Basic guidelines for setting up a breeding seabird monitoring program for Caribbean countries

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BACKGROUND

The Caribbean is an area rich in marine biodiversity. Some 20 species of seabirds breed on islands and isolated mainland sites in the Caribbean area. Populations of some species are important because of their size (e.g., Sooty Tern, *Sterna fuscata*), and the area is also home to a few endangered species (e.g., Roseate Tern, *Sterna dougallii*). Caribbean seabirds are under threat from many sources. The most important in the region are coastal and island development, the introduction of foreign predators such as cats and rats to the offshore islands on which seabirds breed, and continued egging in some places.

With the exception of a few countries, most in the Caribbean do not routinely monitor their breeding seabirds, and some have almost no information at all. Effective conservation requires sound information on distribution and abundance, and population trends, and because of the lack of this type of information, many Caribbean countries are not well placed to conserve their seabird populations. Clearly it is important in these situations to define the distribution and abundance of breeding seabirds and then to establish a program to monitor populations into the future.

The following lays out guidelines for the establishment of a breeding seabird monitoring program for individual Caribbean countries. The guidelines assume that there is currently little knowledge of seabird populations in a particular country and that you are essentially "starting from scratch".

STRATEGY

Your overall strategy in setting up a program such as this is to start from the general, and move to the more specific. What is meant by this is that initially you need to collect basic information on the distribution of your seabirds, i.e., which species are breeding where, before you start to be more specific by defining abundance, i.e., colony size, or population trends. The three steps of (1) determining distribution, (2) determining abundance, and (3) determining temporal trends in distribution and abundance together form the foundation for an effective breeding seabird monitoring:

1. Determine the distribution of species: if possible **survey** all potential seabird breeding habitats in your country and find out which species are breeding where. From these data you can construct a location by species matrix as shown in Table 1.

2. Determine the abundance of each species at each colony location (Table 2) by conducting a **census**: this will involve the generation of direct counts or estimates of the number of pairs, nests, individuals or some other index of population size for each species at each colony. If possible this should be done for the total colony at all breeding locations. If the total colony is too large to count, then a subset of the colony or some other sampling system should be set up, and only birds breeding within these specified areas should be counted. If there are too many colonies to count all of them, a subset of colonies either chosen at random or in some other way (chose the colonies that are obviously the largest and most important, or the most threatened etc), should be counted. **The first time this is done forms the baseline for future counts and is thus a key component of a monitoring program.**

3. Determine trends in distribution and abundance by repeating steps 1 and 2 above on a regular basis to monitor the size of colonies by species. Although it would be ideal to revisit all colonies on a regular basis, it is usually not possible to do this because

Table 1. Hypothetical "location by species matrix" for breeding seabirds in the Culebra archipelago in 1999

