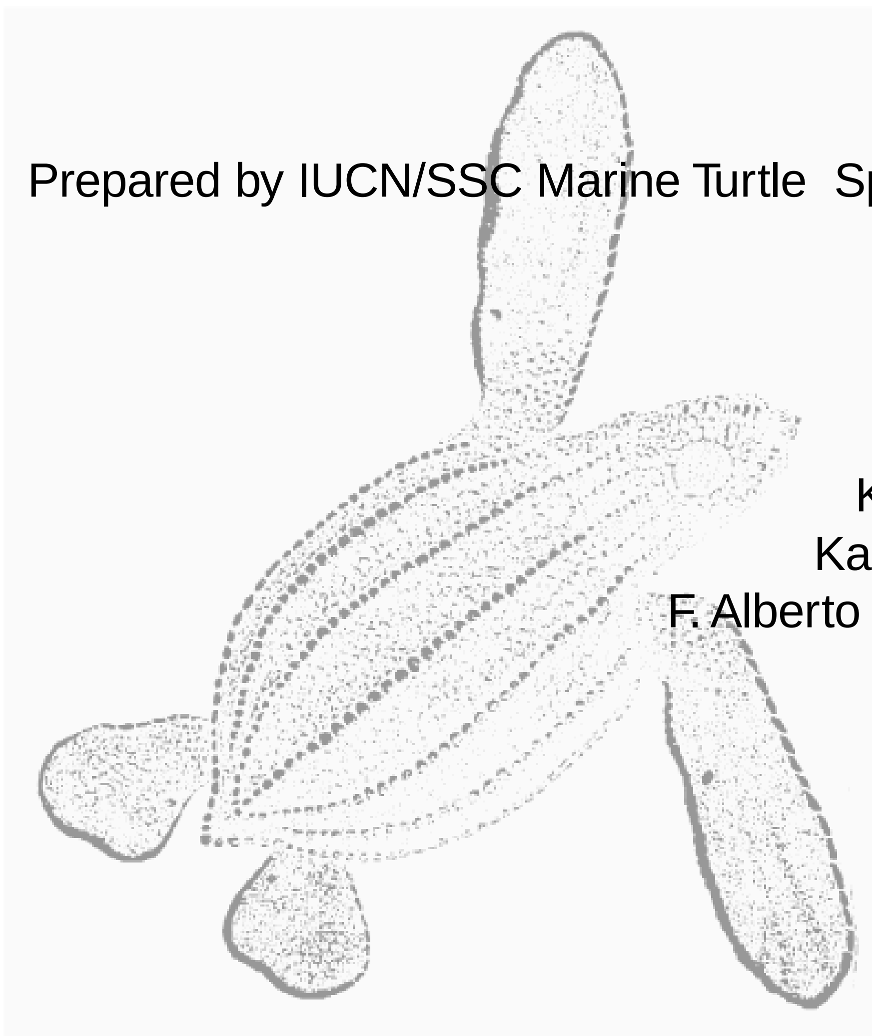
Research and Management Techniques for the Conservation of Sea Turtles



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Preface

In 1995 the IUCN/SSC Marine Turtle Specialist Group (MTSG) published *A Global Strategy for the Conservation of Marine Turtles* to provide a blueprint for efforts to conserve and recover declining and depleted sea turtle populations around the world. As unique components of complex ecosystems, sea turtles serve important roles in coastal and marine habitats by contributing to the health and maintenance of coral reefs, seagrass meadows, estuaries, and sandy beaches. The *Strategy* supports integrated and focused programs to prevent the extinction of these species and promotes the restoration and survival of healthy sea turtle populations that fulfill their ecological roles.

Sea turtles and humans have been linked for as long as people have settled the coasts and plied the oceans. Coastal communities have depended upon sea turtles and their eggs for protein and other products for countless generations and, in many areas, continue to do so today. However, increased commercialization of sea turtle products over the course of the 20th century has decimated many populations. Because sea turtles have complex life cycles during which individuals move among many habitats and travel across ocean basins, conservation requires a cooperative, international approach to management planning that recognizes inter-connections among habitats, sea turtle populations, and human populations, while applying the best available scientific knowledge.

