SWOT

The State of the World's Sea Turtles

Minimum Data Standards for Sea Turtle Nesting Beach Monitoring

VERSION 1.0

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Why Minimum Data Standards?

Monitoring of sea turtle nesting beaches has been conducted around the world for decades. Although there has been some standardization of monitoring protocols nationally and regionally, no global standard has been adopted. The result is that different projects report different types of data, which can be largely incompatible. The State of the World's Sea Turtles (SWOT) database is a regularly updated, global database on all aspects of sea turtle biogeography (nesting, migration, genetics, and more) that relies on a global network of data providers who provide and use the data. As of 2011, the SWOT database includes more than 5,700 individual data records contributed by more than 550 data providers (and literature sources) from more than 2,800 distinct nesting beaches. It is the most comprehensive global sea turtle nesting database in existence and is well positioned to serve as the world's premier data clearinghouse and monitoring system for sea turtles.

Presenting these global-scale data in maps, comparing among sites, and detecting trends are challenging tasks because different projects use different techniques and varying levels of effort to collect nesting data. This means that, for example, one location could appear to have fewer nesting turtles than another simply because the data provider used a lower level of monitoring effort to collect the data (or vice versa). And varying levels of monitoring effort from year to year or from site to site without statistical correction complicate the detection of population trends. Until now, the annually published *SWOT Report* and the SWOT online application on OBIS-SEAMAP (Ocean Biogeographic Information System – Spatial Ecological Analysis of Megavertebrate Populations; http://seamap.env.duke.edu/swot) have displayed data without any method for standardization.

Furthermore, new sea turtle monitoring projects are being started every year and are often in need of guidance in designing effective monitoring protocols. Many projects also find that after one or more years of data collection, the data they have generated do not allow them to meet the goals they have outlined because their monitoring protocol was not well-suited to those goals. This finding is especially true when it comes to trend detection, which will be discussed later in this handbook (see page 9).

With these issues in mind, the SWOT Scientific Advisory Board (2011) recognized the need to establish minimum data standards for data provided to the SWOT database, which will have three main outcomes: (1) to establish a minimum threshold for data quality that provides guidance for improved field-survey methods among the projects that contribute data to SWOT, (2) to facilitate site-to-site comparisons in nesting abundance and (3) to enhance the SWOT database's role as a global clearinghouse for sea turtle data.

This handbook is a guide to the minimum data standards process and its results for two main audiences: existing sea turtle nest monitoring projects and new sea turtle nest monitoring projects. For more detailed descriptions of the contents presented here, as well as information about the process by which this content was generated, a *Technical Report* is available for download at www.seaturtlestatus.org/data/standards.

HOW TO USE THIS HANDBOOK

This handbook summarizes the SWOT minimum data standards results in an easy-to-use, stepwise format. The central feature of the handbook is the Decision Key on pages 10–11, which is a handy guide so nesting beach monitoring projects can identify recommended monitoring protocols for their specific circumstances and determine whether their current efforts meet SWOT's minimum data standards.

Whether your project is already up and running or just getting off the ground, we hope that you will benefit from the information presented in this manual, as well as the free tools that we are providing as part of this effort. The contents of this handbook are organized in stepwise fashion, beginning on page 5. The following page is a complete list of contents.

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Review or Define Your Goals

Whether you are beginning a new sea turtle monitoring project or already have one under way, it is important to establish your project's goals and to revisit them regularly to make sure that the data you are collecting are sufficient. Sea turtle monitoring can be a major investment of time and resources, but that investment alone will not ensure useful results. Good survey design is essential for effective sea turtle monitoring, and it starts with a project's goals.

Different monitoring projects may have different goals. In some cases, the goal will be to monitor the status and trend of a local population over time, while in other cases, the goal will be to establish baseline information about an unstudied population during a single survey, to determine survivorship and reproductive output of nesting females, or to achieve some other goal. Defining your project's goals will help you develop a monitoring protocol that delivers the right results.

What are the goals of your monitoring project? If you have not already defined your goals, keep this question in mind as you read through the following sections. In the end, your decisions should be tied directly to your project's goals. If you have already defined your goals, consider them as you evaluate your protocol; you could be doing less, or more, than is needed to meet your goals.

The "Gold Standard" for Sea Turtle Monitoring Projects

Successful conservation strategies are built upon foundations of solid science. The first step in assessing the conservation status of a population or species is to determine how many individuals exist in a population or species and what the trend in those numbers has been, is currently, and might be in the future. The accuracy of these estimates depends on the amount of effort invested in the collection of abundance data.

Counting nesting females and their nesting activities is an important part of generating abundance estimates and assessing trends, but this information alone is insufficient for understanding the underlying, complex processes that drive population status and trends. The reasons for this insufficiency are clear, considering that nesting females account for only a portion of overall population structure and for probably no more than 1 percent of the total population abundance. Therefore, trends in nesting activity may not be reflective of trends in the entire population. Furthermore, a trend in nesting activity may be due to changes in the processes that drive reproduction, rather than a reflection of the actual number of mature females in a population.

To accurately assess sea turtle population abundances and trends, as well as permit identification of drivers of observed patterns, the best and therefore preferred approach is long-term capture-mark-recapture (CMR) programs on nesting beaches, as well as in in-water feeding and aggregation areas.

SWOT RECOMMENDATION

Although the scope of this manual is limited to nesting beach monitoring protocols, SWOT recommends that the overarching goal—the "gold standard"—for monitoring programs worldwide should be to develop and maintain long-term CMR studies on nesting beaches and in foraging areas for sea turtle populations.

SWOT recognizes that not all projects can meet the significant logistical demands required by comprehensive CMR studies and that not all projects have the goal to assess population abundance and trends. Nevertheless, such studies should be undertaken in as many cases as possible to ensure that valuable abundance and demographic data are being generated to inform conservation management strategies. For more information about CMR methodology see the *SWOT Minimum Data Standards Technical Report*.

Understanding Count Types

Several different types of counts can be reported when monitoring sea turtle nesting. All count types can be considered proxies for total population abundance, and there are advantages and disadvantages to each, depending on the goals of the monitoring effort. Count types include (in increasing order of resolution) number of activities (i.e., number of tracks, crawls, or body pits), number of eggs, number of clutches, and number of nesting females (see the Glossary on page 26 for definitions). Before you decide what your project will count, it is important to consider the advantages and disadvantages of each count type and to determine which is best suited to your project's goals and capacity.

