Research and Management Techniques for the Conservation of Sea Turtles
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Population Surveys (ground and aerial) on Nesting Beaches

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Introduction

Nesting beach surveys are the most widely implemented monitoring tool in use by the global sea turtle community and are an important component of a comprehensive program to assess and monitor the status of sea turtle populations. These assessments are necessary to evaluate the effects of recovery and conservation activities which are being implemented at all life history stages. Appropriately designed nesting beach surveys, in concert with studies of nesting females (see Alvarado and Murphy, this volume; Balazs, this volume; Owens, this volume) and nest success (see Miller, this volume), can provide information relative to the number of nests deposited annually, the number of nesting females that are reproductively active annually, and annual nest productivity. Nesting beach surveys, as discussed in this chapter, refer to ground and/or aerial surveys conducted to gather information on the number of nesting and non-nesting emergences occurring on a non-*arribada* beach. Readers contemplating population surveys on mass nesting beaches should consult Valverde and Gates, this volume.

Nesting beach surveys range from highly structured standardized sampling to "snapshots" of nesting activity within a nesting season. While nesting surveys are currently widespread, the variability in techniques, along with inadequate documentation of methods used or assumptions made, often hampers our ability to make meaningful assessments of the status of nesting populations. The principal purpose of this chapter is to provide a simplified strategy for nesting beach monitoring which may prove useful in designing a valid monitoring program for previously unsurveyed beaches, or for modifying an existing program. The extent to which nesting beach surveys are conducted will depend on many factors including, but not necessarily limited to: remoteness and geography of the survey area, available personnel and equipment, and nest density. This chapter does not discuss the identification of nesting crawls to species, a critical component of any nesting beach monitoring program (see Pritchard, this volume, for guidance).

In order to be of value over a long period of time, surveys on nesting beaches must be cost-effective, reproducible, quantitatively rigorous, and easily taught to others who will continue the surveys. Two nesting beach monitoring methodologies are generally employed—patrolling the beach on foot or by vehicle (ground surveys) and patrolling the beach by aircraft (aerial surveys). This Chapter will review both methodologies and provide the information needed to implement a new nesting beach monitoring program, or, if one is already in place, may provide the reader with suggestions for improvements. This chapter is divided into three general sections: (1) an overview of survey methodologies and aspects of nesting beach surveys common to both methodologies, (2) ground surveys, and (3) aerial surveys.

Which Methodology Should be Used?

The determination of whether to employ ground survey or aerial survey techniques will depend on several factors. Chief among these is the geographic extent of the survey area, beach type, and the resources (money, equipment, and personnel) available. Ground surveys, conducted either by foot or by vehicle, allow close scrutiny of crawls for identification and counting, and are preferable where: (1) other aspects of nesting beach activities require personnel to regularly traverse nesting beaches *(e.g.,* nest monitoring, predator control); (2) the beach is accessible and the survey area is relatively short; (3) the structure of the beach is difficult to survey by air from the standpoint of aircraft maneuverability and/or; (4) crawl signs are obscure due to the beach type *(e.g.,* pebble beaches, nesting under heavy vegetation). Aerial surveys are preferable for reconnaissance of large geographic areas to ascertain relative use of nesting beaches (or presence/absence) and to patrol nesting beaches that are inaccessible by foot or vehicle. Either methodology is useful for long-term standardized surveys provided they are appropriately designed.

Once the survey platform (aerial or ground) has been selected, the next step is to determine the specific methodology that will be employed. There are two methods that have been successfully employed when conducting ground or aerial surveys. The first type requires differentiating between nesting and non-nesting emergences and assessing only "fresh" crawls *(i.e.,* those made the previous night for morning surveys, or the night of the survey, for night-time ground surveys). The second methodology involves counting all crawls, or in some cases, all crawls with visible body pits, without differentiation between nesting and non-nesting emergences, and may or may not involve the enumeration of "fresh" vs. "old" crawls. The methodology chosen will depend on an assessment of the variables explained below and both methodologies require appropriately designed ground-truthing. The authors do not recommend surveys that attempt to differentiate nesting emergences from non-nesting emergences *in situ* when "old" crawls are mixed with "fresh" crawls in the survey counts.

