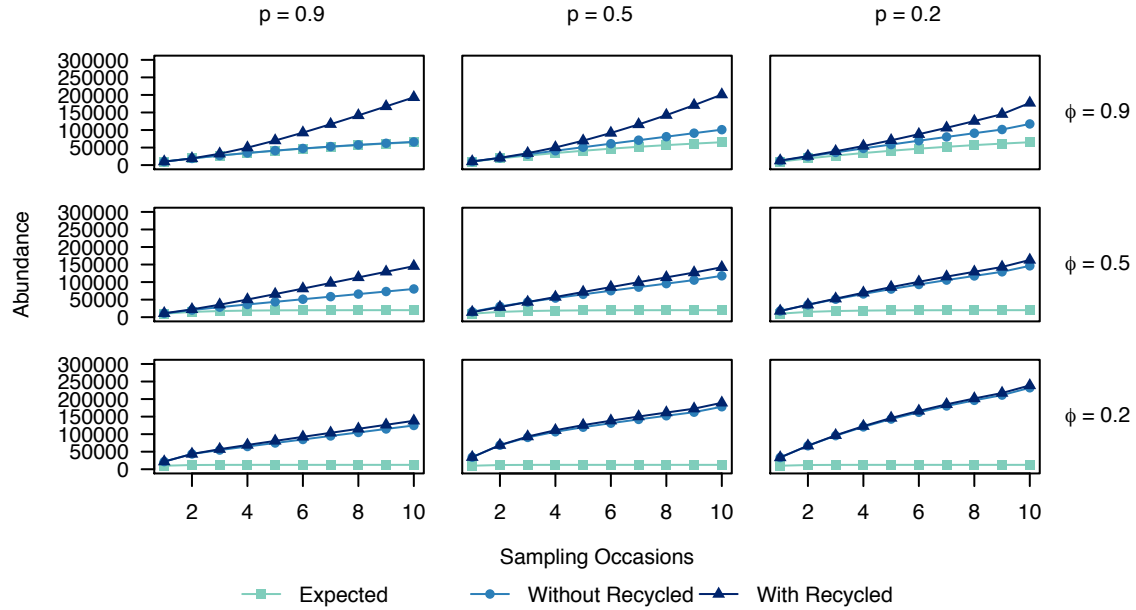


WEB FIGURE 24: Boxplots of super-population size estimates ( $N$ ) of 100 simulated datasets analyzed with and without the effect of recycled individuals for population size 1000 with  $T_2 = 1$  for 7 time periods for varying survival ( $\phi = 0.2, 0.5, 0.9$ ), capture ( $p = 0.2, 0.5, 0.9$ ), and 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.

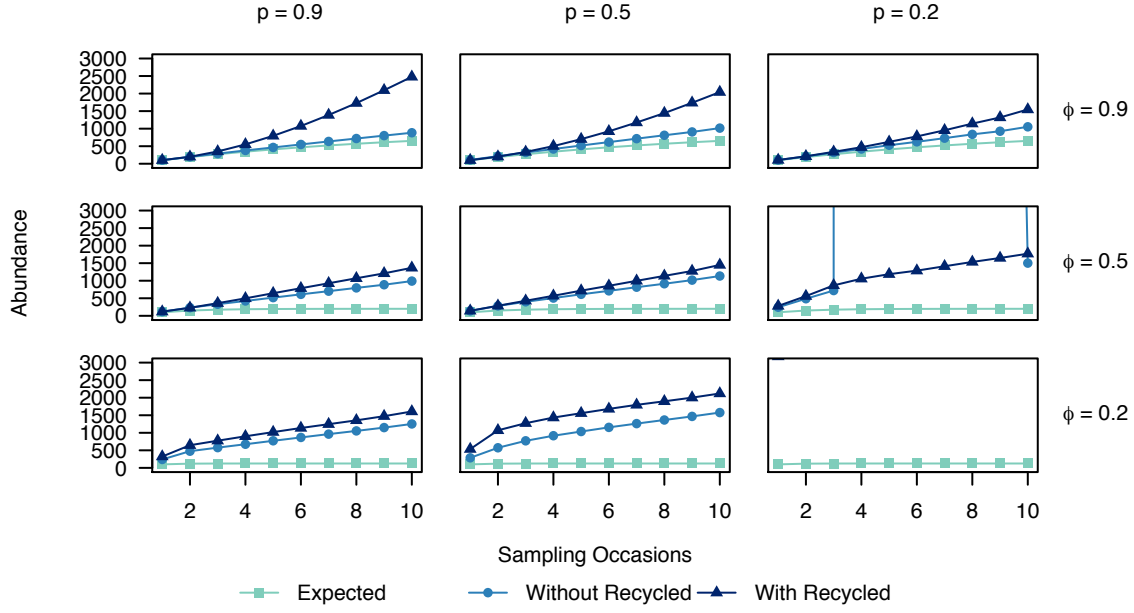
## Abundance Estimates



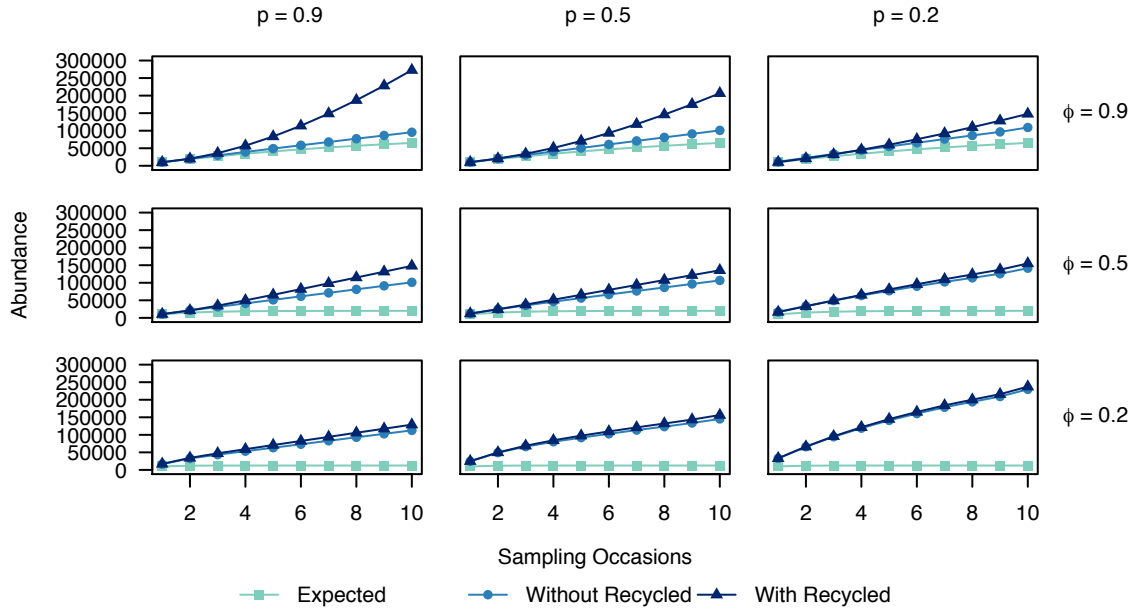
WEB FIGURE 25: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for low tag retention ( $\lambda = 0.2$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