Ultimately, the best count unit for determining population abundance and trend is the actual number of individuals in the population being surveyed. Therefore, in the case of nesting populations of sea turtles, the number of nesting females is the preferred count type for assessing nesting population abundance and trend. However, accurate and complete counts of uniquely identified nesting females are often impossible because of logistical and financial constraints on most nesting beach projects. Other count types (e.g., crawls and clutches) are also sufficient to estimate abundance and trends, as long as the monitoring protocol is sufficient and consistent over time. Count data can be converted from one count type to another (e.g., from number of clutches to number of nesting females) using specific formulas. It is important to note, however, that such conversions require additional data and always introduce additional error. For more information on converting count types, including schematic formulas, see the related section on pages 20–21.

COUNT TYPES

Number of tracks or crawls:

Advantage	No confusion about what is included in the count; less effort needed to perform surveys
Disadvantage	Does not account for variation in nesting success or clutch frequency; tracks from different nights must be distinguished by crossing off old or counted tracks

Number of eggs:

Advantage	Can use eggs harvested or collected regularly to monitor relative abundance
Disadvantage	Does not account for variation in clutch size or clutch frequency

Number of clutches:

Advantage	Includes only successful nesting attempts; more accurate than tracks or crawls to describe patterns in reproductive output
Disadvantage	Does not account for variation in clutch frequency; higher effort required than for counting tracks

Number of females (i.e., uniquely identified individuals):

Advantage	Best metric for assessing population abundance and trends of a nesting population, patterns in reproductive output, and other biological factors
Disadvantage	Very high effort and large amount of resources required; information gathered only on females that nest in a given season, not on those skipping reproduction

STEP 2

Determine the Right Monitoring Protocol for You, or Evaluate Your Existing Monitoring Protocol

Know Your Capacity, Know Your Turtles, Know Your Site

Before you initiate any monitoring scheme for a nesting site, two factors must be determined. First, you must conclusively identify the species present (see the Species Identification Key on pages 24–25), which must be done by visual confirmation based on the unique morphological diagnostic features of each species. If you are unsure about the species nesting at your site, consult the Species Identification Key (see pages 24–25).

Second, once you know what species are nesting, you must determine the temporal distribution of nesting activities, that is, the "shape" of the nesting season (e.g., typical bell-shape with low levels of nesting at the beginning and end of the season and with a pronounced increase to peak levels roughly in the middle, or year-round nesting without an identifiable peak, etc.). Although bell-shaped nesting seasons are most typical, identifying the season's beginning, peak, and end dates is critical for designing an efficient monitoring schedule. Thus, preliminary, year-round surveys of relatively low effort are a key first step in establishing the shape and duration of the nesting season at a site upon which more sophisticated surveys can be based (see Protocol A, described on page 12).

Logistical considerations and project capacity also play an important role in designing your monitoring protocol. Some survey methods are simply not feasible under certain circumstances, and alternative methods should be selected. There is no "one size fits all" approach to sea turtle nest monitoring.

All About Error: How Much Is Acceptable?

As you design or evaluate your nesting beach monitoring project, it is important to consider sampling error in the context of your project's goals. The ability to detect a trend from a time-series of count data depends on several factors, including (a) the number of years (i.e., nesting seasons) surveyed, (b) the percent increase or decrease that you want to detect (e.g. 1%, 5%, 10%), or (c) the variability in the count data (sampling error) in a season and across seasons, and (d) other factors. Essentially, increasing your monitoring coverage (by monitoring more days or nights) will reduce sampling error and allow you to detect a trend in the nesting population within a shorter period of time. For most sea turtle populations, at least 20 years of monitoring with low levels of error are necessary to detect a population trend of ±5%.

SWOT RECOMMENDATION

To detect a ±5% trend in approximately 30 years (for all species; shorter period for species with lower variation in nesting abundance from season to season), SWOT recommends that monitoring projects aim for an average annual abundance estimate with less than or equal to 20% sampling error (CV ≤0.2) in order to allow for robust estimates of abundance and trends.

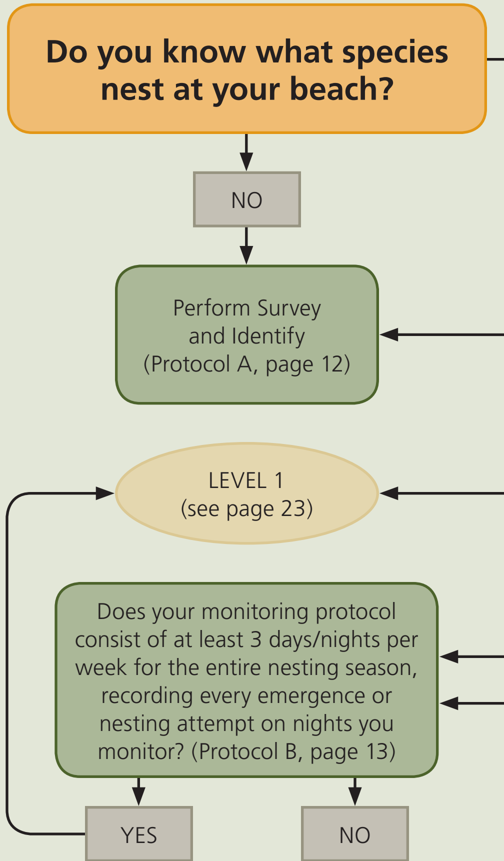
After determining the threshold for allowable error in seasonal abundance estimates (which is ≤20%), SWOT tested several actual sea turtle nesting datasets from around the world to determine monitoring protocols that would minimize error to levels below the threshold; these protocols are presented on the following pages. SWOT also provides examples of published monitoring protocols that can be adopted to meet minimum data standards recommendations.