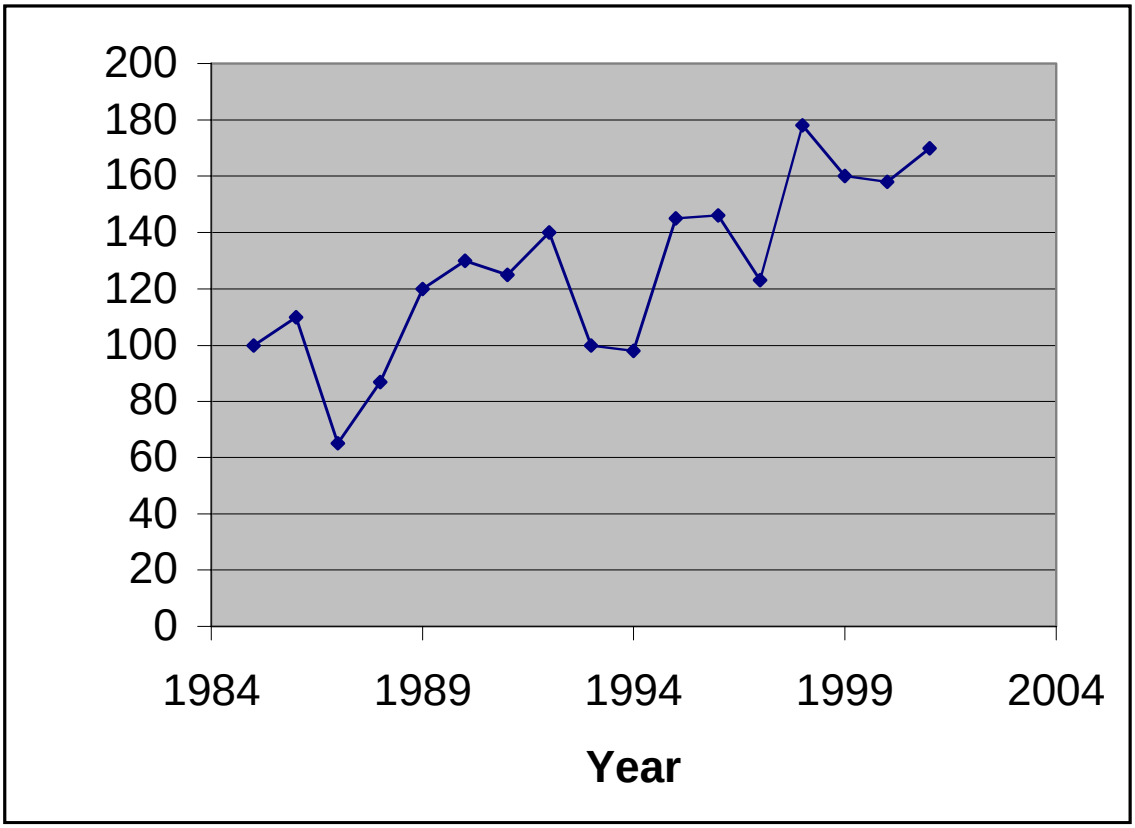
	Status at each colony location			
Species	**Yerba**	**Genqui**	**Noroeste**	**del Agua**
Audubon's Shearwater	absent*	absent	absent	breeder
Black-capped Petrel	absent	absent	absent	absent
Jamaican Petrel	absent	absent	absent	absent
Red-billed Tropicbird	absent	absent	absent	absent
White-tailed Tropicbird	absent	breeder	breeder	absent
Masked Booby	absent	absent	absent	absent
Brown Booby	absent	breeder	absent	absent
Red-footed Booby	absent	breeder	absent	absent
Brown Pelican	absent	absent	absent	absent
Magnificent Frigatebird	absent	absent	absent	absent
Laughing Gull	breeder	breeder	absent	absent
Common Tern	absent	absent	absent	absent
Royal Tern	absent	absent	absent	absent
Bridled Tern	breeder	breeder	breeder	breeder
Sooty Tern	breeder	absent	breeder	absent
Least Tern	absent	absent	absent	absent
Roseate Tern	absent	absent	absent	absent
Sandwich Tern	absent	absent	absent	absent
Gull-billed Tern	absent	absent	absent	absent
Brown Noddy	breeder	breeder	breeder	breeder
Black Noddy	absent	absent	absent	absent
Cayenne Tern	absent	absent	absent	absent

* Note that it is important to record a species as absent so that you can later track expansion of species into areas formally not occupied.

Table 2. Numbers of pairs of each species breeding at each location

	Number of pairs at each colony location			
Species	**Yerba**	**Genqui**	**Noroeste**	**del Agua**
Audubon's Shearwater	0	0	0	9
White-tailed Tropicbird	0	1	1	0
Brown Booby	0	150	0	0
Red-footed Booby	0	4	0	0
Laughing Gull	120	143	0	0
Bridled Tern	23	10	22	78
Sooty Tern	4000	0	57	0
Brown Noddy	54	67	120	23

Figure 1. Hypothetical trend in colony size of a seabird at a particular location



of the time and effort involved. Typically a subset of colonies is chosen to be monitored on a regular basis. You should consider including colonies that:

- are easy to access on a regular basis
- are large so that a higher proportion of the population is monitored
- have several seabird species breeding so that one visit can be used to census more than one species
- are at the periphery of the species distribution because this is where you might expect to see declines first, if the overall population is declining
- are under pressure from human-induced or other threats, and are of conservation concern

LOGISTICS

When to perform a colony survey or census

There is wide variation in the timing of breeding of Caribbean seabirds and they may not be in synchrony with landbirds. When breeding seasons are entirely unknown, you may have to visit a colony on a regular basis over the course of a year to determine the when birds breed.

In general, most Caribbean seabirds breed only at a certain time of the year, and this is usually between about **May and August**. Typically, eggs are laid in May and early June and the chicks fledge by July or early August. Some species remain at the colony after the breeding season for a few weeks and look after their fledged chicks. Note that there are many exceptions to this rule. Some species such as Brown Boobies (*Sula leucogaster*) can be found breeding at any time of the year, although even these have peaks in breeding activity. Also, at some locations, seabirds start breeding as early as January or February (e.g., Trinidad).

Overall it is best to survey a colony for the purposes of confirming breeding activity or counting birds at the middle to the end of the egg-laying period, before any chicks have hatched. That way you will avoid missing birds that have not laid eggs yet. Late season surveys during the chick stage are not advised because you will miss pairs that have lost their eggs or chicks before your visit, and cause undue disturbance because chicks of many species are mobile and could be lost from the nest or killed by predators or neighbouring seabirds if you enter the colony.

Step 1: Determining the distribution of species

The specific methods used to do this depend to a large degree on the number of potential colonies and the geographic extent of those colonies. In smaller countries with few colonies, it may be possible to land on every colony by boat and conduct the survey of breeding seabirds over the course of one or more years. In some situations it may be possible to view the colony from the land with a spotting scope or binoculars. In larger countries, with many offshore islands, aerial surveys by fixed-wing aircraft or helicopter will be needed to cover the distances required in a reasonable amount of time. Note

however, that there are many disadvantages to aerial surveys of seabird colonies as follows:

- diurnal species that nest in the open are most visible from an aircraft. Species that nest under vegetation or in crevices may be difficult or impossible to detect from the air. Also some species of seabirds are only active at the colony at night and so would not be visible in a daytime aerial survey
- it is often difficult to distinguish species from the air (e.g., Common, *Sterna hirundo*, and Roseate Terns; Sooty and Bridled Terns, *Sterna anaethetus*).
- aircraft, particularly helicopters can cause disturbance to the breeding seabirds
- breeding activity cannot be confirmed

In general you should consider using the best methods to accomplish this task first before resorting to other methods. Consider using methods in this order (from most to least effective).

- Land on island by boat or other means
- view island at a distance from a boat or from the land
- fly over the island in a fixed-wing, high wing (e.g. Cessna) aircraft (causes less disturbance)
- fly over island in a helicopter (causes more disturbance)

If you are able to land on the island, take advantage of this by taking as much information as possible while on the island. Here are some recommendations:

- Each colony should be described in as much detail as possible, and the description attached to sketch maps and photographs. A general sketch map shows the location of each colony for each species, in enough detail to allow precise re-location in future years by different observers. For large areas, where the bird distribution is small or highly aggregated, an inset map is drawn to show nesting sites in relation to distinct natural features. A detailed sketch map shows the limits of the colony being censused. Limits of the colony or area cencused are shown in relation to distinct features of the environment, such as gullies, streams, rock falls etc.; these permanent landmarks are essential reference points for re-locating sites in future years. A good example a colony map is in Figure 2.

- Record weather conditions. The attendance of birds at breeding colonies may be influenced significantly by weather. Temperature, precipitation, wind strength and direction, and visibility must all be recorded at the time of the count in order to correct for these sources of variation later on.