WEB FIGURE 26: 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 ( $p = 0.2, 0.5, 0.9$ ).

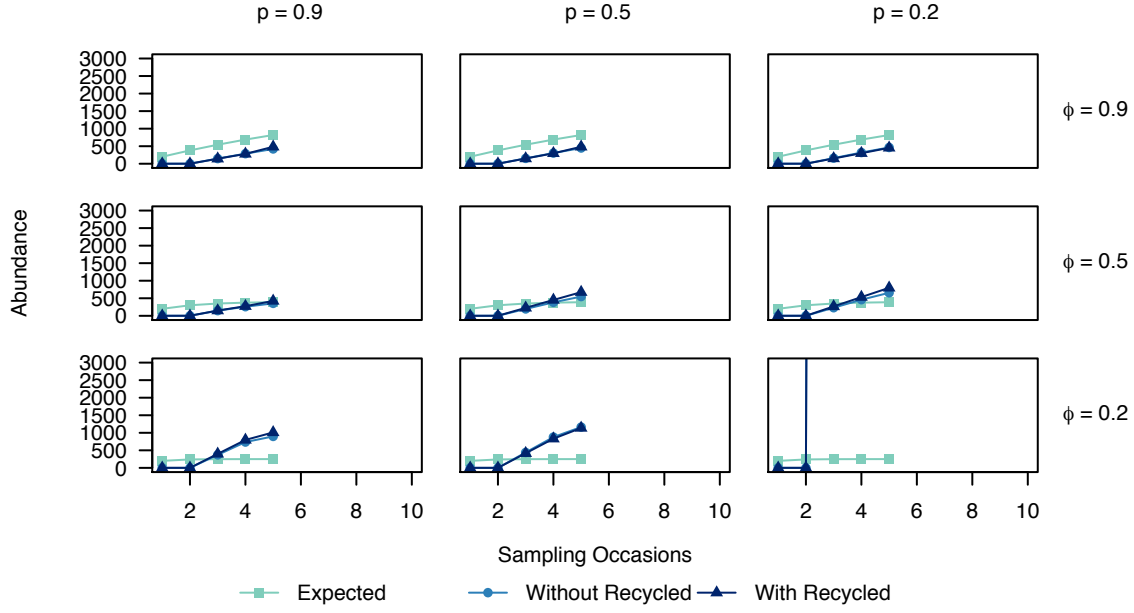


WEB FIGURE 27: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for low tag retention ( $\lambda = 0.2$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

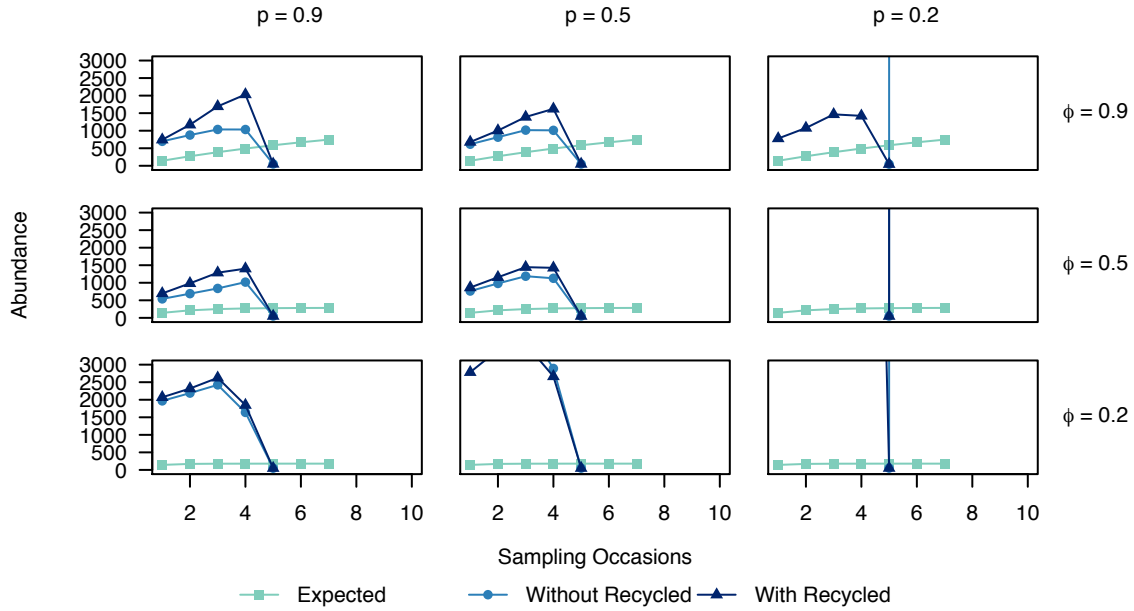


WEB FIGURE 28: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for low tag retention ( $\lambda = 0.2$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).