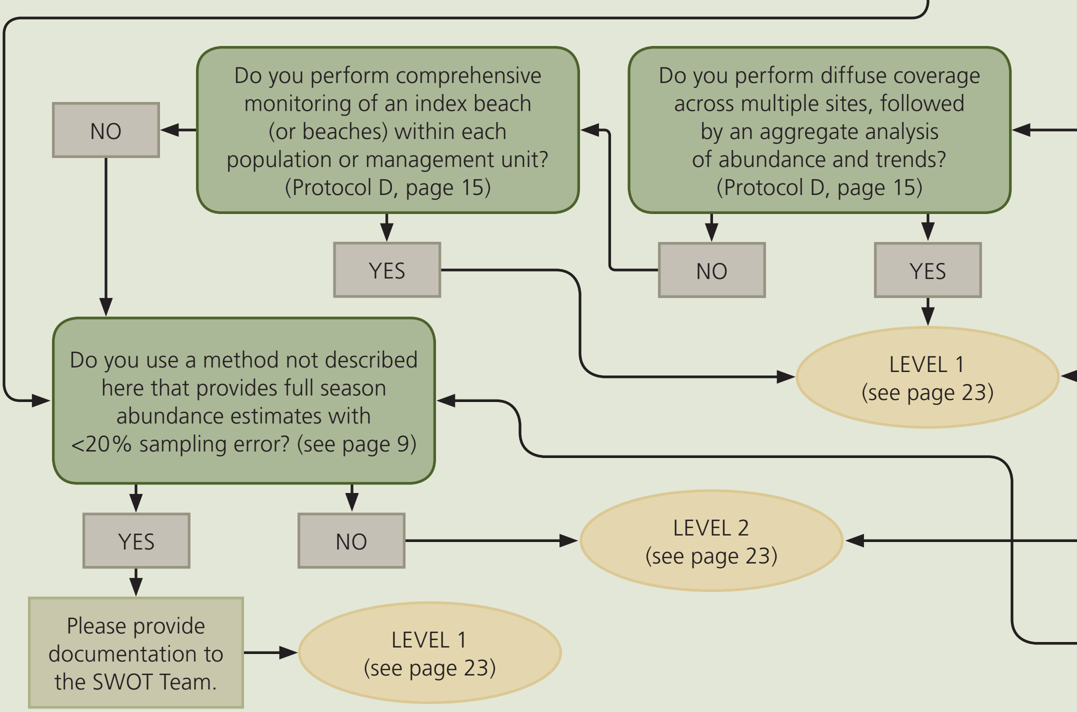
SWOT RECOMMENDATION

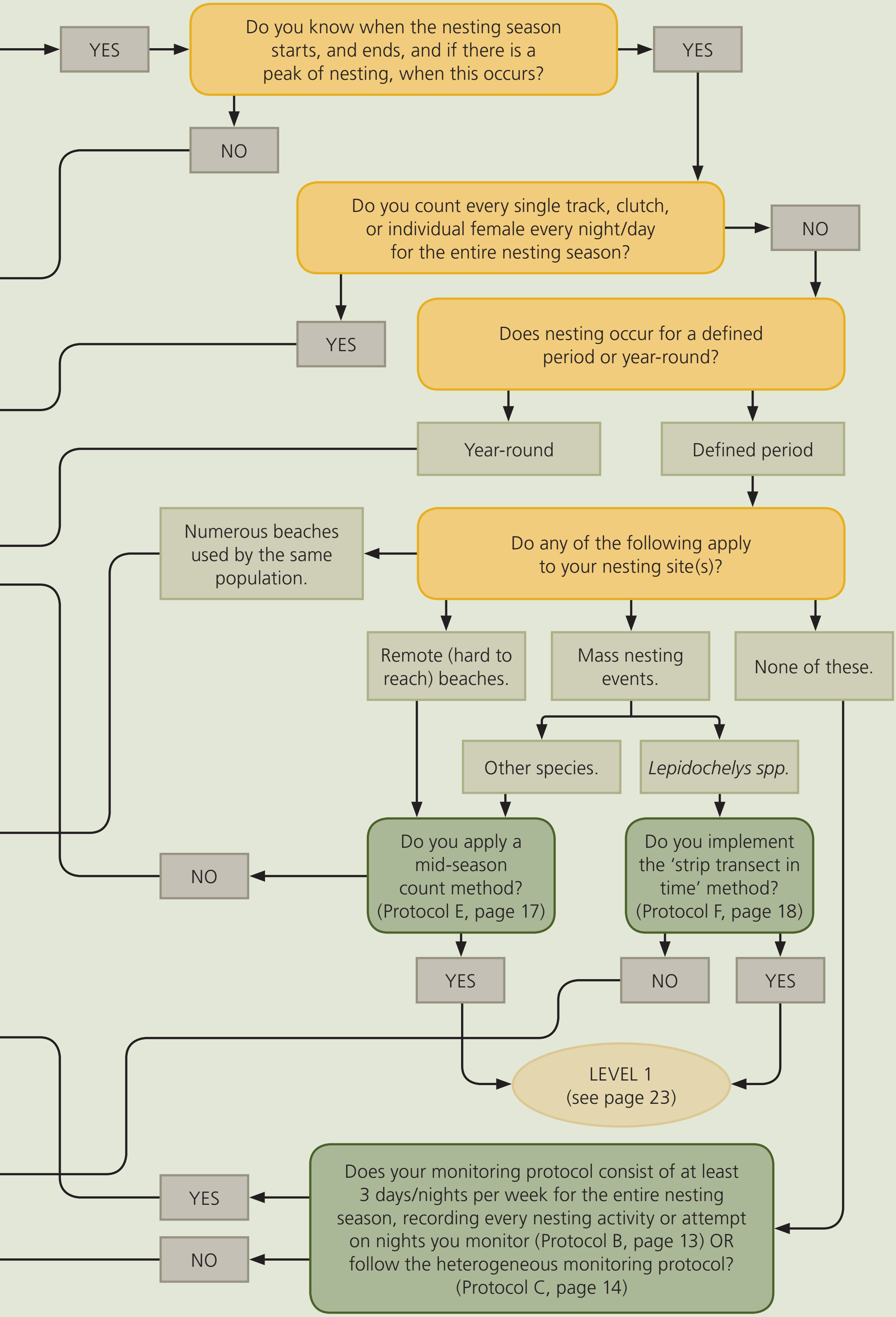
In general, any monitoring protocol that limits error in nesting abundance estimates within a season to ≤20% on average will generate data of acceptable quality for SWOT.

