Ecography

ECOG-02424
Field, C. R., Ruskin, K. J., Benvenuti, B., Borowske, A. C., Cohen, J. B., Garey, L., Hodgman, T. P., Kern, R. A., King, E., Kocek, A. R., Kovach, A. I., O'Brien, K. M., Olsen, B. J., Pau, N., Roberts, S. G., Shelly, E., Shriver, G. W., Walsh, J. and Elphick, C. S. 2017. Quantifying the importance of geographic replication and representativeness when estimating demographic rates, using a coastal species as a case study. – Ecography doi: 10.1111/ecog.02424

Supplementary material

Appendix 1.

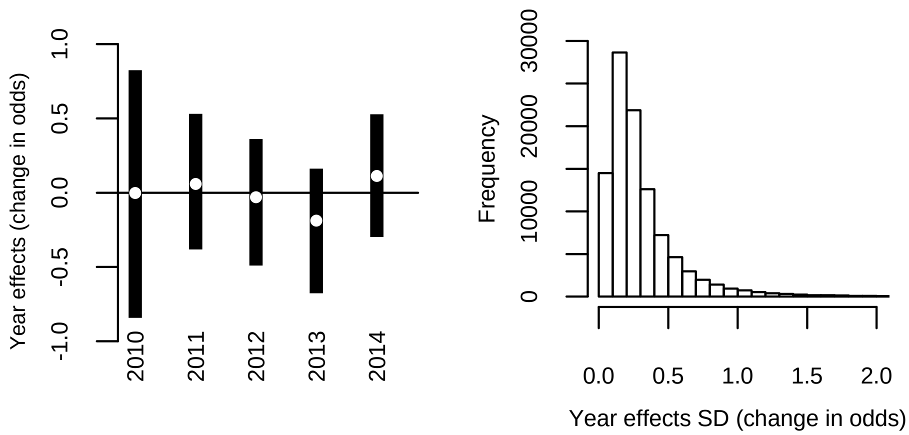


Figure A1. Results for the random year effect in our model of apparent annual saltmarsh sparrow survival without a spatial random effect. Left: Year effects for 2010-2014. Black bars show 95% credible intervals and white dots show the means. Right: The posterior distribution of the standard deviation of the random year effect. A large part of the density is close to zero, suggesting a weak effect.

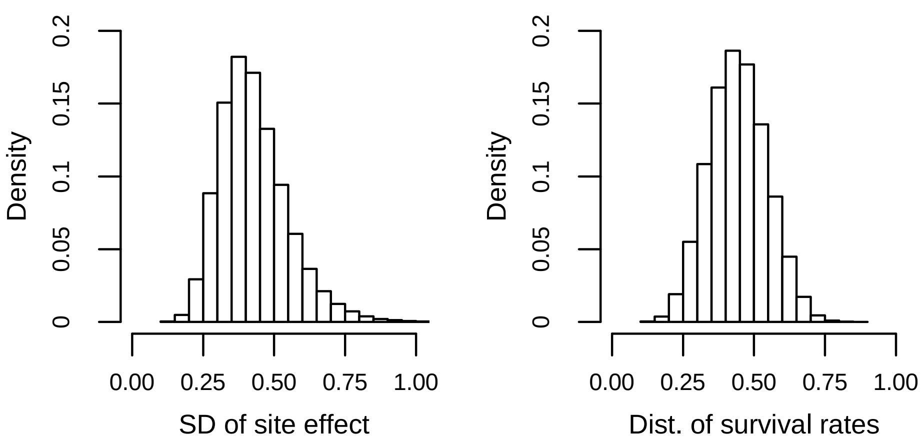


Figure A2. Spatial variation in apparent annual survival for saltmarsh sparrows. Left: the standard deviation of the spatial random effect. Right: the distribution of survival rates across the range.

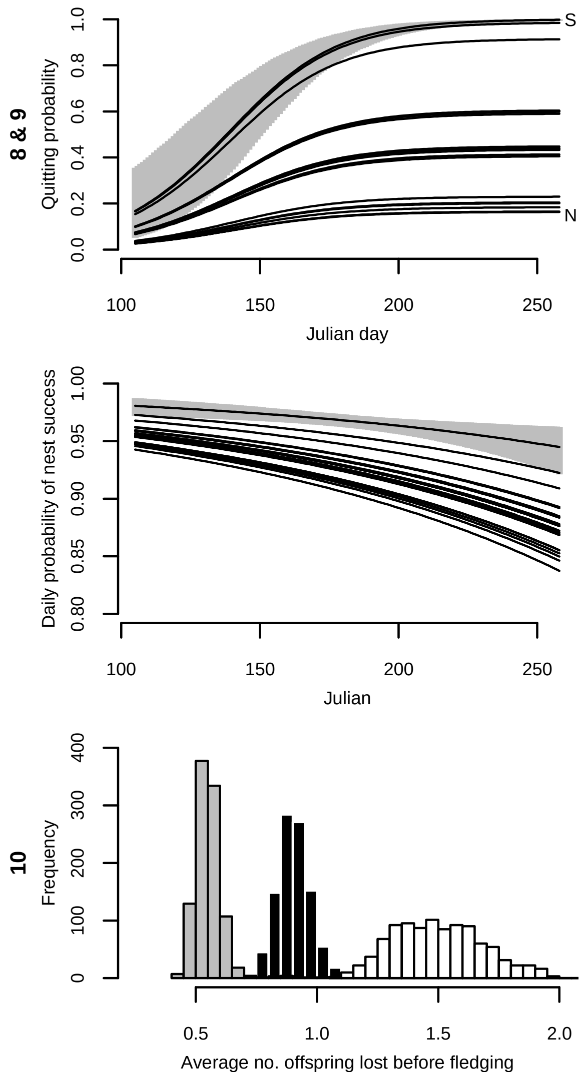


Figure A3. Reproductive parameters used in the population simulations. Top: Probability of ending re-nesting attempts over days since January 1. Lines are for each site, from south to north. 95% credible interval is shown for just the southern-most site for clarity. Middle: Daily probability of nest success over days since January 1 (n = 796 nests). Separate lines are shown for each site; for clarity, 95% credible interval is shown just for the site with the highest nest success. Bottom: Posterior distributions of the average number of offspring lost from the clutch before fledging, shown for starting clutch sizes of three (gray), four (black), and five (white).

