Community-based monitoring of freshwater turtles

Transformative Pathways
ICCS Interdisciplinary Centre for Conservation Science
Forest Peoples Programme

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This guide will be updated based on community needs. We welcome authors as the guide expands.

Cover photo: The community of San Juan del Morona where turtle management is carried out.

Credit: The community of San Juan del Morona and José Hernán Flores

Transformative Pathways partner logos

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The following guide is supplementary to Transformative Pathway's "Community-based monitoring of river health and biodiversity," with the below Section 5 dedicated to monitoring freshwater turtles.

5.0 Introduction

Monitoring turtles in your rivers and streams can help you track changes in turtle populations and their presence in the environment. It can involve collecting information on whether there are more turtles than there used to be, or less, whether there are any changes in how many nests there are each year, and whether there are plenty of young turtles to form the next generation of adults. If not, turtles may need help and protection to make sure they will still be there for many generations to come.

Community members may already have answers to some of these questions, based on their own observations and knowledge. For example, you may know several places where turtles nest each year, or where they are often seen basking in the sun. Coming together once a year to discuss whether there are still plenty of turtles, whether they are increasing or decreasing, whether they have changed the areas that they use, and why any changes might have happened is a good first step in assessing whether turtle populations are in good condition and if action might be needed to make sure they stay that way. But unless you record these observations systematically, you may not notice changes until they are severe. And unless community members go regularly to different parts of the overall territory, you won't have a full picture of turtle populations across the whole area. For example, people's observations might be restricted to the local area, or to transport routes along the lower sections of major rivers.

More information about how to systematically record observations about the state of the environment can be found in the guide Introduction to Community-Based Environmental Monitoring: A Practical Guidance for Monitoring of Natural Resources by Indigenous Peoples and Local Communities. This general guide outlines six stages in setting up and carrying out community-based monitoring of any aspects of the environment (see the figure below). To successfully apply this turtle monitoring guide, the monitoring team is encouraged to receive ongoing training, including proper completion of forms, operation of GPS devices and semi-professional or professional cameras, and recording data in datasheets. Ongoing capacity building, along with technical assistance and support, should be provided until the monitoring team can confidently and independently carry out these tasks.

Overview of the stages in biodiversity monitoring

Stage 1:
Getting prepared

Stage 2:
Determine monitoring needs & objectives

Stage 3:
Develop a participatory monitoring plan

Stage 4:
Prepare the monitoring team

Stage 5:
Collection & analysis of data

Stage 6:
Community reporting & validation

Overview of the stages in biodiversity monitoring. Adapted from *Introduction to Community-Based Environmental Monitoring: A Practical Guidance for Monitoring of Natural Resources by Indigenous Peoples and Local Communities* (http://iccs.org.uk/wp-content/uploads/2024/04/Introduction-to-community-based-environmental-monitoring.pdf). Stage 2 image from Pxhere (https://pxhere.com/en/photo/1227057). Stage 4 image by Alejandro Torres-Abreu (https://www.flickr.com/photos/125391306@N03/50702967173).

Scientists have developed several tools for monitoring turtle populations systematically, and the purpose of this guide is to make these available for use by Indigenous peoples and local communities. Monitoring turtles systematically can be helpful to make sure your own management and use is sustainable. The information collected can also be used to demonstrate to others that turtle populations are healthy, or conversely, to demonstrate that there's a problem that you need support to address. In this guide, we introduce three different methods that biologists use to monitor turtles: nesting surveys, basking surveys, and capture-mark-recapture. Each of these produces different kinds of information, with different levels of accuracy, and has different levels of requirements for technical support. Nesting surveys and basking surveys are quite simple to use whereas capture-mark-recapture studies will normally need ongoing support from experienced biologists. So which method or methods are most useful for you will depend on what your aims are and what level of technical expertise and resources are available. The box below gives a brief summary of the three methods. The rest of this guidance gives detailed instructions on how to use each of these three scientific methods. Blank datasheets for recording information for each method can be found at the end of the guide.

The three survey methods: nesting surveys, basking surveys and capture-mark recapture

Nesting surveys (Section 5.1) involve counting how many turtle nests there are in an area or place during turtle nesting season. Nesting surveys help you learn about which turtle species are nesting in the area, how many of each species are nesting, and if the nests are exposed to any threats. When you have collected information over many nesting seasons, you will be able to see how turtle nesting has changed and how threats to nests have changed, and therefore you will be able to show how turtle population(s) may have changed. You can also use findings from nesting surveys (and basking surveys) to learn more about the turtle population(s). If you have a hatch-and-release program, where your community collects turtle eggs, incubates them, and then releases them back into the wild, you can collect additional information to record the number of turtle eggs collected from nests and then number of turtles that successfully hatched in the program.

Basking surveys (Section 5.2) involve recording turtles that you see basking or sunning themselves on logs, rocks, or other surfaces. Basking is important for turtles, because they are 'cold-blooded' – they can't keep their body temperature steady in the way that we do, but need to bask in the sun to warm up. Basking surveys are typically done during the times of day when turtles are most likely to be seen basking out of the water. Basking surveys can provide you information on how turtles use their environment, which turtle species are most common in the area, and whether areas used by turtles change over time. They can be useful as an early warning system picking up any major changes in populations, although basking surveys alone can't be used to reliably detect population changes.

Capture-mark-recapture (Section 5.3) is much more robust than other methods in gathering information on changes in turtle populations (known as population trends), but it is very technical and it requires a high level of biological expertise and experience. Therefore, it's only appropriate for use by community members if they have members with this expertise, or if they have long-term support from biologists. This method involves capturing turtles, giving them unique marks, releasing them again, and repeating the process over many years. Each year, some turtles captured will already be marked, whereas others will have no mark, showing that they haven't been captured before. Over a long period of time, the number of turtles captured each year for the first time is compared to the number of marked turtles captured. In this way, it is possible to collect strong evidence on whether the turtle population is increasing, stable, or decreasing.