DECISION KEY: Find the right protocol for you, or assess your current protocol

To help you identify an appropriate monitoring protocol for your circumstances and to assess whether your current protocol meets SWOT's minimum data standards, we have developed a Decision Key that poses several questions about your monitoring project and that steers you toward suggestions about which monitoring protocol might be best for your project. Through the chain of questions you will be asked about various monitoring protocols which are possible for your situation. Any of the protocols about which you are asked are possible for your site, and will allow you to meet SWOT's standards. The end of the chain of questions will indicate whether your current protocol meets SWOT's minimum data standards and will send you to further explanations of the classification scheme that SWOT is using based on these standards.






YES
Do you know when the nesting season starts, and ends, and if there is a peak of nesting, when this occurs?
YES
NO
Do you count every single track, clutch, or individual female every night/day for the entire nesting season?
NO
YES
Does nesting occur for a defined period or year-round?
Year-round
Defined period
Numerous beaches used by the same population.
Do any of the following apply to your nesting site(s)?
Remote (hard to reach) beaches.
Mass nesting events.
None of these.
Other species.
Lepidochelys spp.
Do you apply a mid-season count method? (Protocol E, page 17)
Do you implement the 'strip transect in time' method? (Protocol F, page 18)
NO
YES
NO
YES
LEVEL 1 (see page 23)
YES
NO
Does your monitoring protocol consist of at least 3 days/nights per week for the entire nesting season, recording every nesting activity or attempt on nights you monitor (Protocol B, page 13) OR follow the heterogeneous monitoring protocol? (Protocol C, page 14)

Recommended Monitoring Protocols

IMPORTANT NOTES THAT APPLY TO ALL PROTOCOLS

- Identification of the goals of a monitoring project is the key to selection and design of sea turtle nesting abundance monitoring protocols.
- These recommendations describe monitoring protocols, but they do not explain the specific methods used to count sea turtle nesting activity. For detailed descriptions of methods, see *Research and Management Techniques for the Conservation of Sea Turtles* (Eckert et al. 1999), available for free at www.iucn-mtsg.org/publications.
- All nesting activities should be counted during a monitoring event, and all zero values should be recorded. In other words, if monitoring occurs but no nesting attempts are recorded, a value of zero should be included in the overall season's monitoring report.
- Every monitoring event should consist of a complete count of the chosen count type. For example, if a project chooses to monitor nesting activity at night, monitoring should occur for the entire night and morning to ensure that no nesting activities are missed.
- The monitoring protocols on the following pages are designed to consist of the minimum effort required to generate count data that will produce annual estimates of total nesting abundance with sufficient confidence (see previous section). Therefore, all of the protocols described in this section meet SWOT's minimum data standards and achieve a Level 1 ranking in the SWOT data classification system (see page 23 for details). Increasing your monitoring effort above the levels described will improve confidence in your abundance estimates and will improve your ability to detect trends in the nesting population.

Protocol A: Basic survey to identify species and nesting season

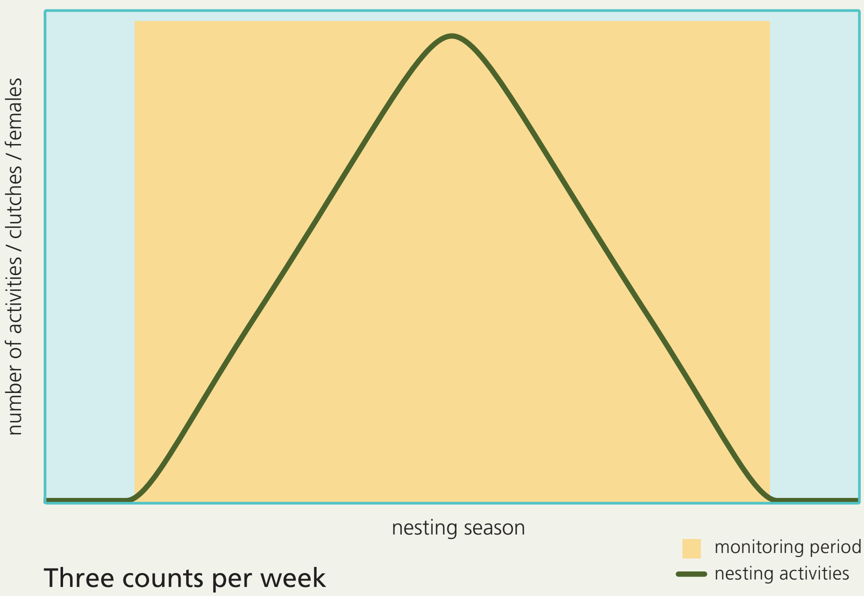
In situations where the species nesting or the shape of the nesting season at a site is unknown, preliminary year-round surveys are recommended to establish those critical pieces of information and, therefore, determine an appropriate monitoring protocol. Monitoring should be conducted at least once every 15 days or nights throughout the year, and nesting females should be observed for species identification. See the Species Identification Key on pages 24–25 and Eckert et al. (1999) for a guide to identifying tracks. When an increase in nesting activities is observed, signifying the beginning of the true nesting season, monitoring should also increase in frequency. Possible monitoring protocols are described on the following pages.

Protocol B: Three times (or more) per week

In this scenario, monitoring occurs *three (or more)* times per week throughout the nesting season, recording every nesting activity or attempt on monitoring nights or days. Monitoring during any combination of three days during a week (i.e., three days in a row, every other day, etc.), combined with statistical modeling as described on page 19 will provide nesting abundance estimates with acceptable error (see page 9). This monitoring protocol applies to typical, bell-shaped, temporal nesting distributions, as well as year-round nesting. Note that although three days per week will provide an acceptable level of confidence in nesting abundance estimates, increasing the number of monitoring days will improve confidence.