- Where possible, photographs of the colony or census area are taken at the time of survey to provide a permanent record. Be sure to take lots of photographs of the colony no matter which survey technique you use. Try to take pictures that will help you in revisiting the colony the next time. Use a good quality 35 mm or medium-format camera with black and white or colour film. A digital camera is also very useful in providing images that you can immediately access using a computer. Photography is particularly important when you conduct aerial surveys as you will be able to produce valuable images of each of the colonies, including

habitats, and you may even be able to count some seabird species, particularly the large conspicuous ones such as the boobies.

If possible you should attempt to confirm breeding activity during the survey by noting the presence of empty nests, eggs or chicks. If you do not see direct evidence of breeding then you may be able to assume that a particular species is breeding by observing (1) courtship behaviour, (2) adults entering a crevice that looks like a nest site, (3) adults issuing alarm calls when you get near a nest site. In these less definite cases you should consider using words such as "possible" or "probable" breeder to qualify your observations.

Step 2: Determining the abundance of each species at each location

The basic unit of measurement of abundance at colonies is the breeding pair and ideally your counting method should produce a count of breeding pairs. However, counting pairs of birds at a colony is not often practical because most species do not spend much time together at the colony as a pair. Typically you will need to count nests, or nest-sites with eggs or chicks to arrive at the number of breeding pairs in a colony. In colonies that are inaccessible, you may be able to see birds attending nests or nest-sites but not be able to determine if they have eggs or chicks at particular nests. In that case the unit of measurement is the "Apparently occupied site". If your methodology allows it, t**he best thing to count is active nests, which are those containing one or more eggs or chicks.** Avoid counting empty nests unless you are sure that eggs will be laid or have been laid in the nest. Adults of some seabird species build more than one nest but only lay eggs in on eof them. Young birds sometimes build a nest but do not lay. Thus, if you include empty nests you run the risk of inflating your estimate of colony size.

Sometimes you can only count individual birds at a colony. Typically this count will overestimate the number of breeding pairs because some pairs are found together at the colony, or non-attending birds sometimes roost in the colony while off-duty. Also, young birds that are not yet breeding attend the colony, prospecting for potential mates and nest-sites. When you can only count individuals you should try to determine a correction factor to convert the number of individuals to the number of pairs. This is done by counting the number of active nests (those with eggs or chicks) in an area and at the same time counting the number of adults attending in the area. The conversion factor or "k-value" is the number of active nests divided by the number of individuals counted in the same area. In colonies where you have obtained a count of individuals only, you can multiply this count by the "k-value" to estimate the number of breeding pairs in the colony.

Within a species, the number of individuals attending the colony varies by time of day and season. Therefore, when calculating a "k-value" you should make repeat counts at a time of day and season that matches as closely as possible your counts of individuals at other colonies. Also "k-values" are species-specific and cannot be calculated for one species and used on another. If you cannot calculate a "k-value" then use counts of individuals to monitor population trends at those colonies.

The specific methods that you use to determine the number of breeding pairs in a colony depend on the species involved, and the size of the colony. For example, burrow or crevice nesting species need to be counted using different methods than for ground nesting species. Small colonies (< 500 pairs) often can be counted completely, whereas in larger colonies you may have to employ some sort of sampling technique and estimate the total colony size later.

Ideally, you should visit the colony several times over the course of the incubation and early chick rearing period, rather than just once. This will provide a more accurate estimate of the total number of pairs breeding at a colony than from one visit. On the first visit, count and mark all active nests. On subsequent visits count only new, unmarked nests. Revisit and repeat this procedure until you are adding very few if any new nests to your tally. Of course this method can only be used in situations where you can enter the colony on foot and examine nest contents directly. Also repeat visits should not be used if you are concerned about causing disturbance.

i. Above-ground nesting species

Species: Masked Booby, Brown Booby, Red-footed Booby, Brown Pelican, Magnificent Frigatebird, Laughing Gull, Common Tern, Royal Tern, Sooty Tern, Least Tern, Roseate Tern, Sandwich Tern, Gull-billed Tern, Brown Noddy

