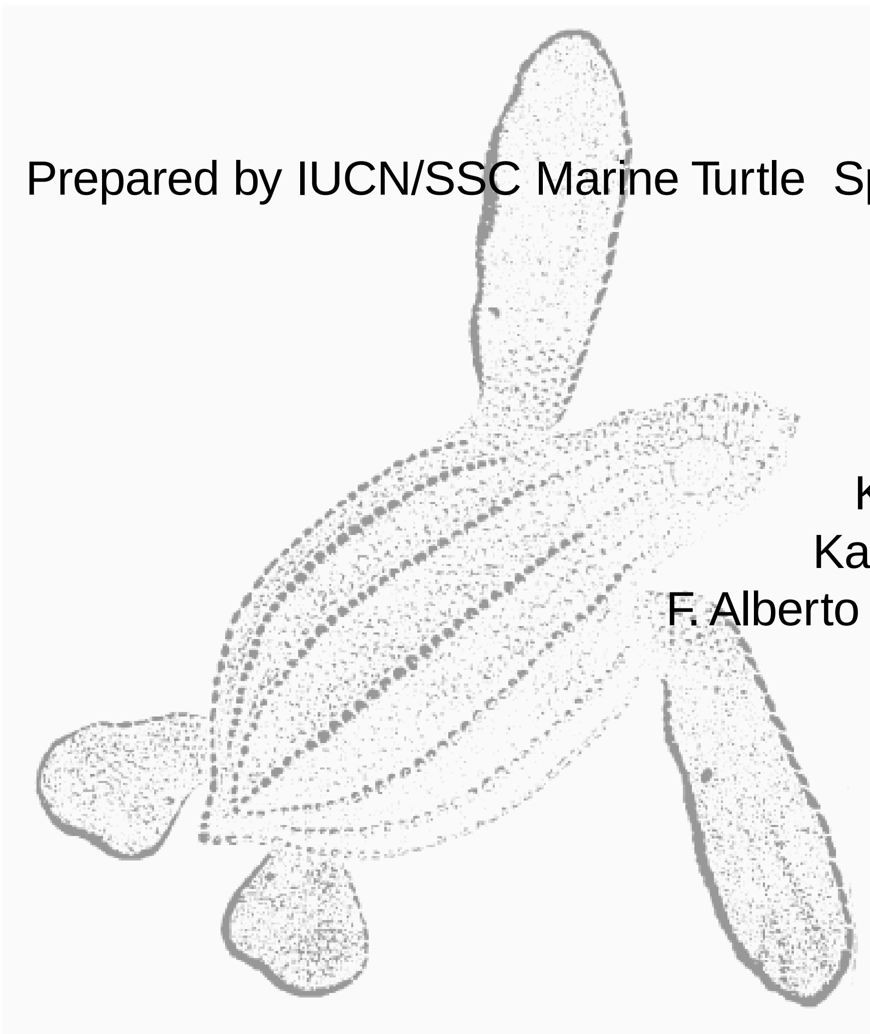
Research and Management Techniques for the Conservation of Sea Turtles



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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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Measuring Sea Turtle Growth

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Studies of growth have played an important part in defining critical aspects of sea turtle life histories, in particular for assessing age to maturity. Growth rates measured in several populations have been used to demonstrate that sea turtles are very slow-maturing and potentially long-lived animals. Turtles are especially suitable subjects for growth research as their size can be determined precisely by measuring the carapace or plastron. However, the elusive nature of free-living sea turtles, especially juvenile and subadult animals, has limited the extent of mark and recapture studies yielding growth data to those species and populations most accessible for research. For example, a considerable amount of growth data has been collected for green turtles (*Chelonia mydas*) in Australia (Chaloupka and Limpus, 1996) and the Bahamas (Bjorndal and Bolten, 1988), but only limited information is available for other species of sea turtles.

Two types of techniques for determining growth in sea turtles can be recognized: direct and indirect. Direct growth measurement consists of determining the size increase of individual animals over time. Because of the long time periods involved with this method, several alternative approaches have been explored that promise to produce results over shorter time periods. These indirect methods yield estimates of past growth rates and include skeletochronology (the examination of periosteal layers in the humerus of individual turtles—see Zug, 1990) and length-frequency analysis of sample populations (Bjorndal and Bolten, 1995). Validation of the growth estimates obtained with these indirect methods, however, requires comparison with direct growth measurements from the population studied. In this chapter we will restrict our discussions to direct techniques of growth measurement and methods of data analysis.