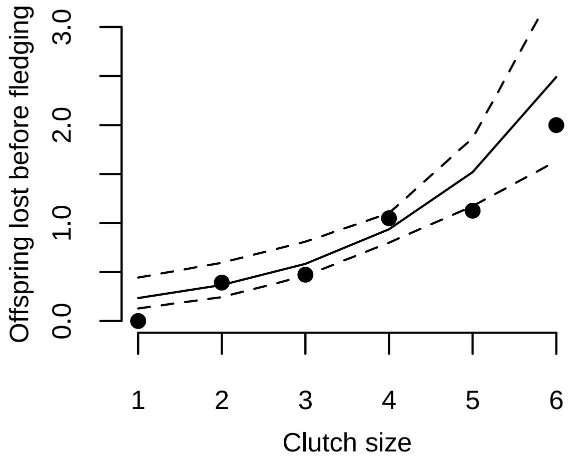


Figure A4. The fit to the observed data of the model for the number of offspring lost before fledging. Black dots show the sample mean for each observed value of clutch size. The solid line shows the mean of the model predictions; dotted lines are 95% credible intervals around the mean.

JAGS code for the model of apparent annual survival:

```
#random site effect if species = 1 (Saltmarsh group)
for(i in 1:21){
site[i, 2] ~ dnorm(0, tau2[2])
}

#random site effect if species = 0 (Nelson's group); there are only 6 sites with
individuals that could be Nelson's group
for(i in 1:6){
site[i, 1] ~ dnorm(0, tau2[1])
}

#when species = 1, there is no possibility of site being 7:21, so set equal to zero
to make exporting the vector easier
for(i in 7:21){
site[i, 1] <- 0
}

#for priors specified below, the s loop is to specify which species-specific
parameters should be used (1 = Nelson's; 2 = Saltmarsh)
#priors for the variance parameters of the random site effect
for(s in 1:2){
sd2[s] ~ dunif(0, 1000)
tau2[s] <- 1/(sd2[s]*sd2[s])
}

#priors for the effect of sex on p (Bsexp) and S (BsexS)
for(s in 1:2){
Bsexp[s] ~ dnorm(0, 0.001)
BsexS[s] ~ dnorm(0, 0.001)
}

#priors for the effect of plot on p
for(s in 1:2){
Bplot[s] ~ dnorm(0, 0.001)
}

#separate intercepts for Saltmarsh and Nelson's
for(s in 1:2){
CSmu[s] ~ dnorm(0, 0.001)
Cpmu[s] ~ dnorm(0, 0.001)
}

#prior for sex ratio
for(s in 1:2){
```

```
sexratio[s] ~ dunif(0, 1)
}

#for 3648 individuals
for(i in 1:3648){
#prior for unknown sex individuals (male is sex = 1)
sex[i] ~ dbin(sexratio[species[i] + 1], 1)
#species_prior is read in as data; 1 for all certain Saltmarsh group and 0.69 for
unknown species
species[i] ~ dbin(species_prior[i], 1)
#firstcapture_aux is a vector of the first captures
#for 5 years
for(z in (firstcapture_aux[i]+1):5){
#logistic regression equation for apparent survival
logit(R[i, z]) <- CSmu[species[i]+1] + BsexS[species[i]+1]*sex[i] + site[Site[i],
Spp[i]+1]
#dead birds stay dead
S[i, z] <- A[i, z-1]*R[i, z]
#matrix A indexes whether individuals are alive or dead
A[i, z] ~ dbin(S[i, z], 1)
#logistic regression equation for capture probability
logit(q[i, z]) <- Cpmu[species[i]+1] + Bsexp[species[i]+1]*sex[i] +
Bplot[Spp[i]+1]*plot[i]
# capturing an individual depends on whether it is alive (A) and the capture
probability
p[i, z] <- q[i, z]*A[i, z]
data[i, z] ~ dbin(p[i, z], 1)
}
}
```

JAGS code for the model of daily nest survival:

```
#prior for random site effect
sd ~ dunif(0, 1000)
tau <- 1/(sd*sd)

#prior for random date effect
sd2 ~ dunif(0, 1000)
tau2 <- 1/(sd2*sd2)
#mean of random date effect
B ~ dnorm(0, 0.001)
#prior for intercept
int ~ dnorm(0, 0.001)

#random site and date effects
```

```
#random site effect is centered on zero; random date effect is centered on B
for(i in 1:21){
site[i] ~ dnorm(0, tau)
C[i] ~ dnorm(B, tau2)
}

#for 796 nests
for(i in 1:796){
#total_nest_days is a vector of the number of days each nest was active
for(t in 1:total_nest_days[i]){
#logistic regression equation
logit(mu[i, t]) <- int + C[Site[i]]*(date[i]+(t-1)) + site[Site[i]]
#data are Bernoulli distributed
nest_fate_matrix[i, t] ~ dbern(mu[i, t])
}
}
```

JAGS code for the model of quitting probability:

```
#prior for latitude effect
B ~ dnorm(0, 0.001)
#prior for date effect
B2 ~ dnorm(0, 0.001)
#prior for intercept
int ~ dnorm(0, 0.001)

#for 613 nests
for(i in 1:613){
#logistic regression equation
logit(mu[i]) <- int + B*lat[i] + B2*date[i]
#data are Bernoulli distributed
quitting_prob[i] ~ dbern(mu[i])
}
```

JAGS code for the model of brood size at fledging:

```
#prior for intercept
int ~ dnorm(0, 0.001)
#prior for effect of clutch size
B ~ dnorm(0, 0.001)

#for 325 nests
for(i in 1:325){
#regression equation with log link
```

```
log(lambda[i]) <- int + B*clutch[i]
#the number of chicks lost from nest before fledging is Poisson distributed
chicks[i] ~ dpois(lambda[i])
}
```