5.1 Turtle nesting survey

Overview

For turtle nesting surveys, you will need to do the following:

1. Decide collectively on the overall size and boundaries of the area you want to survey, and the types of information you want to collect. These will depend on the purpose of the survey (which should already have been agreed – see summary box above), the time and resources that are available, and the ease of mobility within the area, among other things.

2. Then, work to identify as many turtle nesting sites in the survey area as possible. You may be able to do this based on your own existing knowledge, or by reaching out to different people who know different parts of the overall survey area well. You may also need to quietly and cautiously visit different parts of the area at the start of the breeding season in the first year, to check where the turtles are nesting. **Do not approach or capture turtles nesting, as it will disturb their nesting behaviours.**

3. Once you have a list of nesting sites, collectively plan visits to the study area. This involves working out a calendar or schedule to visit each site repeatedly, from shortly before the start of the nesting season to shortly after it finishes. It can be done by a group of volunteer or turtle guardians.

4. Well before the surveys start, prepare a form to record information during site visits in a standard format (known as a datasheet). The form can be filled out on paper or it can be incorporated into a phone app if there's adequate technical expertise available to set this up.

5. At the same time, decide how (and by whom) the information will be analysed and presented back to the community (and to any external parties).

6. Especially in the first year, it's also important to discuss how well the survey went and whether any minor changes should be made to make it work better in the future. Assuming nothing major needs changing, the results from the first year should give you a baseline of information that you can use to compare the results of the following years.

Once you are happy with the procedures and data format, keeping them consistent from year to year in the way you collect data is very important for producing accurate information on long-term turtle nesting trends. This includes keeping the survey area the same, being consistent with how often you survey the nesting sites, and keeping the data collection form the same. However, sometimes these things may be outside your control. If the surveying time and area changes over the years, please make a note of it.

Identifying sites to survey and planning your survey visits

Identify and map all the sites you know where turtles nest by using your local knowledge and by consulting with people who live in different parts of the survey area. Give each site a distinct name that you can use to refer to it amongst yourselves (for example, this might be the name of the river where it is found or a settlement nearby). Mark all the sites on a map – either on paper or, if possible, using digital mapping.

Unless there are only a few nesting sites, you may need to train up a group of people as community turtle monitors. They can then work in pairs or teams, with each team taking responsibility for monitoring specific sites.

We recommend starting surveys shortly before the start of the nesting season and continuing until just after the end of the nesting season, so that you can capture any changes to the start and end dates of the season. Ideally, someone should visit each nesting site daily throughout the survey period, but for sites that are very remote, this may not be possible. A visit every few days to a week may still be enough to provide a general understanding of how turtle nesting patterns are changing from year to year. The choice of how often you survey the sites should be based on how often turtles nest in the area, and practical considerations such as accessibility of the different sites and the available time and resources.

Nesting survey data collection

Here is an example of a datasheet or form to use during turtle nesting surveys. There's also a blank template at the end of this guide:

Nesting Survey				
Your name(s): *Maria Garcia, Juan Rodriguez*		**Date of visit:** *01.04.2024*	**Time of visit:** *11:00-12:00*	**Distance surveyed:** *2 km*
General nesting site name: *Upper Blanco River*				
Turtle species	**Nest location**	**Observed threats to nest**	**Site description**	**Additional observations**
Taricaya	44.5623, -76.3200	Signs of unauthorized egg removal	Sandy area, no vegetation	Eggs collected for hatch-and-release
Charapa	44.5600, -76.3156	Tracks of nearby jaguar	Sandy area, some vegetation	No eggs found

And here are some notes on the different types of data:

Your name(s): It's important to record the name or names of everyone who participates in the visit, in case it would be useful to have further information about the visit later – especially if you record major disturbances to the site.

Turtle species: Write the species of turtles that are using the site, in the relevant column in the datasheet. You may already know this from previous visits, or you may see turtles, or you may be able to identify different species from track marks around a nest, egg characteristics (if you are collecting for a hatch-and-release project), or other means. If you are don't know, put 'don't know' – the rest of the data will still be useful.

Nest location: Ideally this will be in the form of coordinates using GPS and apps such as Google Maps. Keep data consistent in either latitude/longitude or UTC location recordings. Recording nest locations each year lets you track any shifts over time (for example, because of annual extreme weather events, flooding, droughts, erosion or changes in levels of boat traffic or nest disturbance). Recording nest locations also makes sure you avoid counting the same nest twice when surveying within the same nesting period.

Observed threats to nest: Apply local knowledge to examine potential threats in and around the nest, including predator, human threats, weather changes, environment changes, and more. If there are common or key threats in the area, instead of writing one main comment in this section, more data columns can be added per threat (for example, a column for presence/absence of a common predator's tracks). Signs of natural predation can include broken eggshells or partially eaten egg remnants outside the nest, disturbed or exposed nests with surrounding animal tracks, and/or visible wildlife excavation marks. Signs of human removal can include signs of nearby human activity such as footprints and removed/partially eaten eggshells.

Signs of weather and environmental changes can include excessive flooding on nesting sites or changes to shorelines.

Site description:

- *On the first visit to each site each year:* Describe the site. For example, is it on the side of a river or lake, and if so, how many metres does it reach from the water's edge and how many metres long is it? What is the ground like (e.g., soily, sandy, stony)? What is the surrounding vegetation like?

- *Subsequent visits in the same year:* Describe any changes to the site since the last visit.

Adapting the data collection sheet:

You can adapt this datasheet by adding columns for any additional data your community is interested in collecting. For example, if turtle eggs are being collected for a hatch-and-release programme, it's useful also to record the number of eggs found in each turtle nest during collection (known as the "clutch size"), and also to record what proportion of turtles hatch successfully from the eggs in incubation or artificial beaches (also known as "hatchling success rate"). For more information, see "Hatch-and-release program data collection" section below.

Precautionary steps:

If you see a turtle nesting, make sure to keep your distance and do not disturb the turtle in the process.

Think carefully before sharing information about the location of turtle nesting sites. Nest locations in the wrong hands can lead to human disturbances and threats to turtle nests.