Aspects of Nesting Surveys Common to Both Techniques

Variables Affecting Data Collection

In any nesting survey, the detectability of a nesting event, and hence, the accuracy of the survey, is influenced by many factors. These variables are important regardless of whether the survey employs ground or aerial techniques. The most critical component of both types of surveys is the implementation of appropriately designed ground-truthing on a subsample of beaches. Ground truthing provides verification of the data collected by survey personnel and enables the development and application of appropriate corrections in the final data analyses. The major variables associated with identifying, differentiating, and enumerating crawls on the nesting beach are: observer/surveyor accuracy, turtle species, nesting density, beach type, time-of-day (position of sun), wind, rainfall, and human activity on the beach.

1. Observer/Surveyor Accuracy: Intrinsic observer error can heavily influence survey accuracy. A comprehensive nesting survey program must include observer training and ground-truthing (see below, this chapter).
2. Turtle Species: Some species exhibit nesting behaviors that inordinately complicate the identification and differentiation of crawl sign. For example, hawksbills generally prefer to nest in heavy vegetation and may traverse rock or coral rubble leaving little or no crawl sign. In contrast, leatherback crawls generally result in extensive beach disturbance which can equally confound the differentiation of nests from non-nesting emergences. Nesting behavior variability among species must be taken into account in planning and implementing nesting surveys.
3. Nesting Density: Nesting beaches that support high density nesting may not be good candidates for use of the aerial survey technique. The sheer number of crawls, often overlapping each other, can make it extremely difficult, if not impossible, to accurately assess crawls from the air. Aerial surveys are best suited for nesting beaches that support low to moderate levels of nesting activity, unless a helicopter is available for surveys on high density nesting beaches.
4. Beach Type: Variations in beach type may affect the reliability of crawl counts. Beaches can have fine sand, coarse sand, coarse sand mixed with some shell, and very hard packed areas composed almost entirely of shell. On the latter, impressions made by the flippers are indistinct. Variability in beach profiles can affect the width and symmetry of crawls and complicate species identification and/or differentiation of nests from non-nesting emergences.

5. Time-of Day (Position of Sun): The low sun angle in the early morning casts a deep shadow behind the tracks and makes them highly visible. By mid-morning, this shadow effect is lost and crawls are more difficult to see. For aerial surveys, glare becomes more of a factor later in the survey. Overcast days eliminate the shadow effect on tracks and make it more difficult to discern nest field signs. It is recommended that surveys be conducted at the same time each day, preferably in the early morning, to eliminate one of the variables affecting survey accuracy.
6. Wind: Crawls may be weathered or obliterated depending upon wind intensity, duration, and direction. The moisture content of the sand moderates the effects of the wind to some degree and the portion of a track in damp sand may remain more distinct than the portion in dry sand. Crawls weather differently depending upon the wind's direction relative to the orientation of the beach. One part of the beach might contain clear, distinct crawls, while crawls made the same night in another area may appear faint or older.
7. Rainfall: Rainfall obscures crawls and confounds crawl identification to varying degrees. Emergences before a rain generally appear older than emergences that occur after a rain. This same effect can occur during a survey if rain falls on all or part of the survey beach. Under these conditions, when employing surveys that require the differentiation of "fresh" crawls from "old" crawls it is essential to rely on the crawl's relationship to the intertidal zone to determine the age of the crawl (provided the survey beach has an obvious tidal fluctuation). Crawls are generally still visible after slight or moderate rainfall, but heavy rainfall will often obliterate crawls completely. Aerial surveys, and to a lesser extent ground surveys, are of little value after nights of widespread, prolonged rain or strong winds.
8. Human Activity on the Beach: Human activity obscures crawls, body pits, and other nest field signs. On-going nest protection projects also destroy field signs when screening or relocating nests. It is important to have an understanding of the level of human activity on your survey beach, including nest protection efforts, and to ensure that this is taken into account when planning both ground and aerial surveys.

