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Tortugas Marinas
Programa para América Latina y el Caribe

Caribbean Hawksbills

An introduction to their biology and conservation status

Didiher Chacón-Chaverri

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Design: Adriana Montanaro Mena

English translation: Lucinda Taft

Cover photograph: WWF Canon / Cat Holloway

This document should be cited as follows:

Chacón, D. 2004. *Caribbean hawksbills – An introduction to their biology and conservation status*.

WWF-Regional Program for Latin America and the Caribbean, San José, Costa Rica.

ISBN 9968-825-27-1

Digital publication available at www.hawksbillwwf.org

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ACKNOWLEDGEMENTS

The author wishes to recognize and reiterate his gratitude to the large number of people and organizations that supported and facilitated the realization of this effort.

To Jack Frazier, Anne Meylan and all the members of the IUCN Marine Turtle Specialists Group who contributed to the preparation of documents used during regional dialogues held by CITES on hawksbills, which were the foundation of this work.

To all the partners of WIDECAST, the Regional Network for Sea Turtle Conservation in Central America, the Caribbean Conservation Corporation and other organizations that cooperated with information and contacts.

Special thanks to Karen Eckert, Carlos Drews, Sebastian Troëng, Alberto Abreu and other anonymous reviewers for their contributions and time dedicated to this initiative.

To the researchers who cooperated with information even when it had not yet been published, my appreciation for their confidence and for the clear demonstration that their objective is to cooperate with knowledge and its dissemination.

To all the people of ANAI and the work colleagues who contributed time, ideas and recommendations.

And finally, thanks to WWF for entrusting me with this task.

PREFACE

This document presents aspects of the biology of hawksbills that are pertinent for their conservation and compiles current information about their nesting and population status in the Caribbean. It is based mainly on the documents generated between 2001 and 2002 by the Marine Turtle Specialists Group of the World Conservation Union (IUCN) during dialogues on Caribbean hawksbills negotiated through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), specifically the works of J. Frazier and A. Meylan. It is also supported by various documents that previously analyzed subject matter associated with this species, such as that of Groombridge and Luxmoore (1989) for the CITES Secretariat, and the special volume of the Chelonian Conservation and Biology journal that was dedicated to a review of this species in 1999. This text was particularly enriched by two articles from that volume, "Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as Critically Endangered on the 1996 IUCN Red List of Threatened Animals" by A. Meylan and M. Donnelly, and "Biology and Status of the Hawksbill in the Caribbean" by A. Meylan and others. This work is intended for readers with a technical interest in population and conservation aspects of this species and a general interest in sea turtles.

Didiher Chacón

Photo: WWF Canon / C. Holloway

SUMMARY

Hawksbills (*Eretmochelys imbricata*) are very complex and specialized marine reptiles. To mature, reach adulthood, reproduce and complete the life cycle, they need a variety of environments, including beaches, open sea, and coastal and estuarine waters. During the normal life cycle, the turtles disperse and migrate; traveling long distances, often thousands of kilometers long, habitually moving between the open sea and the territorial waters of many nations.

Growth rates vary according to size classes and places, but they are sufficiently slow to cause hawksbills to require decades to mature: the time from egg hatching to a turtle's return to the same beach to reproduce for the first time may take twenty to forty years. Under normal conditions, the average hawksbill is capable of living and reproducing for at least ten years after reaching maturity. Their fecundity, or reproductive output, is usually very high: they lay an average of 140 eggs in a single clutch, depositing several clutches per season and nesting for many seasons, though not every year.

Their high fecundity is offset by elevated mortality during the early phases of the life cycle. Many eggs do not survive the incubation period, many hatchlings do not reach the sea and of those that do, many do not survive more than a day. In many ways, turtle survival depends on correct reactions at the right moment and finding suitable conditions in particular environments. This means responding correctly to light on the horizon when emerging from the nest, successfully running the gauntlet from the beach to the sea, avoiding certain bodies of water in the open sea, and choosing a specific environment for food and shelter. After several years of pelagic existence, the immature turtles move to live in benthic waters, where they remain in residence for a limited time, possibly maintaining a territory free of other hawksbills. Upon reaching maturity, they orient and swim toward a specific nesting beach. A large variety of predators may prey on hawksbills in all stages of the life cycle, but the eggs, hatchlings and small immature individuals suffer the most intense predation. From one development stage to the next, the number of turtles remaining in the population grows progressively smaller, and at the end, probably less than one egg in a thousand survives to produce an adult turtle.

Not enough is known about the sex ratio, but females tend to predominate in populations of immatures. There are few studies on age structure, recruitment and survivorship of different phases of the life cycle, but when a turtle attains large size and matures, the survival rate is potentially high, around 95% per year for some nesting females.

The available scientific data on migrations and genetic markers show that hawksbills are shared international resources. Genetic studies also reveal that each nesting population should be treated as a distinct management unit. Those studies, especially when accompanied by tag recovery data from marked individuals, indicate that each nesting population forms an independent demographic entity, genetically isolated from other populations. In contrast, the groups in the feeding zones are mixed stocks, and although the individuals may be found together on the same reefs, they usually represent distinct management units, temporarily united by a common biological activity. Therefore, the management of the nesting populations as well as the non-reproductive assemblages depends on international cooperation.

Surprisingly, many known cases of sea turtle hybridization have occurred with hawksbills. The importance of this fact regarding the evolution of sea turtles or the concept of “biological species” is not known.

Many of the demographic characteristics of hawksbills characterize them as having “late maturation and longevity.” These characteristics include attributes such as the presence of numerous age classes or superimposed generations in the same population, as well as the relatively large number of immature individuals, which are necessary for maintaining a stable population with a relatively small number of adults. This kind of population structure is particularly vulnerable to certain disturbances, in particular to the impact of some human actions that compromise the vitality of the adult population segment, as is the case with directed take.

Photo: WWF Canon / C. Holloway

It is impossible to calculate the absolute size of the populations with any certainty, but throughout the world most hawksbill populations are debilitated and diminishing, often precipitously. In addition to overexploitation of their eggs and meat, their reduction has largely been caused by an ongoing demand for the scutes of their shells, which are used to make craft items. At present, the species is considered to be critically endangered with extinction, according to the World Conservation Union (IUCN). In the Caribbean, with few exceptions, most of the units of the genetic mosaic are in decline. As has occurred with other living marine resources, decimated hawksbill populations are subject to the "shifting baseline syndrome," in which people perceive current population levels as normal, due to the lack of collective memory regarding past population levels. It is believed that the reduction in hawksbill abundance has caused changes in the structure and function of the coral reefs.

Sea turtle conservation poses great challenges for modern societies. Although much has been learned about the biology of these animals in the last fifty years, there are still large gaps in our knowledge. Decisions regarding resource management and conservation are inevitably made with information that is insufficient and fragmented. Nevertheless, we now know that hawksbills travel through the jurisdictional waters of various nations during their migrations and that animals from diverse sources and genetic units converge in feeding zones. Therefore, hawksbill conservation in the Caribbean is a regional challenge that will require multinational coordination and the commitment of diverse players from public and private sectors.

INTRODUCTION

In contrast with the terrestrial medium, marine environments and the organisms that live in them are not easy to observe and study. Many oceanic and coastal animals, including sea turtles, disperse and migrate through diverse surroundings over great distances that cover many jurisdictions. This poses complex logistical and political harmonization challenges for learning more about their biology. Until recently, the perception prevailed among modern societies that the seas and everything living in them were inexhaustible and capable of supporting unlimited human exploitation indefinitely. We now know that the overexploitation of a species can lead to an irreversible condition and affect other species in the ecosystem. In the case of marine species threatened with extinction that constitute shared resources, the complexity of their management is coupled with the need to prepare and implement regionally acceptable conservation plans. The biological characteristics of each species determine the options for their use and, according to each case, provide a framework to direct their recovery and conservation.

Photo: WWF - S. Troëng

The hawksbill (*Eretmochelys imbricata*) inhabits tropical environments of the world. It is a unique case among the sea turtles of today because it has overlapping scutes on the carapace. As occurs with other species of sea turtles, hawksbill eggs, meat and oil are products that have been sought for thousands of years, but it is the coloration and the properties of the keratin in the scutes on the carapace that make this animal very highly prized commercially for the fabrication of handcrafted articles. High demand for their shells has contributed, among other factors, to the critically endangered status of the species today.

Photo: G. Pedersen

Figure 1: Color pattern on the overlapping scutes of the hawksbill.

Many years ago it was determined that hawksbills require special conservation measures. With that background, different societies, cultures and governments of the world have chosen different means for resolving the problems posed by the hawksbill and its conservation. When those solutions are discordant, they block progress toward the recovery of the species. Sometimes misunderstandings occur because the pertinent biological information is fragmented or simply incomplete.

The purpose of this document is to compile and summarize the basic biological information about hawksbills to facilitate a common knowledge base. It is not an attempt to encompass all the aspects of the biology of the species; instead it concentrates on those aspects whose comprehension is indispensable for making decisions that affect their conservation outlook. In order to understand fully how human beings and hawksbills interact, much more than biological data is needed; anthropological, cultural, economic, historic and social information and knowledge are required, among other things. Certain biological aspects should be considered non-negotiable in the coordination of hawksbill management and conservation, regardless of the human interests at play.

The objective of this work is to promote a foundation for dialogue, comprehension, appreciation and, ultimately, improved common objectives and values regarding hawksbills.

NATURAL HISTORY

Globally, hawksbills have a pantropical distribution in coastal waters; they are found in the waters and on the beaches of 82 geopolitical units, and they may occur in another 26 (Baillie and Groombridge, 1996). Nesting occurs on the beaches of at least 60 countries, although mostly at low densities (number of nests/kilometer; Groombridge and Luxmoore, 1989). Important nesting sites include the islands of the Seychelles, the Yucatan peninsula, Mona and Monito Islands in Puerto Rico and some beaches associated with the Great Barrier Reef of Australia, among others. No numerically important nesting zones have been reported in the eastern Atlantic, along the Pacific coast of the American continent, or in the Central Pacific (Groombridge and Luxmoore, 1989; Eckert, 1993; Limpus, 1995a). Hawksbills, like other sea turtles, have a complex life cycle. Although the following description gives a general reference framework, it should be kept in mind that the details of each zone, nesting season and individual can vary significantly.

Like most other species of sea turtles, the hawksbill depends on diverse surroundings for its growth and development, from high energy beaches to benthic reefs, and the open waters of the seas. After attaining reproductive maturity between twenty and forty years of age, the turtles emigrate to feeding and nesting zones. This sometimes means movements of thousands of kilometers in a determined direction, which end with the return of the females to the same beaches or the same zone where they were born, where they themselves nest. Healthy animals are able to survive and reproduce for decades.