Alternatives: heterogeneous monitoring (see Protocol C, page 14); mid season surveys (see Protocol E, page 17)

Resource: Russo and Girondot (2009b)



Three counts per week

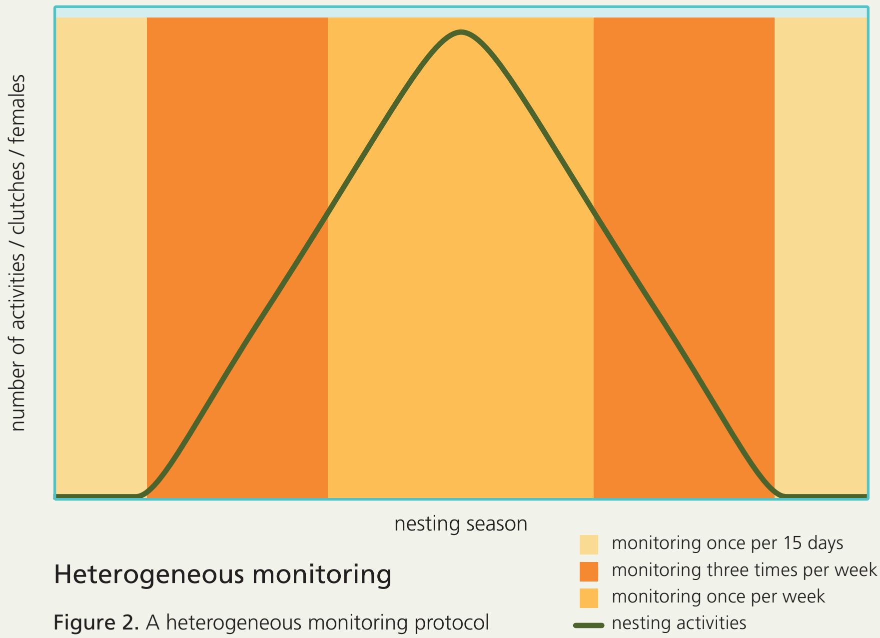
Figure 1. Monitoring of the nesting site is conducted at least three times per week throughout the nesting season. Curved line shows a typical, bell-shaped nesting distribution with a defined beginning, peak, and end.

Protocol C: Heterogeneous monitoring

This monitoring protocol may be an alternative to Protocol B, in situations where the nesting season is bell-shaped. In this protocol, monitoring is conducted one out of every 15 days outside of the known nesting season; three times per week during the first month of the nesting season; one time per week during the middle of the nesting season (when peak nesting occurs); three times per week during the last month of the nesting season; and, finally, one count per 15 days thereafter (figure below). This method, when combined with statistical modeling as described on page 19, will provide nesting abundance estimates with acceptable error (see page 9). This method applies only to bell-shaped nesting seasons.

Alternatives: three times (or more) per week (see Protocol B, page 13); mid season surveys (see Protocol E, page 17).

Resource: Russo and Girondot (2009b)



Heterogeneous monitoring

Figure 2. A heterogeneous monitoring protocol consists of differing levels of monitoring effort at different periods throughout the nesting season. Curved line shows a typical, bell-shaped nesting distribution with a defined beginning, peak, and end.

Protocol D: Numerous sites used by the same nesting population

In situations where numerous, separated nesting beaches are used by the same population of nesting females, it is sometimes not possible to monitor all sites to ensure maximum coverage. In those situations, *SWOT recommends either of two different protocols, depending on the situation:*

1. Monitoring of an index beach or beaches within each population or management unit. The index beach approach assumes that annual abundance patterns observed by comprehensive monitoring of an index beach reflect a broader pattern that occurs at all other beaches used by the same nesting population of that species. An index beach might be selected because it hosts a significant proportion of the overall nesting population within a region or other defined unit. For more information, see Limpus (2008).

2. Diffusing coverage across multiple sites, followed by aggregate analysis of abundance and trends. In cases where (a) the lifetime of beaches because of ephemeral coastal erosion and sand transport patterns is shorter than the time necessary to detect population trends (i.e., within a few years) or (b) nesting turtles show lower fidelity to particular nesting sites or (c) several dispersed sites host nesting but none at significantly high levels to be index beaches, then the index beach approach might not be appropriate. In such cases, a more favorable protocol would consist of monitoring many sites at low levels of survey effort and then analyzing abundance estimates across sites. For more information, see Delcroix et al. (in review).

Resources: for index site monitoring, see Limpus (2008); for diffuse coverage across sites, see Delcroix et al. (in review).

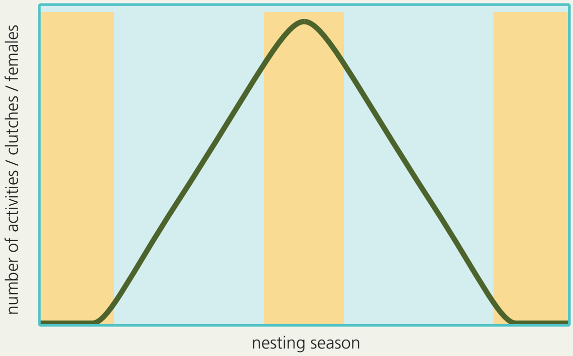
Figures on the following page.

Protocol D continued…

Site #1

Figure 3a. Intermittent monitoring is performed throughout the nesting season at each of several sites that are used by the same nesting population.

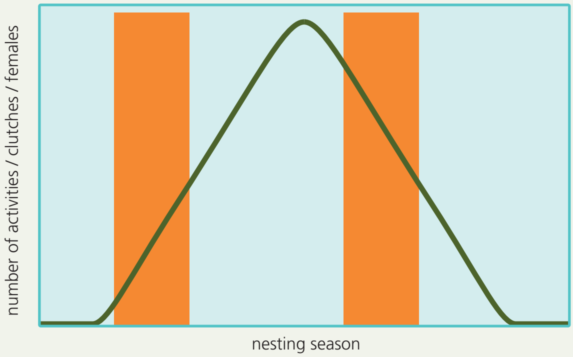
site #1 monitoring event
nesting activities



Site #2

Figure 3b. Intermittent monitoring is performed throughout the nesting season at each of several sites that are used by the same nesting population.

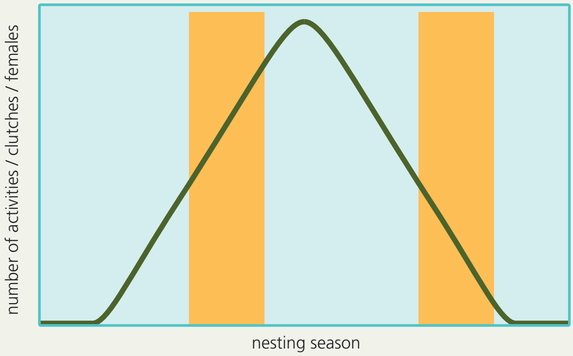
site #2 monitoring event
nesting activities



Site #3

Figure 3c. Intermittent monitoring is performed throughout the nesting season at each of several sites that are used by the same nesting population.