R code for subsampling scenarios:

```
#site_growth_rates is a matrix with 21 rows (for each site) and columns for each
iteration of the population simulation

#for mean of growth rates
#for each of five scenarios
for(w in 1:5){
#create a blank scenario-by-site matrix
index_mat = mat.or.vec(5, 21)
#North to South
index_mat[1,] <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
20, 21)
#South to North
index_mat[2,] <- rev(c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
19, 20, 21))
#from the edges in
index_mat[3,] <- c(1, 21, 2, 20, 3, 19, 4, 18, 5, 17, 6, 16, 7, 15, 8, 14, 9, 13, 10,
12, 11)
#center of range out
index_mat[4,] <- c(11, 10, 12, 9, 13, 8, 14, 7, 15, 6, 16, 5, 17, 4, 18, 3, 19, 2, 20,
1, 21)
#random
index_mat[5,] <- sample(1:21, 21)
#load "index" with the correct scenario
index <- index_mat[w, ]
#starts at 3 sites
#create a blank number of sites-by-number of iterations matrix
mean_est = mat.or.vec((length(index)-2), 100000)
#for 100000 iterations
for(z in 1:100000){
for(i in 1:(length(index)-2)){
#create a temp vector that indexes which value from the vector of simulations to
draw
temp <- sample(1:length(site_growth_rates[21, ]), 2+i, replace=TRUE)
#create a temp matrix with only the sites being considered at this step in the
scenario
temp_site <- site_growth_rates[index[1:(2+i)], ]
#pull iteration of simulation vector to get a vector with one value for each site
temp_site <- diag(temp_site[, temp])
```

```
#calculate the global mean
mean_est[i, z] <- mean(temp_site)
}
}

#for standard deviation of growth rates
#for each of five scenarios
for(w in 1:5){
#create a blank scenario-by-site matrix
index_mat = mat.or.vec(5, 21)
#North to South
index_mat[1,] <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
20, 21)
#South to North
index_mat[2,] <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
20, 21)
#from the edges in
index_mat[3,] <- rev(c(1, 21, 2, 20, 3, 19, 4, 18, 5, 17, 6, 16, 7, 15, 8, 14, 9, 13,
10, 12, 11))
#center of range out
index_mat[4,] <- c(11, 10, 12, 9, 13, 8, 14, 7, 15, 6, 16, 5, 17, 4, 18, 3, 19, 2, 20,
1, 21)
#random
index_mat[5,] <- sample(1:21, 21)
#load "index" with the correct scenario
index <- index_mat[w, ]
#starts at 3 sites
#create a blank number of sites-by-number of iterations matrix
sd_est = mat.or.vec((length(index)-2), 100000)
#for 100000 iterations
for(z in 1:100000){
for(i in 1:(length(index)-2)){
#create a temp vector that indexes which value from the simulation chain to draw
temp <- sample(1:length(site_logit[21, ]), 2+i, replace=TRUE)
#create a temp matrix with only the sites being considered at this step in the
scenario
temp_site <- site_growth_rates[index[1:(2+i)], ]
#pull iteration of simulation chain to get a vector with one value for each site
temp_site <- diag(temp_site[, temp])
#calculate the global standard deviation
sd_est[i, z] <- sd(temp_site)
}
}
```

MIST-NETTING PROTOCOL

Site selection

Demographic plots for SHARP should be set up as contiguous areas of marsh, ~5-20 ha in size, in areas where sparrow nesting densities are reasonably high. Exact size of the plots is not critical and can be modified depending on the needs of particular research groups, the topography of the study marsh, the bird density, and the amount of field help. Our goal is to ensure that sites are large enough to allow a high potential for recapture of banded birds and small enough to ensure that thorough nest-searching and mist-netting can be conducted. Sites with fewer birds or larger field crews will be able to accommodate larger plots. At smaller marshes (<25 ha) it may make sense to sample the entire marsh, as long as you can ensure that all birds have a high chance of being caught and all nests found.

For logistic reasons it is best to set up plots with clearly defined topographic boundaries (i.e., major creeks, upland edges, etc.), but this is not essential. Random selection within a range of potential sites would be ideal, but is probably not practical in most cases. Effort, however, should be made to ensure that plots are not atypical for the site/region (e.g., don't pick a site with a heavily-used boat launch in the middle of it). Data from randomly selected points can be used to test whether SHARP plots are atypical.

Maps for all sites should be posted in the dropbox for subsequent posting on the SHARP web site.

Sampling design

Within each demographic plot the goal is to band as many birds as possible to maximize the quality of our survival estimates. Some standardization of effort is important, however, to allow comparisons among plots and to improve the quality of the survival estimates. Consequently, we will divide banding efforts into standardized sampling and targeted (opportunistic) netting.

Standardized sampling: Divide each plot into subplots each of which will be sampled at least 3 times (more is better) over the course of the field season. For example, at CT sites, each plot has been subdivided into 4-5 subplots. Banding visits cycle through the subplots such that each is visited once before second-round visits begin, each is visited twice before third-round visits, etc.

The exact size and shape of subplots is not critical. The reason for having the subplots is primarily to ensure that sampling effort within each round of netting is distributed approximately evenly across entire plots, rather than to collect specific spatial information relative to the subplots themselves. For this reason, it is not necessary to always put the net arrays in the same place within a subplot. Similarly, although it is best for subplot boundaries to remain consistent between years, if logistic or other issues make a change in subplot boundaries desirable that is OK (but please document the change). Changes in the boundaries of the plots themselves are much more serious and should be avoided unless absolutely necessary. If plot boundaries are changed, that information should be conveyed to others and clearly denoted in the data set.

Each standardized banding session should begin (i.e., all nests set and open) before ~7:30, and last for 3 hours. Exact start times will vary depending on site accessibility, tide state, latitude (sunrise), weather, etc. In most cases, a banding session should last for a contiguous period of 3 hours. Occasionally brief showers, high tide, too many birds, etc., may require that nets be closed for short periods. If this happens, then nets may be reopened and any remaining time added to the end. In CT, we aim to complete standardized banding sessions before 11:00 to ensure that they occur during the period of early morning activity and to avoid the heat of the day. Extending the banding session a little beyond this time (e.g., if rain has disrupted the session) is OK as long as weather (heat) does not pose a risk to the birds. If you know it is going to be a hot day, then plan to finish earlier.

Within each banding session, use 2-3 arrays, each containing six 12-m nets (or equivalent length). Using these standard multi-net arrays (rather than 6 individual nets) is important because it is likely that long net arrays catch differently from single nets or net-pairs. The number of arrays should be determined by the characteristics of the plot and your ability to run them effectively without risking harm to the birds. If the plot has a lot of birds, is quite small, or is logistically difficult to get around in, then two arrays is probably best. If you can easily run three arrays while maintaining frequent net checks then use a third array. In CT, we find that three arrays is manageable at most sites. It is important to use the same number of arrays on every visit to a given plot and that you record the number of arrays on the data sheet.

In CT, we use 2-panel nets and this is recommended because few birds are caught in higher panels and shorter nets are probably less visible to the birds (2-panel nets are also cheaper and much easier to set up quickly). 4-panel nets do, however, catch plenty of birds, so do not worry about using them if they are what you have available. A disadvantage of the 2-panel nets is that they do not come in smaller mesh sizes, which may make it easier for birds to get out, but we have not felt that this is a major problem, especially if the reduced cost allows more nets to be used. If you use 4-panel nets, then track which birds were caught in the top-2 panels. There is a column for this on the data sheet.