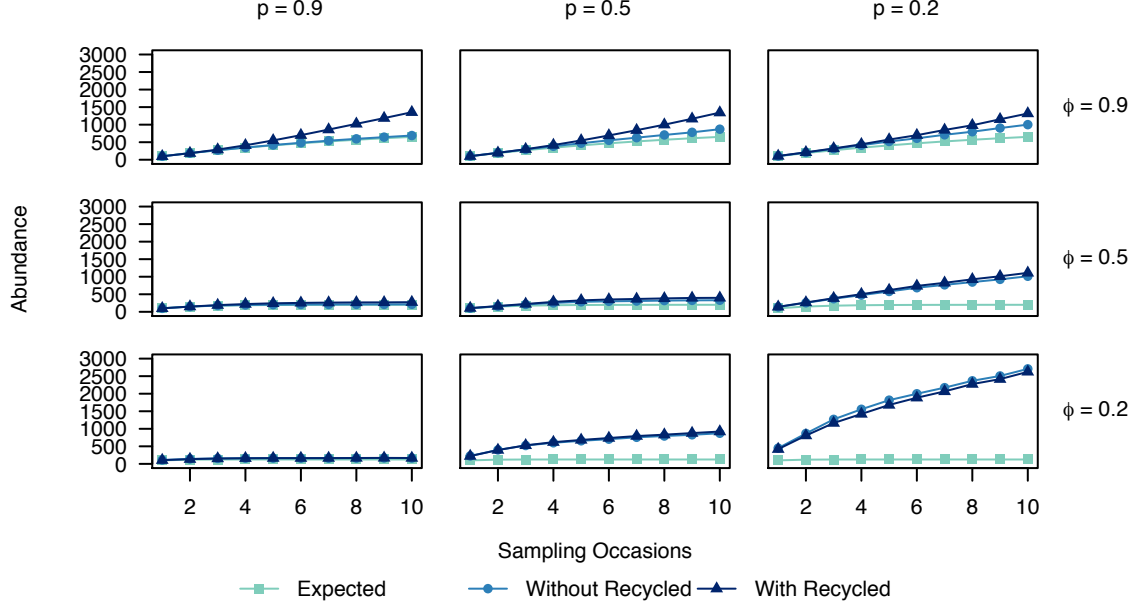




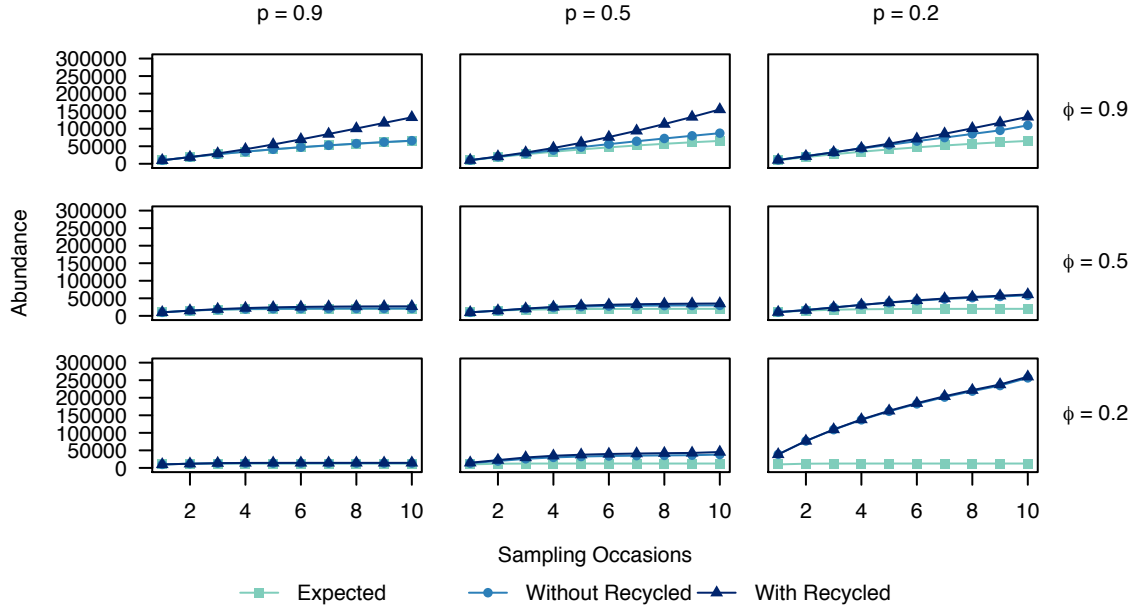
WEB FIGURE 29: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 5$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 5 time periods for low tag retention ( $\lambda = 0.2$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



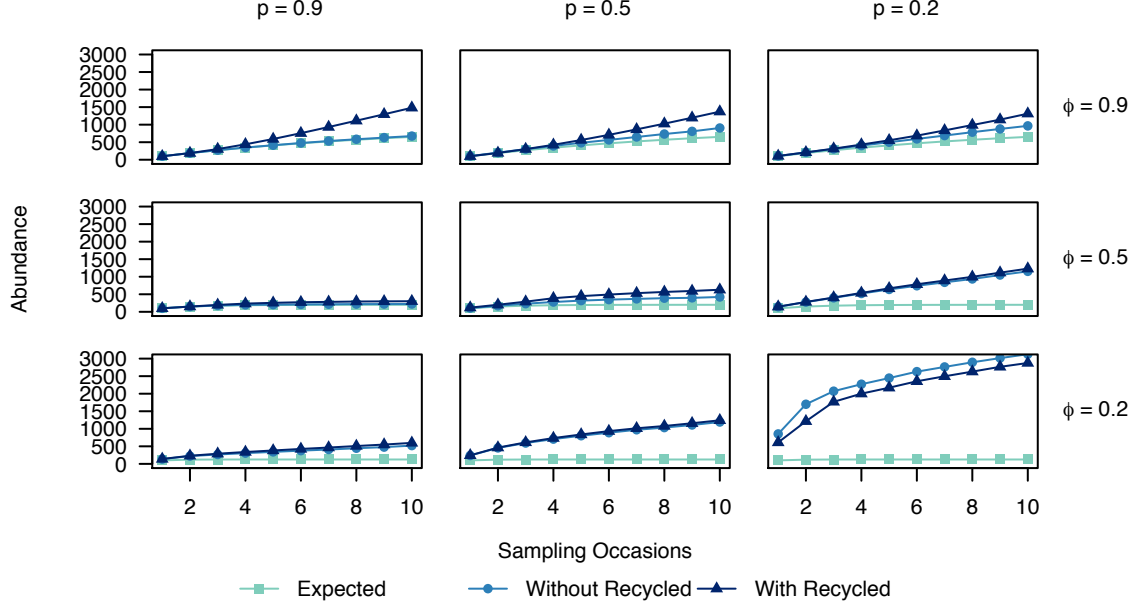
WEB FIGURE 30: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 7$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 7 time periods for low tag retention ( $\lambda = 0.2$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