Data Collection Forms

Data collection forms for ground and aerial surveys of nesting beaches should be simple and straightforward and all surveyors should use the same data form for a particular beach. The reader may wish to consult researchers having established nesting survey programs for examples of data collection forms. These can serve as models, however, forms should always be tailored to your particular beach and include all relevant information (see Appendices 1 and 2).

Partitioning the Nesting Beach

One of the most important components of establishing a long-term nesting beach monitoring program is defining the survey area. In order to make year to year comparisons of nesting beach survey data, the survey area must be known, must be consistent, and must be measured. It is useful to partition the beach into equal segments or zones, so that data are available at a resolution finer than the entire survey length. The ability to analyze survey data by zone is particularly useful when evaluating or assessing the effects of habitat alteration on nesting success *(e.g.*, artificial lighting, coastal armoring). The maximum distance recommended for survey zones is 1.0km. Zones can be demarcated by using marked stakes or posts, however, because these markers are usually temporary, a more permanent record of the zone endpoints should be made, either by referencing a direction and distance from more permanent features when they exist *(e.g.*, buildings, rivers, or inlets) or through the use of Geographic Positioning System (GPS) units if available. Since data will be collected by survey zone, it is important that all personnel involved in the survey are knowledgeable about the start and endpoints of the various zones.

Examining Survey Error – Ground Truthing

Inherent in all nesting beach surveys is a level of survey error. Track sign can be difficult to interpret and errors will be made in separating nesting emergences from false crawls, discerning "fresh" crawls from "old" crawls (for surveys that require differentiation), and differentiating one species crawl from another. Errors may be more pronounced on moderate or high density nesting beaches when the magnitude of crawls complicate nesting field sign. In the case of ground or aerial surveys designed as total crawl counts, correction factors must be developed to estimate nests and false crawls. A critical component of ground or aerial surveys is assessing the magnitude of these errors. Ground-truthing should take place several times throughout the course of the season, on a sub-sample of the entire survey area under varying tidal and weather conditions, and on all beach types within the survey area, in order to assure an unbiased sample. In the case of aerial surveys, ground-truthing is conducted for every flight. Ground-truthing must employ techniques that confirm the presence or absence of eggs. The only way to confirm the presence of eggs is to see them, either during egg deposition, or later by excavation or probing, or as a result of the activities of predators. The former method involves directly observing the activities of nesting females (without interfering with their behavior), marking the resultant crawls with numbered flags or stakes, and using these data to check the survey information gathered by surveyors on the nesting beach the following day. Alternatively, as described below, crawls can be excavated or probed within the ground-truth area(s) to verify the presence or absence of eggs and the authors differ on which is the preferred method. The first method involves slow and methodical localized digging (use small diameter test holes and dig with the hands only—no implements!) to confirm that eggs are present or absent. The second method involves the use of a small, narrow diameter probe stick which is gently inserted into the sand to test for the softened area of sand directly above the clutch. Extreme care must be exercised when probes are used so that eggs in the clutch are not punctured. Either technique should be used only by experienced, well trained, and properly permitted personnel. Care should always be taken to ensure that clutch "finding" techniques are not taught (either directly or by indirect observation) to persons who may illegally poach nests. Where ground truthing is conducted to calibrate aerial survey data, additional information collected on the ground survey which may be helpful includes a description of the crawls observed, their sequence, and their location relative to the same landmarks used by aerial observers (see Partitioning the Nesting Beach above).

Regardless of the ground-truthing methodology employed, for either ground or aerial surveys, the results will yield an estimate of survey error(s) which must be applied as a correction factor(s) in the final data analyses.