Nesting survey data analysis

After you have collected information (data) from turtle nesting surveys, at the end of each nesting season, you will need to analyze the data **for each species of turtle**. This will help you to learn more about turtle nesting and how it changes from year to year, as well as about potential threats to nests.

The following sections outline analyses for 1) annual nest trends and 1.5) annual nesting trend accounting for sampling effort, 2) changes in nesting locations, and 3) changes in threats to nests.

Analysis 1) Annual nesting trend

Purpose: To show whether turtle nesting has increased, stayed the same, or decreased from one year to the next.

Step 1: Add up the total number of nests recorded for each species during the year.

Step 2: Compare the total number of nests in each year. Has it gone up, down, or stayed the same? A good way to present this information is to make a graph (see the Technical Tips box below).

Step 3: Make a note if the sampling efforts have changed over the years. As data is collected over time and analyzed, you can omit years that have unusually low or unusually high sampling efforts. Or, you can account for sampling efforts in the calculation below.

Analysis 1.5) Annual nesting trend accounting for sampling effort

Purpose: If your nesting survey sampling efforts change over time, you can analyze annual nesting trends while accounting for this difference. The sampling effort can be measured as the time spent surveying nests, or the distance travelled surveying nests. For the following example, we use distance travelled (km) where the longer distance means the higher the surveying effort.

Step 1: Calculate the annual nesting rate by dividing the number of nests surveyed by the hours spent surveying the nesting site.

$$\frac{\text{NESTS COUNTED}}{\text{SURVEYING EFFORT (DISTANCE TRAVELLED IN KM}} = \text{NESTING RATE}$$

For example, if in the year 2020 there were 10 nests counted for 2 km of surveying, then the nesting rate is 2 nests/km.

$$\frac{\text{10 NESTS}}{\text{2 KM}} = \text{5 NESTS/KM}$$

Step 2: Do the above calculation for each year of surveying the nesting site.

Year	Nesting rate (nests/distance surveyed in km)
2020	10/5 = 2 nests/km
2021	6/1 = 6 nests/km
2022	12/4 = 3 nests/km
2023	16/4 = 4 nests/km

Step 3: Choose a standard effort for sampling based on the common number of hours spent surveying nests.

In the above example, a common sampling effort can be 4 km.

Step 4: Use the standard effort to adjust the nesting

$$\text{NESTING RATE X SAMPLING EFFORT = STANDARDIZED NEST COUNT}$$

For example, for the year 2020, the nesting rate of 2 nests/km is multiplied by the standard effort for sampling of 4 km. The result is a standardized nest count of 8 nests.

$$\text{2 X 4 = 8 NESTS}$$

Step 5: Do the above calculation for each year.

Year	Nesting rate (nests/km)	Standardized nest count
2020	10/5 = 2 nests/km	2 x 4 = 8 nests
2021	6/1 = 6 nests/km	6 x 4 = 24 nests
2022	12/4 = 3 nests/km	3 x 4 = 12 nests
2023	16/4 = 4 nests/km	4 x 4 = 16 nests

Step 6: Compare years for nesting trends now that they are adjusted for the distance travelled surveying nesting sites.

In the above example, you can see that although the year 2023 had more nests that were recorded, when adjusting for the time spent surveying nests, there was actually a higher density of nests in the year 2021.

Analysis 2) Changes in nesting locations

Purpose: To identify whether turtles have changed where they nest from one year to the next. If so, this could be an indication of environmental changes, or of increased human disturbance. Each year, make an updated map, adding or removing nesting sites. This might mean adding a layer to your digital map or it might mean making a new copy of the paper map you are using. Be sure to check back at these nesting sites again in future nesting season, as turtles are faithful to their nesting site and may return despite disturbances in previous years.

Step 1: Use "Nest location" data to determine any shifts in locations over time.

Step 2: Compare "Site descriptions" from nesting surveys over the years.

Analysis 3) Changes in threats to nests

Purpose: To identify threats that affect turtle nests, and check if the number and types of threats have changed over the years. You can also identify if threats are the same or different across different nesting sites.

Step 1: Using the information you recorded on "Observed threats to nests," count how many sites are affected by each type of observed threat.

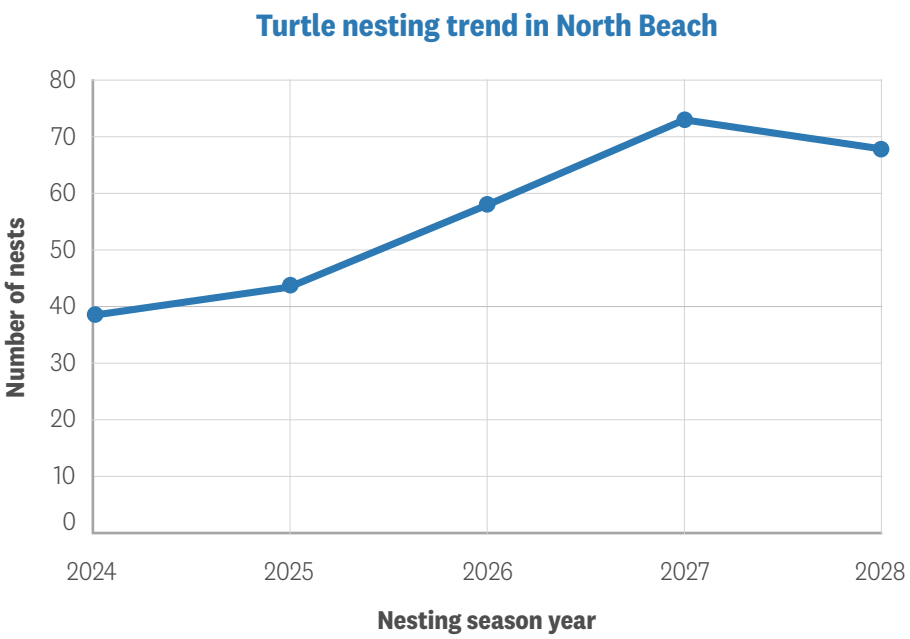
Step 2: Using the counts, determine if the number of each observed threat has increased, stayed the same, or decreased over time. If multiple nesting sites are surveyed, count if the number of observed threats changed over time for each nesting site.