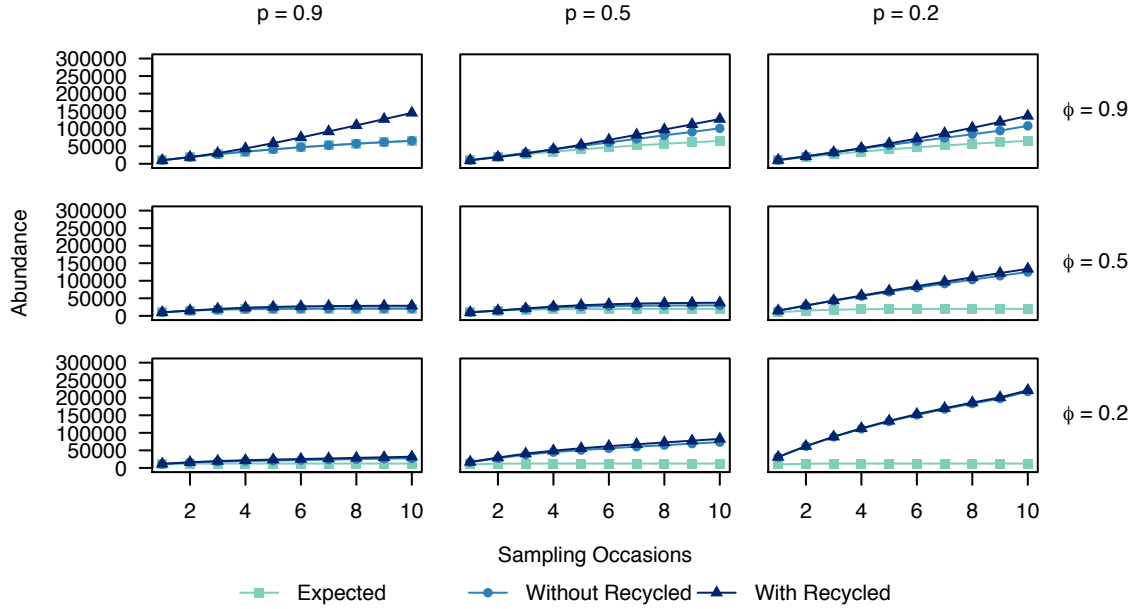
WEB FIGURE 31: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



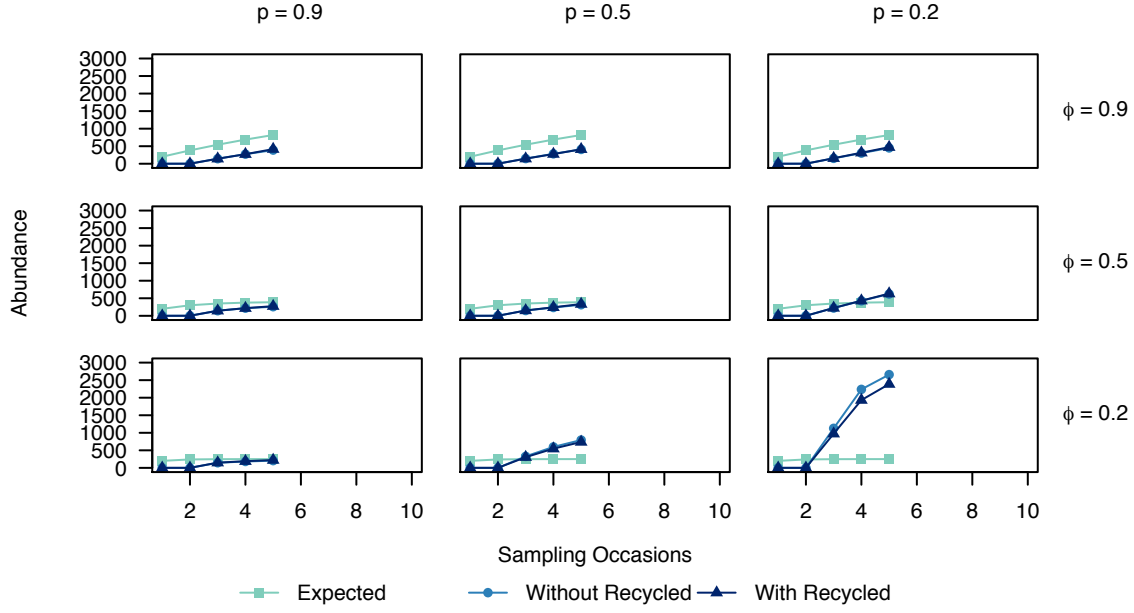
WEB FIGURE 32: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 100000$  with  $T_2 = 1$  with 10 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



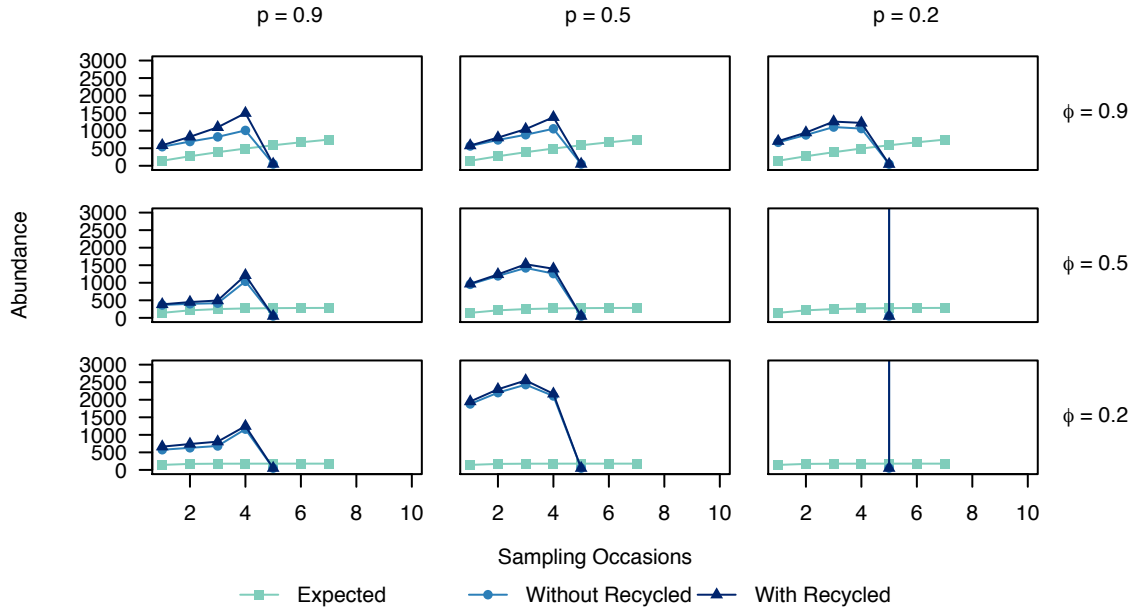
WEB FIGURE 33: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