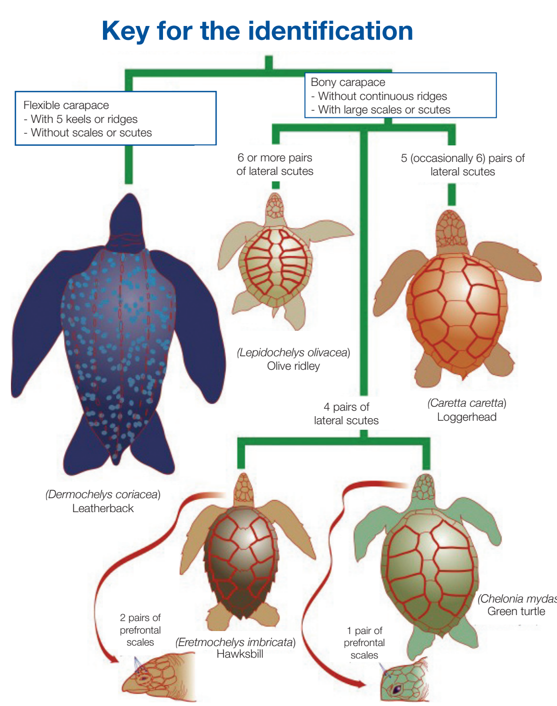
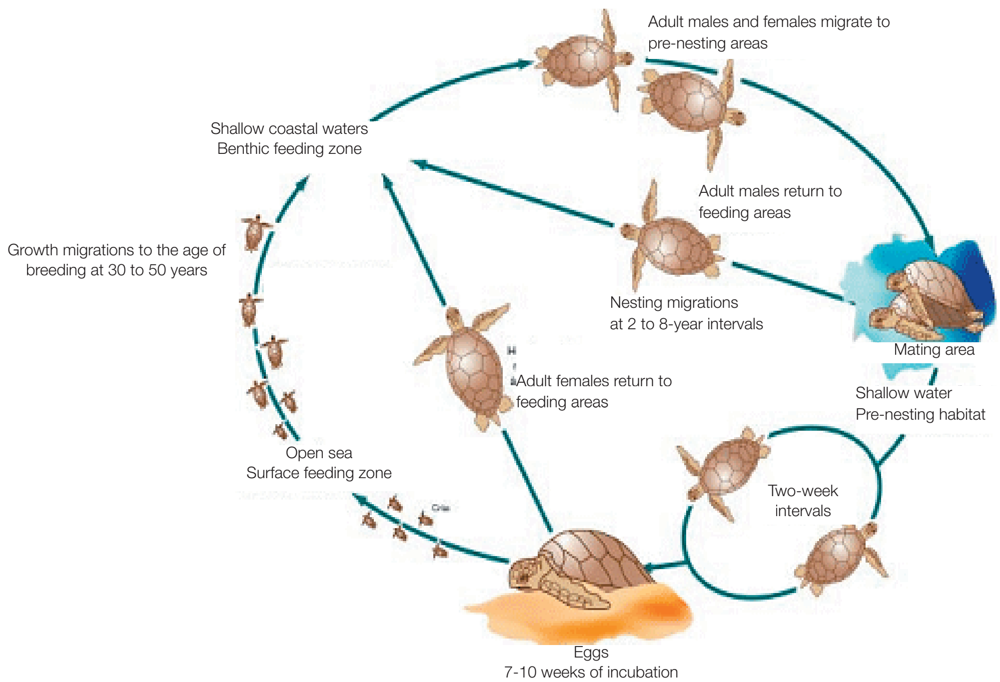


Figure 2: Key for the identification of the hawksbill in Central America.

Apart from a legitimate interest in learning about and appreciating the biology of these animals, certain aspects of hawksbill biology are crucially important for the survival needs of the species. Each one of the specific biological traits summarized below has consequences for the ecology and the demographic characteristics of the hawksbill, and these, in turn, have profound repercussions for the determination of the most appropriate conservation measures. These characteristics exist and persist independent of human motivation or action; in other words, so that the interaction between human beings and the turtles endures and becomes sustainable, these are non-negotiable aspects that must be appreciated, understood and taken into account.

Figure 3: Generic life cycle of the hawksbill, based on Miller (1997) and Chacón (2002).



GENERALITIES OF THE HAWKSBILL LIFE HISTORY

- Hawksbills can be included in the category of animals with “late maturation and longevity.”
- Hawksbills probably require more than twenty years to reach sexual maturity.
- An adult may survive and reproduce for at least ten years.
- The survival of each individual depends on diverse habitats: terrestrial (beaches), open sea, coastal waters and reefs.
- Their main foods are sponges on coral reefs.
- During its life, an individual probably travels thousands of kilometers, visiting the territories of various nations as well as the open sea.

NESTING

After mating, each female leaves the sea, crawls up on a sandy beach and finds a place above the tide line to nest. Usually, hawksbills nest within or below the terrestrial vegetation. A female may make more than one attempt to dig a nest before successfully laying her eggs in a chamber at least 10 cm below the sand surface and up to 90 cm deep. Each egg weighs around 25 grams and the average clutch has around 140 eggs (occasionally up to 250 eggs); these values are very specific for each nesting colony. After covering the nest and passing one to two hours on land, the turtle returns to the sea. At approximately fifteen-day intervals, the same female nests again, usually on the same stretch of beach. This process will be repeated until her energy reserves for this nesting season are depleted, and she will have deposited at least two and perhaps as many as eight clutches of eggs. There is no parental care: the female leaves the eggs to incubate alone on the beach. After depositing all her egg clutches for the season, the female migrates back to the feeding zone, and she will remigrate to the beach usually at two to three year intervals, although the internesting period may last up to eight years. These migrations between the feeding and reproduction zones continue for the rest of their lives, which may last several decades.

EARLY DEVELOPMENT

The time required for development up to eclosion depends mainly on temperature, and varies from seven to ten weeks (50-70 days, normally). Incubation temperature also determines the sex of the embryos. For this species Ackerman (1997) determined that above 29.32 oC, mostly females are produced, and below this temperature, most become males. After eclosion, the newly hatched turtles ("hatchlings") may need several days to dig out and emerge from the nest, which usually occurs at night when the ambient temperature is lower. Once they are on the beach surface, they crawl to the sea and swim away from the coast. During the time they are on land, the eggs/embryos/hatchlings may be preyed upon by many predators (fungi, bacteria, crabs, a variety of birds and mammals, among others) or subject to other sources of mortality, such as compaction or erosion of the beach where the eggs were deposited. To exit the nest and reach the sea as quickly as possible, the hatchlings must make a series of innate, non-learned responses to diverse stimuli. Simplifying various complex behaviors, it can be said that, with no prior experience, each hatchling

Photo: G. Pedersen

Figure 4: Hawksbill hatchlings emerging from the nest at dawn, Bay Islands, Honduras.

Table 1: Months of hawksbill nesting in the Caribbean Sea*

Nations/Months	J	F	M	A	M	J	J	A	S	O	N	D
Anguilla					■	■	■	■	■	■		
Antigua and Barbuda						■	■	■	■	■	■	
Aruba							■	■	■	■		
Bahamas												
Barbados					■	■	■	■	■	■		
Belize					■	■	■	■	■	■		
Bermuda												
Bonaire					■	■	■	■	■	■		
British Virgin Islands (UK)								■	■	■	■	
Cayman Islands					■	■	■	■	■	■		
Colombia					■	■	■	■	■	■		
Costa Rica					■	■	■	■	■	■		
Cuba												
Dominica												
Dominican Republic												
Guadalupe					■	■	■	■	■			
Guatemala						■	■	■	■			
Haiti												
Honduras						■	■	■	■			
Jamaica												
Martinique												
Mexico				■	■	■	■	■	■	■		
Montserrat						■	■	■	■	■		
Netherlands												
Nicaragua					■	■	■	■	■	■		
Panama				■	■	■	■	■	■			
Puerto Rico												
St. Kitts and Nevis												
St. Lucia												
St. Vicente and the Grenadine												
Suriname					■	■	■					
Trinidad and Tobago												
Turks and Caicos				■	■	■	■	■				
United Kingdom												
United States												
US Virgin Islands (US)												
Venezuela					■	■	■	■	■	■		

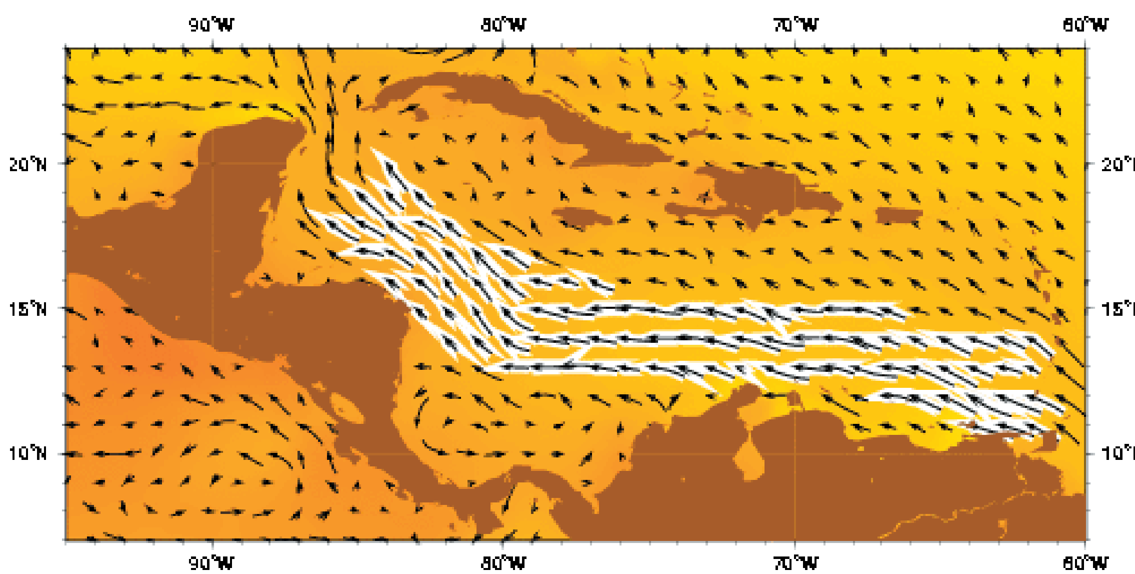
* This table was prepared with information from: I. Alvendas, W. Kratz, M. Aronne, C. Ordóñez, Y. León, C. Lagueux, C. Campbell, W. McCoy, H. Guada, M. Garduño, V. Guzmán, J. Gumbs, J. Horrocks, P. Mason and E. Delroix, and Godley *et al* (2004).

digs itself out against gravity to the upper part of the nest, and remains inactive in the upper layers there if the temperature encountered is too high. Upon emerging, it orients itself on the beach, moving toward that part of the horizon where the light is most intense, generally light with the shortest wavelengths; at the same time, it moves away from objects and certain classes of shapes that can be distinguished on the horizon.

Upon reaching the water, each hatchling enters the breaking waves and immediately attempts to cross them. Once they are past this zone, they swim toward the open sea, generally against the waves. Evidently, the hatchlings can detect the direction of wave generation along their bodies with orbital movements, which allows them to orient into the waves when they are on the surface or under the water, even in complete darkness. After moving away from the coast toward the open sea, the hatchlings tend to maintain the same direction they took when leaving the beach, even if the angle of wave generation is not the same as when they began their journey. Apparently, in the initial stages of departure from the beach, the hatchlings can use the earth's magnetic field for orientation. The magnetic heading they choose when well out to sea is obviously influenced by the direction they took when they left the nest and swam toward the sea, orienting themselves by light stimuli, the waves, or both (Lohman *et al.*, 1997). Once they are in the oceanic currents of the open sea, the hatchlings can disperse and take refuge in floating mats of materials in the sea (*Sargassum*, for example; Bjorndal, 1997; Luschi, *et al.* 2003).

Clearly the turtles spend several years in the open sea, a time when some species are dispersed around the marine basins, circulating in the oceanic gyres. However, little is known about this pelagic phase of the hawksbill life cycle, which is also known as "the lost year."

Figure 5: Map of the Caribbean zone showing directions of marine currents (Image courtesy of G. Samuels, RSMAS).



BENTHIC GROWTH PHASE

When the carapace has reached a length of some 20 cm, in the Caribbean region at least, immature hawksbills begin to appear in coral reef zones, known as "developmental habitats." The turtles take residence there, clearly establishing an area in which they feed and find shelter. The move from pelagic to benthic waters involves a significant change in habits, especially in the diet. Hawksbills have a bird-like beak, which they use to bite and extract soft invertebrates from the reefs. In many places, their diet consists of certain sponges, which presumes the systematic ingestion of toxins and glass spicules (Meylan, 1988). With the exception of several very specialized coral reef fish (for example, the clown fish, *Amphiprion sp.*), no other vertebrate is known to be able to tolerate a diet this toxic. In some regions, particularly in the Indian Ocean, hawksbill meat is very poisonous to human beings, but the nature of the toxin involved is unknown.

AGE AT MATURITY

No reliable methods for calculating sea turtle age are available, apart from long term mark-recapture studies, or cross-sectioning of the humerus (Bjorndal and Zug, 1995); therefore, ability to determine age is very limited. Attempts have been made to calculate the age of maturity by examining the gonads. Of 6,879 females captured in Cuba's fisheries, 1.5% of the animals as small as 51-55 cm SCL (straight carapace length) had enlarged ovarian follicles, and it was assumed that all the animals of at least 81 cm SCL were sexually

Figure 6: Typical size of a pelagic stage juvenile hawksbill.

Photo: G. Pedersen

mature (Moncada *et al.*, 1999). However, detailed laparoscopic analysis of the gonad structure combined with reproduction data on different individuals indicated that the presence of enlarged follicles did not precisely predict sexual maturity in all the turtles. Some individuals can have gonads that appear mature morphologically, but they may not reproduce until several years later (Limpus, 1992a).