To date our success in achieving both of these tasks has been minimal. Sea turtle species are recognized as "Critically Endangered," "Endangered" or "Vulnerable" by the World Conservation Union (IUCN). Most populations are depleted as a result of unsustainable harvest for meat, shell, oil, skins, and eggs. Tens of thousands of turtles die every year after being accidentally captured in active or abandoned fishing gear. Oil spills, chemical waste, persistent plastic and other debris, high density coastal development, and an increase in ocean-based tourism have damaged or eliminated important nesting beaches and feeding areas.

To ensure the survival of sea turtles, it is important that standard and appropriate guidelines and criteria be employed by field workers in all range states. Standardized conservation and management techniques encourage the collection of comparable data and enable the sharing of results among nations and regions. This manual seeks to address the need for standard guidelines and criteria, while at the same time acknowledging a growing constituency of field workers and policy-makers seeking guidance with regard to when and why to invoke one management option over another, how to effectively implement the chosen option, and how to evaluate success.

The IUCN Marine Turtle Specialist Group believes that proper management cannot occur in the absence of supporting and high quality research, and that scientific research should focus, whenever possible, on critical conservation issues. We intend for this manual to serve a global audience involved in the protection and management of sea turtle resources. Recognizing that the most successful sea turtle protection and management programs combine traditional census techniques with computerized databases, genetic analyses and satellite-based telemetry techniques that practitioners a generation ago could only dream about, we dedicate this manual to the resource managers of the 21st century who will be facing increasingly complex resource management challenges, and for whom we hope this manual will provide both training and counsel.

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Estimating Hatchling Sex Ratios

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Introduction

When confronted with the information that hatchling sex is affected by incubation temperature (see Merchant, this volume), one of the first questions to be asked is, “What is the natural sex ratio of sea turtles?” A second question that soon follows is, “What is the optimal sex ratio, for conservation?” These questions are closely related, and at the present time neither can be easily answered. No one has designed and completed a long-term study that shows whether the manipulation of sex ratio is beneficial or detrimental. Until more information is made available, and in the light of some possible negative consequences of interference (Lovich, 1996; Girondot *et al.*, 1998), for the time being it is assumed that the safest course of action is to maintain natural hatchling sex ratios.

Knowledge of the natural sex ratio of nesting sea turtle populations is an important component of any management plan. Such information provides a baseline against which the effects of certain conservation techniques can be evaluated. These techniques may include: (1) nest relocation elsewhere on the nesting beach or to a hatchery, either of which may be thermally different from the original site (see Boulon, this volume; Mortimer, this volume); (2) limited egg harvest, which may result in the disproportionate removal of one sex from the beach (for instance, by authorizing egg collection only during certain times of the year); and (3) beach renourishment, which may alter the thermal characteristics of a beach by introducing a different type of sand (see Witherington, this volume).

Methods

Estimating sex ratios requires the synthesis of two types of information. First, the sex of the hatchlings must be determined (see Merchant, this volume). Second, data on sex must be combined with information on the nesting patterns of a population. It is necessary to know where the turtles are nesting on the beach, and when they nest, as there is spatial and temporal variation in sand temperature.

Spatial Variation

On a sea turtle nesting beach there may be distinct zones that are thermally different. For example, some zones have vegetation, others do not. Nests laid under dense vegetation are likely to be cooler, and thus produce more males than those laid in the open zone, which are likely to be warmer (cf. Spotila *et al.*, 1987). The distance from the high tide line may affect the depth of the water table, and thus influence temperatures at nest depth. In addition, if a nesting beach is long, all subsections should (ideally) be sampled to account for any thermal variation along beach length. Finally, if the aim is to estimate the hatchling sex ratio of the entire breeding population, then information from all the nesting beaches in the range of the meta-population should be included. Genetic information (see FitzSimmons *et al.*, this volume) is likely to be required to ascertain the extent of the breeding population (note that despite the apparent segregation of females by distinct nesting beaches, these groups of females may still be part of a larger interbreeding population if the males move and mate freely among the different groups).

Temporal Variation

Over the course of a nesting season, which may last several months, there are likely to be changes in weather. For example, rainy seasons can affect sand temperatures at nest depth, which in turn can affect sex ratio. Therefore, a proper estimate of the sex ratio should be based on samples taken throughout the nesting season. In practice, it is often easier to divide up the season into discrete units of time, such as month or half-month periods, and estimate the mean sex ratio for each of those periods *(e.g.,* Godfrey *et al.*, 1996). Also, it is important to remember that individual sea turtles tend to nest every second or third year (or more). Therefore, an estimate of hatchling sex ratios from a single season may represent nest site selection by only a third or so of the total adult population. Ideally, estimates of hatchling sex ratio should be based on data from several consecutive years. Of course, some variation in sex ratios from year to year is to be expected, since weather and nesting frequency are variable. By collecting data on sex ratios from a number of years, it is possible to determine an average hatchling sex ratio. If it is possible to determine sex ratios in only a single year, then it is desirable to consider whether or not that year was thermally typical. Meteorological records can be used for this purpose.