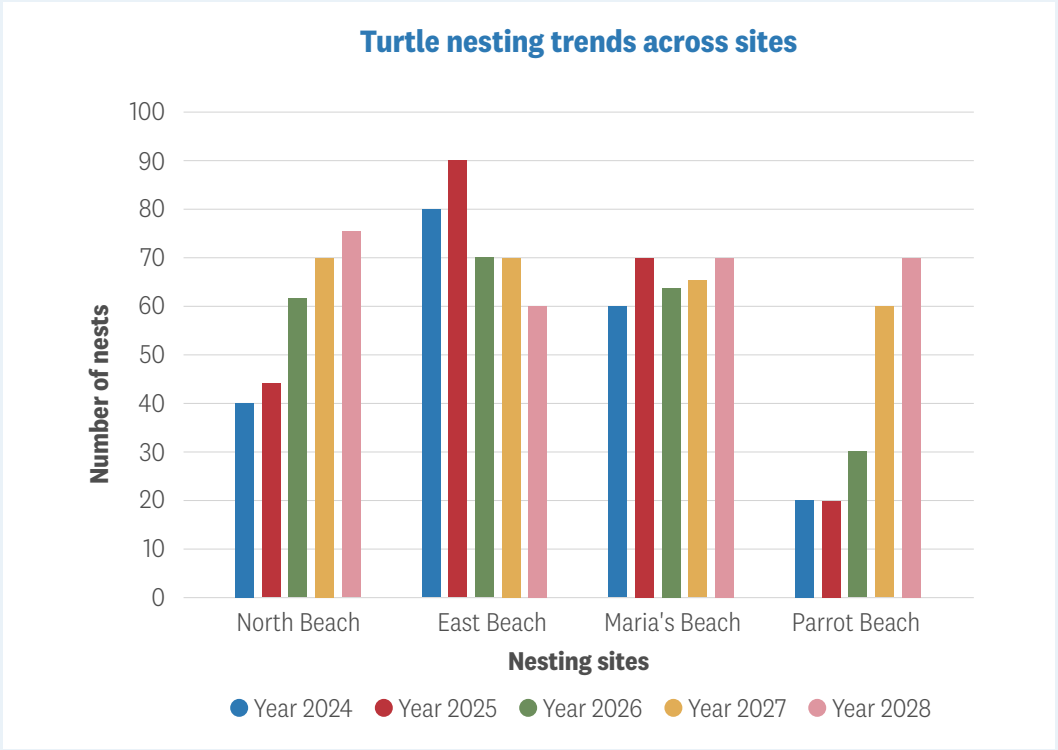
Technical tip

You can show changes in nesting and basking over time in graphs, which is useful for presenting findings to others. You can make graphs like this using the Microsoft Excel spreadsheet programme. Below are two examples:

(i) a line graph showing yearly changes at one site, which is called North Beach (top figure). It shows that the number of nests increased steadily from 2024 to 2027, but then decreased slightly in 2028. Once you know this, you may be able to identify reasons why this has happened, based on information you have collected about environmental changes and threat. Then, if the decrease continues in the following years, you will have the information you need to consider what you could do to take action to help turtle populations to start to increase again.

(ii) a bar graph showing yearly changes at several sites (bottom figure). Each year is shown with a different colour. This graph shows that nests have increased at North Beach and Parrot Beach but decreased at East Beach and stayed about the same at Maria's Beach. Again, once you know this you can look at your data on environmental changes and threats for possible explanations and think through possible reasons and possible actions you could take to help maintain turtle populations.





Hatch-and-release program data collection

If you have a hatch-and-release programme, you can collect the following information as part of your activities. This will give you more detailed information on turtle populations:

Nest location: If you want to identify individual nests for analysis, you can use the location coordinates from the 'Nesting Survey' sheet to show which nest is which.

Number of eggs in nest (clutch size): A "clutch size" is the total number of eggs found in a turtle nest. You can record this as you collected eggs from individual nests to take to your hatcheries.

Number of successful hatchlings: Hatchlings are turtles that have hatched from their eggs. Count the number of turtles that have successfully hatched from their eggs in the hatcheries and are ready to be released. If you want to count the hatchlings that have hatched for each nest, you need to keep their eggs separate from the others in the hatchery.

Hatch-and-release							
Your Name	**Turtle Species**	**Nest location**	**Number of eggs in nest (clutch size)**	**Number of survived hatchlings**	**Release date (yyyy-mm-dd)**	**Release time (hh:mm)**	**Release location**
Maria Garcia	Taricaya	44.5623, -76.3200	5	4	2024-08-22	08:30	44.5623, -76.3205

Hatch-and-release program data analysis

After you have collected information (data) from your hatch-and-release program, you will need to analyze the data **for each species of turtle**. This will help you to learn more about how turtle health and trends for successful turtle hatchings over time.

The following sections outline analyses for 1) average eggs per nest (average clutch size), 2) hatchling success rate for each nest and average hatchling success rate for a nesting site, and 3) hatchling success rate for the whole hatchery.

Analysis 1) Average clutch size

Purpose: Counting the total number of eggs in a nest (clutch size) could give an indication of turtle health or environmental changes. Large clutch sizes could reflect favourable conditions such as a healthy turtle and environment, and smaller than usual clutch sizes can signal declining health.

Step 1: For each species, add the total number of eggs per nest in an area. This can be done for either a nesting site (for example, a beach) or the whole territory.

For example, if there are 3 taricaya nests with clutch sizes of 19 eggs, 15 eggs, and 20 eggs, then the total number of eggs is 54.