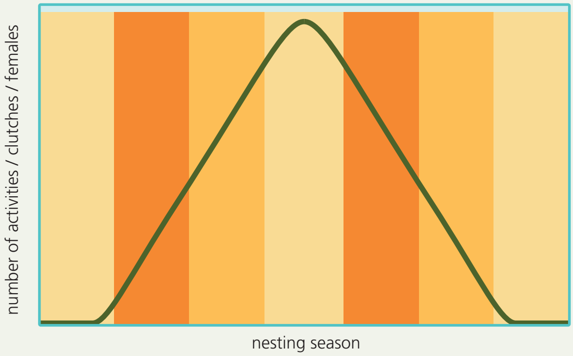
site #3 monitoring event
nesting activities



Multiple sites combined

Figure 3d. Nesting data from several sites that are used by the same population are combined to estimate overall nesting abundance.

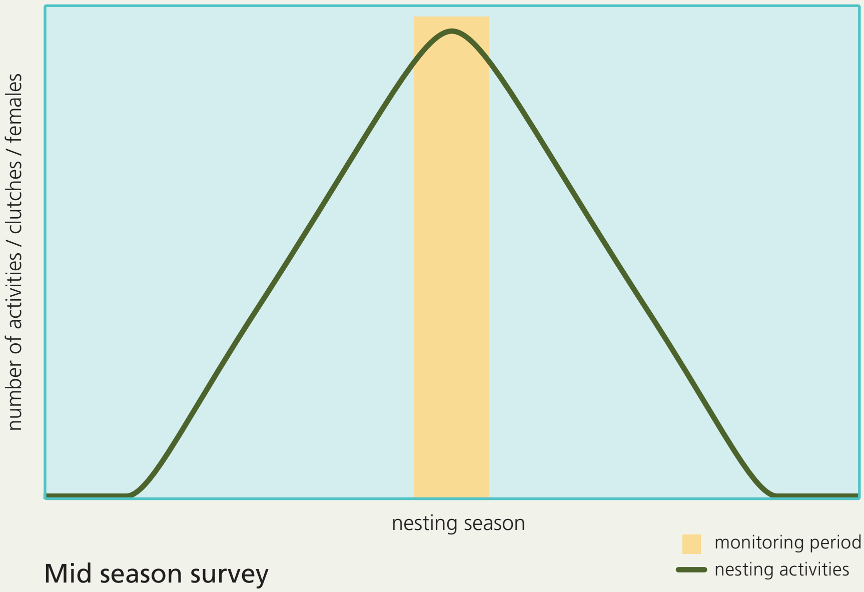
site #1 monitoring event
site #2 monitoring event
site #3 monitoring event
nesting activities



Protocol E: Remote sites and mid season surveys

For remote nesting sites where access and prolonged monitoring events are not possible because of logistical challenges, *SWOT recommends that projects perform mid season counts*, briefly described here and in the resources recommended below. Once the nesting season is known, including the period of highest density, a census should consist of complete counts of nesting females during a roughly two-week period (or longer, if possible) within the period of highest density nesting. A mean value (± standard deviation) can then be calculated for the number of females per night to provide an index for each nesting season. If intensive survey efforts are well-timed (i.e., coincide with the period of highest abundance of nesting females) then sighting probability increases, thereby improving abundance estimates and shortening the required number of years for trend detection. This protocol is also applicable to mass nesting sites (see Protocol F, page 18).

Alternatives: Protocols B (page 13) and C (page 14) for bell-shaped nesting seasons
Resources: Limpus et al. (2003); Jackson et al. (2008); Limpus (2008); Sims et al. (2008)



Mid season survey

Figure 4. Intensive monitoring is conducted during the period of highest density nesting.

Protocol F: Mass nesting sites

Several species (e.g., *Lepidochelys* spp., green turtles, and flatbacks) have sites that host extremely high-density nesting. Because a complete census is impossible at these sites, alternative methods are necessary. *SWOT recommends that projects monitoring abundance and trends of synchronous mass nesting populations (i.e.,* arribadas*) of the* Lepidochelys spp, *(olive ridleys and Kemp's ridleys) implement the "strip transect in time" method described by Valverde and Gates (1999).* This method is being implemented at arribada sites around the world; thus it should be used wherever possible and applicable to allow comparisons across sites.

For mass nesting sites of other species (e.g., green turtles, and flatbacks), *SWOT recommends that a census should consist of complete counts of nesting females during a two-week period within the period of highest density nesting*, as described in Protocol E. A mean value (± standard deviation) can then be calculated for the number of females per night to provide an index for each nesting season (Limpus et al. 2003; Limpus 2008). Alternatively, Protocols B (page 13) or C (page 14) would suffice.

Resources: Valverde and Gates (1999); Limpus et al. (2003); Jackson et al. (2008); Sims et al. (2008)

Analyze and Interpret Your Data

If you have conducted comprehensive monitoring of individually recognized nesting females at your site throughout the entire nesting season, congratulations! You can contribute your data directly to SWOT's global database, without further analysis. If you were not able to achieve this high level of effort, don't worry; there are tools available to help you make the most of your data.

If you were not able to achieve complete daily or nightly coverage throughout the nesting season, you can use statistical modeling to estimate the total nesting abundance at your site. This approach works by "filling in the gaps" (i.e., estimating the count values for the days that you did not monitor). Several statistical methods can be used to estimate total nesting abundance in the absence of complete coverage, as referenced in the preceding monitoring protocols and in the *Technical Report*. However, SWOT recognizes that many nesting beach projects do not have the technical capacity to perform statistical modeling on their own; therefore, we have developed a free, easy-to-use software program that uses one such modeling technique, as described next.

Estimating Seasonal Abundance: Free Software and Recommendations

In collaboration with SWOT, Prof. Marc Girondot has developed a model that is available for free as a user-friendly software interface. Data providers can download the software to their own computers and enter a *.txt file of their count data (containing two columns: date and count), and the model will produce a figure with the total estimate (with 95% confidence intervals). The results can be e-mailed to the SWOT database manager for inclusion in the global SWOT database, along with all other data provided by the user. In this way, SWOT data providers can obtain total seasonal abundance estimates for their beach or beaches, which they can use in reports and other applications, as well as obtain confidence estimates to show the degree of uncertainty associated with these estimates, which can be used to assess the effectiveness of the current monitoring protocol. At the same time, SWOT will obtain total abundance estimates for the global database that are comparable to those provided by other projects, which will lay the groundwork for future mapping efforts, trend analyses, and more.