The measurement of growth in sea turtles through mark and recapture of juvenile and adult animals is in principle a simple matter (see Ehrhart and Ogren, this volume, for capture methodology), and much can be achieved with a tape measure or calipers. It is important to recognize that the quality of the growth data to be collected is greatly enhanced by developing and following an appropriate research protocol. Collecting direct growth data requires: (1) the unequivocal identification (tagging/marking) of individual turtles (see Balazs, this volume), (2) the measurement of well defined body structures (see Bolten, this volume), and (3) the re-encounter and re-measurement of marked turtles.

Measuring growth over time consists of determining the difference between two or more measurements. This calculation yields size increment data that are highly sensitive to measurement error. Fortunately, sea turtle carapaces are generally rigid body structures that allow precise measurements to be made. It is important to select unambiguous reference points on the turtle carapace so that measurements can be taken consistently; these points may vary among species.

Most growth studies have used carapace length as the principal measure for assessing turtle body size changes. Straight-line carapace length (SCL) measurements taken with calipers have been shown to be preferable to over-the-curve tape measurements because of their greater precision (Bjorndal and Bolten, 1989). Errors associated with tape measurements may be generated by tape stretch or shrinkage over time, variable tape tension, and interference by barnacles or other epibiota along the measurement path. Inter-observer measurement errors are discrepancies caused by differences in measurement technique between observers; these errors are eliminated when a turtle is always measured by the same person.

An assessment of overall measurement error is easily performed, and the results can be of great value to the interpretation of growth data (see Bolten, this volume). For growth increments to be reliably measured, they should be at least one order of magnitude greater than the measurement error. Given a turtle population for which a rough estimate of growth rate already exists, the *(measurement error)/(growth rate)* quotient can be used to determine an appropriate minimum time interval between captures. Intervals of close to one year (or multiples thereof) are ideal, as this minimizes the possible distortion of growth data by seasonal effects. Because of the generally slow growing nature of marine turtles, growth increment data collected over periods of only a few months should be avoided, unless measurements can be performed under controlled, laboratory conditions.

In practice, measured SCL increments occasionally yield negative values, reflecting actual decrease in measurable turtle length or measurement error. Such negative values should be included in any subsequent analysis, unless the measured size decrease is attributable to physical damage *(e.g.,* scute breakage). In damaged individuals, a size increase can sometimes still be inferred from measurements of unaffected body parts.

Turtle size and growth can also be expressed in terms of body mass. For understanding certain physiological processes, a knowledge of body mass growth rates may be more important than information on linear growth. Body mass of turtles is typically measured by weighing with a spring or platform scale. It should be noted, however, that variation in nutritional status and reproductive condition of turtles generally introduces greater variability in body mass data than in linear size measures.

Once growth increment information has been collected, a variety of analytical methods may be employed to interpret the data. Perhaps the simplest but most insightful of all is the conversion of individual growth increments to growth rates using the formula:

mean annual growth rate = (measurement 2– measurement 1) ÷ interval in years

Likewise, the measurement error associated with each calculated growth rate can be obtained using the formula:

mean growth rate error = measurement error ÷ interval in years

Growth rate information is usually presented for individual turtles (in scatterplots of individual growth rates vs. carapace length) or in tabular form, by individual or grouped by size class.

Model-based approaches assume that the examined turtles all follow similar growth trajectories. Turtle growth patterns can be expressed concisely once the critical parameters of an appropriate model *(e.g.,* von Bertalanffy, logistic, Gompertz) have been determined. The use of models facilitates comparisons of growth patterns between populations by allowing differences between parameters to be detected with standard statistical tests. A technical review of growth rate analyses is presented in Chaloupka and Musick (1997).

Sea turtle growth rates have often been found to be highly variable, even within a single population *(e.g.,* Bjorndal and Bolten, 1988). Growth rates are thought to be controlled by a variety of factors that can be divided in two categories: factors intrinsic to an individual, and environmental factors. Intrinsic factors besides size that are likely to affect growth include the sex, genotype, and health status of individual turtles. Environmental factors include water temperature, food quality and availability, and foraging opportunity. Effects of intrinsic factors can be examined by partitioning the collected growth data into groups of interest and testing for differences between groups. Using this method, Bolten *et al.* (1992) found no significant differences between growth rates of male and female juvenile green turtles in the Bahamas. Determining the environmental factors that influence growth is likely to be a much more complicated process requiring extensive ecological knowledge.

Studies of growth in free-living sea turtles have the potential for yielding valuable insight into the time-scale of developmental processes in these animals, such as time to maturation. Whereas growth rates have now been determined for several green turtle populations, the growth rates in other sea turtle species (and in additional green turtle populations) remains a fertile ground for research. Due to the nature of their subjects, growth studies are necessarily very labor intensive and long-term endeavors. Many different methods for turtle capture, tagging, and measurement are available and determining the most appropriate for a given turtle population at the onset of the study will greatly increase the potential for success.

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