Consider Nesting Frequency

In general, more turtles nest in the middle of the season than at its beginning or end. This change in nesting frequency must be integrated with the information on how sex ratio varies over the season. The aim is to combine sex ratio information for specific periods of the nesting season with data on the relative numbers of nests laid during that same time. For example, a sex ratio profile of a hypothetical nesting beach is shown in Figure 1. The nesting season spans three months, and marks the transition from the dry to the rainy season. The relative nesting frequency in each month is shown on the right, with the majority of the nests being laid in June. The mean sex ratio from several sampled nests laid in each month is also shown on the right, presented in % female. Combining the two sets of data from all three months produces an overall seasonal sex ratio of 57% female. However, if sampling is restricted to one month *(e.g.,* June), then the estimate of sex ratio *(e.g.,* 40% female) would be inaccurate. Also, data from one beach or one year may well not be representative of the average long term population sex ratio (Figure 2). Finally, it may be the case that clutch size or hatching success varies from beach to beach (or over time). If the variation is large, it would be important to take these factors into account when calculating the sex ratio.

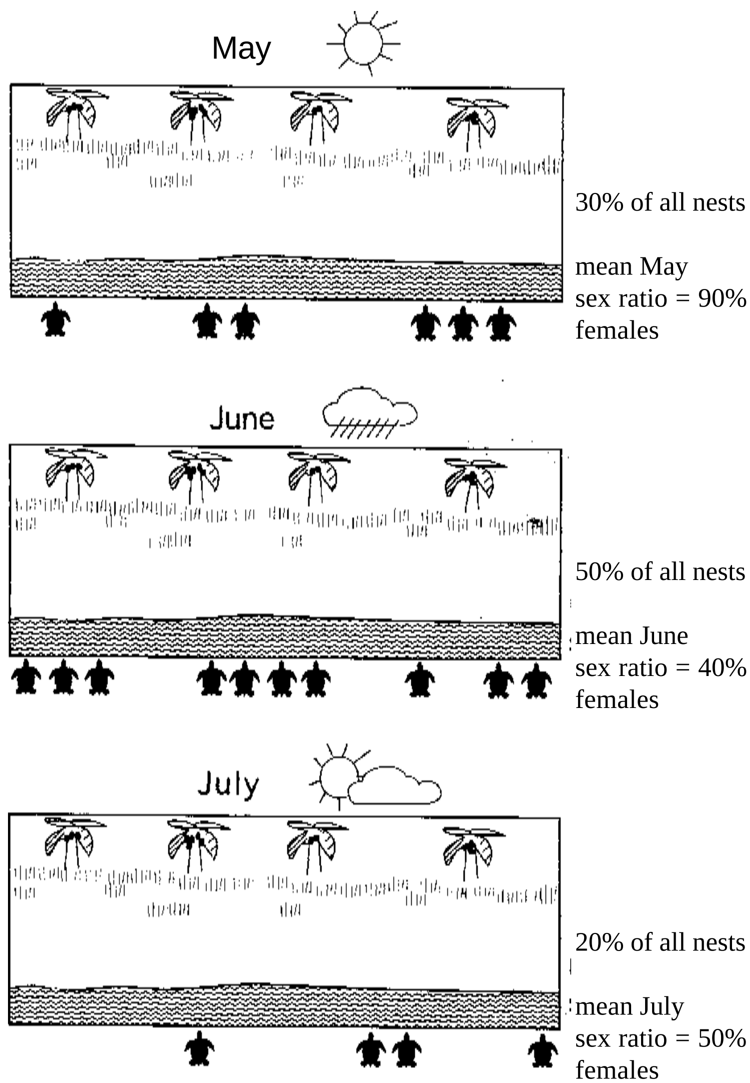

Figure 1. Example of turtle nesting frequency and sex ratio in a single season.