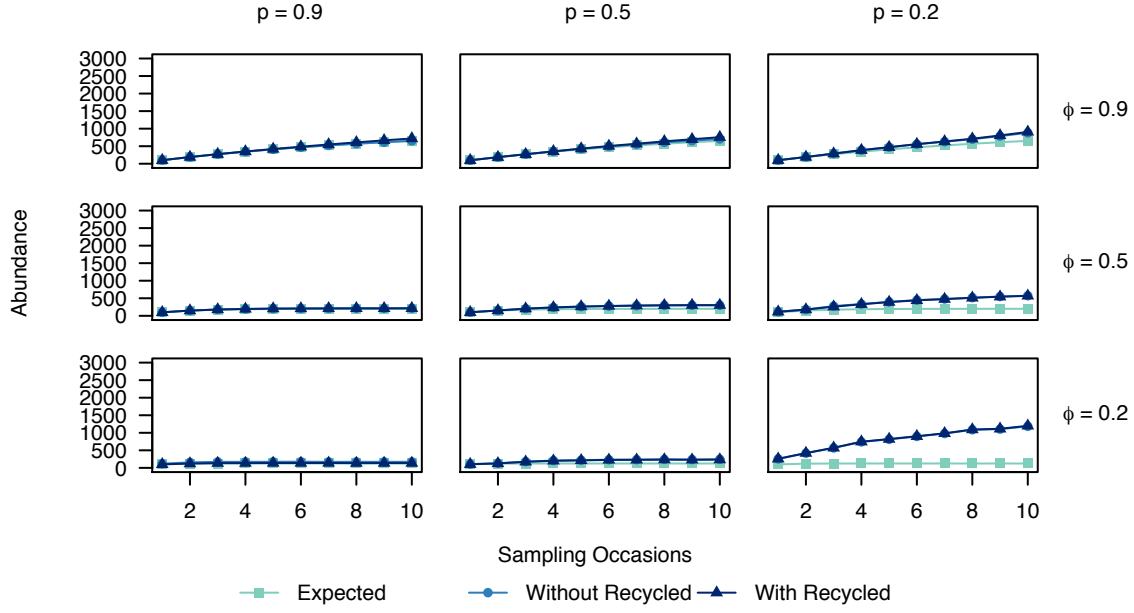
WEB FIGURE 34: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 100000$  with  $T_2 = 0.5$  with 10 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



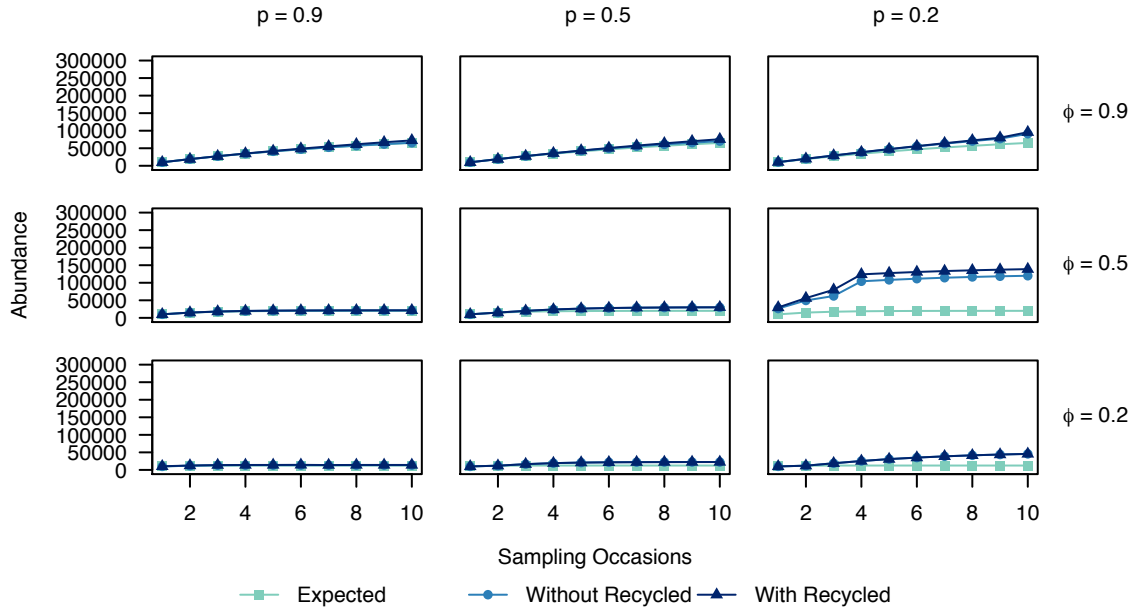
WEB FIGURE 35: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 5$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 5 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