Determination of Nesting vs. Non-Nesting Emergences

As described above, under "Which Methodology Should be Used?", certain ground and aerial surveys are designed to differentiate nesting and non-nesting emergences at the time of the survey. This type of survey employs methods used to assess nesting activity that do not require the direct confirmation of eggs at every nest site. Under certain beach conditions and for certain species, field or "crawl" signs can be used to determine whether an emergence has resulted in egg deposition provided the observer has sufficient training and experience. As noted above, appropriately designed ground-truthing must be implemented to assess the accuracy of all survey techniques so that correction factors can be developed and applied in the final data analyses. Although each species has certain characteristics which result in unique crawl sign, many of the characteristics are highly similar (for species specific crawl and nest descriptions see Pritchard, this volume). You must gain experience with the crawl sign nuances of all of the species nesting on your survey beach, thus reducing survey error. Certain terminologies, which may or may not be familiar to the reader, are regularly used to describe and interpret crawl sign. It is valuable for the reader to have a through understanding of this terminology before proceeding further. The following glossary and discussion of crawl sign, primarily based on loggerheads, may be useful and will be applicable to a certain extent to all species of sea turtles:

Backstop: An approximately 45° incline made in the sand as sand is pushed back with the rear flippers during the excavation of the primary body pit. Such a steeply inclined backstop is not present in the secondary body pit.

Crawl: Tracks and other sign left on a beach by a sea turtle.

Egg Chamber: The cavity excavated by the rear flippers into which the turtle deposits a clutch of eggs.

Escarpment: The perimeter of the secondary body pit where the front flippers have cut away a small cliff into the surrounding sand.

False Crawl: A crawl resulting from an abandoned nesting attempt (a non-nesting emergence).

Nesting Crawl: A crawl resulting from a nesting attempt in which eggs were deposited.

Primary Body Pit: The excavation made by a turtle on the beach just prior to digging the egg chamber.

Secondary Body Pit: An excavation made by a nesting turtle primarily using the front flippers following the deposition of eggs. The spoil from the secondary body pit generally covers the primary body pit and the egg chamber with sand.

Nesting Crawl Field Signs

The first step is to identify the emerging and returning crawls by observing which direction the sand is pushed—as a turtle crawls it will push sand backward with each flipper stroke (Figure 1, note arrows). Noting the direction of travel will help in understanding the behavior of the turtle, which results in the crawl sign. Follow the path taken by the turtle and look for evidence of front flipper covering—sand misted or thrown back over the emerging track (Figure 1 (B)), a secondary body pit and/or escarpment (generally a crescent shaped cliff), and sand thrown in the vicinity of the secondary body pit (Figure 1 (C)). The shape of the secondary body pit may be somewhat circular or oblong, depending on the location of the nest site. The sand which is misted or thrown during body pitting and covering generally has a higher moisture content than the dry sand on the beach surface and this difference can be helpful in understanding and evaluating crawl sign.