If you want to band for longer than three hours, then that is OK, but use separate data sheets for the initial three hour "standardized" banding and for any additional "targeted" banding. If you net for less than three hours, then consider the session targeted banding (see below). If you do not use 6-net arrays, then also treat the banding as targeted. Whether banding is systematic or targeted should be marked on the data sheet (there is a place for you to circle at the top), and the two types of data collection should never be put on the same data sheet.

During every session, be sure to note for each net array: (a) the start time (the point at which you complete set-up and walk away from the array), (b) the end time (the point at which you arrive at the array to take the nets down), and (c) how many nets were used, and the location of each array (if possible, GPS the end points of the array, or each net pole; if that is not possible make a sketch of the approx. location in a field notebook, just in case it is needed in the future).

For the survival analyses, standardized sampling sessions should not begin until a large percentage of the birds have returned from migration and should end before adults begin to leave. This guideline arises because better survival estimates will be possible if we have standardized sampling from a period in which it is reasonable to assume that the population is more-or-less "closed" (i.e., has few birds coming and going from the site). Determining this point will be a judgment call and there is no simple rule, but if birds have begun to nest (as evidenced by birds carrying nest material, females with brood patches, etc.) or if the marsh seems to be full of birds then it is probably time. In CT, this happens by the last week of May.

Targeted ("opportunistic") banding: Additional banding within each plot will be valuable because it increases the proportion of birds that are marked and the potential for recaptures. Moreover, banding during early arrival, fall banding, targeted netting at nests, etc., will all be done for other purposes. The survival models can accommodate all of this information, but it needs to be tracked separately from the standardized banding.

Groups should feel free to do whatever additional mist-netting they need to, but should be careful to ensure that it is always noted as such on the data sheet and that systematic and targeted netting are not put on the same data sheets and are appropriately coded when the data set is entered. Doing this will allow us to ensure that the two types of data are easily separated for analysis.

For opportunistic banding it is important to track (a) the times nets are opened and closed, (b) the number of nets used, (c) the locations of nets (SHARP Nest ID for nest locations ex. "JO13SALS001"; UTMs of net arrays for non-nest locations such as over a ditch, ex. "390766, 4823442" for the center of a 4-net array), and (d) what birds are caught in which nets. Opportunistic banding does not need to use six-net arrays.

Setting up mist nets

Our general protocol for mist netting is to use six 12 m, two-panel nets in a continuous string (i.e., with the ends of consecutive nets on the same pole, such that 7 poles are used per array). Nets should be left in place for the entire 3 hour session (i.e., don't move them around). If you want to do additional trapping it should be considered targeted netting and done in addition to the standardized sampling. There are no restrictions on the amount of additional targeted netting at a site, but be aware that excessive activity may cause disturbance that harms both study species and other species.

It usually helps to make the string of nets somewhat U-shaped, or to angle the outermost nets inwards, as this helps to catch birds that bounce or see the net and veer to the side. Sparrows often fly along drainage ditches/creeks, so it also helps if the net line runs perpendicular to ditches and crosses as many as possible. Generally, however, nets should not cross channels that are too wide to cross, as this will make extracting birds difficult. Mosquito ditches or the upland ends of creeks are ideal. There is little point stringing nets across deep/wide ditches, as birds will either fly under the net or the lack of vegetation will make the net obvious and easy to avoid. Other standard net-setting guidelines apply (e.g., if possible, set them so that there is a line of vegetation behind them to make them less visible).

Nets should generally be set low to the ground (most saltmarsh vegetation is forgiving and does not get caught up in nets, so you can get away with more than in other habitats – but still take care with nets as they don't work well if they get holes in them, and are expensive to replace). Great care should be taken to ensure that nets are not set in a way that rising tide water could cover the bottom of the net. At times the tide can come in fast, so it is very important to know when high tide will be, and to track rising water. When nets cross ditches, special care should be taken to ensure that the net will not sag and be in the water if a bird is in it (you can test this by throwing a bird bag into the lower panel and seeing how low it hangs). Nets should always be set so that they are taut, with a good level of tension on the main trammel lines. Also, remember that you need to be able to get to the bird to extract it from the net! As the tide rises it can sometimes be hard to get to the mid-point of a ditch. If in doubt, move the net so that it doesn't cross the ditch (it is OK to do this in the middle of a banding session, if doing so will improve bird safety).

Nets should be checked every ~20 mins. Start on the opposite side of the subplot with everyone present in a line. If more than 2 people are present the outermost people should be slightly ahead of the rest. Walk towards the nets watching for any flushing birds. Birds often concentrate in channels, so have someone walk along the edge of the channels in the subplot.

Any birds seen flying into the net should be extracted immediately. Birds that have just entered the net are often not caught very well, and it is not unusual for them to get out before you get there. Enclosing the net pocket around the bird when you first get to the net, and then getting hold of the bird in a standard bander's grip with the netting around it can help reduce the risk of escape. Once removed, birds should be put in a bag and taken to the processing site. If you are taking blood samples for time-sensitive endocrine work, take the blood immediately at the net (make sure you have equipment with you when you approach the net). If the bird is banded, note the bands when you extract it – just in case it gets away unexpectedly.

ALWAYS check the net very carefully after you have extracted birds. Take special care to double-check the bottom panel, by walking its entire length, and lifting it every few meters. It is surprisingly easy to miss a bird in the bottom panel if you do not do this, especially when the marsh grass is tall.

In CT we typically set up a processing site at a location intermediate between our net arrays. If there is a high spot in the marsh this is often a good place in case the tide comes up higher than expected. At the processing site, we lay down a tarp to keep things dry and make it easier to find items (such as bands) if they are dropped. We also set up a beach umbrella to provide shade. Bird bags should be hung in the shade to protect birds from overheating.

For target sampling, the mist-netting procedures are similar. Rather than a continuous multi-net string, it might make more sense to target-net particular smaller areas. A three-net U formation, or a two-net V centered on a ditch (e.g., for fall banding) or a nest (e.g., for catching a particular female) is usually effective. If you are trapping at a nest, make absolutely certain that everyone knows where the nest is, and be sure not to keep the female off the nest for too long. The best way to eliminate any risk to the eggs is to replace them with wooden replicas, painted to look like real eggs, while trapping. The real eggs should be placed in a protected and cushioned box and kept somewhere away from the trapping area; they can be put back in the nest while the adult is being banded.