Although most nesting hawksbills have a carapace length of at least 75 cm (78.6 cm according to Miller (1997) for 15 populations studied, with a standard deviation of 1.7), several studies report nesting females with carapace lengths of 60 cm or less (Puerto Rico: Thurston and Wiewandt, 1976; Solomon Islands: McKeown, 1977; Sudan: Hirth and Abdel Latif, 1980; Cuba: Moncada *et al.*, 1999; Sabah, Malaysia: Pilcher and Ali, 1999; Saudi Arabia, Persian Gulf: Pilcher, 1999). Observations of minimum size or calculations of the average size of nesting females have often been used to deduce and generalize whether individuals that have not yet reproduced are sexually mature or not (Moncada *et al.*, 1999). Detailed long term

Figure 7: Juvenile hawksbill.

Photo: D. Chacón

studies carried out in the Southern Great Barrier Reef (SGBR) of Australia reveal that a large number of hawksbill do not begin to reproduce until they have attained a size considerably larger than the average body size of nesting females (Limpus, 1992a). This phenomenon has been described for other species of sea turtles, and several investigators have warned that it is deceiving and even risky to use body size as the only indicator of maturity (Limpus, 1992a; Limpus *et al.*, 1994a and 1994b; Chaloupka and Musick, 1997; Dobbs *et al.*, 1999;). The problems with determining maturity based on gross information about condition and body size are not unique to research on sea turtles, but they reflect some of the limitations that experts face when trying to determine management measures.

Growth data from studies on individuals tagged and recovered in the SGBR indicate that adults "are several decades old" (Limpus, 1992a), and this is consistent with prior research on increases in size of immature hawksbills carried out in other regions. In the Caribbean, data on growth rates of immature individuals have been used to extrapolate the number of years needed to exceed the size of the small immatures when they are first found in benthic environments, to the average size of the nesting turtles observed in the nearest colonies. Based on average growth rates observed in populations that feed in the U.S. Virgin Islands (USVI), Boulon (1994) calculated that after reaching the average size of immature individuals when they are first seen in benthic areas (SCL 21.4 cm), they turtles may require 16.5 to 19.3 years more to reach the average nesting female size. Similarly, Diez and Van Dam (1997) estimated an average of some 20 years to reach maturity from the time when immatures of 20 cm SCL first appear in the benthic waters of Puerto Rico. This estimate took differences and variability in growth rates between size classes into account, as well as the fact that immature hawksbills in the feeding zones apparently consist of mixed populations. It is clear that a complete calculation of age at maturity would have to include the time needed for the growth from hatchling size (some 4 cm SCL in the Caribbean) to the size of immature individuals when they are first seen in the benthic environments, around 20 cm SCL in the Caribbean; however, this phase of the hawksbill life cycle in the natural environment is practically unknown.

In summary, population models for hawksbills have calculated that they reach sexual maturity between 20 to 40 years of age (Boulon, 1983 and 1994; Limpus, 1992a; Chaloupka and Limpus, 1997, Mortimer, 1998). Crouse (1999) reviewed information on age at maturity for Caribbean hawksbills and concluded that after attaining a carapace length of 20 cm and taking residence in the benthic feeding zones near the coast, they may need 16 to 20 years to attain sexual maturity. Other authors, based on gonad condition and body size, have hypothesized that smaller females in Cuban waters that have reached maturity may be around 10 years old, but the average age when 100% of the females have matured is closer to 20 years (Moncada *et al.*, 1999). Even if the lower value for age at maturity is correct, when compared with other species of marine animals, a 10-year old adult hawksbill can still be considered an animal with slow maturation.

FECUNDITY

Various measurements are essential for elucidating sea turtle fecundity, or "reproductive output." In ascending chronological order, these are: clutch size (number of eggs deposited in a single nest), number of clutches per season, interval between nesting seasons ("remigration interval") and length of reproductive life. The basic values on hawksbill fecundity that have been reported are variable, even when error occurring in data collection is discounted, including in simple egg counts (Cruz and Frazier, 2000) and in subtle differences in the interpretation of these values.

Clutch size

Hawksbill clutches tend to have more than 100 eggs, and the largest clutches documented for any turtle –250 eggs– occur in this species (Witzell, 1983); clutches with more than 200 eggs are not unusual (Frazier, 1993; Chan and Liew, 1999; Dobbs *et al.,* 1999; Pilcher and Ali, 1999; Richardson *et al*., 1999, Chacón 2003). In contrast, clutch sizes reported for the Persian Gulf are considerably smaller, with an average of only 87.3 eggs (Pilcher, 1999). Hawksbills that nest on the Arabian Peninsula (the Red Sea and the Persian Gulf), often lay unusually small eggs without yolks, such that the number of viable eggs in the clutch is lower than the total clutch size (Frazier and Salas, 1984; Pilcher, 1999). This phenomenon is unknown, or very infrequent, in other parts of the geographic distribution of the species; however, Dobbs *et al.* (1999) report that 2% of the clutches on Milman Island (Australia) have up to five yolkless eggs per clutch.

Surprisingly, in the case of hawksbills nesting on the Yucatan Peninsula, there are indications that egg fertility (determined by visible embryonic development) is inversely proportional to clutch size. Therefore, it is possible that there is no direct correlation between gross measurements of fecundity (clutch size, for example) and other basic ecological values for understanding the demography of these animals (Frazier, 1993).

Clutches per season

The number of clutches per female per season can vary from one to eight (Chan and Liew, 1999; Dobbs *et al.*, 1999; Pilcher and Ali, 1999; Richardson *et al.*, 1999), and the average usually ranges from two to five (cfr. Witzell, 1983; Chan and Liew, 1999; Mortimer and Bresson, 1999). In general, higher average values have been reported when there have been long term monitoring activities with complete coverage of the nesting beach.

This means that if the empirical value depends, for example, on repeated observations of marked females on the study beach, it is susceptible to the intensity of the monitoring effort at the place.

Sometimes relatively low average values are reported, for example, from two to three clutches per year; incomplete coverage of nesting activities underestimates the nesting effort of individually tagged turtles (Dobbs *et al.*, 1999). "Internesting interval" (the average length of time between two consecutive nestings in the same season) is usually used to calculate the number of clutches per season. When the number of clutches per individual per season has been calculated based on general records from a season (not on individual observations), the values reported tend to be extremely low (Garduño-Andrade, 1999). One of the highest average values – 4.5 clutches per individual per season – comes from Jumby Bay (Antigua), where a meticulous eleven-year research effort has focused on "exhaustive, almost saturation tagging", identifying almost 100% of the animals that nest there each season (Richardson *et al.*, 1999). This suggests that low monitoring intensity on the beach probably underestimates the number of clutches per female. Calculating the number of females from the total number of nests and number of clutches per female creates a bias that in turn, overestimates the total number of nesting females. Possible sources of error must be taken into account when making inferences about population size on a given beach, one of the topics that complicates the generation of comparable information that is useful for estimating population tendencies.

Figure 8: Hawksbill eggs recently deposited in the nest.

Photo: G. Pedersen

Remigration interval

The term "remigration", coined by sea turtle biologists, refers to a return migration from the feeding zone to the nesting zone that an individual makes after having nested in a prior season. The interval between nesting seasons (or "remigration interval") for hawksbills is generally two to four years (Witzell, 1983), but it can vary from nine months (Pilcher and Ali, 1999) to at least ten years (Mortimer and Bresson, 1999); these values assume observation coverage of the population so reliable that no sightings of an individual are missed during a particular nesting season. These observations also depend on the identification of individuals, which is normally based on the recapture of tagged animals, so tag loss and efficacy of coverage on the nesting beach must be taken into account (Dobbs *et al.*, 1999; Pilcher and Ali, 1999; Balazs, 2000). Given that it is easier to document short intervals, there is a tendency to miss or overlook the longest intervals, and to calculate underestimated averages. For example, the use of techniques that increase the chance of identifying marked individuals –even when a tag has been lost– make the observation of particularly long remigration intervals of eight years or longer possible (Mortimer and Bresson, 1999). The population mean, based on the average mean interval for each individual, was 2.69 years for Jumby Bay in Antigua. Although this result was obtained after an eleven-year study that assumed exhaustive tagging, it was still considered to be an inadequate estimate (Richardson *et al.*, 1999). However, there is significant biological variation in this parameter. The average remigration interval determined for Pulau Gulisaan, Sabah (Malaysia) was 1.8 years, and it has been reported that some turtles return to nest after only six months while others return after at least seven years (Pilcher and Ali, 1999).

Reproductive life span

The eleven year study at Jumby Bay (Antigua) yielded an average of 4.5 clutches per season, with a high statistical mode of five clutches per individual. With an average clutch of 155 eggs, the reproductive contribution per season of a single female is calculated at 697.5 eggs, using the average number of clutches per individual; taking into account the modal number of clutches, the estimate was 775.0 eggs per female per season. Considering an average remigration rate for the population of 2.69, median annual individual fecundity is calculated as 228 eggs/female/year. It was also estimated that fecundity for the lifetime of a female (which would survive 8.1 years of non-annual nesting) would be 3,108 eggs (Richardson *et al.*, 1999).

At least one long term study conducted on Cousin Island (Seychelles) showed that return nesters nest appreciably more times per season than females that have not nested previously (Mortimer and Bresson, 1999). Therefore, it can be assumed that annual fecundity increases after the female hawksbills have nested for the first time, and that they have better nesting results as they acquire more experience.

SURVIVORSHIP AND MORTALITY

Very little systematic information is available on hawksbill survivorship, and it is mostly limited to eggs and hatchlings in the nests. The values for the eclosion index (percentage of the clutch that survives to eclosion) as well as the emergence index (percentage of the clutch that survives to emergence from the nest), can vary enormously from one beach to another and from one nesting season to another, and even on the same beach during the same period, because of natural variation in environmental conditions even on geographically small coastal sections. However, for “natural” nests (those that remain *in situ*), the average eclosion index tends to exceed 80%, and the emergence index is not much lower (Witzell, 1983; Frazier, 1993; Dobbs *et al.*, 1999; Richardson, Bell and Richardson, 1999; Chacón 2002 and 2003). When some anthropic and natural threats make it necessary to move the eggs to sites that are “safe and monitored” as a conservation measure, it is the opinion of some authors that the eclosion values are lowered, sometimes considerably, leading to recommendations for *in situ* conservation (Frazier, 1993; Marcovaldi *et al.*, 1999; Mortimer, 2000).

It is likely that the hatchlings suffer relatively high mortality in the sea, but to date, there have been no systematic studies for hawksbills. It is estimated that up to 30% of the hatchlings released from the incubation station of Pulau Gulissan, Sabah (Malaysia) fall prey to marine predators in a radius of ten meters around the island, and it is believed that the main predators are bony fish and sharks (Pilcher and Ali, 1999). Results from the Jumby Bay (Antigua) study, which was based on exhaustive marking for eleven years, indicate an annual loss of 6% of the nesting females, or an annual survival rate of 0.94. Annual survivorship of seasonal cohorts varies from 0.93 to 0.96, and although the difference between these values seems small, it has important consequences for demographic models. Although this detailed research was carried out for more than a decade, it should be continued to understand better the annual survivorship of nesting females in that zone (Richardson *et al.*, 1999). However, the estimates from the Jumby Bay study show that, for a population to remain stable, the average nesting female not only must survive to the age of sexual maturity, she must also reproduce for at least nine more years. Given that some females of the population will die before making the average reproductive contribution, those "premature deaths" must be compensated by other females that survive and reproduce for a period considerably longer than nine years. It is probable that some members of the population survive fifty years or more (Richardson *et al.*, 1999). It can also be noted that the values for mortality and other variables used in the demographic models are particular for each site, given that the magnitude of the threats and the impacts that affect these parameters are different in each place.

The basic information available about the hawksbill biological cycle only allows the calculation of speculative demographic models (Crouse, 1999). However, based on the best models available for sea turtles, it can be said that high annual survivorship

Photo: WWF Canon / G. Marcovaldi

of immature benthic individuals and large adults is needed to maintain a stable population (Heppell *et al.*, 1995).