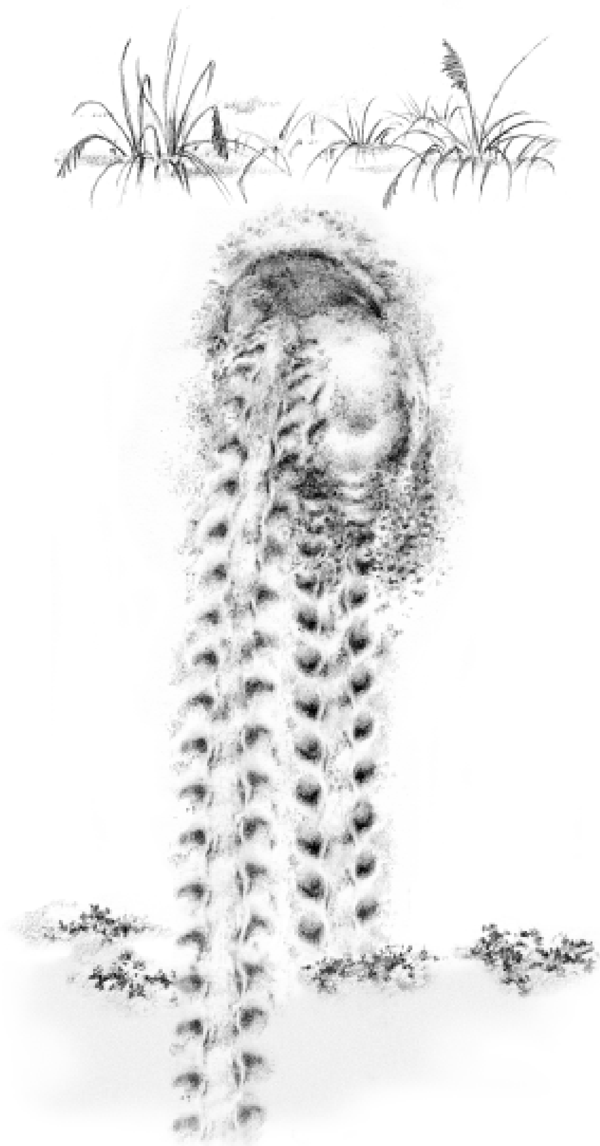

Figure 1. Stages of successful loggerhead *(Caretta caretta)* nesting, with emerging crawl (A); sand misted or thrown back over the emerging track (B); a secondary body pit and escarpment, with sand thrown in the vicinity (C); and returning crawl (D). (E) marks the high tide line.

During aerial surveys that are designed to differentiate nesting from non-nesting emergences and "fresh" from "old" crawls, the relative lengths of the emerging and returning crawls can also be an indicator of nesting, on survey beaches with obvious tidal fluctuations, but this differentiation technique should only be used in the absence of any corroborating evidence and when the apex of the crawl is obstructed from view. If the emerging track is considerably shorter than the returning crawl, this provides evidence that the turtle spent a considerable time on the beach and may have nested. However, it is important to ensure that the turtle was not simply wandering on the beach or making repeated attempts at nesting.

False Crawl (Non-Nesting Emergence) Field Signs

Observe the entire crawl carefully and look for any of the following signs: (1) very little or no sand disturbed, other than the crawl itself which is most commonly U-shaped or a simple arc, but which may include moderate to extensive wandering (Figure 2 (A) and (B)); (2) a backstop with sand pushed back (not thrown) over the emerging crawl, typically between two mounds of sand piled by the front flippers during construction of the primary body pit (Figure 2 (D)); (3) considerable sand disturbed from a digging effort, but with the crawl exiting the disturbed area and returning toward the ocean (4) considerable sand disturbed from a digging effort, but with a smooth-walled or collapsing egg chamber (devoid of eggs) and no evidence of covering (Figure 2 (C)). Note that a depredated nest will generally be characterized by eggshells or partially consumed eggs littering the nesting site. Depredated nests must be counted as nesting emergences during the survey, but should be noted as depredated if quantifying nest success. During aerial surveys, some crawls may be classified as "unknown,"

Figure 2. Examples of false crawls (non-nesting emergences) made by loggerheads *(Caretta caretta)* include extensive wandering with no body pitting or digging (A); U-shaped crawl to the high tide line (B); considerable sand disturbance and evidence of body pitting and digging and no evidence of covering (D); and considerable sand disturbance, evidence of body pitting and digging with a smooth-walled egg chamber and no evidence of covering (C). (E) marks the site of a crawl where the relative lengths of the emerging and returning crawls are the same. (F) marks the high tide line.

for example, when the face of the dune collapses on the apex of the crawl (obscuring the crawl sign) or when the apex of the crawl is obscured by dune vegetation and the relative lengths of the emerging and returning crawls are the same (Figure 2 (E)).