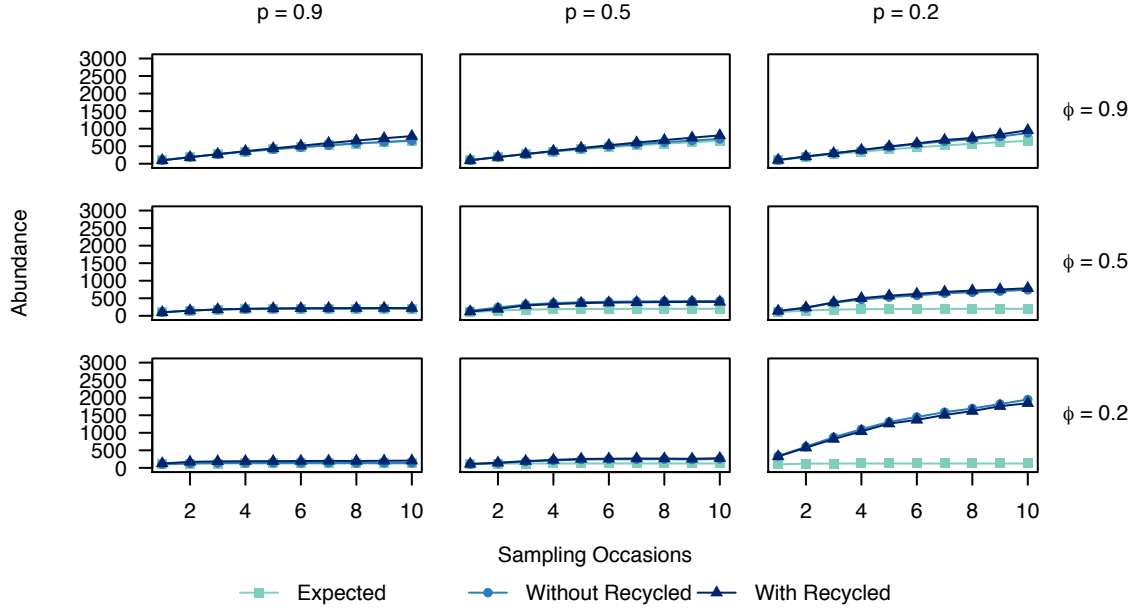
WEB FIGURE 36: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 7$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 7 time periods for medium tag retention ( $\lambda = 0.5$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



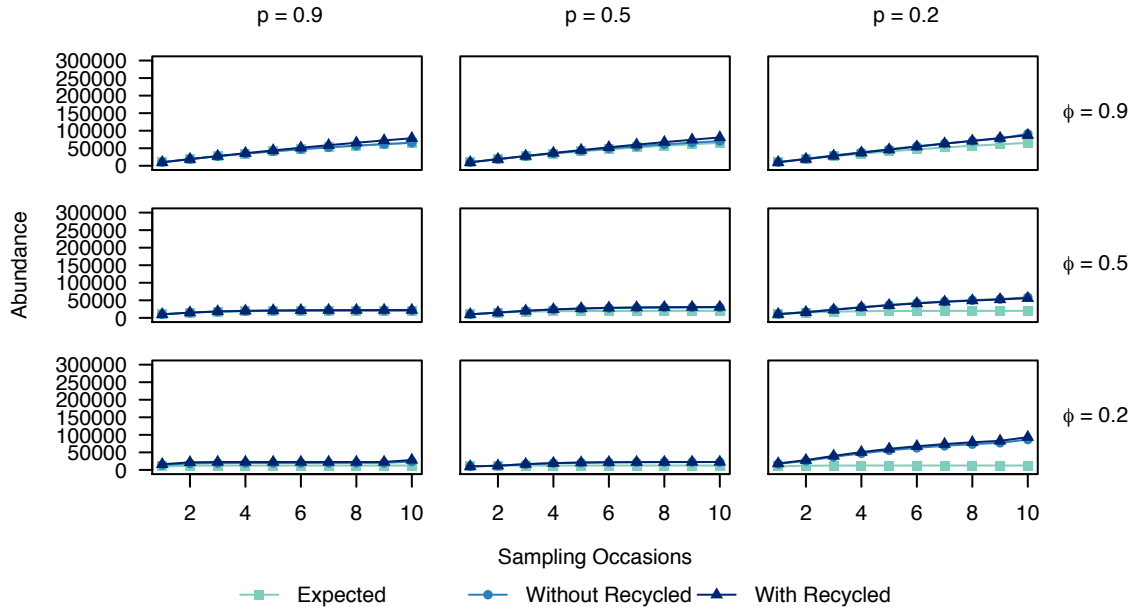
WEB FIGURE 37: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 1$  with 10 time periods for high tag retention ( $\lambda = 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



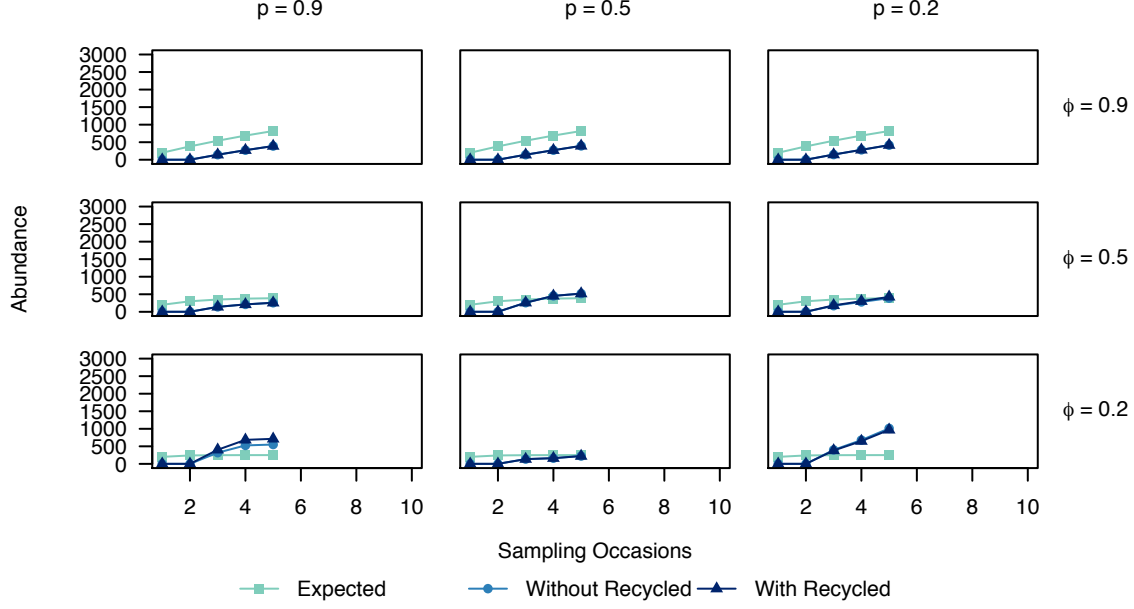
WEB FIGURE 38: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 100000$  with  $T_2 = 1$  with 10 time periods for high tag retention ( $\lambda = 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