Step 2: Divide the total number of eggs (Step 1) by the number of nests.

$$\text{AVERAGE CLUTCH SIZE} = \frac{\text{TOTAL NUMBER OF EGGS}}{\text{NUMBER OF NESTS}}$$

For example, divide the total number of eggs (54 eggs) by 3 nests sites to get the average clutch size of 18 eggs per nest.

$$\text{AVERAGE CLUTCH SIZE} = \frac{54}{3} = 18 \text{ EGGS PER NEST}$$

Analysis 2: Hatchling success rate for each nest and nesting site

Purpose: To understand percentages of eggs that have successfully hatched. This can be done for a nest and is done for each species. You can compare hatchling success rate for each nest across your territory to give an indication of nest viability.

Hatchling success rate for each nest:

Step 1: Identify the number of eggs (clutch size) for each nest (number of eggs per nest).

For example, a nest may have 5 eggs.

Step 2: Identify how many turtles hatched from the eggs.

For example, in that nest, there may only be 4 hatchlings (turtles that hatched from eggs).

Step 3. Divide the number of hatchlings by the clutch size, and multiple by 100 to get a percentage.

$$\text{HATCHLING SUCCESS RATE} = \left(\frac{\text{NUMBER OF HATCHLINGS}}{\text{TOTAL NUMBER OF EGGS}}\right) \times 100$$

For example, for the nest that has 5 eggs and 4 successful hatchlings successfully, the hatchling success rate is 80%.

$$\text{HATCHLING SUCCESS RATE} = \left(\frac{\text{NUMBER OF HATCHLINGS}}{\text{TOTAL NUMBER OF EGGS}}\right) \times 100$$

$$= \frac{4}{5} \times 100$$

$$= 0.8 \times 100$$

$$= 80\%$$

Average hatchling success rate for a nesting site:

Step 4. After calculating the hatchling success for each nest, you can find the average hatchling success rate for a nesting site (for example, a beach).

$$\text{AVERAGE HATCHLING SUCCESS RATE FOR A NESTING SITE} = \frac{\text{(SUM OF HATCHLING SUCCESS RATE PER NEST)}}{\text{TOTAL NUMBER OF NESTS}}$$

For example, if the nesting site Upper Blanco River has 3 nests, each with hatchling success rate of 80%, 70%, and 90%, then the average hatchling success rate for Upper Blanco River is 80%.

$$\text{AVERAGE HATCHLING SUCCESS RATE FOR UPPER BLANCO RIVER} = \frac{(80+70+90)}{3}$$

$$\text{AVERAGE HATCHLING SUCCESS RATE FOR UPPER BLANCO RIVER} = \frac{(240)}{3}$$

$$\text{AVERAGE HATCHLING SUCCESS RATE FOR UPPER BLANCO RIVER} = 80\%$$

Step 5. You can compare the average hatchling success rate across multiple nesting sites. This will show which areas of your territories have more successful nests, and which have less successful nests.

Analysis 3: Hatchling success rate for the whole hatchery

Purpose: To understand percentages of eggs that have hatched successfully in the hatcheries. This can help you understand how many successful hatches there are in the hatch-and-release program. **If you are unable to distinguish which eggs came from each nest or nesting site, you can use this analysis to get a hatchling success rate for all eggs in the hatchery.**

Step 1: Identify the number of eggs per species.

For example, the hatcher may have collected 200 taricaya eggs.

Step 2: Identify how many turtles hatched from the eggs.

For example, from the 200 taricaya eggs, only 140 may have successfully hatched.

Step 3: Divide the number of hatchlings by the clutch size, and multiple by 100 to get a percentage.

$$\text{HATCHLING SUCCESS RATE} = \left(\frac{\text{NUMBER OF HATCHLINGS}}{\text{TOTAL NUMBER OF EGGS}}\right) \text{X } 100$$

For example, for the 200 taricaya and 140 successful hatchlings successfully, the hatchling success rate for the whole hatchery is 70%.

$$\text{HATCHLING SUCCESS RATE} = \left(\frac{\text{NUMBER OF HATCHLINGS}}{\text{TOTAL NUMBER OF EGGS}}\right) \text{X } 100$$

$$= \left(\frac{140}{200}\right) \text{X } 100$$

$$= 0.7 \text{ X } 100$$

$$= 70\%$$

5.2 Turtle basking survey

Overview

Turtle basking surveys involve systematically recording observations of turtles basking (also known as sunning or sunbathing). You will note down the number of turtles you see basking, and where possible, the turtle species, whether it is male or female or unknown sex, and whether it is young or adult. This may involve visiting specific places where turtles often bask (such as half-submerged rocks or logs), or you can survey basking turtles as you travel along rivers, streams, or lakes. Either way, it's really important that you also record how often you go to different sites and how much time you spend looking for them, so that if you record more turtles one year than the previous year, you can check whether it's just because you spent more time looking for them. Turtle basking surveys can confirm or reveal locations that turtles regularly use, and this information can be used in management plans to decide whether certain areas should be protected for turtles. The surveys will also give you an idea of the general makeup of the turtle population, such as how many young or adult turtles there are in the population.

Photo: Taricaya hatchlings basking on a log in the community San Juan del Morona. Photo provided by José Hernán Flores.

Choosing a site to survey

Using a base map of the river, consider the rivers, streams, and lakes in your lands and territories. As you have travelled in your area, where have you seen basking turtles most often in the past couple of years? This may be in very specific places (such as a particular rock or half-submerged log), or it may be along certain sections of a waterbody. It is best to bring people together to discuss this and map out these areas together, either as a sketch map or on a prepared base map. If the area you want to survey is very large, you can do this with several different groups, each with people who are familiar with one part of the overall area. During the discussion, it is useful also to ask what changes people have noticed in turtle basking and basking areas over time, and why they think these changes happened. For example, you might ask about changes over the past five, ten or twenty years, or since a particular event. You can also note down people's opinions about why these changes might have happened. All of this information can be useful later on in thinking about what is happening to turtle populations and why.

You can cover river lengths of 1 to 10 kilometers in a single basking survey, a length that is enough to observe basking turtles while still being manageable to study in detail. Be sure to record the location of the area where you conduct basking surveys. You should revisit these same sites repeatedly, to monitor changes in turtles basking over time.