Ground Survey Methodology

Equipment Needed

If the survey is to be conducted on foot, no extensive equipment is needed beyond a sturdy hat and sunscreen. If vehicles are to be used they should be small, three or four-wheeled, all terrain vehicles (ATVs). ATVs are relatively lightweight and have large balloon-style high pressure tires which leave low-relief tire tracks and which do not exert extensive force over incubating nests, which may be traversed (though never intentionally) during the course of the nesting season. ATVs are ideal for surveys that are geographically extensive, however, they must be regularly maintained to protect against the wear and tear resulting from daily exposure to sand and salt-spray. Regardless of the survey mode, the only other equipment necessary are data sheets, writing utensils, and a camera for any unusual findings.

Periodicity and Timing of Ground Surveys

In many cases nesting beach surveys are conducted daily in conjunction with other sea turtle conservation activities such as nest protection efforts (see Boulon; Miller; Mortimer, this volume). Complete counts of nesting and non-nesting emergences require daily monitoring throughout the nesting season. However, daily monitoring is not always necessary or logistically possible and data from intermittent surveys can be used as an index to total nesting, provided there are baseline data available and provided the survey is appropriately designed to periodically sample throughout the nesting season. Intermittent surveys may be designed in two ways: those that count only fresh crawls *(i.e.,* those made the previous night) or those that count all crawls regardless of age. In the latter case, data on track longevity must be collected and incorporated as a correction factor in the final data analyses.

Where daylight survey techniques are employed, nesting surveys should begin just after sunrise for the best viewing of crawls. Track sign begins to deteriorate as the sun dries out the sand, and the crisp shadows that facilitate track identification are lost as the sun rises in the sky. Additionally, on beaches that are visited by humans for recreational purposes, foot traffic and beach activities will obliterate nesting crawls. Daytime nesting surveys are the recommended approach as they do not require repeated traversing of the survey area which can cause disturbances to nesting females and because it is easier to accurately discern crawls in the daylight. However, in some cases, it may be necessary and/or preferable to conduct night-time surveys when other research activities necessitate night-time patrols or when nest protection efforts must be carried out during the night.

Ground Survey Techniques

The following discussion describes how to conduct daytime ground surveys designed to differentiate nesting from non-nesting emergences and "fresh" from "old" crawls. Surveyors should move along the beach at the level of the latest high tide line. Upon discovery of a crawl, the surveyor must first determine that the crawl is fresh. Depending on weather conditions crawls can persist for days or even weeks. The only completely reliable method to ensuring that only fresh crawls are counted is to traverse the survey beach, by foot or vehicle, above the expected high tide line, on the day prior to the day the survey will be conducted. In this way, the impressions from all fresh crawls will cross over the vehicle track or will not have been previously "marked" by sweeping the feet across the track. An alternative method of discerning fresh crawls from old crawls, described under the section of this chapter dealing with aerial surveys, will depend greatly on the tidal conditions at the nesting beach and is slightly less reliable. The surveyor must next visually determine whether or not the crawl is a nesting or non-nesting emergence (see above) in addition to determining which species of turtle made the crawl (see Pritchard, this volume). Surveyors must have the experience necessary to accurately make these determinations based on the characteristics of the crawl. All crawls are enumerated and recorded on the data sheet. After each crawl is evaluated and recorded, the track should be "marked" *(e.g.,* effacing the upper part of the track) to avoid duplicate counting on subsequent survey days. Regardless of the method used to "mark" the crawl, it should be consistent among and familiar to all survey personnel to avoid duplicate counting.

Training

All surveyors should be fully trained prior to conducting surveys on their own. A comprehensive training program will include a classroom session and field sessions. Classroom training should include slides or photographs of various types of crawls for each of the species that are known to nest on the survey beach. A thorough understanding of the nesting behavior of each species is critical to accurate interpretation of nesting track sign. New surveyors should be introduced to these nesting behaviors by observing nesting turtles with an experienced surveyor who can explain each part of the nesting process and how each behavior influences track sign. New surveyors should work side-by-side with experienced surveyors until they are fully confident of their ability to identify nesting emergences from false crawls and distinguish among the species using the survey beach.