To download the modeling software, please visit http://seaturtlestatus.org/data/standards, where there is also a user's manual that explains how to use the software. You will find details on the statistical methodology at that same link or in Girondot (2010), as referenced in the Resources section of this handbook.

Getting the Desired Result: When and How to Convert Your Data from One Type to Another

Depending on the type of count data that you were able to collect, as well as your project's needs, it may be necessary to convert your count data from one type to another. For example, if you have counted only the number of crawls during a nesting season but would like to estimate how many nesting females this value represents or to compare your site's nesting abundance with another site that counted the number of nesting females, then you will need to convert your data.

To facilitate these conversions, data providers should provide local conversion factors whenever possible. If conversions are not available for a given site or nesting population, SWOT recommends that rigorous efforts are undertaken to generate estimates for these values (see formulas). It is important to point out that conversion factors introduce additional error to abundance estimates, so SWOT requests that the original unit be reported along with any converted values.

The following schematic formulas demonstrate the conversion factors necessary to convert one count type to another.

Number of Clutches = Total Tracks (or Crawls) – Failed Nesting Attempts

Required conversion factor: Nesting success (i.e., the number of tracks [or crawls] that result in oviposition)

Nesting success can be confirmed by the following methods: (a) directly observe oviposition (preferred method), (b) excavate fresh nest site to confirm eggs, (c) confirm egg harvest (by human or nonhuman predators) of a nest site, (d) observe hatchling emergence at a specific nest site (not recommended, because inaccurate unless nesting sites are known and protected completely).

Number of Clutches = Total Number of Eggs / Number of Eggs per Clutch*

Required conversion factor: Number of eggs per clutch

Number of eggs per clutch can be confirmed by the following methods: (a) direct counts of eggs upon relocation to a new nest site (preferred method), or (b) direct counts of eggs during oviposition (not recommended because of inaccurate counts). *This example is relevant for cases of comprehensive egg harvest.

Number of Females = Number of Clutches / Number of Clutches per Female

Required conversion factor: Number of clutches per female

Number of clutches per female can be confirmed by the following methods: (a) identification by tagging of individual females and direct observation of clutches laid by individual females (preferred method), or (b) estimates of clutch frequency (inaccurate because of variation among females; not recommended unless robust estimates of clutch frequency are available).

SWOT RECOMMENDATION

Whenever possible, conversion factors should be determined and used on a site-specific basis. Researchers should obtain site-specific conversion factors, especially on nesting success (tracks/crawls to clutches) and report these with data provided to SWOT. However, when a conversion factor is unavailable for a study site, we recommend the use of the best estimate derived from a long-term study site within the same geographic region. If a regionally relevant conversion factor is unavailable, use the best species-specific estimate.

Repeat and Improve

Understand Your Data's Quality: The SWOT Data Classification System

With the launch of Minimum Data Standards, SWOT will now begin to classify all nesting data into two categories, as defined on page 23. Although SWOT will continue to collect and compile all nesting data, regardless of their classification, SWOT recommends that all nesting beach monitoring programs aim to achieve a Level 1 ranking, as defined on page 23. This level will ensure that the project's nesting data are of maximum use to the project, to SWOT, and to global sea turtle research and conservation.

It is important to remember that, although counting nesting females and their nesting activities is an important part of generating abundance estimates and assessing trends, this information alone is insufficient for understanding the underlying, complex processes that drive population status and trends. As explained on page 5 and in the *SWOT Minimum Data Standards Technical Report*, SWOT believes that the "gold standard" for sea turtle monitoring programs worldwide should be to develop and maintain long-term CMR (capture-mark-recapture) studies on nesting beaches and in foraging areas for sea turtle populations.

LEVEL 1

These data meet SWOT Minimum Data Standards, and are of the highest quality in the SWOT database. The data include total abundance counts, total abundance estimates with sampling error of less than or equal to 20% (CV ≤0.2), or a reliable index of seasonal abundance. However, SWOT prefers that partial seasonal abundance counts that meet monitoring effort requirements be processed using the Girondot model (or another published modeling approach) to generate estimates of total seasonal abundance with confidence intervals.

LEVEL 2

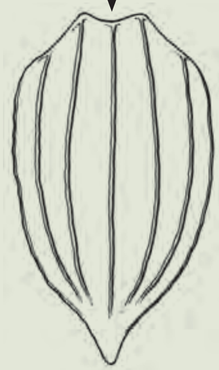
These data do not meet SWOT minimum quality standards but will be included in the SWOT database. The data will produce annual abundance estimates with sampling error of greater than 20% (CV >0.2). Nevertheless, they should be processed using the Girondot model (or another published modeling approach) to generate estimates of total seasonal abundance with accompanying error in order to give data providers and SWOT a clear assessment of the degree of uncertainty that is associated with their data as a result of their monitoring effort.

Develop a Plan to Improve, If Needed

If your data are not classified as Level 1, don't worry; there is plenty of time to improve, and you now have a better idea about what is needed. Nesting beach monitoring, in most cases, is a long-term commitment that will take many years to yield the desired results. It is important each year to review your results and to determine whether your monitoring protocol has been sufficient to help you meet your goals or whether you will need to increase your level of effort. Once you have established that your monitoring protocol is producing sufficient results, maintaining a consistent protocol from year to year will simplify your analyses down the road.