Turtle basking surveys are usually done in the dry season, when the water levels are lower and turtles can come out more often to bask in the sun on logs, rocks, or other platforms. How often you conduct basking surveys depends on your resources available, time, and weather. It is recommended that you monitor in consecutive days, no more than three days apart. Basking surveys should be done during hot, sunny days, when the turtles are most likely to be basking (10am to 3pm). It is important to record any changes in how often you survey (sampling effort) over time. For example, roughly two hours may be enough to record basking turtles along a stretch of a river, but if significantly less or more time is spent surveying for a day, that should be noted in the datasheet.

Getting too close and startling basking turtles will disrupt the monitoring of basking turtles. To avoid startling the turtle back into the water, make sure enough distance is maintained between you and the turtle, and that you are using low impact travelling methods when possible (for example, paddling in canoes may be less disruptive to basking turtles than motorised boats). Startled turtles may resurface further downstream, so it is important to continue moving through the basking area to avoid counting the same individual twice.

Basking survey data collection

During basking surveys, you can take photos of turtles basking in the sun and then record the data from photos later. Make sure that your camera quality is high enough to take photos from a distance, and still be able to identify important data like turtle species, sex, and age group (young or adult). Keeping these photos helps you maintain a record of evidence of basking turtle groups in case the original data needs to be referred to. If cameras or smartphones that can take high-quality photos are unavailable for basking surveys, then you can use real-time observations to record data. However, you will need to have sufficient training to make sure the data is recorded accurately.

Many turtle species have distinct characteristics between males and females, and young and adult. For example, they can vary in size, shape of head, or vibrancy of colour patterns. Before collecting data, use local knowledge of the species and/or consult local biologists to determine what these identifiable characteristics are so that you can record the sex and age group of the turtles observed. For example, local knowledge of turtles can inform you that for some turtle species, only larger adults poke their head out of the water. For some turtle species, it can be very difficult to determine sex during the early stages of life. In such cases, recording 'Unknown sex' will be necessary.

Also consider that some species have differences in basking patterns, for example, female taricayas bask more often than males. Therefore, if you survey more female basking taricayas, it doesn't necessary mean there are more females in the population, but instead is explained by the differences in turtle basking behaviours between males and females.

For your consideration...

Turtles might seem like their populations are doing well because there are a lot of them, but they could actually be in trouble. They live long lives, and it's hard to observe changes in population dynamics right away, unless you record changes in how many males, females, young and adults there are. For example, if there are plenty of turtles but no young ones, numbers will decrease in the future. This means you shouldn't rely on basking surveys alone to understand population trends, especially as observations of basking can be influenced by many factors, like environmental changes or human disturbances. Instead, you can use basking surveys along with other monitoring methods to get a clearer picture of how turtle populations are changing over time.

Below is an example of a datasheet for recording data on basking surveys, followed by some notes explaining the different columns.

Basking survey datasheet example:

Your Name	Date (yyyy-mm-dd)	Time (hh:mm)	Species ID	Basking location	Type of basking area	Turtle sex (Male/ Female/ Unknown)	Turtle age (Young/ Adult/ Unknown)	Photo file name (If photo taken)	Additional observations
Maria Garcia	2024-04-22	14:55	Taricaya	44.5646, -76.3223	Rock	Female	Young	IMG_001	Strong wind
Juan Rodriguez	2024-04-22	15:15	Taricaya	44.5655, -76.3268	Log	Male	Adult	IMG_002	Strong wind
Juan Rodriguez	2024-04-22	15:20	Charapa	44.5657, -76.3270	Beach	Male	Adult	IMG_003	None

Basking location: GPS trackers, or apps such as Google Maps, can give coordinates on the basking location. Keep data recording consistent in either latitude/longitude or UTC location recordings. Location can also be descriptive. Basking locations are recorded so that surveys can be consistent over time.

Basking area type: Recording basking area types can help you keep track of what turtles prefer and need to bask in their environment, and any changes in the types of areas they are using. These platforms might include logs, rocks, sandbanks, or other features.

Data columns can be added for additional basking site characteristics of interest. For example, these might include the distance to the shoreline (in meters), or canopy coverage (fully covered, more than half covered, half covered, less than half, and no coverage).

Basking survey data analysis

The following analyses should be done for **each turtle species.**

Analysis 1) Changes in turtle basking behaviours

Purpose: To see if there are more or fewer basking turtles from one year to the next.

Step 1: Count the total number of basking turtles each year for **each stretch of river, stream, or lake.**

Step 2: Compare these numbers to previous years, identify if that number is going up, down, or is stable.

Step 3: Identify if there are other factors that could have led to this trend, for example, changes in environment or turtle threats over time.

Analysis 2: Age and sex structure of basking turtles

Purpose: To understand the general makeup of the turtle population(s), we can assess the sex distribution (male, female, or unknown) and age group distribution (young, old, or unknown). Keep in mind that some turtle species have different basking behaviours, which can bias your data into show which sex and age group is more likely to bask.

Step 1: Count how many young, adult, male, female, and unknown there are per year.

For example, in 2022 you may have observed 50 turtles: 20 males and 30 females, and 15 young and 35 adults.

Step 2: Each count can be divided by the total number of observed turtles and multiplied by 100 for a percentage each characteristic for sex and age group observed basking turtles.

With the example above, you can take find the percentage of males as the following:

$$\text{PERCENTAGE OF MALES BASKING} = \left(\frac{\text{NUMBER OF MALES}}{\text{TOTAL OBSERVED TURTLES BASKING}}\right) \times 100$$

$$= \left(\frac{20}{50}\right) \times 100$$

$$= 0.4 \times 100$$

$$= 40\%$$

The same calculations can be done for other characteristics in the example: number of females would be 60%,number of young turtles would be 30%,and adult turtles would be 70%.