Aerial Survey Methodology

Equipment Needed and Technique

Helicopters have the best visibility, adjustable speed and the capacity to hover. These aspects are especially useful when training new observers. However, in most cases they are expensive and may not be readily available for regular survey flights. Single engine, wing-over-cockpit aircraft are generally more readily available and most frequently employed. The following variables must be taken into consideration when using aircraft to survey nesting beaches.

1. Speed: Crawls will obviously be missed if the aircraft's speed is too fast. The speed of the aircraft should be adjusted to the track density. On low density beaches (<1 track/km/flight) crawls can be recorded accurately at 100 knots. On moderate density beaches (1 to 5 crawls/km/flight) it is possible to accurately count crawls at 80 knots. Where track densities are higher, (>5 crawls/km/flight) it is necessary to fly at 60 knots.
2. Altitude: Flying too low causes a similar prob-

lem as flying too fast. Objects are in the field of view for a shorter time, causing increased eye movement which results in lowered accuracy and observer eye fatigue. Survey altitude is dependent on species. For example, loggerhead beaches in the U.S. are best surveyed at 60m, while leatherback beaches in Mexico are best surveyed at 250m. Before undertaking a survey it is prudent to test the best speed and altitude by making a few test flights with simultaneous ground surveys. Choose the speed and altitude that results in the lowest percent error.

3. Position: The position of the aircraft is important in order to accurately assess crawls. The most important aspect is to gain the best view of the area where most of the nests are located (often the upper beach) while still allowing good viewing of crawls that terminate lower on the beach *(e.g.,* many false crawls). The best position for the aircraft is the one that maximizes crawl viewing, taking into account the relative angle of the sun on the beach, which enhances shadowing and the discernment of field signs. As with speed and altitude, a pre-survey test flight can help determine the optimal track-line.
4. Pilot: The importance of the pilot in maintaining the correct speed, altitude, and position of the aircraft, while maintaining safety, cannot be overemphasized. Working with the same pilot on multiple surveys is recommended whenever possible.
5. Fatigue: Fatigue causes a loss of observer concentration. This aspect generally becomes noticeable after about three hours of flight time or where long sections of coastline have few crawls. Surveys should be designed to minimize observer fatigue.

Timing and Periodicity of Aerial Surveys

Aerial surveys are best flown beginning at dawn. The relatively low angle of the sun creates a shadow effect and enhances crawl sign, sand thrown by the turtle is still moist resulting in fresher crawl sign, and human activity is minimal. Aerial surveys are, by their nature, intermittent or periodic surveys, whereas ground surveys may be daily or intermittent. The interval between surveys is important to the accuracy of the overall survey. Aerial surveys designed to enumerate only fresh crawls should be scheduled to maximize monthly tidal cycles, on beaches where there are obvious tidal fluctuations. In the southeast U.S., for example, the twice monthly spring tides wash the widest area of the intertidal zone and remove the lower portion of old crawls. Scheduling flights on the morning *after* the optimum tide (one that peaks just at dark), the morning *of* that optimum tide and one day *prior to* this tide prevents most of the errors in aging crawls and provides a three-day window for the surveys. Flying three consecutive days tends to smooth out daily variability in turtle activity. The accuracy of counting only fresh crawls is affected by: the time of the evening high tide relative to the time at which the turtles crawl, and the relative height of this tide on consecutive days. The difference of one hour in the tidal cycle can result in track aging errors if the tide peaks after dark. Aerial surveys designed as total track counts that rely on ground-truthing to develop correction factors for estimating nests and false crawls need not rely on the methods explained above regarding tidal fluctuations.

Aerial Survey Techniques

During aerial surveys designed to differentiate nesting emergences from non-nesting emergences, and enumerate only "fresh" crawls, the observer should scan the rack line created by the previous night's high tide. Ignore any crawls that **do not** extend below this line regardless of how "fresh" they may appear. If a crawl extends below the most recent high tide line, the eye should follow the crawl to its apex. Examine the track for the field signs related to species identification (see Pritchard, this volume) and examine the area for the field signs described above under "Determination of Nesting vs. Non-Nesting Emergences". If identification of the track type (nesting vs. non-nesting) cannot be made, based on characteristics at the apex of the crawl, examine both legs of the track to determine if they were of equal or unequal lengths. The difference in these lengths may be helpful in identifying crawls (see above). The assessment of crawls is rapid and observers must take into account all available field sign to make the best assessment at each crawl. Aerial surveys that are designed as total crawl counts do not involve differentiation of each crawl.