Predation

There is abundant evidence of predation on sea turtles in different stages of their lives by diverse animals. However, observations of this are incidental and, as such, incomplete and not systematic. On the beach, hawksbill eggs and hatchlings can be preyed upon by different animals, especially insects (for example, ants), crabs (ghost crabs, *Ocypode* spp., and hermit crabs, *Caenobita* spp., for example), alligators, birds (a large variety) and mammals (a large variety; in Cahuita, Costa Rica, the most common mammal predators are *Spilogale putorius, Procyon lotor* and *Nasua narica*; Stancyk, 1982; Witzell, 1983; Chan and Liew, 1999; Dobbs *et al.*, 1999; Pilcher and Ali, 1999). Predation of hatchlings during their transit from the beach to the sea can be intense, by sea sharks, bony fish and marine birds (Stancyk, 1982; Dobbs *et al.*, 1999; Pilcher and Ali, 1999). Even adult turtles can be attacked by tiger sharks (Galeocerdo cuvieri) and bull sharks (*Carcharhinus leucas*; Stancyk, 1982).

RECRUITMENT

Very little systematic information is available on recruitment rates for any of the hawksbill life stages. León and Diez (1999) indicate that the high density of immature hawksbills and the near total absence of adult size animals at their study site in Jaragua de Cabo Rojo National Park, Dominican Republic (J/CRNP; see the location at www.hawksbillwwf.org), may be evidence that hawksbills use different developmental habitats in different phases of their life cycle. These results are comparable with those of Limpus (1992a) from the Great Barrier Reef. Decades ago, sea turtle biologists discussed the idea of developmental habitats, which is a widely accepted explanation in the hawksbill biological cycle and other species of sea turtles (León and Diez, 1999).

Therefore, knowledge about recruitment is complicated by the fact that there are many vital phases and each one assumes different ecological conditions. The previously cited results from the Jumby Bay (Antigua) study indicate that, each year, from 13.3% to 25.6% of the annual nesting females are new individuals, and that the annual recruitment rate (for reproductive females) is 9%. In general, it has been calculated that less than one egg per thousand survives to become a reproductive adult (Richardson *et al.*, 1999).

AGE STRUCTURE

Available systematic information on age structure in hawksbill populations is also scarce. According to the work of Limpus (1992a), only one of 109 turtles captured on the Great Barrier Reef (SGBR) was mature. In this study it was argued that this zone had not been subjected to exploitation recently and therefore it was concluded that the age structure was “natural.”

León and Diez (1999) found surprisingly dense assemblages of immature hawksbills, but a near total absence of adult size animals, in determined sites of Jaragua de Cabo Rojo National Park (J/CRNP). In contrast, other feeding zones in the Caribbean have immature and adult individuals (Cahuita National Park in Costa Rica, for example). Using these data and various reports on dispersed nests, as well as the carcasses of adult turtles found on the sandy beaches in J/CRNP, León and Diez (1999) determined that this had been an important nesting site in the recent past. The absence of adults in the park led the authors to conclude that this was due to intense (illegal) exploitation of the nesting animals. However, the extreme difference in habitats and feeding habits that separate immature and adult individuals of the zone can not be dismissed.

It is interesting that similar findings of immature hawksbill concentrations in the SGBR and J/CRNP give rise to two very different explanations. Although this may reflect the diversity of situations in which this species is found, it may also be because Limpus (1992a) could have overlooked where the animals live during each phase of their life cycle. Although the specific areas mentioned by this author may be free of exploitation, this does not mean that the populations that live in the vast areas of the reef are also free from exploitation. If their maturation assumes propagation in other developmental zones, the immature hawksbills of the SGBR may well be able to migrate to waters where they are the victims of intense exploitation, which would probably have important repercussions on the situation at the SGBR. This is further evidence of the limitations that biologists confront in designing models for making well-founded decisions.

COMPOSITION BY SEX

As has occurred with other species of sea turtles, few studies have been made on sex distribution in hawksbills. Limpus (1992a) made laparoscopic exams of the gonads of 109 specimens from the SGBR of Australia; with only one adult animal, this sample yielded a ratio of 2.57:1, significantly favoring females.

León and Diez (1999) investigated a group of immature turtles in the J/CRNP of the Dominican Republic, using testosterone analysis of the blood serum. They also reported that there were almost three times as many females as males, in a ratio of 2.71:1. Records from the Cuban hawksbill fishery indicate that from 1983 to 1997 the catch was predominantly females, with ratios commonly exceeding 4:1 (Carrillo *et al.*, 1999; CITES National Authority-Cuba, 2001). In contrast, a slight tendency favoring males was found at Mona Island (Puerto Rico) in a study based on laparoscopic observation of the gonads (Diez and van Dam, in León and Diez, 1999). On the other hand, Diez and van Dam (2003), found a 1:1 sex ratio using testosterone analysis on a sample of 120 individuals.

Although female-biased sex ratios are well known in other species of sea turtles, these results raise questions about whether or not hawksbill populations usually have excess females, or if the males and females have very different habits that make the females more vulnerable to capture.

One global issue is the precision of the information itself. In all studies on non-reproductive sea turtles based solely on external morphology, there is always doubt about the degree of precision in sex determination: a male without secondary sexual characteristics is impossible to distinguish from a female. The criterion of "minimum reproductive size" is also not reliable for classifying an animal as mature, because a large proportion of hawksbills can reach sexual maturity after attaining a size "considerably larger than the average reproductive size" (Limpus, 1992a). On the other hand, tail length of some nesting females may be misinterpreted as a masculine trait (Dobbs *et al.*, 1999). Examination of the gonads and concentrations of testosterone in the blood do not have these problems (Wibbles *et al.*, 2000).

RESIDENCE AREAS AND TERRITORIALITY

Decades ago it was discovered that hawksbills take up residence in feeding zones (Thurston, 1976; Frazier, 1984). Limpus (1992a) tagged 205 animals in the SGBR of Australia, 30 of which were reencountered at Heron Island. Based on new sightings, he concluded that the hawksbills take up residence on a particular reef, but they do not easily take residence on new reefs where they have been relocated.

In more detailed studies, the exact positions of hawksbills tagged on specific reefs were determined. The distance between subsequent captures of immature individuals at Mona Island (Puerto Rico) averaged 0.45 km (S.D.= 0.66 km; Van Dam and Diez, 1998). In J/CRNP of the Dominican Republic, the information obtained from the recovery of 34 individuals gave an average of 204.4 days (S.D.= 141.0, range 45-571) between capture events; the distance between the first and last capture varied from 0.60 km to 1.55 km, with an average of 0.36 km (S.D.= 0.32 km; León and Diez, 1999). Due to the site fidelity shown by immature hawksbills, León and Diez (1999) concluded that it would be important to protect feeding zones with high densities of individuals over the long term, as a mechanism for sustaining the population base.

Studies on reproductive females at Buck Island (U.S. Virgin Islands) indicate that these turtles take up temporary residence between nesting events in certain shallow water zones, up to a maximum of 3 km from their nesting beaches. But when a female finishes nesting, she leaves the zone adjacent to the nesting beach (Starbird *et al.*, 1999), presumably to return to her usual residence zone outside the reproductive period.

Along with the evidence from different sources about feeding site fidelity, there are some indications of territoriality in hawksbills. Underwater observations made in different places, such as the SGBR of Australia (Limpus, 1992a) and Fernando de Noronha in Brazil (Sánchez and Bellini, 1999), show that these turtles are habitually solitary, whereas other species such as green turtles (*Chelonia mydas)* are often found in small groups.

MIGRATIONS

Based on partial studies with small sample sizes, it was once thought that hawksbills were not migratory, and possibly even sedentary, but this opinion has been refuted by numerous investigations carried out in different places. In this context, one problem has been considering the absence of information as equivalent to negative information, along with the small sample size that has been worked with for decades. For example, in a forty-year period, 2,500 hawksbills were tagged in the Caribbean whereas nearly the same number of green turtles (*Chelonia mydas*) was tagged during a single nesting season on one of their main nesting beaches (Meylan, A. B., 1999a). This, obviously, largely reduces the chances of obtaining information from recaptures of tagged individuals, and since tagging has been the main technique used to study migration, the effort to study hawksbill migration has been relatively low.

One of the most important limitations surrounding this topic is that the hawksbill is protected in many nations because of its critically endangered status. Almost no external tags are returned by the fishers or poachers that find them, probably because of fear of being apprehended and punished upon returning the tag and claiming any reward. Thus, the theoretical information return system fails. There is no doubt that many tags placed on hawksbills that were later poached are in private hands.

Data obtained from the recapture of specimens with identification tags on the flippers have been criticized strongly due to tag loss (Mrosovsky, 1983; Witzell, 1998). The results of these investigations should be interpreted with the understanding that the tags are often lost, in a way that an unknown proportion of the initial sample maybe impossible to identify. Despite the recognized gravity of this problem in studies on sea turtles (Mrosovsky, 1983; Alvarado *et al.*, 1988; Limpus, 1992b; Parmenter, 1993; Bjorndal *et al.*, 1996; McDonald and Dutton, 1996), few studies have systematically evaluated the issue with respect to hawksbills. At Fernando de Noronha (Brazil), Monel metal tags were completely covered by ectobiota within a few months (Sanchez and Bellini, 1999). At Mona Island, almost half the hawksbills identified with the same kind of tag had lost their tags within three years (Van Dam and Diez, 1999). Similarly, it has been calculated that in the nesting population at Jumby Bay (Antigua), from one nesting season to the next there is a 10% chance that a turtle will lose the inconel identification tag placed on its fin (Richardson *et al.*, 1999).

Despite these deficiencies, a review of the recapture data from specimens tagged in the Caribbean has helped determine clearly that international migrations as well as movements of nearly 2,000 km are not unusual. Given that these results only reveal the distance between the tagging point and the recovery point, the routes actually traveled are unknown, but they are certainly longer than what has been reported (Meylan, A. B., 1999a). Not all the recoveries of tagged animals indicate long distance movements: there are cases of hawksbills tagged in Cuba and Mexico that have not been found outside of Cuban waters (Manolis *et al.,* 2000). However, almost all the countries of the Caribbean in which hawksbills have been tagged report at least one international recovery, and the distances suggested by some recoveries reveal that a hawksbill is capable of crossing the Caribbean Sea in different directions. There is evidence that an immature hawksbill from Brazil crossed the Atlantic, meaning that movements between points more than 3,600 km apart are possible (Marcovaldi and Filippini, 1991).

Studies carried out using radiotelemetry at Buck Island (U.S. Virgin Islands) indicate that, the nesting females do not move more than three kilometers away from the nesting beaches of the island from one nesting event to the next, but as soon as they finish nesting for the season they immediately migrate out of the zone (Starbird *et al.*, 1999).

Recent investigations in which satellite transmitters have been used have clearly shown the migration routes of Caribbean hawksbills. At least one individual tagged on the island of Bonaire (Dutch Antilles) migrated to Puerto Rican waters. Specimens with transmitters attached in Cuba dispersed to the Cayman Islands, Honduras/Nicaragua, Belize/Colombia, Jamaica/ Montserrat/ Guadalupe and the Yucatan, covering distances up to 2,450 km. In two cases, the turtle left Cuban waters only to return later, while the travels of another four occurred exclusively in those waters (Carrillo *et al.*, 1999; Manolis et al., 2000). Of four females that nested on the Yucatan Peninsula (Mexico) to which satellite transmitters were attached, two swam to the Campeche banks where they remained, and two swam through international waters of the Gulf of Mexico and the Caribbean Sea (Byles and Swimmer, 1994). Four females with satellite transmitters attached at the end of their nesting activities in Barbados were followed for periods of 7 to 18 days. During these short periods, each one migrated to the territorial waters of a different country: Dominica, Grenada,

Figure 9: Migration routes estimated from the return of external tags (based on Meylan, A. B.,1999).

Figure 10: Migration routes determined using satellite transmitters.

Trinidad and Tobago, and Venezuela, covering distances from the nesting beach that varied from 200 to 435 km. There are data from satellite-tracked hawksbills from Nicaragua that are still not available to the public, but they could yield similar information.

GENETIC STUDIES

Bass (1999) examined the first results (Bass *et al.,* 1996) from investigations on mitochondrial DNA (mtDNA) –DNA that is passed on from females to their daughters – from hawksbills from eight nesting and two feeding areas. She concluded that Caribbean nesting populations are genetically distinguishable, due to the very low genetic flow rates between nesting populations, indicating isolated population units from this point of view. Therefore, each nesting population exists independently of the others, regardless of the geographic distance between them, and it is very unlikely that the size and composition of a population would include the immigration of turtles from other populations. In terms of management, if a nesting population is decimated, the chance of recolonization from other populations is minimal, and it is likely that this would only occur after a long period. This is consistent with what is already known about hawksbills of the Indian and Pacific Ocean regions (Broderick *et al.,* 1994).