Step 3 (optional): To estimate turtle reproductive rates, count the number of young turtles each year. This helps you check if the turtle population might be growing, with the assumption that these youth will reach adulthood. Compare the number of young turtles to the number of adults to see if there are enough young turtles to replace the adults as they grow older.

5.3 Turtle capture-mark-recapture

Overview

Capture-mark-recapture is a robust method used by biologists to study animal populations. We would only recommend this method if there's an experienced biologist who can help set up the monitoring method in your community and analyse the data over at least a few years. For this method, you capture turtles, give turtles unique marks, and then release them. Later, when you recapture more turtles, you can count how many are marked. This can allow you to estimate the total population size with a high level of accuracy.

Important considerations

To make sure turtle capture-mark-recapture is done carefully and successfully, there are important considerations to think about.

1. **Marking and handling turtles:** Marking turtles means handling them and making changes to their shells or using tags. Communities must think carefully about whether this is appropriate for the turtles' well-being and aligns with community members' beliefs and ethics.

2. **Permits and protection:** You will probably need special permits to mark and handle turtles. Communities must check what these requirements are and if required, get approval from local, state, or national organizations and/or governments. This is especially important for types of turtles that are endangered or at-risk.

3. **Teamwork and expertise:** Biologists with experience in turtle capture-mark-recapture are needed to provide training and guide the process, and a statistician will need to analyze the data.

4. **Resources:** The cost of capture-mark-recapture can vary. It can be expensive, depending on the tools and expertise needed. Communities must plan for the costs to ensure they can continue capture-mark-recapture monitoring over a long time.

Capture-mark-recapture data collection

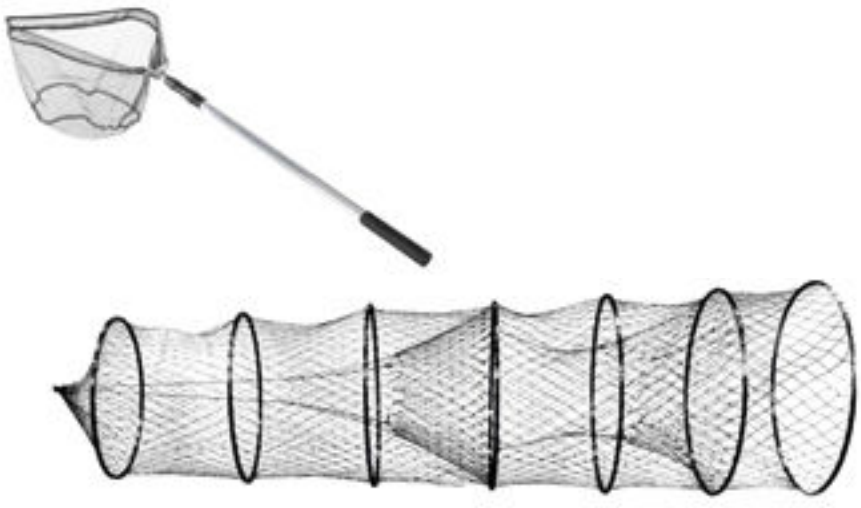
What do you need?

- ☑ A datasheet (provided below) and a pencil.
- ☑ Equipment to capture turtles, such as nets
- ☑ Big bins with freshwater to place captured turtles
- ☑ File to mark turtle shells

Capturing turtles

There are different ways to catch turtles, and local people may already have their own ways to do so. It needs to be safe for community members and must not involve harming the turtles.

Scientists capture turtles in different ways: they may use dip a net in the water while swimming and looking in the water, or set up special nests called hoop nets that turtles can swim into. If you are using hoop nets, make sure turtles have space to breathe by leaving part of the net above water and attaching something that floats, so that the net doesn't sink into the water. Always check the hoop nets within 24 hours to keep turtles safe.



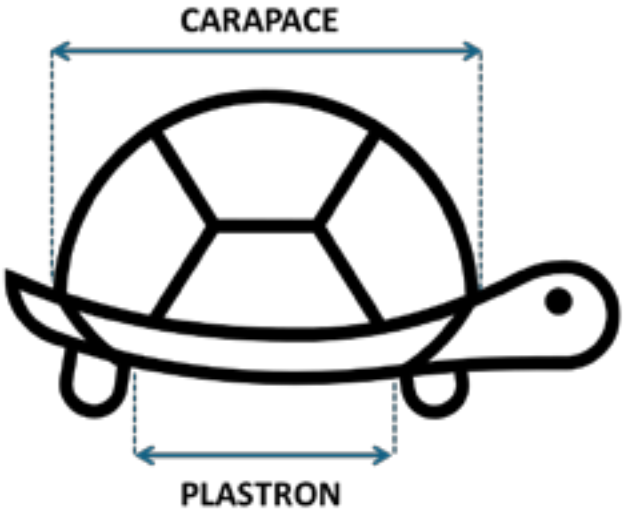
Turtles can be caught with dip nets (top image) or hoop nests (bottom image).Drip net image by RiToEasysports https://www.amazon.ca/Foldable-Fishing-Landing-Release-Telescopic/dp/B08MTDY5DK . Hoop net image by NetsAndMore https://www.netsandmore.com/products/fishing-nets/catfish

The best way to catch turtles can also depend on how they behave. Turtles that swim in the middle of a waterbody are easier to catch with a dip net and swimming. Turtles that are found near the shorelines are easier caught with hoop nets or swimming.

If you need to transport turtles after catching them, put them in a big open container with some water from the river or lake they were in, to keep them cool. Make sure that the container is tall enough, so the turtle does not climb out, and big enough so turtles are not squashed together. Do not put turtles that are competitive or reproductively active together. If you do transport them, make a note of where turtles were captured, as they will later be released in the same location.

Recording initial information:

- Measure the size of the turtle (see example datasheet below). You do this by measuring the length, width and height of top part of the shell (carapace) and the length of the bottom part of the shell (plastron). You can use either a calliper or a fabric tape measure. Either is fine, but keep to one or the other of these, because they will give slightly different results: the calliper gives a straight line measurement but the tape measure follows the shell's curve and can give a bigger measurement.