(a) Boobies, pelicans, frigatebirds: These are large, conspicuous birds that typically nest on the ground or in low bushes on the flat tops of islands or peninsulas. Because of their size, these birds usually can be seen easily from an aircraft and aerial surveys often work well as a census technique. Direct counts from an aircraft are usually not possible because of the time they take. In these cases aerial photography is recommended with counting taking place back in the lab using enlargements of the negatives or high-resolution scans on a computer. A very high quality camera system, ideally medium format (2 1/4 square, 6x7, 645), works best as this gives you optimum resolution for counting purposes. Use fine-grained colour or black and white film. Kodak TMAX-100 is particularly good.

If aerial censuses or ground counts are conducted it may not be possible to determine if nests contain eggs or chicks, so the unit of measurement is the Apparently Occupied Site. If the actual number of breeding pairs is required, ground counts of active nests can be used to correct the aerial survey for the proportion of adults occupying sites but not breeding. Breeding activity can easily be determined in ground surveys of species such as Brown and Masked Boobies, both of which are relatively insensitive to careful observers.

(b) Gulls, terns, and noddies (family Laridae). These species are smaller and more difficult to see from the air, so ground counts are preferred. Complete counts of all active nests can be achieved on the ground at small and medium sized colonies. These species often nest in mixed colonies, which requires that counters are able to identify nests and eggs or chicks to species. To reduce the time in the colony, counters should work in teams, starting at one end of the colony and walking carefully through the colony in a line, counting all active nests the narrow strips between observers. Observers should be about 1-2 metres apart when nests are dense, and up to 3-5 metres apart in more dispersed nesting situations.

At larger colonies where complete nest counts are not possible, some sort of sampling system should be used to determine colony size. There is a variety of ways to do this. Two are outlined here:

1. Line-transects or strips through the colony are marked on the ground, and delineated on maps, and all active nests within each transect counted. The boundary of the colony and its area is determined by ground survey. The number of active nests in each transect is divided by the area of the transect to determine the nesting density in each transect. The mean nesting density across transects is multiplied by the colony area estimate to obtain a total estimate. An example of the results from a line transect census are shown in Figure 3.

2. Circular plots. Posts made of re-bar are placed at random points or in some stratified way with respect to habitat or other colony feature, within the area of the colony. PVC tubing is placed over re-bar for safety and for visibility. A piece of string is looped at one end, and the loop is placed over the PVC pipe. The length of the string is determined to give an appropriate area for the circular plot (a 3 m piece of string would give a 19 m^2 plot). A person holds the string taught at one end and walks around the PVC pipe making sure the string stays taught. Another person is responsible for counting all the active

nests of each species occurring between the pipe and the end of the string. As with the transect method, the total area of the colony is estimated independently and multiplied by the average density of active nests occurring in the circular plots, to determine the total number of active nests in the colony. Plots can of course be of any shape. Square plots are often used, with the re-bar marking a particular corner (consistent across plots) of the plot.

ii. Burrow-nesting species

Audubon’s Shearwater, Black-capped Petrel

Burrow-nesting species are time-consuming to count because of the effort normally involved in finding nests. These species cannot be counted aerially or from boats.

The actual counts that you make at the time of the census are of occupied burrows. The general method involves detailed examination of potential burrows within intensively-counted circular plots, quadrats or transects set up to cover the entire range of densities exhibited within a colony and extending beyond its borders. Burrow densities tend to vary with topography, usually in relation to distance from the coast, so transects containing plots for detailed counts should be run perpendicular to the coast.

The standard way to examine a burrow is to reach in with your arm and attempt to feel for the presence of an egg or chick. The process is referred to as "grubbing". Grubbing burrows can be very difficult if the burrows twist around rocks or tree roots, or if they are so long that the nest chamber cannot be reached. Although you can dig an access door over the nest chamber in these situations, it is not advisable due to the potential for disturbance.