Genetic studies on hawksbills found in feeding zones in Cuba and Puerto Rico indicate that, in both cases, the feeding "population" is composed of assemblages of individuals from at least six different nesting areas. Bass concluded that although the published results only included those two sites, the finding of mixed populations in the feeding zones could be extrapolated to other places.

Díaz-Fernández *et al.* (1999) analyzed samples from nesting and feeding zones from Cuba, Mexico and Puerto Rico. Using longer mtDNA sequences, they were able to subdivide two of the haplotypes described by Bass *et al*. (1996) into two and three haplotypes, respectively. They also studied samples that were not available to Bass *et al*., from a larger number of more geographically diverse hawksbills. Although there are differences in the results from the two studies, Díaz-Fernández *et al.* confirmed the same general conclusions: each nesting population has a distinct haplotype, and each non-reproduction zone has a mixture of haplotypes that are specific for different nesting zones dispersed throughout the Caribbean. Like Bass *et al*., they determined that the largest contribution of haplotypes in the feeding zones of Puerto Rico was from distant nesting zones, while haplotypes from Cuban nesting zones made the greatest contribution in the non-reproduction zones of Cuba.

Notable differences have been found in the same feeding area according to season (Díaz-Fernández *et al.*, 1999). For example, the contribution of haplotypes of the Cuban nesting population in the non-reproduction zone around Pinots Island rose from 33% in spring to 53% in autumn. A large variation between years was also observed: the percent contribution of haplotypes from Cuban nesting beaches in the samples from the feeding zone of Doce Leguas fell from 83% in 1994 to 54% in 1996. Values also varied between different non-breeding areas (in fishing zones) of the same country.

Bass (1999) warned that the values of the percent contribution derived from current statistical analyses should be interpreted as qualitative indications and not as precise estimates of the genetic composition of Caribbean hawksbills. More precise conclusions can only be drawn after making a regional inventory of haplotypes, to discover the identities, unknown until now, of the source populations of some of the haplotypes observed and to understand better how, where and which populations mix and separate in time and space. This information should also be related with other non-biological parameters (oceanographic, for example) that determine the dynamics of the populations.

Broderick *et al.* (1994) made genetic studies on hawksbills from Australia, which revealed that mixed populations appear together in non-reproduction zones. Okayama *et al.* (1999) showed that samples of hawksbills from three non-reproduction areas (Cuba, Puerto Rico and the Yaeyama Islands of Japan), in all cases, had much higher genetic diversity than those of any nesting zone in Indonesia or Japan. They also observed that although each nesting population had specific haplotypes, the main haplotype characteristic of the nesting population of Puerto Rico was detected in an individual that was found nesting in Cuba. This led them to believe that the nesting females might not be limited to a particular nesting zone, and that the nesting populations may have haplotypes from diverse origins.

Genetic analysis of hawksbills has revealed differences in the estimates of the contributions of haplotypes, not only between studies but also with respect to different seasons or years in the same study, which indicates that the complexity of the genetic composition of some non-reproductive assemblages can be increased by spatial as well as temporal factors. Evidently, these investigations "have only recently passed the preliminary stages", and larger samples, representing greater geographic diversity and encompassing longer periods must be studied (Bass, 1999). However, general verification of mixed populations in the feeding zones was repeated in all the studies. With the exception of an anomalous specimen reported by Okayama *et al.* (1999), the results from the different analyses also coincide in that each nesting population has at least one haplotype of distinctive mtDNA.

The results of the genetic studies are consistent with other lines of investigation, particularly with those on recoveries of tagged animals and migration. Together, they show that each nesting population should be treated as a distinct management unit, despite the fact that the individuals disperse, migrate and live in different territories. However, the non-reproductive hawksbill assemblages found in a determined feeding zone do not constitute management units per se, because they are made up of animals from diverse nesting populations. The contribution of the distinct nesting populations present in a determined feeding zone is susceptible to change according to season and year, and there are also large differences between feeding zones regarding the genetic composition of the turtles. Although in some sense this might be a revelation about hawksbills, the general phenomenon of mixed populations inhabiting the same feeding zone has been known in other species of sea turtles for many years (Carr, 1975; Pritchard, 1976) and it is also common in many other marine species (Musick, 2001).

Hybridization

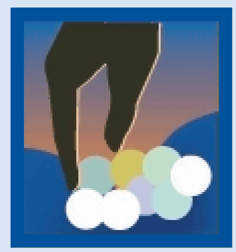
Many of the cases of hybridization reported for species of sea turtles have included hawksbills. Hawksbill and *Caretta caretta hybrids have been identified in* Bahía (Brazil), where there were indications that the hybrids were at least second generation (Conceiçao *et al.*, 1990; Bass *et al.*, 1996; Bass, 1999; Marcovaldi *et al.*, 1999). In Florida (United States), the presence of a male hawksbill and female *Caretta caretta* hybrid was reported, and an egg collected in Suriname produced a hybrid that was determined to come from a male hawksbill and a female green turtle (*Chelonia mydas*); it was estimated to be a second (or earlier) generation (Karl *et al.*, 1995). Due to the antiquity of the taxonomic units in question, Bowen and Karl (1997) said that these sea turtle hybrids were "the oldest bastards known to science." If the original hawksbill–*Caretta caretta* or hawksbill-*Chelonia mydas* hybrids were fertile, this poses a series of interesting and complex questions that would feed the debate about how to define a biological species.

THREATS TO HAWKSBILLS

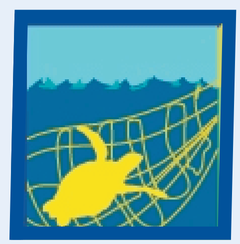
The threats to which hawksbills are exposed can be grouped into two kinds: those that directly impact the species and those that affect its habitat. These threats occur in the water and on land, they can be temporary or permanent, reversible or irreversible and they can be local, national or even international in scope.

The threats that directly affect hawksbills impact their regeneration capacity, their indices of survivorship, the structure and even the function of the species. These include the following:

Egg collection: this is one of the oldest human activities. Initially, it was done to satisfy hunger, but with improved means of transport and preservation of the product with refrigeration, consumption has become more intense and the eggs have become an article of trade that is exchanged for money or other goods.

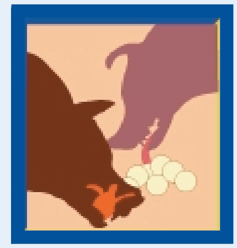


Incidental catch in fisheries: the use of fishing gear on coral reefs and adjacent zones runs the risk of trapping species that are not the target of the fishery; different sea turtle species are occasionally caught in the nets, including hawksbills. The fisherman who finds a live animal rarely allows it to escape, because this species is highly valued as a source of protein and tortoiseshell. When the turtle has spent several hours trapped, the condition of the meat deteriorates and it is sometimes used for bait or thrown away, but not before the shell is removed.



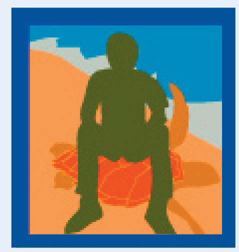
Hunting for various purposes: this threat is one of the most severe, because it destroys organisms that often have great value for the population, as reproducers or because they represent a relevant genetic stock. The most important hunting is that which is made intentionally to obtain meat for consumption and the shell for eventual sale. In some places, the oil is extracted from the meat as a commercial product.

Predation by domestic animals: this threat occurs when coastal communities or cities fail to control domestic animals and allow them to seek food on their own, behaving like wild animals and predating nests as well as turtles. Sometimes, when owners train their dogs to smell and find nests for collection, the dogs return to the beach to continue taking eggs on their own, which affects nesting substantially.

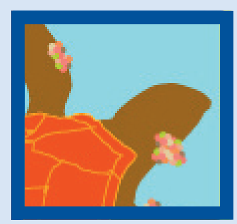


Trade in products: this human activity, due to its mercantile nature, attaches an economic value to the meat, eggs, carapace and other sub-products, inducing the expansion of other threats, such as hunting, egg collection and even visits to nesting sites. Trade definitely encourages human actions that increase mortality and diminish the species capacity for regeneration.

Mistreatment: this threat is associated with activities on land as well as recreational diving operations in coastal zones. It occurs when people handle the organisms imprudently or abusively, whether to take photographs or to make the turtle carry them back to the sea, or to cause harm.



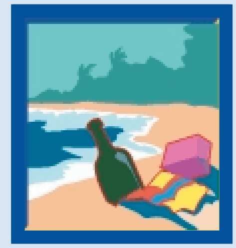
Diseases: the most serious and potentially cruel disease is fibropapilloma, which reduces the physiological capacities of the turtles and even causes their death.



The second group of threats, those that affect the turtles' habitat, correspond to factors that alter nutrient cycles, energy flows, the trophic network, and of course, the structure and function of a particular habitat. These threats include:

Coastal development: includes the construction of structures that alter the morphology of the coastal zone, where lighting is installed, noise generation is increased, and the arrival of visitors is promoted. Contamination and the loss of biodiversity are characteristic of this threat. The conversion of a coastal zone into a tourism area with high urban development predominates in the Caribbean.

Solid and liquid wastes: this threat may originate in the immediate area, as in communities near the coral reef, but also from zones in the upper watershed. This occurs with timbers and wastes that are carried by the rivers toward the marine currents, and then end up deposited on the beach by the tides and the waves; this leads to a loss of nesting habitat because these materials can be large physical barriers. Liquid wastes can be divided into those that introduce nitrogenous substances into the environment, such as those found in sewage; contaminants in drain waters such as detergents and bleaches, and synthetic chemicals associated with agriculture.



Nitrification of the environment where hawksbills live and feed is a serious problem, because the nitrogenous components can promote the growth of algae that can lead to the suffocation of sponges and corals, causing a drop in biodiversity and changes in the structure and function of the coral ecosystem.

Petroleum spills are another severe problem, for the species as well as different marine habitats. Effects on animal physiology and ecosystem functions are some of the impacts of this threat.

Erosion: the use of sand as a material for construction, reparation and raw material for concrete causes coastal erosion. When sand is removed, the currents create alterations in the coastal dynamic, eroding large parts of the beach and eggs. Sediment plumes from the rivers deposited on the marine bottom can change current patterns and lead to coastal erosion that affects nesting.

Tourist influx and behavior: in areas where tourist influx is high, this can be a threat when people carry out actions that interfere with turtle nesting or interact with them by diving in the zones where they live. Any human action that causes a change in natural turtle behavior can affect and be a threat to the survival of the species.

TORTOISESHELL TRADE: A SPECIFIC THREAT

Hawksbill scutes are as prized as ivory, rhinoceros horn, gold and some precious stones. The magnitude and long history of the global market for hawksbill shell has strongly influenced the survivorship of the species (Carr, 1972; Parsons, 1972; Mack *et al.*, 1979 and 1982; Nietschmann, 1981, Mortimer, 1984; Milliken and Tokunaga, 1987; Cruz and Espinal, 1987; Groombridge and Luxmoore, 1989; Meylan, 1989; Canin, 1991; Eckert, 1995; Limpus, 1997; Palma, 1997, Chacón 2002a).

Called "bekko" or "tortoiseshell", the thick scutes that cover the carapace of the turtle are composed of keratin (a fibrous structural protein, probably in the beta-keratin group; Mathews *et al.,* 2002), the same substance that forms nails, hair and rhinoceros horn. Tortoiseshell is a richly colored material and in the hands of experienced artisans it can be soldered, molded, cut and converted into infinite products. It was the first plastic material used by humans, and was traded internationally even before the Christian era. Current prices of some tortoiseshell articles make this one of the most valuable products of animal origin; a kilogram of raw, unworked shell can sell for thousands of dollars.

Hawksbills have been protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1975 when this instrument entered into force. In that era, the population of the Atlantic was included in Appendix I of the Convention, and the Pacific population was listed in Appendix II. In 1977, the Pacific population was placed in Appendix I.

Figure 11: Threats that affect hawksbills on land as well as in the sea (Chacón *et al.,* 2001).