- Weigh the turtle in grams, using a weighing scale.
- Using local knowledge and/or knowledge from biologists, note down whether it is male or female
- Note down any additional observations, such as natural turtle markings, injuries, or others, in the “Additional Notes” section.

Below is an example datasheet for capture-mark-recapture data collection for each turtle. Make sure to title the datasheet with the turtle species.

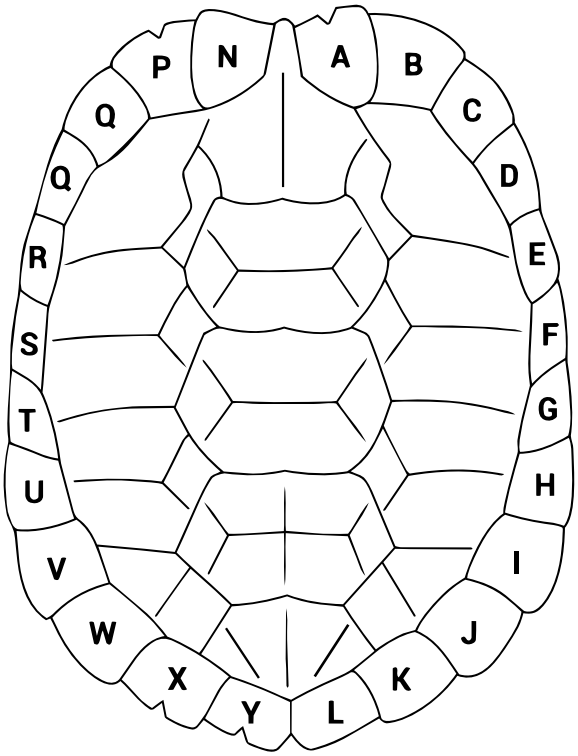
Taricaya capture-mark-recapture datasheet:

Your name	**Capture date (yyyy-mm-dd)**	**Approximate Capture time (hh:mm)**	**Location (Coordinates or Landmark name)**	**NA Code**	**New or recaptured**
Maria Garcia	2024-04-22	14:55	Parrot's Point	DNO	New
Carapace length (mm)	**Carapace width (mm)**	**Carapace height (mm)**	**Plastron length (mm)**	**Weight (g)**	**Sex (Male, female, unknown)**
123	40	20	100	85	Male
Additional Notes					
Missing left toe on bottom left foot.					

Marking turtles

There are many ways to mark a turtle. A common way is the North American (NA) marking system. It is named after the markings (you start with N and A: see Figure X).

The North American (NA) marking system involves notching the outer scales (scutes) of the turtle's shell turtle to match letters (Nagle, 2017). As shown in the figure below, the top right of the turtle shells represents scutes A to L, then top left N to Y. Scutes E, F, R, and S are never included in the NA code as they are too close to the turtle nerves and can cause harm if notched. Once you have a unique NA code for a turtle, you can use a file to notch the edge of the scutes that match the letter in the code. **You cannot use the same NA code for different turtles**. When notching the turtle scute, the file should be deep enough for the mark to last over time (and can be touched up at recaptures if the turtle has grown and the mark is harder to read). But, the mark should not be deep enough that it punctures a nerve. Consult a turtle expert to know how deep to file the turtle species you are monitoring, without causing damage to the turtle.



NA coding system is applied to a Wood Turtle (*Glyptemys insculpta*) with NA at the head and YL at the tail. This shell has scutes marked with NA code AOXY. Turtles with 13 marginal scutes on either side of the carapace can also have letters M and Z marked. However, scutes E, F, R, and S are never marked, and scutes G and T are marked only in adults. Adapted from Nagle et al. Herpetological Review 48(2), 2017.

Releasing turtles

To minimize disturbance and avoid turtle displacement, turtles should be released at the same site they were captured.

Recapturing turtles

In the following year, as turtles are captured in the same stretch of a river, some will have marks from previous years and others won't. Over time, the proportion of recaptured (marked) turtles compared to new turtles can be used to calculate the turtle population size and other information about the turtle population.

Capture-mark-recapture data analysis

Experts in population ecology will need to conduct the analyses of capture-mark-recapture data. We recommend contacting a population ecologist before you finalise the plans for data collection, to ensure the correct data are being collected for what findings your community needs. There can be many ways to analyze capture-mark-recapture data, and findings can include understanding the population trend over time (increased, decreased, or stayed the same), and how threats have affected the population.

References and futher information

5.1 Turtle nesting survey

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5.2 Turtle basking survey

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5.3 Turtle capture-mark-recapture

Nagle, R. D., Kinney, O. M., Gibbons, J. W., & Congdon, J. D. (2017). A simple and reliable system for marking hard-shelled turtles: the North American Code. *Herpetological Review*, 48(2), 327-330.

Appendix: datasheets

Nesting survey:

Your name(s):				
Date of visit:				
Time of visit:				
Distance surveyed:				
General nesting site name:				
Turtle species	**Nest location**	**Observed threats to nest**	**Site description**	**Additional observations**

Hatch-and-release data:

Your name(s):				
Turtle Species:				
Nest location:				
Number of eggs in nest (clutch size)	**Number of survived hatchlings**	**Release date (yyyy-mm-dd)**	**Release time (hh:mm)**	**Release location**

Basking survey:

Your name(s):				
Date (yyyy-mm-dd):				
Time (hh:mm):				
Basking location:				
Basking platform type:				
Species ID	**Turtle sex (Male Female/Unknown)**	**Turtle age (Young/ Adult/Unknown)**	**Photo file name (If photo taken)**	**Additional observations**

Catch-mark-recapture:

Species Name:			
Your name:			
Capture date (yyyy-mm-dd):			
Location (Coordinates or Landmark name):			
NA Code	**New or recaptured**	**Carapace length (mm)**	**Carapace width (mm)**
Carapace height (mm)	**Plastron length (mm)**	**Weight (g)**	**Sex (Male, female, unknown)**
Additional Notes			

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