BANDING PROTOCOL

Permits and regulations

NO ONE should handle birds, band birds, or remove birds from a net without direct permission from the study site PI. Bird banding is strictly controlled and conducted only under Federal (USGS) permit and banding should never take place unless a Federal permit holder is present. State permits are also required in most cases. Anyone working for a university (and some agencies) is probably also required to have some form of animal care training through their local Institutional Animal Care and Use Committee (IACUC). No one can handle any bird until they have been approved to do so by the relevant IACUC.

Everyone is also individually responsible for knowing what they are covered to do under their banding permits and IACUC protocol. Most people will be restricted to only certain species and certain activities and approvals may vary among individuals within a field crew. MAKE SURE YOU KNOW WHAT ACTIVITIES APPLY TO YOU. Details may vary among study sites, but copies of all permits should be easily accessible to each field crew. Ideally, there will be a copy of the Federal and state banding permits in each banding kit and a binder in the field vehicle that contains copies of all permits, all site permission letters, and the approved IACUC protocol.

Processing captured birds

Basic banding protocols require considerable training and cannot be explained in detail here. For detailed information see the USGS banding lab web site: http://www.pwrc.usgs.gov/BBL/default.htm. A few simple guidelines, however, are:

1. **Always put the bird's welfare first.** If you think the bird is suffering, let it go. If you think you might have held onto it for too long, let it go. If you have ANY concerns about how a particular banding event goes, then talk to your study site PI as soon as possible. Remember that the data are worthless if the bird is being adversely affected by our actions.
2. **When you first catch a bird, ALWAYS check both legs to make sure it is not already banded**. It is surprisingly easy to miss bands especially if they are on the opposite leg to the one you usually band on. If it is banded, write down the number in your notebook as soon as possible (in case you let the bird go prematurely). Doing this at the net, is a good idea.
3. **Work quickly and efficiently, but do not rush.** It's better to take a little longer than to make a mistake.
4. **When processing a bird, prioritize the most important activities.** In almost all cases, this means banding the bird first (after you have identified it – NEVER band a bird unless you are certain that you know what it is). By prioritizing you guard against the risk that the bird might escape before you are finished. Also, if you are busy and worried about holding birds for too long, it is OK to drop incidental measures that are not critical to the study (e.g., certain morphometrics). It is often advisable to weigh birds last, as this is the time when they are most likely to escape. If you are taking blood for endocrine work, it is important to take blood within 2-3 minutes of capture (capture = the time the bird hits the net), so do that first.
5. **Prioritize females.** As you are removing birds from nets, quickly check whether they have a brood patch and process any incubating/brooding females first. This is especially important for species in which the females do all of the parental care (e.g., saltmarsh sparrow).
6. **Take great care when recording data.** Although banding is very safe, we are interfering in a small way with the bird's life, and we therefore have a responsibility to learn as much as we can and to do it efficiently (i.e., to get as much as possible out of the data). The band number is most important, so read it when you put it on and again right before you release the bird. If another

person is recording data have them read back to you what they wrote down, to ensure that they heard you correctly. When using calipers be especially careful not to misread the scale.

7. **Everyone lets birds go prematurely occasionally.** If (when) this happens to you, do not feel bad. Just think about why it happened and about how you can work to avoid it happening again.

<u>Banding kits</u>

Each sparrow project banding kit should contain the following items at minimum (extras welcome if supplies allow):

2 pairs 0A-1A pliers
1 pair 2-3 pliers
1 pair band removal pliers
1 color band spoon
1 pair band cutting scissors
1 band sizer
1 short wing ruler
1 digital scale (when possible)
1 pesola (30g best)
1 weighing cone/tube
1 pair of calipers (digital best)
extra batteries for scale, calipers, camera
1 seam ripper
hand sanitizer
pencils
sharpies
metal bands
color bands 50-100 of each color
digital camera
white board for photo background
copies of USGS and state permits

Additional supplies that might be needed if taking tissue samples (e.g., feathers, blood, salvage):

sharps disposal container
needles
capillary tubes, critocaps, vacutainers
Eppendorf tubes
filter cards for blood samples
styptic powder
nitrile gloves (multiple sizes)
cotton pads
alcohol swabs
envelopes for feather samples
whirl-pacs for salvaged chicks/eggs

More details on these supplies are available in the tissue sampling SOP.

<u>Band colors</u>

On data sheets and in the data base, each band color is coded as follows:

A = aluminum (metal)
K = black
B = blue
Lg = light green
Lb = light blue
R = red
W = white
O = orange
G = green
Y = yellow
E = gray
P = pink (no darvic)

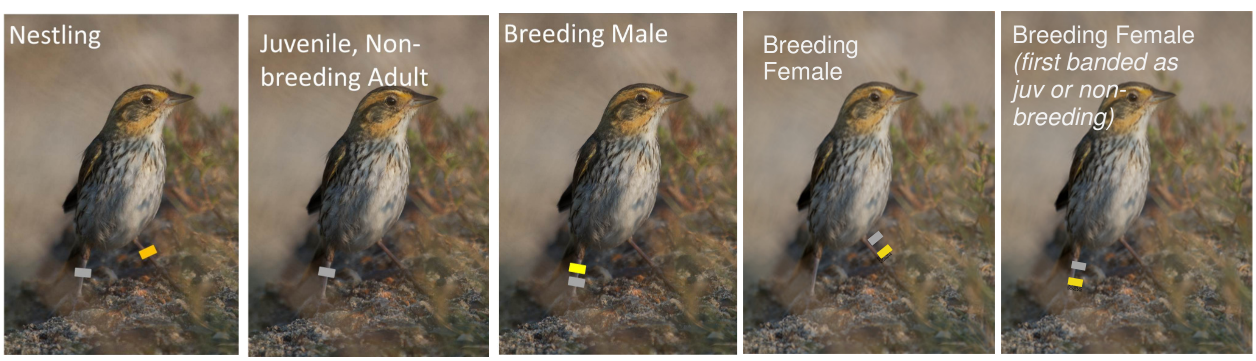
<u>Banding conventions</u>

Read bands on the standing bird right leg to left leg and top to bottom (i.e., you read as though a book when the bird is facing you, or when lying on its back in your hand with its legs pointing towards its tail). If two bands are on the same leg, use the terms proximal (nearer to the bird's core) and distal (farther from the bird's core, nearer to its foot) to avoid under/over confusion when the bird's legs are tucked.