Training

Observer experience is an important variable in any aerial survey. It is rare, though not impossible, to have total agreement between the aerial observations and the ground truth data. In order for new observers to improve their aerial survey techniques, it is important for them to recognize the types of errors that can be made. Depending on the specific aerial survey methodology employed, observer errors include: missed observations, misidentification of track type, misidentification of species, and mis-aging. Inexperienced observers should be made aware of the types of errors that they are making (determined from ground-truthing) so that they can improve their accuracy based on objective criteria. This type of observer training requires mapped ground-truthing during the training period.

Data Analyses and Interpretations

The goal of nesting beach surveys is to determine the abundance of nests on a beach over a specified time interval. There are multiple approaches to survey design that have been successfully employed by researchers at different nesting beaches across the globe. The published literature is generally lacking in detailed accounts of methodologies for nesting beach surveys. In some cases, methodologies are under development and the reader is encouraged to further his/her knowledge by communicating with experienced researchers to remain abreast of new developments and to ascertain which methodologies will best fit their particular circumstances.

Well designed nesting surveys can and do provide short-term information that is integral to management and recovery programs. However, it is important to recognize that population trends at nesting beaches take many years to accurately discern, thus emphasizing the value of long-term standardized surveys. Most sea turtle species take well more than a decade to mature. Therefore, the population-level effects resulting from management efforts may not be evident for many years, especially if impacts are occurring that reduce population size at the early life history stages. Sea turtle biologists, managers, and enthusiasts should be cautious in interpreting nesting beach survey data collected over a short time frame. Year-to-year fluctuations are common and should be thoughtfully reviewed and considered rather than immediately construed as absolute indications of the health or status of the population. Equally important is the caution that nesting survey data from one area cannot be extrapolated to unsurveyed areas as nesting densities can vary greatly from one stretch of beach to another. Neither can nesting survey data be assumed constant in a temporal sense, data collected over a specified time interval cannot be extrapolated to large, unsurveyed time intervals. The real value in nesting beach surveys lies in establishing a standardized, repeatable, and statistically rigorous long-term record of nesting activity to monitor population status.

Appendix I
[SAMPLE] Nesting Beach Ground Survey Daily Report Form

Date of Survey ______________________ Beach Name ____

Observer(s) ____

Time Start ____________ AM PM Time End _____________ AM PM

Beach Zone or LAT/LONG	Species 1 (e.g., *Caretta)*		Species 2 (e.g., *Chelonia)*		Species 3 (e.g., *Dermochelys)*	
	#Nests	#False Crawls	# Nests	#False Crawls	#Nests	#False Crawls
A						
B						
C						
D						
E						
F						
G						
etc/						
Total						

Comments

[SAMPLE] Nesting Beach Aerial Survey Data Collection Form

Date of Aerial Survey ____________________ Observer(s) ____________________

Recorder ____________________ Pilot ____________________

Survey Beach Name ____________________

Time Start Survey __________ AM PM Time End Survey __________ AM PM

Type of Aircraft ____________________ Speed __________ Altitude __________

Current Weather Conditions ____________________

Previous 24-Hour Weather Conditions ____________________

Beach Zone or LAT/LONG	Species 1 (e.g., *Caretta)*			Species 2 (e.g., *Chelonia)*			Other
	#Nests	#False Crawls	Total	# Nests	#False Crawls	Total	Strandings, Vessels, etc.
A							
B							
C							
D							
E							
F							
G							
etc/							
Grand Total							

Comments ____________________

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Ground Truth Survey Made ____________________

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