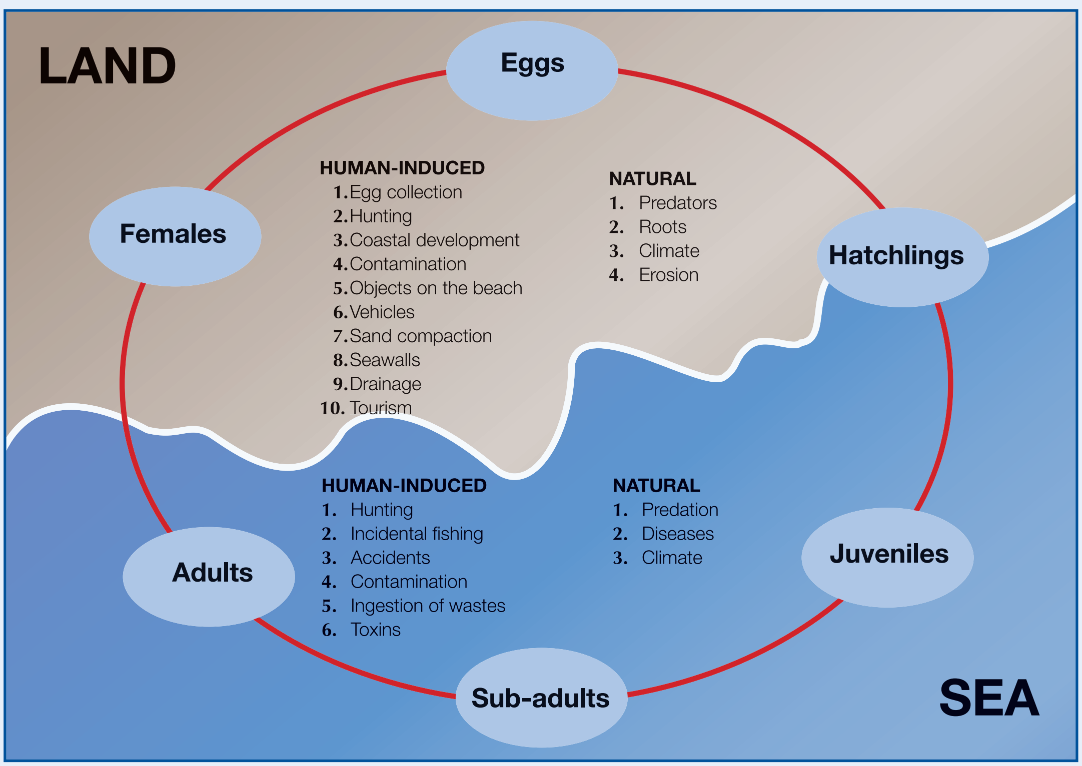


Figure 12: Hawksbill scutes ready to be made into jewelry.

Photo: W. Quirós

Twelve years later, in a study of the global hawksbill situation sponsored by CITES, Groombridge and Luxmoore (1989) reached the conclusion that populations of this species were declining in 56 of the 65 geopolitical units for which some information was available regarding nesting density, with duly documented reductions in 18 of these zones, and presumed reductions in the other 38. As a result, they recommended keeping the species in Appendix I.

The global ban on international trade in sea turtles has taken effect gradually, to the extent that nations that are strong importers and exporters comply with CITES provisions. However, legal trade in tortoiseshell between signatory nations to the Convention did not cease until the end of 1992. In that year the main importing nation, Japan, which had maintained a reservation against the inclusion of hawksbills in Appendix I, adopted an importation quota of zero. Trade between non-signatory nations continues to be legal, and in many places products are sold publicly, mainly to international tourists.

Despite the ban on international trade in hawksbills under CITES, domestic trade and illegal international traffic continue to exert pressure on the world's decimated populations of this species. Recent changes in Vietnam's national legislation guaranteeing absolute protection of hawksbills recognized that their commercial use has caused overexploitation of the resource there (TRAFFIC Southeast Asia, 2004). Large-scale illegal international trade persists in Asia and impedes the recovery of turtle populations (TRAFFIC Southeast Asia 2004; Van Dijk and Shepherd 2004). Similarly, in Central America and the Caribbean, illegal domestic exploitation and illegal international trafficking of hawksbill products persist (Fleming 2001; Chacón 2002a; TRAFFIC, 2002).

Figure 13: Hawksbill articles for sale at the Santo Domingo airport, Dominican Republic, in April 2004.

Photo: WWF – C Drews

POPULATION SIZE AND TRENDS

Knowledge about population sizes and tendencies are essential for the management and conservation of a species. However, this is one of the most problematical aspects for sea turtle management. Given that many simple questions about the basic biology of hawksbills remain unanswered, not much more can be expected because knowledge about the size of the population will depend on the information available for those other questions. One important matter to consider first is to determine exactly what constitutes a "population." As genetic studies have revealed, hawksbills that are found together in the same place at the same time are not automatically members of the same population.

Apart from the nests and young on the beaches, most of the debate on population size focuses on nesting females, because this segment of the population is relatively easy to observe and count. But even so, the concept of a "nesting female population" is complex. For example, the size of the cohort that nested each year in Jumby Bay (Antigua) varied by more than 50%, increasing from 21 to 38 turtles, with a total of 126 tagged females, after eleven years of continuous study. The "nesting female population" not only varied in size from one year to the next, but its composition was unstable and unpredictable. Each season, a different group of animals gathers near the nesting beach to reproduce: some individuals are reproducing for the first time, while others are returning to nest after variable remigration intervals.

One approach is to evaluate notable variations in the general abundance of sea turtles present in a particular area. Nevertheless, very little information is available on the abundance and the density of hawksbills and, therefore, this procedure is not exempt from problems of interpretation either. Recent scientific and historical data from the Southern Great Barrier Reef (SGBR) of Australia indicate that hawksbills are not as abundant as green turtles or *Caretta caretta*. Since this area has not been subject to intensive exploitation, it was believed that in some areas of coral reef the density of the species present might be naturally low (Limpus, 1992a). However, it should be borne in mind that, throughout their life cycle, immature hawksbills living in the SGBR may disperse to other zones of neighboring countries, and be subject to intensive exploitation, which could have repercussions on the density and demographic composition of the SGBR. In the Caribbean, the authors of a complex analysis of Cuban fishery records concluded that it would probably never be possible to know the extent to which these populations have been reduced as a result of exploitation (Carrillo *et al.*, 1999).

ESTIMATE OF POPULATION STATUS

To understand what has happened to hawksbill populations in the last century, it is essential to refer to the historical literature, trade statistics and the qualitative information, as well as monitoring data from the nesting beaches.

The great mobility of sea turtles makes them difficult to survey. For reasons of accessibility, the most commonly used method to monitor population trends is to count the number of females that arrive at the nesting beaches each year (Meylan, 1982). It is difficult to estimate the population because females lay eggs several times during a season, generally follow a non-annual egg-laying pattern and can actively reproduce for decades (Carr *et al.*, 1978; Fitzsimmons *et al.*, 1995; Mortimer and Bresson, 1999). Therefore, long-term monitoring is essential for documenting real population trends. However, to estimate population size and trends today, annual counting of nest numbers instead of the number of nesting turtles is preferred, because many projects do not tag turtles (relying on track counts only), and therefore it is not possible distinguish multiple nests made by the same individual. In addition, by using the annual totals of nests it is not necessary to tag individuals to distinguish them when they remigrate or renest, nor is it necessary to consider geographic differences in the remigration intervals. One inherent risk with this technique is in counting a track and body pit with significant sand movement as a nest where a clutch (group of eggs) has been laid on 100% of the occasions, a situation that is not always the case.

The number of nests made each year can be related to the number of female turtles that lay eggs annually, dividing by the average number of nests per female (Richardson *et al.,* 1989; Guzman *et al.,*

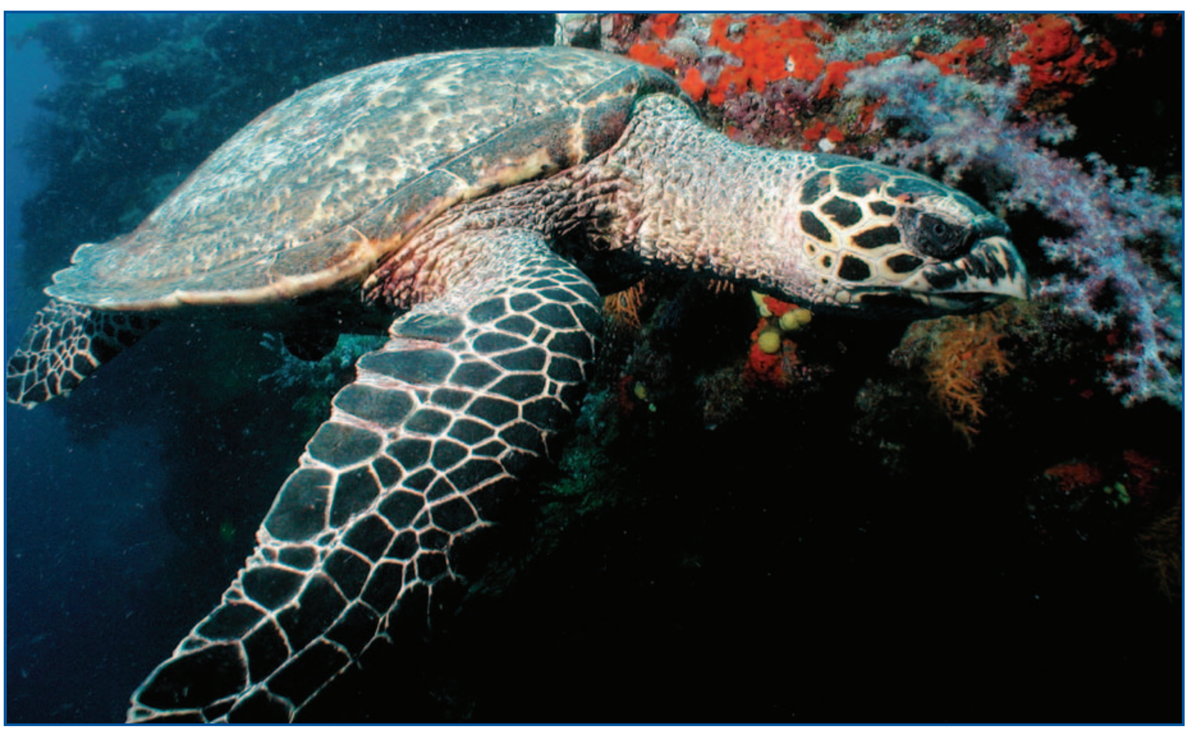


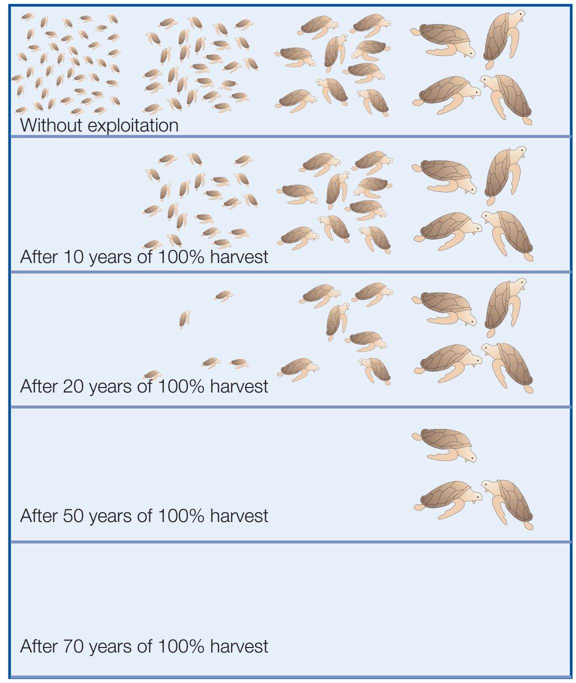
Photo: WWF Canon / C. Holloway

1995; Hillis, 1995). For demonstration purposes, a range of 3 to 5 nests per female has been used. Thus, if the total number of nests is 500, the estimated range of nesting females would be from 100 to 167 individuals, if we divide by 5 and by 3, respectively. The number of nesting females may be related to the total population size (although not with precision) if other relevant data are known about the population (structure, proportion of the sexes).