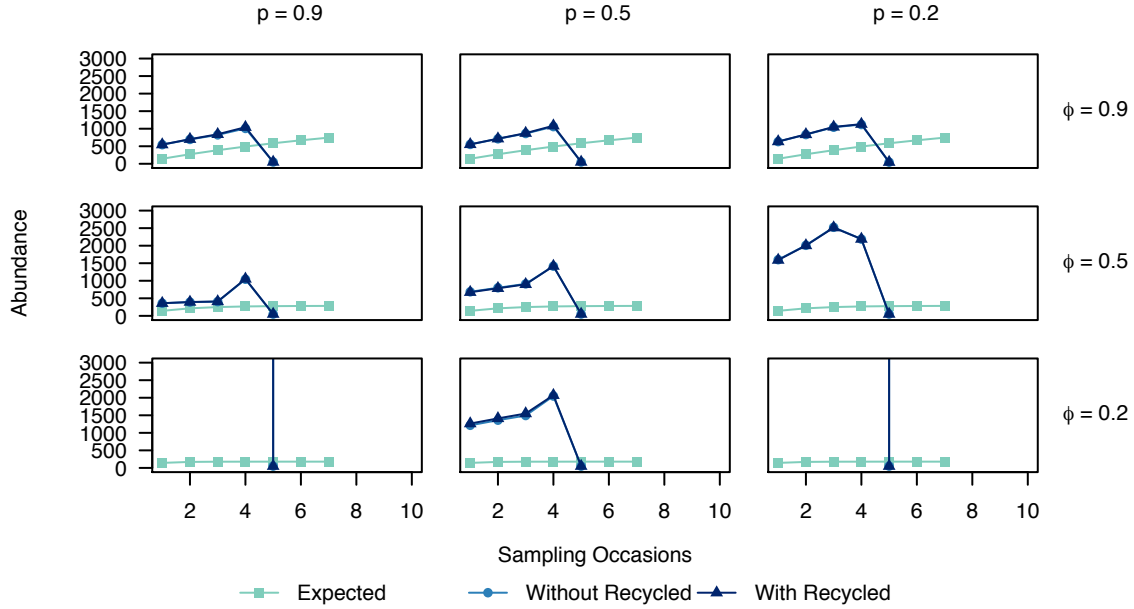
WEB FIGURE 39: Mean abundance estimates ( $N_j$ 's) for each sample time ( $k = 10$ ) between analysis with and without recycled individuals with population size  $N = 1000$  with  $T_2 = 0.5$  with 10 time periods for high tag retention ( $\lambda = 0.9$ ), varying survival probabilities ( $\phi = 0.2, 0.5, 0.9$ ) and varying capture probabilities ( $p = 0.2, 0.5, 0.9$ ).



WEB FIGURE 40: 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 ( $p = 0.2, 0.5, 0.9$ ).



WEB FIGURE 41: 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 ( $p = 0.2, 0.5, 0.9$ ).



WEB FIGURE 42: 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 ( $p = 0.2, 0.5, 0.9$ ).

## Recycled Individuals

WEB TABLE 17: Examples of the fraction of recycled individuals (number of recycled individuals captured / total number of individuals captured) at each sample occasion for a 10 occasion experiment with super-population size  $N = 1000$  with 100% double-tagging.

|                                      | Sampling Times |      |      |      |      |      |      |      |      |      |
|--------------------------------------|----------------|------|------|------|------|------|------|------|------|------|
|                                      | 1              | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   |
| $\phi = 0.9, p = 0.9, \lambda = 0.2$ | 0.00           | 0.30 | 0.36 | 0.47 | 0.51 | 0.53 | 0.54 | 0.55 | 0.56 | 0.57 |
| $\phi = 0.9, p = 0.9, \lambda = 0.5$ | 0.00           | 0.12 | 0.12 | 0.20 | 0.29 | 0.26 | 0.29 | 0.30 | 0.31 | 0.31 |
| $\phi = 0.9, p = 0.9, \lambda = 0.9$ | 0.00           | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 | 0.04 | 0.04 | 0.03 |
| $\phi = 0.9, p = 0.5, \lambda = 0.2$ | 0.00           | 0.14 | 0.28 | 0.38 | 0.43 | 0.48 | 0.54 | 0.54 | 0.55 | 0.56 |
| $\phi = 0.9, p = 0.5, \lambda = 0.5$ | 0.00           | 0.02 | 0.12 | 0.14 | 0.27 | 0.28 | 0.28 | 0.33 | 0.29 | 0.38 |
| $\phi = 0.9, p = 0.5, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 0.04 | 0.06 | 0.06 |
| $\phi = 0.9, p = 0.2, \lambda = 0.2$ | 0.00           | 0.05 | 0.15 | 0.35 | 0.18 | 0.28 | 0.30 | 0.33 | 0.40 | 0.37 |
| $\phi = 0.9, p = 0.2, \lambda = 0.5$ | 0.00           | 0.00 | 0.06 | 0.09 | 0.14 | 0.13 | 0.20 | 0.21 | 0.30 | 0.26 |
| $\phi = 0.9, p = 0.2, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 0.04 | 0.03 |
| $\phi = 0.5, p = 0.9, \lambda = 0.2$ | 0.00           | 0.18 | 0.23 | 0.27 | 0.34 | 0.36 | 0.32 | 0.32 | 0.32 | 0.26 |
| $\phi = 0.5, p = 0.9, \lambda = 0.5$ | 0.00           | 0.10 | 0.10 | 0.15 | 0.10 | 0.15 | 0.18 | 0.13 | 0.19 | 0.12 |
| $\phi = 0.5, p = 0.9, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| $\phi = 0.2, p = 0.9, \lambda = 0.2$ | 0.00           | 0.10 | 0.14 | 0.07 | 0.15 | 0.10 | 0.11 | 0.13 | 0.13 | 0.12 |
| $\phi = 0.2, p = 0.9, \lambda = 0.5$ | 0.00           | 0.02 | 0.06 | 0.05 | 0.05 | 0.11 | 0.04 | 0.06 | 0.08 | 0.09 |
| $\phi = 0.2, p = 0.9, \lambda = 0.9$ | 0.00           | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $\phi = 0.5, p = 0.5, \lambda = 0.5$ | 0.00           | 0.01 | 0.07 | 0.06 | 0.12 | 0.13 | 0.14 | 0.16 | 0.13 | 0.14 |