Band arrangement

- Nestling – Hatch year birds captured as nestlings will be banded with the aluminum band on the bird's RIGHT leg and the color band to denote site on the bird's LEFT leg.
- Juvenile – Hatch year birds that are captured as juveniles (not associated with a nest) will be banded with the aluminum band on the RIGHT leg and NO color band to denote site (since they might not have hatched at that site).
- Non-breeding adult – After hatch year birds of unknown sex (no brood patch or cloacal protuberance), including those captured outside of the breeding season, will be banded with the aluminum band on the RIGHT leg and NO color band to denote site (since they might not be breeding).
- Breeding adult male – After hatch year birds that are breeding males (cloacal protuberance present) will be banded with the color band on the RIGHT leg proximally and the aluminum band to denote site on the RIGHT leg distally. No bands on the left leg.
- Breeding adult female – After hatch year birds that are breeding females (brood patch present) will be banded with the aluminum band on the LEFT leg proximally and the color band to denote site on the LEFT leg distally. No bands on the right leg.

  Adding color bands on recapture* – If a juvenile or non-breeding bird is subsequently recaptured and can be sexed (implying that it breeds at the recapture site), then a color band can be added to indicate the site where it is breeding. These birds will already have an aluminum band from the original capture on the RIGHT leg. If the bird is a MALE, the color band should be placed on the RIGHT leg proximally so that it matches other known males. If the bird is a FEMALE, the color band should be placed on the RIGHT leg distally. Note that adding color bands means that there are two possible combinations that denote females. Known females will always have the color band distal to the aluminum band, usually on the left leg, but sometimes on the right. Only known females will have an aluminum band on the left leg. Males will always have the color band proximal to the aluminum band on the right leg.



***Note, each master permit holder must get authorization to change the banding status of a bird after its original capture (e.g., adding a color band to a previously banded bird). When banding status is changed, there are specific reporting requirements. Using the recapture function, "How Otained" must be recorded as "Captured by bander, status of bird changed" and "Remarks" should include "Status changed by bander" and a description of the markers that were added. For more information, see: http://www.pwrc.usgs.gov/bbl/MANUAL/aarespus.cfm**

Site colors:

Each major site will be represented by a single color band. If individual teams need to use additional bands then they should make sure that others know their scheme to minimize risk of overlap. The table below lists all demographic plots, along with site codes and site-specific colors.

State	Site	Site Code	Color	Additional color codes used?	Team (leader)	Notes
ME	Scarborough Marsh (Scarborough)	SC	orange	N	UMaine (Brian Olsen)	
ME	Scarborough Marsh (Nonesuch)	NO	orange	N	UMaine (Brian Olsen)	
ME	Scarborough Marsh (Libby)	LI	orange	N	UMaine (Brian Olsen)	2011 only – few birds
ME	Scarborough Marsh (Jones Creek)	JO	orange	N	UMaine (Brian Olsen)	New in 2012, to replace LI
ME	Rachel Carson NWR (Spurwink)	SW	green, blue, black	Y	BRI (Oksana Lane)	
ME	Rachel Carson NWR (Furbish)	FB	green, blue, black	Y	BRI (Oksana Lane)	Used Y,G,B,W,R,P,K,O in 2008
ME	Rachel Carson NWR (Little River)	LR	gray	Y*	UNH (Adrienne Kovach)	Used P in past; extra band for species vs hybrid (see below)*
ME	Rachel Carson NWR (Eldridge)	EL	red	Y*	UNH (Adrienne Kovach)	Extra band for species vs hybrid or to denote individuals*
NH	Chapman Landing	CL	white	Y*	UNH (Adrienne Kovach)	Extra band for species vs hybrid or to denote individuals*
NH	Lubberland Creek	LU	white	Y*	UNH (Adrienne Kovach)	Extra band for species vs hybrid or to denote individuals*
MA	Parker River NWR	PR	yellow	Y	PRNWR (Nancy Pau)	Used Y,G,B,W,R,P,K,O in 2008
RI	Chafee NWR	CH	blue	Y	USFWS (Erin King)	4-band combos in 2010/pink or blue for sex in 2008-2009
RI	Sachuest Point NWR	SP	green	Y	USFWS (Erin King)	4-band combos in 2010/pink or blue for sex in 2008-2009
CT	Barn Island WMA	BI	orange	Y (in past)	UConn (Chris Elphick)	4-band combos used in 2002-2004
CT	Hammonasset SP	HM	yellow	Y (in past)	UConn (Chris Elphick)	4-band combos used in 2002-2004
CT	East River Marsh	ER	red	Y (in past)	UConn (Chris Elphick)	4-band combos used in 2002-2004
CT	Waterford Beach	WB	blue	N	UConn (Chris Elphick)	
CT	Pattagansett Marsh	PM	blue	N	UConn (Chris Elphick)	
CT	Past other sites (no current banding)	N/A	black, white, green, blue	Y (in past)	UConn (Chris Elphick)	These colors have all been used at other sites in past years
NY	Sawmill Creek (Staten Island)	SA	white	N	SUNY (Jonathan Cohen)	New in 2012
NY	Four Sparrow Marsh (Brooklyn)	FS	black	N	SUNY (Jonathan Cohen)	New in 2012
NJ	Forsythe NWR (Oyster Creek)	OC	red	N	UDel (Greg Shriver)	
NJ	Forsythe NWR (AT&T)	AT	blue	N	UDel (Greg Shriver)	
NJ	Forsythe NWR (Mullica Wilderness)	MW	yellow	N	UDel (Greg Shriver)	

*At LR, EL, and CL additional color bands will be used on breeding adults to designate the bird as either a saltmarsh sparrow (G), a Nelson's sparrow (B) or a hybrid (K), or to produce a unique 4-band code for specific individuals. Any extra bands will be placed on the opposite leg to the metal band.

Assigning nest fates

Every nest that has been monitored regularly should be assigned a nest fate. Preliminary assessments should be made in the field, with as much detail as possible written down. Final assignments should be made at the end of the field season, to ensure that all fates are assigned using a common standard, and that everyone who has been collecting data is using the same methods. Often information that is not available in the field (e.g., from iButtons) can alter your understanding of what happened, hence the need for careful reassessment at the end of the field season.