Limited access to breeding males and to all non-reproductive segments makes it difficult to estimate the total population size. Long generation time in sea turtles also affects the analysis of population trends (Congdon *et al.,* 1993). Generations are calculated as the age at sexual maturity plus half the period of reproductive longevity (Pianka, 1974). In the case of the hawksbill, estimates of age at maturity range from 20 to 40 years (Boulon, 1983 and 1994; Limpus, 1992a; Mortimer, 1998). Based on growth and breeding longevity statistics for the entire world (Meylan and Donnelly, 1999), the Marine Turtle Specialist Group conservatively estimates that the generation period for hawksbills is 35 years. Thus, making a robust assessment of population trends in hawksbills according to IUCN criteria would require population data for at least 105 years, equivalent to three generations.

In determining population trends, it is essential to bear in mind the important differences in population variations that have occurred in the last two to four decades (the most common period of reference) and those that have occurred in the last 105 years, which are really the most relevant for the criteria of the IUCN Red List. Some populations

Figure 14: Graphic representation of the process of population reduction caused by human collection, based on Mortimer (1997) and Chacón *et al*. (2001).



that had already been greatly reduced at the beginning of the twentieth century now appear stable and even show signs of increasing. However, because of their reduced size, their contribution to the long-term survival outlook for the species continues to be limited.

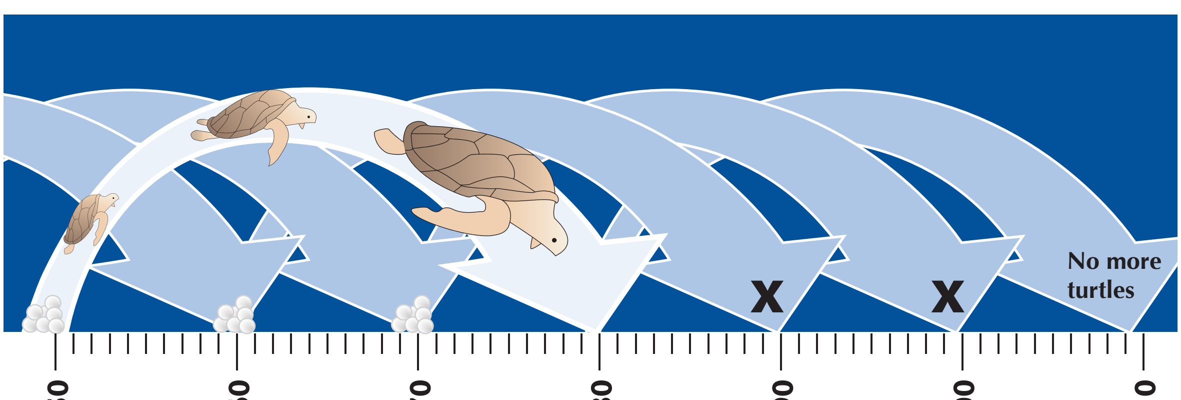
As a result of the long generation period, studies of nesting beaches are more precise in measuring the reproductive success of nesting females of the previous generation (and the survival of their young) than current population status. Future trends are determined using specimens that have not yet reached maturity. Studies of nesting beaches do not detect changes in young individuals or in populations of sub-adult turtles that occur due to excessive collection of eggs or females, interfering with the production of new offspring.

When excessive exploitation is intense, the reduction in the number of nesting females is deferred until virtually all the young and sub-adult groups have been eliminated (Bjorndal *et al.,* 1985; Mortimer, 1995a). When the number of nests begins to decline, the overall population is already fairly decimated (Fig.14).

The impact of egg-collecting on the survival of the species is expressed in the impossibility of generating hatchlings to replace the mature females that disappear due to natural or human-induced mortality. It is for this reason that after several years of having their eggs plundered on a beach, the females stop arriving, because there are no maturing young females to replace their mothers. The impact is not immediately apparent on the beaches, but rather over longer periods of years, equivalent to several cycles of sexual maturity and according to the species. Figures 14 and 15 show the long-term effects of collecting turtle eggs. If nests are overexploited, this will lead to a break in the cycle (the white arrow), and no females will return to nest by the end of an interval equal to the age at first reproduction.

One major drawback is that scientific monitoring of sea turtle populations on nesting beaches did not begin until the mid-1950s and since then relatively few projects have focused on the hawksbill, which in many cases is the secondary or tertiary species due to issues of limited abundance. Indeed, one reason that only remnant hawksbill populations are available to biologists is because there are very few projects for monitoring and protecting their nests (Meylan, 1999a). As a result, population estimates are weak and follow-up of the variations is deficient in most of the distribution areas of this species. Data on hawksbills are often gathered as auxiliary information in studies on other sea turtle species.

Figure 15: Model that exemplifies the generational process and the effects of total egg collection on recruitment, based on Mortimer (1997) and Chacón *et al.* (2001).



Tortugas Marinas
Programa para América Latina y el Caribe

WWF AND THE SUSTAINABLE USE OF SEA TURTLES

WWF supports the sustainable utilization of wildlife when such utilization is truly sustainable, does not threaten other species or populations, provides real benefits to local people and generates incentives and benefits for the conservation of the species. We evaluate all situations on a case-by-case basis. Sometimes, non-consumptive sustainable utilization of sea turtles can provide greater economic benefits for local communities than extractive use. WWF opposes a resumption of international commercial trade in marine turtles, or their products, until it can be shown that: the species in question has sufficiently recovered to sustain trade; governments have sufficient capacity and commitment to enable enforcement and implementation of national and international laws; other populations will not be put at risk; any trade will primarily benefit local communities and enhance species conservation; and such trade will not negatively affect the recovery of populations to fulfill their ecological roles in their ecosystem, and maintain their demographic health and genetic diversity. In some instances, small-scale subsistence use of marine turtles may still allow for a recovery of the species. However, in the light of the endangered status of marine turtles and the history of overexploitation, it is not precautionary to promote consumptive uses of these species at this point.

WWF- Regional Plan of Action on Sea Turtles for Latin America and the Caribbean

STATUS OF HAWKSBILLS IN THE CARIBBEAN

In 1968, the IUCN for the first time included the hawksbill in the category of *endangered species*, the highest category of threat at that time. This status was maintained in subsequent publications of the Red List until 1996, when it was upgraded to *critically endangered*, according to the reviewed criteria (Baillie and Groombridge, 1996). The IUCN's Marine Turtle Specialist Group concluded that the hawksbill merited this status after examining historical records and information from studies and data on the number of animals observed in the market.

The classification was based on the following criteria:

1. An observed, estimated, deduced or assumed reduction of at least 80% over the last three generations, based on direct observation, an appropriate abundance index for the taxon and real or potential levels of exploitation.

2. A projected or supposed reduction of at least 80% over the next three generations, based on an abundance index appropriate to the taxon, a decrease in the occupation zone, range and/or quality of habitat, and real or potential exploitation levels.

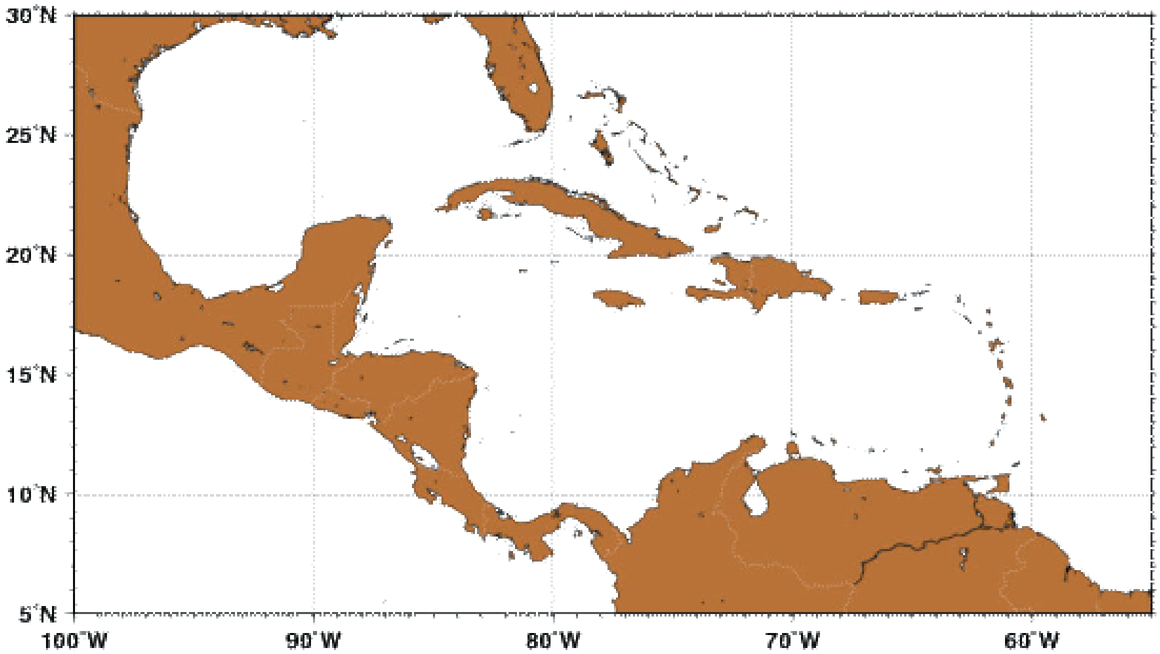
The 1996 classification was criticized and subjected to another review by the IUCN. In 2001, this organization issued its ruling regarding the petition for a revision, concluding that the classification of *critically endangered* was justified (Meylan and Donnelly, 1999; IUCN, 2001, also see http://www.redlist.org/search/details.php?species=8005[1]).

The hawksbill is also included in Appendix I of the Convention on Migratory Species (CMS) as an endangered migratory species, and is included in Appendix II, which calls for concerted action to support its conservation through international agreements. The Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol) of the Cartagena Convention forms part of Appendix II, which refers to species under total protection. Since 2001, all sea turtles in the western hemisphere are protected under the Inter-American Convention for the Protection and Conservation of Sea Turtles. Similarly, all sea turtles are included in Appendix I of CITES, which prohibits their international trade.

1. Red List Standards & Petitions Subcommittee 1996. *Eretmochelys imbricata*. In: IUCN 2004. *2004 IUCN Red List of Threatened Species.* <www.redlist.org>. Downloaded on 09 January 2005.

Figure 16: The Wider Caribbean region (Western tropical Atlantic, Gulf of Mexico and Caribbean Sea).

Source: G. Samuels, RSMAS.



Recent studies have led some to conclude that hawksbills have been decimated worldwide (Meylan and Donnelly, 1999; Suganuma *et al.,* 1999 and 2000) and in the Caribbean (Meylan, 1999b). However, there are indications that by implementing a series of conservation measures over several decades, particularly the protection of the nesting beaches, the number of hawksbills that nest each year ("nesting populations") may increase (Garduño-Andrade *et al.*, 1999; Mortimer and Bresson, 1999).

Perceptions on the status of hawksbill populations continue to be a matter of controversy, due in part to the limited information available - and sometimes the total lack of it. What is certain is that in the last five years researchers have managed to compile and generate more information, providing us with a clearer vision in some cases.

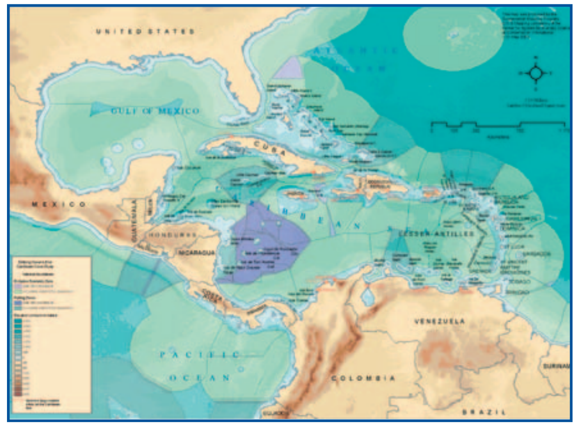
The status of hawksbill populations in the Wider Caribbean region has been the subject of numerous analyses. Meylan (1989) examined the status of the hawksbills for the Second Symposium on Turtles of the Western Atlantic and came to the conclusion that in nearly all the countries of the Wider Caribbean there were fewer than 100 nesting females per year. However, a larger population remained in Mexico (Yucatan peninsula). In turn, Groombridge and Luxmoore (1989) concluded that hawksbill populations "are very diminished in the entire western Atlantic-Caribbean region". Population calculations by these authors estimate a maximum of 4,975 nesting females in the Wider Caribbean (Meylan, 1989). In a subsequent estimate using several studies, Meylan (2001) determined that, at most, 5,000 hawksbills nest annually in the Caribbean region, excluding Guyana, French Guiana, Suriname and Brazil.