WEB TABLE 18: Examples of the fraction of recycled individuals (number of recycled individuals captured / total number of individuals captured) at each sample occasion for a 7 occasion experiment with super-population size  $N = 1000$  with 100% double-tagging.

|                                      | Sampling Times |      |      |      |      |      |      |
|--------------------------------------|----------------|------|------|------|------|------|------|
|                                      | 1              | 2    | 3    | 4    | 5    | 6    | 7    |
| $\phi = 0.9, p = 0.9, \lambda = 0.2$ | 0.00           | 0.32 | 0.40 | 0.49 | 0.50 | 0.53 | 0.55 |
| $\phi = 0.9, p = 0.9, \lambda = 0.5$ | 0.00           | 0.10 | 0.18 | 0.21 | 0.22 | 0.29 | 0.29 |
| $\phi = 0.9, p = 0.9, \lambda = 0.9$ | 0.00           | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| $\phi = 0.9, p = 0.5, \lambda = 0.2$ | 0.00           | 0.12 | 0.30 | 0.35 | 0.42 | 0.47 | 0.50 |
| $\phi = 0.9, p = 0.5, \lambda = 0.5$ | 0.00           | 0.06 | 0.15 | 0.22 | 0.26 | 0.24 | 0.27 |
| $\phi = 0.9, p = 0.5, \lambda = 0.9$ | 0.00           | 0.01 | 0.00 | 0.02 | 0.02 | 0.03 | 0.04 |
| $\phi = 0.9, p = 0.2, \lambda = 0.2$ | 0.00           | 0.05 | 0.12 | 0.15 | 0.22 | 0.21 | 0.30 |
| $\phi = 0.9, p = 0.2, \lambda = 0.5$ | 0.00           | 0.00 | 0.06 | 0.10 | 0.15 | 0.20 | 0.20 |
| $\phi = 0.9, p = 0.2, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| $\phi = 0.5, p = 0.9, \lambda = 0.2$ | 0.00           | 0.19 | 0.30 | 0.32 | 0.30 | 0.34 | 0.38 |
| $\phi = 0.5, p = 0.9, \lambda = 0.5$ | 0.00           | 0.09 | 0.12 | 0.13 | 0.15 | 0.11 | 0.14 |
| $\phi = 0.5, p = 0.9, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 |
| $\phi = 0.2, p = 0.9, \lambda = 0.2$ | 0.00           | 0.10 | 0.11 | 0.12 | 0.13 | 0.16 | 0.08 |
| $\phi = 0.2, p = 0.9, \lambda = 0.5$ | 0.00           | 0.04 | 0.05 | 0.07 | 0.07 | 0.03 | 0.02 |
| $\phi = 0.2, p = 0.9, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $\phi = 0.5, p = 0.5, \lambda = 0.5$ | 0.00           | 0.05 | 0.04 | 0.05 | 0.09 | 0.11 | 0.12 |



WEB TABLE 19: Examples of the fraction of recycled individuals (number of recycled individuals captured / total number of individuals captured) at each sample occasion for a 5 occasion experiment with super-population size  $N = 1000$  with 100% double-tagging.

|                                      | Sampling Times |      |      |      |      |
|--------------------------------------|----------------|------|------|------|------|
|                                      | 1              | 2    | 3    | 4    | 5    |
| $\phi = 0.9, p = 0.9, \lambda = 0.2$ | 0.00           | 0.29 | 0.34 | 0.45 | 0.52 |
| $\phi = 0.9, p = 0.9, \lambda = 0.5$ | 0.00           | 0.08 | 0.22 | 0.23 | 0.28 |
| $\phi = 0.9, p = 0.9, \lambda = 0.9$ | 0.00           | 0.01 | 0.01 | 0.02 | 0.02 |
| $\phi = 0.9, p = 0.5, \lambda = 0.2$ | 0.00           | 0.14 | 0.27 | 0.33 | 0.38 |
| $\phi = 0.9, p = 0.5, \lambda = 0.5$ | 0.00           | 0.05 | 0.13 | 0.18 | 0.25 |
| $\phi = 0.9, p = 0.5, \lambda = 0.9$ | 0.00           | 0.00 | 0.01 | 0.01 | 0.02 |
| $\phi = 0.9, p = 0.2, \lambda = 0.2$ | 0.00           | 0.06 | 0.15 | 0.16 | 0.29 |
| $\phi = 0.9, p = 0.2, \lambda = 0.5$ | 0.00           | 0.03 | 0.06 | 0.08 | 0.12 |
| $\phi = 0.9, p = 0.2, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.01 | 0.01 |
| $\phi = 0.5, p = 0.9, \lambda = 0.2$ | 0.00           | 0.14 | 0.25 | 0.30 | 0.33 |
| $\phi = 0.5, p = 0.9, \lambda = 0.5$ | 0.00           | 0.05 | 0.13 | 0.10 | 0.15 |
| $\phi = 0.5, p = 0.9, \lambda = 0.9$ | 0.00           | 0.00 | 0.01 | 0.01 | 0.00 |
| $\phi = 0.2, p = 0.9, \lambda = 0.2$ | 0.00           | 0.11 | 0.10 | 0.13 | 0.12 |
| $\phi = 0.2, p = 0.9, \lambda = 0.5$ | 0.00           | 0.02 | 0.03 | 0.05 | 0.04 |
| $\phi = 0.2, p = 0.9, \lambda = 0.9$ | 0.00           | 0.00 | 0.00 | 0.00 | 0.00 |
| $\phi = 0.5, p = 0.5, \lambda = 0.5$ | 0.00           | 0.03 | 0.09 | 0.10 | 0.12 |