Once study plots have been established, each burrow within each plot is found and scored as occupied or unoccupied. Signs of occupation include presence of an egg (or eggshell or egg membrane), chick, nest material, or dropped food. Note that signs that the burrow has been entered (e.g. soil scrapings, defecation) are not reliable because non-breeding birds may leave identical signs. This is a potentially serious problem in monitoring burrow-nesting seabirds as many are very sensitive to disturbance, particularly when on an egg. Once the density of occupied burrows is determined it can be multiplied by an estimate of the colony area to provide an estimate of the total number of occupied burrows (and thus breeding pairs) in the colony.

iii. Crevice-nesting species

Audubon’s Shearwater, Red-billed Tropicbird, White-tailed Tropicbird, Bridled Tern

These species nest in a variety of habitats that can be loosely described as crevices, such as in between or under rocks and boulders, and in true crevices or clefts in rock cliffs. Audubon's Shearwaters sometimes conceal their nest under vegetation. They are the most difficult to count of all Caribbean seabirds because their nests are so difficult to find. As a rule, the more time you spend in the colony looking for nests of these species, the more you will find. In a study of Bridled Terns conducted on Cayo del Agua, Culebra, in 1986, Chardine et al. (unpubl.), continued to find previously un-found nests throughout

the season. This also applied to Audubon's Shearwaters that were studied incidentally. Because of this it is almost impossible to get an unbiased estimate of the number of pairs of these species occupying a colony, particularly from short or at worst single visits. Furthermore, because they are limited to nesting in well concealed crevices or holes between or under rocks, their distribution within the colony is determined by the distribution of suitable nesting places. The result is that pairs tend to be spread out in a colony and the likelihood of getting a single pair in a small circular or square plot is minimal. The species are sufficiently different that they are discussed separately below:

Audubon's Shearwater: Adults are active at the colony only at night, but fortunately are very vocal. Their calls are unmistakable and unlike anything else you might have heard before, at least in a seabird colony. Visits to colonies after dusk through the early night hours will reveal calling shearwaters, if they are breeding there. Adults incubate their egg continually but soon leave their chick a few days after hatching. At that time adults are rarely seen at the colony and only when they are returning to feed their chick, which they do relatively infrequently. The only effective way to count nesting pairs in a colony is to examine as many potential nest sites as possible for signs of breeding. Remember, the more you look, the more you'll find!

Tropicbirds: These species tend to be active off the colony over the water in the early to mid-morning. Boat surveys at this time of day should reveal courting and prospecting birds flying off the colony and careful observations may allow these birds to be followed back to their crevice nest-sites at this time of the day. As with shearwaters, adult tropicbirds incubate their egg continually but soon leave their chick a few days after hatching. Again the only effective way to census a colony is to attempt to examine all potential nest-sites for signs of breeding activity. Some tropicbirds nest in crevices on cliffs that are inaccessible.

Bridled Terns: As mentioned, nest-sites are hard to find, however, Bridled Terns have a habit of standing outside their nests on rocks and other substrate, issuing alarm calls. If you see and hear this it is a good sign that they are breeding close-by. As the species above, try to examine all possible nesting places for evidence of breeding. Note that this species will sometimes lay its egg 2 metres or more under a boulder. They occasionally nest in tires discarded on beaches.

Step 3: Monitoring temporal trends in distribution and abundance

Distribution

Ideally you should conduct geographically extensive surveys of your breeding seabirds every 5-10 years to establish trends in the distribution of species. The results will show where growing populations are expanding, and declining populations are disappearing. Extensive surveys will usually involve boat or aerial coverage of as many potential and known colonies as possible. Extensive surveys can be time consuming and costly, depending on the geographic area you have to survey, and the number of colony locations you have to look at. High costs may preclude repeating extensive surveys at all, and you may be force to limit activities to a subset of colony locations.

Abundance

Once you have conducted one extensive survey of your seabird colonies and a baseline has been established, you will want to repeat counts at some or all of your colonies on a regular basis. In this way you will be able to track changes in the abundance of your seabirds, identify problems that might be occurring, and possibly provide solutions in a timely manner.

