Research and Management Techniques for the Conservation of Sea Turtles
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Aerial Surveys in Foraging Habitats

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One proven method of obtaining at-sea information on sea turtle distribution and abundance is the use of trained observers aboard aircraft. This technique is applicable to sea turtles because they must surface periodically to breathe, and a fraction of the turtles in an area will be on the surface and available for counting at any given time. This fact is well supported by radio, sonic and satellite tracking experiments where surfacing behavior of several turtle species has been documented. The applicability of this technique for population estimation is dependent upon overall objectives, funding levels, area size, target species, turtle size, turtle abundance, observer experience, and a number of other factors.

Theory

Every biologist has at some point been exposed to the concept of sampling to estimate the total population. With aerial surveys, this sampling is in the form of transects through an area during which all sightings are recorded. Sightings from each transect are converted to sightings per unit area and extrapolated to estimate the population for the total study area. In the case of sea turtles, this estimate is for turtles on the surface, not the total population. To estimate the total population, it is necessary to determine the proportion of turtles on the surface and correct the surface densities accordingly.

Two commonly used analytical approaches for estimating the area covered along a transect are line-transect and strip-transect. Both have been used for analyzing aerial survey data; if the distance of each sighting from the transect is measured, either method of analysis can be used for analyzing the data. For additional discussion on the strengths and weaknesses of the two approaches refer to Buckland *et al.* (1993), Cormack *et al.* (1979), and Epperly *et al.* (1995). For a discussion of the analysis of the data, see Gerrodette and Taylor (this volume).

Methods

Aircraft selection is important in planning an aerial survey. A single engine aircraft may be adequate for low budget operations in nearshore waters (within gliding distance of land). Larger twin-engine aircraft are recommended for offshore operations. Plexiglass bubbles on the sides or in the nose of the aircraft providing forward, aft, and downward trackline visibility are essential to meet the assumptions of line-transect theory.

Aircraft should be equipped with a Global Positioning System (GPS) or other navigational system which ideally is interfaced with an onboard laptop computer for continuous position recording. Flight altitude and airspeed should be constant within a study and depend upon primary objectives of the survey and variables such as species of turtle, size, sex, behavior, study area, and a number of other factors. For studies of sea turtles, altitudes should be about 150m (500ft) or less and airspeed should be 150 to 225km/hr.

The perpendicular distance of each sighting from the transect can be determined using clinometers and/or interval marks on plexiglass bubbles, window frames, wing struts, or other fixed aircraft parts. For all sightings, the location, time, environmental parameters, distance from trackline, turtle species, and associated species are normally recorded. The survey team usually consists of two or more observers and a data recorder to ensure constant viewing from both sides of the aircraft.

In theory, the minimum distance between transects is determined by the maximum swimming speed of the target species, so that multiple counts of the same individual do not occur. In reality, however, transect spacing generally relates to practical considerations of how much effort can be devoted to an area to accomplish the overall survey objectives; usually it is available effort that limits the number of transects. To maximize the effectiveness of individual surveys, transect length should be selected on the basis of area to be surveyed, available time, aircraft, and survey objectives. Transects are usually parallel to each other (primarily for logistical reasons) and are perpendicular to gradients (such as depth) that may affect turtle density. The more transects flown, the more accurate the estimation of density, assuming that transects are spaced far enough apart to avoid multiple counts of the same individual.

Environmental conditions influence whether a flight should be conducted. Safety is of utmost importance. Safety equipment, such as a life raft, survival kit, flares, and VHF radio, should be carried on all over-water flights. Survival suits should be standard equipment when flying over cold water. Secondly, sea state influences the ability of observers to detect turtles on the surface and also may affect turtle behavior. Ideally, flights should be conducted only when sea states are less than 0.6m with no or few whitecaps (*e.g.,* Beaufort Sea State -2). Lastly, glare is a confounding factor. Flights should be conducted as close to noon as possible to minimize glare. Researchers should consider issuing polarized sunglasses to all observers to standardize for glare as much as possible.

The ability to determine turtle species depends on observer experience. Experienced observers comment that color, rather than silhouette, is most important in identifying sea turtle species from the air. When a determination of species cannot be made, it is sometimes useful to indicate whether the sighting represents a leatherback (*Dermochelys*) turtle or a hard-shelled species; in this case, the silhouette is diagnostic.

Discussion

Aerial surveys are probably most appropriate when very little is known about turtle distributions and abundance over relatively large areas. In such a case, the aerial survey would be used to determine turtle distribution and abundance and to identify "hot spots" for future in-water studies. Aerial surveys are also appropriate for documenting seasonal or annual variations in distribution and abundance patterns.

Anyone contemplating the use of this technique should carefully consider the types of data that can and cannot be obtained from the air. No biological information *(e.g.,* size, weight, sex, condition, age, growth, tags) can be acquired from aerial sightings. This type of information must be obtained from in-water studies (see Ehrhart and Orgren, this volume) that should be conducted in conjunction with aerial surveys for purposes of ground-truthing. In addition, some level of radio and sonic tracking (see S. Eckert, this volume) is essential to determine the proportion of time spent at the surface by turtles within the study area. The major advantage of aerial surveys rests in the fact that they are a relatively fast way of obtaining a quasi-synoptic picture of turtle distribution and abundance over broad study areas.

Aerial surveys are not something that can be accomplished easily. Observer experience is critical to the success of an aerial survey. Untrained and/or inexperienced observers often have difficulty seeing turtles from an aircraft. Skill in sighting and identifying turtles improves with time, and every effort should be made to ensure that a survey is not dominated by inexperienced observers.

Literature Cited

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