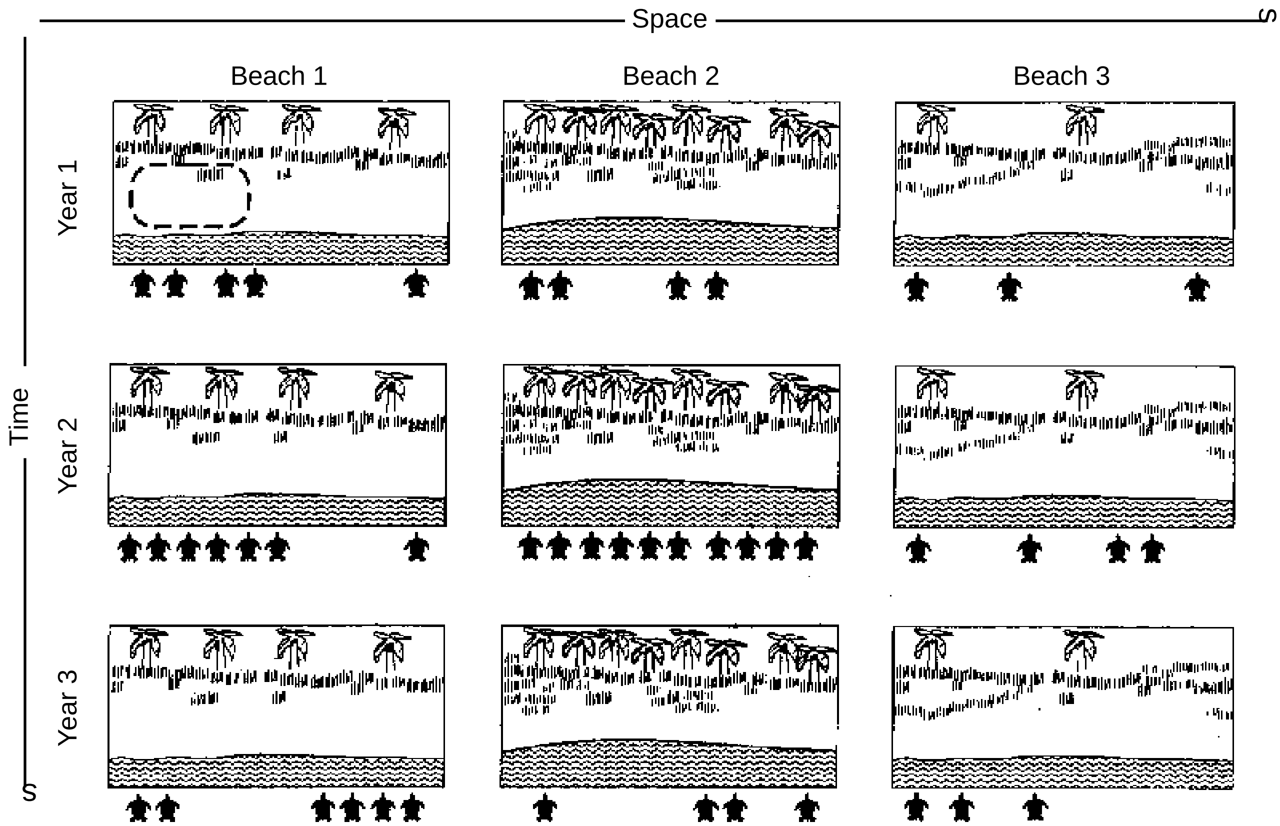

Figure 2. Requirements to constitute an adequate sample. If sampling is confined to one area only (dashed circle at top left), this does not represent the full spatio-temporal variation, or changes in nest density.

Determining Confidence Intervals for Overall Sex Ratio Estimate

In order to facilitate statistical comparison among different beaches or populations, it is necessary to calculate a confidence interval for the overall sex ratio estimate for the nesting population in question. In most cases, the overall estimate will not be based on data from all nests laid during the season(s); rather, it will be based on a sample of nests from a larger population. A good way of determining a confidence interval is to use the bootstrapping technique, which involves computing a large number of estimates by random sampling with replacement from the original set of data. For more detail, see Effron and Gong (1983).

Conclusion

In summary, understanding relationships between temperature and sex ratio on a beach enables protection to be organized in such a way that conserves both sexes. For instance, when relocation of eggs is necessary, it helps managers avoid an undesirable influence on sex ratios. However, measures taken in one place or time should be assessed in the context of the spatio-temporal variation of sex ratio (and nesting patterns) in the population as a whole.

Acknowledgments

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