An ideal monitoring program for abundance should (a) provide an accurate index of population trends, (b) be quick to carry out, (c) be readily transferable between different observers, and (d) cause negligible disturbance. Criteria (a) and (b) involve a trade-off because accuracy and precision of a sample usually increase with the sampling effort used. Established techniques involve a range of methods from 'quick and dirty' surveys when time is short or people are few, to intensive high-precision methods when conditions and resources allow. The important point for a long-term monitoring program is that the same methods should be used throughout; this requires careful identification of the objectives of the program (to estimate the precision required) and the resources available.

There is no general consensus about the period of time between surveys. Some monitoring programs are conducted annually if funds allow, and this protocol produces the best possible data-set for detecting changes. A disadvantage of annual surveys is that the disturbance they this may cause may be unacceptable. Seabirds are long-lived and populations tend not to fluctuate widely in the short-term. There are several examples of ongoing seabird surveys from around the world that re-census colonies every 5 years. Longer periods between censuses are not recommended.

Another important question is how much of the colony do you count as part of your monitoring program? Ideally complete colony counts provide the best information, but these may not be possible to repeat regularly because of the time and effort involved. When they are not, colony trends can be determined on a sub-sample of the whole colony, i.e., in circular or square plots that have been set up and permanently marked. The problem with this method is that trends in plots do not always agree with trends at the whole colony level. The level of agreement depends to a large degree on how representative are the chosen plots.

Monitoring breeding success and other parameters

It is also important to measure seabird breeding success on a regular basis. Problems in a colony can often be related to depressed breeding success caused for example by predation, and solutions can be provided if the mechanisms accounting for colony decline are known. There are many ways to monitor breeding success and it is outside the scope of this document to describe them all. However, some general principles can be provided:

- if the whole colony cannot be studied, set up breeding success study plots in the colony within which observations are made. Do this before eggs have been laid or at least in the initial stages of egg-laying if possible.
- monitor at least 50 nests if possible.
- choose plot locations at random or stratified by habitat, location (centre or peripheral), or some other variable.

- once plots have been set up, number all study nests as clutches are initiated. Mark nests unobtrusively with tongue depressors, tags or some other marking method.
- mark eggs as they are laid in study nests with pencil or non-toxic magic marker so that you can detect if eggs are lost and re-laid.
- visit the plots every few days (every day is ideal if disturbance is not a factor) and record nest contents in all study nests. This can be done from a blind set up in front of the study plot or by entering the plots and checking nests directly.
- try to determine the fate of eggs when possible
- once eggs start to hatch, record hatching dates for each nest, and band chicks.
- continue to visit or observe nests through the chick development period until fledging, recording chick fates when possible.
- express breeding success as three proportional or percent measures: hatching success (eggs hatch per egg laid), fledging success (chicks fledged per egg hatched), and total breeding success (chicks fledged per egg laid).
- breeding success can also be expressed as chicks fledged per nest.

It may be useful for monitoring purposes to measure other biological variables as you are measuring breeding success as follows:

- as eggs are laid, you can measure their length and breadth using a vernier caliper. Egg volume index can be calculated by multiplying length by breadth. Egg size is considered an indicator of female body condition, and in species that courtship feed, an index of courtship feeding rates on the part of the male.
- In species that lay more than one egg per clutch, record clutch size. Clutch size is also considered a measure of female condition and courtship feeding activity
- as you check nests with chicks you can take chick measurements that will provide information on growth rates. Typically, chick body mass is measured along with one or more linear measurements such as wing, culmen or tarsus length. The condition of chicks can be calculated by correcting body mass for chick body size using the linear measurements. Chick growth rates are considered in index of food availability and parental feeding activity during chick development.
- Timing of egg-laying is a useful indicator of the overall environmental conditions that the birds have experienced prior egg-laying (e.g., temperatures, food availability, etc).