Determining nest fates can be tricky and if you are unsure it always helps to discuss the series of events for a given nest with other members of the field crew. (These discussions also increase consistency in the way that fates are assigned.) We have, however, developed a series of rules for assigning fates, and the consistent use of them is critically important. Note that the different fates are not mutually exclusive (e.g., a nest can lose contents to flooding and still produce fledglings), so one nest can fall into multiple categories. Overall the guidelines below have been designed to be conservative, such that, when there is any doubt, nests will be placed in one of the uncertain categories. Doing this can be frustrating when you feel confident that you "know" what happened. But, a guess is a guess even if well informed, and our goal is to eliminate variation in the judgment calls of different people as much as is possible, even if it means we have to admit that we are not certain about a larger proportion of the nests. The fate categories listed below are simplified in a dichotomous key that leads to a categorical fate assignment for each visit (which can include partial failures). When using the key, refer to this SOP for the full details on what constitutes evidence for each fate category.

In some cases, it is possible to use auxiliary data, such as re-captures, re-sights or behavioral observations, as evidence for assigning fates. Examples are provided below, highlighted in blue. Fates assigned using these auxiliary data should be recorded in a separate column because, in most cases, they can only provide evidence of success, not failure, and therefore might bias fecundity estimates if effort is inconsistent across sites (e.g. if some sites have more banding effort in the late summer or fall).

At this stage a lot of people have been over these guidelines many times, but if you identify major flaws in the rules, please bring them up with Chris Elphick or one of the other project PIs. The odds are good that we have identified, discussed *ad nauseum*, and done what we can to account for them, already. But, it is also possible that we might have missed something important.

Fate categories and the evidence required for them are as follows:

Flooded – Note that flooding does not always wipe out an entire nest; partial flooding loss happens, and should be noted. Flooding should be assigned when there are losses prior to the earliest likely fledging date (i.e., prior to when chicks are 8 days old, when the hatch date equals day zero), and at least one of the following conditions applies:

- the nest is observed to be underwater during a high tide and a subsequent nest check confirms that the nest is empty (= complete failure due to flooding) or has fewer contents (= partial failure due to flooding);
- the nest is found with intact eggs outside the nest (presumably after floating out) following a spring tide or heavy rainfall;

- the nest is found with intact cold or dirty eggs in the nest immediately after a high tide or heavy rainfall, and eggs do not subsequently hatch;
- the nest is found with a combination of the intact eggs outside the nest and intact cold or dirty eggs in the nest immediately after a high tide or heavy rainfall, and eggs do not subsequently hatch;
- the nest is found with intact dead chicks in, or close to, the nest following a spring tide or heavy rainfall (note that chicks should be inspected carefully for injuries that could have caused death, see Depredation, below);
- the nest is found with barely-alive nestlings (usually in a rigid posture, with wings and legs stretched out, head up, unable to move) the morning after a flooding event, and the nestlings are eventually found dead in or near the nest;
- the nest is found to be empty and soaking wet immediately (next day) after a high tide, and was known to have been active immediately prior to the high tide (care should be taken in these cases; this assignment should only be used when you are certain that the loss of nest contents coincided with the high tide);
- iButton data indicate that nest temperatures matched ambient, starting immediately after nest flooding.

Depredated – In this circumstance, we are defining depredation as the killing of eggs or nestlings by another animal, which includes killing without the intent to ingest (e.g., a marsh wren poking holes in eggs or killing nestlings). Additional information that might indicate the perpetrator should be noted in the "comments" field. As with flooding, partial depredation is possible, with only some of the nest's contents removed or destroyed by a predator on a single visit. If this happens, it should be noted. (Note too that partial nest loss means that it is possible for a nest to suffer both depredation and flooding). Depredation should be assigned when there are losses prior to the earliest likely fledging date (i.e., prior to when chicks are 8 days old), and:

- the nest is found with its structure disturbed (pulled apart);
- the nest is found with obvious depredation remains (e.g., remnant body parts, broken egg shells, dried yolk, etc.);
- dead chicks or eggs are found with injuries that likely resulted in death (if you are unsure about the severity of an injury then do not assign this failure cause);
- the nest is found empty, or with partial loss, on a day when the tides could not have accounted for the losses (check the observed high water measures on the web to make sure that there were no elevated tides due to rainfall, which sometimes occurs even when there is not a high spring tide predicted; checking iButton data may also be helpful). This is the most common scenario leading to an assignment of depredation.

Note, that it is possible that we overestimate depredation relative to flooding as a result of these criteria, because we may miss occasions when nests go underwater, washing away eggs or nestlings at times when we are not expecting it. The use of iButtons in nests is the best way to reduce the chance of these errors.

Failed-unknown cause –No matter what rules we apply there is always a degree of uncertainty in assigning causes of nest loss. We try hard to be conservative in assigning fates and only do so when one of the criteria described above applies. Consequently, there are some cases when the situation is ambiguous and no specific fate can be assigned. Basically, this fate should be used whenever none of the others apply. Specific examples include:

- One or more eggs disappear at a time when flooding might have washed them out of the nest (but nest inundation is not confirmed, or >3 days passed between nest checks to be sure it is the cause), female apparently continues to incubate, but eventually nest appears unkempt/abandoned, remaining eggs never hatch. This might be a situation where flooding occurred, some eggs washed away, while the others remained but died. Alternatively, it might be a partial depredation event. Going back to the tide data might help resolve some of these situations, but others will remain ambiguous.

- One or more eggs cracked (but, not punctured) in nest, no signs of disturbance or flooding;
- Eggs/nest intact, never hatch, possibly female has disappeared/abandoned/died. Again this scenario might imply death of eggs due to flooding, and tide records should be checked.
- Some (but not all) eggs in a nest fail to hatch. These unhatched eggs may have been unfertilized may have experienced prolonged water contact during laying/incubation, or may have suffered from any number of developmental defects. If these eggs flood out of the nest after the rest hatch, make a note of it, but at this point they have already failed, and hence cannot 'fail' again due to flooding.

Fledged – This assignment is only given if there is good reason to believe that chicks fledged from the nest. Due to partial nest losses, it is possible for a nest to be classified as fledged as well as having been flooded/depredated/unknown loss. Whenever possible you should estimate the number of fledglings produced from a nest (because a 4-fledgling nest is vastly different from a 1-fledgling nest, in terms of the birds' population dynamics). Determining exactly how many young fledge is generally impossible, and our convention is to use the number of nestlings present in the nest on the last nest check before fledging is assigned. Assignment of fledging is made based on the following evidence:

- day 9+ visit finds an intact nest, well worn, with some droppings in the nest or immediately adjacent;
- fledglings present on day 9+ and gone at next nest check with no signs of nest failure (as defined above);
- banded nestlings (must be confirmed to be from the nest, e.g., by reading bands, radio, etc.) are re-sighted or re-capturd after they leave the nest;
- the banded female (must be confirmed to be from the nest, e.g., by reading bands, radio, etc.) is observed exhibiting provisioning behavior in the vicinity of the nest within 7 days of the predicted fledging date. Make note of any female provisioning behavior no matter how long after the predicted fledging date;
- iButton data indicates that the nestlings departed the nest coincident with the high tide, when old enough to fledge (i.e., 9+ days old). This criterion may also be refined as we learn more about how to interpret iButton data, and about the behavior of nestlings during fledging.