Species Identification Key

Flexible carapace with
- 5 distinct ridges
- no scutes

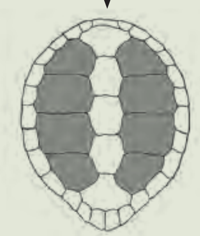


Leatherback turtle
(Dermochelys coriacea)

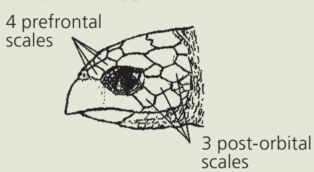
- Carapace strongly tapered
- Carapace leathery, flexible
- Color dark gray or black with white or pale spots
- Jaw deeply notched
- To 500 kg, "shell" to 180 cm

4 pairs of lateral scutes
(shown shaded)

GREEN TURTLE

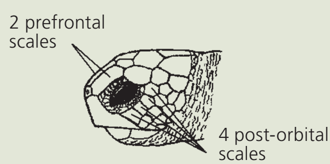


BLACK TURTLE



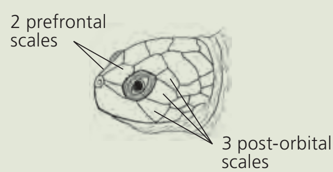
Hawksbill turtle
(Eretmochelys imbricata)

- Overlapping shell scutes
- Pointed face, distinct over-bite
- Adult color orange, brown, yellow
- To 85 kg, shell to 95 cm



Green turtle / black turtle
(Chelonia mydas)

- No over-lapping shell scutes
- Round face, serrated jaw
- Black turtle carapace is posteriorly tapered
- Adult color highly variable: dark gray green, yellow, brown, black
- To 230 kg, shell to 125 cm (black turtles to 120 kg, shell to 90 cm)



Flatback turtle
(Natator depressus)

- Australian continental shelf only
- Shell broad and rounded with upturned lateral edges
- Adult color gray, pale gray green, or olive
- To 90 kg, shell to 100 cm

Use the identification key below to identify the species of adult, nesting turtles at your beach, as described in Protocol A (page 12). For identification of sub-adult turtles, hatchlings, and tracks, see Eckert et al. (1999).

Bony carapace (shell) with
- no continuous ridges
- large scutes (shell plates)

5 (rarely 6) pairs of lateral scutes (shown shaded)

6 or more pairs of lateral scutes (sometimes asymmetrical) (shown shaded)

Loggerhead turtle
(Caretta caretta)

- Carapace longer than wide
- Head broad (to 25 cm)
- Color red-brown to brown
- To 200 kg, shell to 120 cm

Kemp's ridley turtle
(Lepdochelys kempii)

- Carapace very round
- Nesting in the Gulf of Mexico only
- Adult color dark gray-green
- To 45 kg, shell to 70 cm

Olive ridley turtle
(Lepidochelys olivacea)

- Carapace nearly circular
- Adult color dark gray-green
- To 50 kg, shell to 72 cm

Artwork by Tom McFarland and Stephen Nash / CI. Adapted from WIDECAST © 1992

Glossary of Terms

The glossary includes terms used throughout this handbook and in future SWOT publications on minimum data standards. The definitions here are specific to the SWOT Minimum Data Standards protocol.

Beginning of nesting season: date when frequency of nesting activities increase above background levels during a defined nesting season

Body pit: depression made by nesting female sea turtle following emergence from the sea and before excavating an egg chamber; also refers to the depression made by a female turtle following oviposition and nest covering; feature used as a proxy activity to represent nesting attempt

Census: coordinated effort to monitor (i.e., count) sea turtle nesting activities during a certain period of time, usually conducted during a defined nesting season

Clutches: a count of the number of egg clutches laid by female sea turtle(s) during the monitoring period.

Crawls: a count of the observed number of emergences of female sea turtles from the ocean onto the beach during the monitoring period; also referred to as tracks; crawls may include successful oviposition events (egg clutches), aborted nest attempts, or false crawls.

End of nesting season: date when frequency of nesting activities returns to background levels during a defined nesting season

Monitoring effort: the level of effort used to monitor nesting on a given beach

Nest: the physical structure created by a female sea turtle into which she deposits her eggs

Nesting activity or attempt: any attempt by a female sea turtle to make a nest into which to lay eggs; if successful, includes a crawl, body pit, nest, and eggs, but could be counted during a census even if eggs are not laid or if oviposition (or lack thereof) is not directly observed.

Nesting females: a count of unique, observed nesting female turtles during the monitoring period.

Nesting population: a common group of nesting female turtles

Nesting season: period of time during which nesting activities by a colony or population of nesting sea turtles occurs

Nesting success: the proportion of nesting activities that result in successful oviposition

Number of observations: count of observed nesting activities, which could include crawls, clutches, or female turtles

Number of unique observations of turtles: count of distinct nesting females that are usually identified using individually numbered tags (external or internal)

Observation: nesting activity by a female sea turtle documented by a researcher during monitoring efforts

Oviposition: when a nesting female sea turtle deposits a clutch of eggs into a nest that she excavated during a nesting attempt.

Peak of nesting season: period during a given nesting season when highest frequency of nesting activities occurs

Tracks: see also crawls

Trend: pattern of increase, decrease, or stable series of consecutive counts of nesting activities, or other units that represent population abundance.

Literature Cited

The contents of this handbook are a condensed, user-friendly version of the detailed information provided in the following publications. These publications are available for free download on the SWOT website at www.seaturtlestatus.org/data/standards.

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SWOT Recommendations for Monitoring Efforts At-a-Glance

1. For any of the monitoring recommendations in this handbook to be implemented, the species present and the phenology (i.e., start and end, timing of the peak, etc.) of the nesting season(s) must be determined. Thus, if nesting phenology is unknown, a preliminary census of nesting activity is recommended (see Protocol A, page 12).
2. Once nesting phenology is known, the monitoring effort should follow the recommended protocol appropriate for the identified type of nesting season (see Decision Key, pages 10–11, for details), or any other protocol that results in annual abundance estimates with error ≤20%. Capture-mark-recapture methods on nesting beaches and in foraging areas are the "gold standard" for estimating vital demographic rates, assessing abundance, and diagnosing trends.
3. All nesting activities should be counted during a monitoring event, and all zero values should be recorded. In other words, if monitoring occurs but no nesting attempts are recorded, a value of zero should be included in the overall season's monitoring report.
4. Because the minimum nesting activity unit is the number of tracks or crawls, but count data come in various units, site-specific conversion factors should be obtained to allow estimations of number of clutches (or females) from the number of crawls.
5. Abundance estimates should be made using a published method and reported with an estimate of the error associated with the value (see the *Technical Report* for specific methods).
6. Periodic monitoring of the entire potential nesting area should be conducted roughly every 5 years to account for the spatial shift in nesting activities. If spatial shift is apparent, the boundaries of the study area should be adjusted to account for this shift.

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