Note that the timing information given above relates to sparrows. For species with precocial young (e.g., willets, ducks) evidence of successful hatching is taken to be equivalent to fledging. Post-hatching survival in these species is essentially impossible to estimate without the use of special methods (e.g., telemetry). If the nest was discovered during or prior to incubation, then check to make sure that the incubation period was long enough to allow fledging: **Willets: +22 days; Mallard: +25 days; Clapper Rail: +18 days; Virginia Rail: +16 days.** Floating the eggs to determine the stage of development is also a good way to determine approximately how old a nest is when it is discovered (see Liebezeit et al. 2007).

Unknown fate – This category should be used when you cannot confidently assign the nest fate to any of the above categories. In general this situation will only arise when there is conflicting evidence right around the time the nestlings are due to fledge – e.g., birds disappear without trace, around a high tide but with no evidence that the nest was soaked, and slightly before fledging is anticipated (e.g., day 8), or when nest visits are delayed for some unforeseen reason shortly before fledging.

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TWO TYPES OF ASSIGNMENT

For every nest there are two types of assignment that need to be made: (1) a single categorical variable that summarizes "overall" fate for the time between each visit to the nest and (2) quantitative fate information that describes what happens to individuals within the nest. The associated nest fate assignment key should be used to assign (1) for each visit from the list of 10 possible categories. Six of these categories (3, 5, 7, 8, 9, and 10) are "ultimate" fates, in that they describe the completion of the nest, which usually coincides with the last visit. This ultimate fate is synonymous with the "nest success" parameter used in most ornithological studies.

1. Categorical fates

This assignment relates to the factor that determined the "completion" of the nest, and is measured according to mutually exclusive categories. In other words it is the fate that relates to the last individual(s) in a nest.

- If any individual fledges, then the nest would be assigned an ultimate fate of "Fledged" (= "successful").
- If no individual fledges, then the nest would be assigned an ultimate fate of "Completely flooded", "completely depredated", or "failed, unknown cause" (all of which = "unsuccessful").
- If it is not certain whether any individuals fledge, then the nest would be assigned an ultimate fate of "unknown fate".

The individual fates outlined below can be assigned when nest-level fates are assigned, or alternatively code can be written to compile them from visit-level fate assignments produced by the key, in which case it might be appropriate to have fewer categories.

2. Quantitative fates

This assignment allows us to summarize the factors that determine the fates of individuals in the nest. We will not always be literally tracking individuals, but we want to be able to summarize the fates of all nest contents through a set of summary variables. Under this scheme we need to use the guidelines above to determine the fate of each individual and the stage (egg vs. chick) at which the individual meets its fate. The variables we want to quantify are (color-coded by fate category: flooding, depredation, unknown):

a) ***Clutch size***: the maximum number of eggs known to have been in the nest. This will often be the total number of eggs seen at one time, unless there is additional information.
b) ***Brood size***: the maximum number of chicks known to have been in the nest. This is also equivalent to the minimum number of eggs that survived to hatch.
c) ***Fledglings***: the minimum number of chicks that fledge from the nest. See above for how to determine this number.
d) ***Number of eggs flooded from nest***: the total number of intact eggs found outside the nest. Broken eggs do not count if there is any indication of depredation; eggs that are simply cracked should be included.
e) ***Number of eggs flooded in nest***: the total number of intact eggs found in the nest immediately after a flooding event that are wet/cold and show no sign of subsequent incubation.
f) ***Number of unhatched eggs***: the total number of intact eggs found in the nest, that never hatch, but for which failure cannot be directly linked to a flooding event (see e above). This number

only includes failed-to-hatch eggs in a nest where at least some eggs hatched (in contrast to j below).

g) ***Number of eggs depredated***: the minimum number of eggs found showing evidence of having been taken by a predator – e.g., broken, egg shell pieces, yolk remains. Note that sometimes it may not be possible to tell how many eggs are involved so the minimum possible should be determined. E.g., traces of yolk alone would result in a minimum of one. Several fragments including two shell ends that clearly don't go together would indicate a minimum of two. Note: this number will include eggs that died from causes other than depredation that were later scavenged.

h) ***Number of eggs missing because of flooding***: the total number of individuals that are known to have disappeared during the egg stage because of a flooding event. When losses occur when there could have been eggs or chicks, they should be assigned to whichever category occupied the greatest percentage of unmonitored time.

i) ***Number of eggs missing because of depredation***: the total number of individuals that are known to have disappeared during the egg stage because of a depredation event. When losses occur when there could have been eggs or chicks, they should be assigned to whichever category occupied the greatest percentage of unmonitored time.

j) ***Number of eggs failed, unknown cause***: the total number of intact eggs found in or out of the nest, for which failure cannot be directly linked to a flooding event. Note that abandonment of these eggs might still be due to flooding. This number only includes eggs in a nest where no eggs hatched (in contrast to f above).

k) ***Number of eggs missing, unknown cause***: the total number of eggs that disappeared for which failure cannot be directly linked to a flooding event or depredation.

l) ***Number of chicks drowned***: the total number of intact dead chicks found in association with a nest known to have been flooded (see criteria above).

m) ***Number of chicks depredated***: the total number of chicks found dead and showing signs of physical injury (includes deaths by competition). Note: this number will include chicks that died from causes other than depredation that were later scavenged.

n) ***Number of chicks dead, unknown cause***: the total number of chicks found dead or missing from the nest before day 8, but for which the fate is uncertain.

o) ***Number of chicks missing because of flooding***: the total number of chicks that disappeared from the nest before day 8, for which failure can be directly linked to a flooding event.

p) ***Number of chicks missing because of depredation***: the total number of chicks that disappeared from the nest before day 8, for which failure can be directly linked to a depredation event.

q) ***Number of chicks missing, unknown cause***: the total number of chicks that disappeared from the nest before day 8, for which cause of failure is unknown.