It is believed that 600 hawksbills, at most, nest in those four countries, based on the following estimates: 1-5 nests/year in French Guiana (Fretey, 1987), 30 nests/year in Suriname (Reichart and Fretey, 1993) and from 1,200 to 1,500 nests/year in Brazil (Meylan, 2001). There is no national estimate for Guyana. Hawksbill nests occur in low densities.

Meylan (1999b) evaluated the status of hawksbills in the 35 geopolitical units that make up the Caribbean and determined that populations were decreasing or had declined in 22 of the 26 units for which information was available on their status and trends (nesting does not occur in the four remaining units; Kaufmann, 1975; Nietschmann, 1981; Ottenwalder, 1981; Carr *et al.,* 1982; Meylan, 1983; Edwards, 1984; Finley, 1984; Fletemeyer, 1984; Higgs, 1984; Hunte, 1984; Incer, 1984; Morris, 1984; Murray, 1984; Rosales-Loessner, 1984; Wilkins and Meylan, 1984; Moll, 1985; Burnett-Herkes, 1987; Cruz and Espinal, 1987; Dropsy, 1987; Lescure, 1987; Medina *et al.,* 1987; Ottenwalder, 1987; Goombridge and Luxmoore, 1989; Eckert *et al.,* 1992; Eckert and Honebrink, 1992; Fuller *et al.*, 1992; Horrocks, 1992; Smith *et al.*, 1992; Sybesma; 1992 Barmes *et al.*, 1993; Bjorndal *et al.*, 1993; D'Auvergne and Eckert, 1993; Scott and Horrocks, 1993; Eckert, 1995; Ottenwalder, 1996; Cordoba, 1997).

Meylan (1999b) considered that the hawksbill fulfills the criteria of the 1996 IUCN Red List for critically endangered species, based on an 80% or more reduction of its global population in the last three generations (105 years) and projected reductions over the next three generations. The

Figure 17: Map of maritime borders in the Caribbean.



Source: Conservation International

majority of the populations show numerical declines, are reduced or are remnants of previously healthy populations. Costa Rica, Guatemala, Nicaragua and Panama, among other countries, have witnessed a decline both in the number of nests and in the number of individuals. In several areas, population decreases of 80% have been recorded in less than fifty years.

According to Meylan (1999b), in the Caribbean there is only one population with more than 1,000 nesting females per year: the Yucatan peninsula, in Mexico. Other small but diminished populations are now stable, such as those in Jumby Bay in Antigua, and Buck Island in the U.S. Virgin Islands (Meylan, 2001). A few have begun to increase, but only after several years of protection: Cahuita National Park (Costa Rica), Yucatan (Mexico), Mona Island (Puerto Rico) and some beaches on the islands of Barbados and Antigua. Nevertheless, the recent decline in Yucatan's nesting population from the year 2000 (Fig. 20), suggests that these populations are not out of danger either.

All the areas that show population increases have other factors in common, such as policies on the restriction of use and implementation of protection activities for more than twenty years. Although these increases are more the exception than the rule, those few successes show that hawksbill populations can respond positively to long-term conservation efforts. In this regard, it is important to emphasize two qualities in conservation activities: long-term efforts and the regionalization of programs, which requires congruent plans and actions agreed upon by the countries of the Wider Caribbean.

Hawksbills were abundant in the past, as confirmed by historical records, high-density nesting at some sites that remain and trade statistics. Parsons (1972) and Chacón (2002a) have determined that of all the sea turtle species, the hawksbill is the one that has suffered the longest ongoing exploitation. In addition to the threats that it shares with other sea turtles, such as loss of nesting and feeding habitats, oil pollution, incidental fishing, and ingestion of and entanglement in marine wastes, the hawksbill is exploited for the keratin scutes on its carapace that are used to make craft items.

Meylan (1999b) suggested that the true magnitude of the accumulated effects had not been recognized previously, and that our current perception of the status of the population of this species has been influenced by the so-called “shifting baseline syndrome” (Pauly, 1995; Sheppard, 1995; Jackson, 1997). This concept refers to people’s tendency to measure change by making comparisons with what they suppose to be an initial or reference condition, generally the moment in their lives when they observed a phenomenon for the first time, and not based on historical occurrences, including accumulated impacts or remnant status. Thus, the frame of reference is constantly (and unconsciously) being readjusted, so that the historical perspective is lost and a decimated population may be regarded as normal.

Photo: D. Chacón

Figure 18: Hawksbill carapace used as a canvas for painting, in a Central American craft shop.

The hawksbill is still captured for its meat, shell and eggs, in most of the areas where it is found. Its exploitation has increased due to technological advances in fishing equipment and tackle, a process that is taking place on beaches and in marine areas. Because this activity occurs in reef habitats, along with the capture of fish and lobster of great commercial value, turtles are particularly vulnerable to exploitation, which means they are easily pushed beyond the point of economic extinction. Undoubtedly, pressure is growing with increased fishing efforts in the distribution areas of the species.

SITES OF IMPORTANCE FOR THE HAWKSBILL IN THE CARIBBEAN

Anguilla. On its southeastern shore, this island has 17 km of the healthiest coral reefs in the Eastern Caribbean (Oldfield 1999). Although nesting has not been quantified, it is known to occur on Prickly Pear and Dog Island, the sites of greatest importance (Oldfield 1999). The same author has determined that the feeding grounds are located to the north of the island and in the cays around it. Godley *et al.* (2004) note that the hawksbill is the most common and abundant sea turtle species on the island, with an average of 25 nests/year between 1998 and 2003. These researchers have recorded the presence of adults and juveniles in the surrounding waters, and even significant numbers of juveniles in some areas.

Antigua. The breeding population in Jumby Bay, Long Island, seems to be static (Meylan, 1999a; Richardson *et al.,* 1999) with a maximum of 139 nests in 1991 and an estimated population of 78 adult females (Richardson *et al.*, 1999). Monitoring of the nesting beach at Jumby Bay is very strict. At present, nesting females and their nests are well protected because the beach belongs to a private conservation-oriented resort. No other concentrated nesting sites are known in Antigua. According to Muenz and Andrews (2003), from 1987 to 2001 a maximum of around 160 nests were counted per season.

Bahamas. This archipelago is composed of around 700 islands and some 2,000 cays, which extend for 960 km towards the southeast from Mantanilla Shoal, off the Florida coast, to some 80 km north of Haiti. Nesting by hawksbills has been confirmed on several of these islands, including: Abaco, Inagua, Acklins, Crooked Island and Conception Island. Hawksbills have been encountered bearing tags from Cuba and the Turks and Caicos. There are believed to be significant numbers of specimens in the extensive coral banks that serve as feeding ecosystems (CITES National Authority-Bahamas, 2001).

Barbados. A continuous increase in the number of nests and tagged female hawksbills has been reported since 1997, and researchers are increasingly convinced that the population is in the early stages of recovery. In 2000, 103 nesting females were tagged and the number of nests went from 807 in 2000 to 1,179 in 2001. This represents nesting activity on approximately 10 km of beach and it is estimated to account for 80% of hawksbill nesting activity in Barbados.

Belize. The most important nesting site documented recently is Gales Point in Manatee Bar, where 100 to 150 nests have been monitored annually in recent years. Sapotilla Cays and Long Coco Cay are also mentioned as important nesting sites. It is probable that the great barrier reef located off the coast of Belize contains an enormous number of feeding sites for this species (CITES National Authority-Belize, 2001).

Bermuda. The hawksbill is found fortuitously in the waters off Bermuda by divers and other people. The size of these individuals, in terms of straight carapace length, ranges from 24.6 to 64.8 cm, while specimens beached on the coast range from 8.7 to 69.7 cm. No nesting has been documented here, which confirms that the continental shelf of Bermuda is used by this species as a developmental site in their life cycle (Meylan *et al.,* 2003, Godley *et al.,* 2004). Godley *et al.* (2004) have reported the presence of juveniles in the surrounding waters, but in small numbers.

British Virgin Islands. This group of islands has a land area of 153 km^2, and consists of Tortola, the largest island (54 km^2), Virgin Gorda (21 km^2), Anegada (38 km^2), Jose Van Dyke (9 km^2) and more than 40 islets, cays and rocks. The surrounding marine zone is at least 5 times larger than the land area (Oldfield, 1999). This author considers that the numbers of hawksbills have been slowly decreasing in recent years and that their feeding grounds are located in East End on Tortola, northeast of Virgin Gorda and east and west of the coast of Anegada. According to Godley *et al.* (2004) the nests of this species number approximately 50 and the population trend is unknown.

Cayman Islands. These islands (Grand Cayman, Little Cayman and Cayman Brac) are situated to the west of the Greater Antilles and cover an area of 259 km^2 (159 km^2 in Grand Cayman alone). According to Oldfield (1999), hawksbills are found in small numbers. Four nests were reported in 1999, but there were no reports for the 2000-2003 period (J. Blumenthal, personal communication). Feeding sites have been reported in the waters around the three islands, especially on coral reefs. Blumenthal *et al.* (2003) record feeding sites around Little Cayman. The reports by these authors coincide with the information published by Godley *et al.* (2004), which reports fewer than 5 nests per year and for several years nesting has been nil or extirpated at the site. Despite this, a limited presence of juveniles has been observed in the waters around these islands.

Colombia. There are several recognized nesting sites with no more than 20 nests per season, including the Rosario islands, the San Andrés archipelago and Providencia, Isla Fuerte and Tortuguilla Island. On the beaches of the Gulf of Urabá and several sites in the departments of Sucre and Cordoba (1997), no more than 10 nests per season are reported (C. Ceballos, personal communication). Córdoba, López and Amorocho (1998) reported 21 nests in Serranilla (67%) and Cayo Bolivar (1.2%). Córdoba *et al.* (2000) report a large number of hawksbill nesting sites along the continental coast of Colombia, as well as in the nearby islands, a situation that obviously increases the level of nesting occurring in this country.

Costa Rica. On Tortuguero beach, the country's largest green turtle nesting site, the hawksbill is also monitored. Monitoring has taken place there since 1955 (Carr and Giovannoli, 1957), making it the longest ongoing research effort in the hemisphere. Carr and Stancyk (1975) compared the number of hawksbills found per patrol in two four-year periods. The findings were substantially reduced from 2.3 turtles per patrol in 1956-1959 to 0.60 in 1970-1973. For 1988-1991 Bjorndal *et al.* (1993) calculated a figure of 0.35 turtles, which is equivalent to a reduction of 85% with respect to 1956-1959 levels (less than one generation period). It was observed that the median carapace length of hawksbills nesting at Tortuguero had declined considerably between 1955 and

1977 (p<0.001), indicating the instability of the population (Bjorndal *et al.,* 1985). Analysis of the data from 1972 to 1991, which includes years of regular patrolling activities, revealed a significant downward trend (p=0.014), which led researchers to conclude that the breeding population of Tortuguero had decreased continuously since monitoring began in 1956 (Bjorndal *et al.* 1993). In the last 21 years (1980-2000), along the 8 km of continuously patrolled beach in Tortuguero an annual maximum of 13 hawksbill nests have been reported.

On the same 8 km stretch that is regularly monitored, 18 nests were reported in 2001. This only represents a sample of the total number of nests on the 35 km-long nesting beach. A comparison of the number of hawksbills found per unit of effort in four 4-year periods from 1956-1959 and 1997-2000, showed an average annual decrease of 3.9% and an overall reduction of 82% of the population during that period (Tröeng, 2002). Nevertheless, the number of findings per unit of effort increased slightly between the two most recent four-year periods (1988-1991 and 1997-2000). Tröeng (2002) reports that the recent trend (1985-2000), calculated by natural logarithmic linear regression (hawksbill nests), suggesting an increase of 5.1% per year or 111% over the fifteen-year period. However, he points out that patrol efforts may have varied over the years, and that if that variation is considerable (in terms of the number of months patrolled) the estimate of the trend might be somewhat weak for formulating reliable conclusions.

Figure 19: Aerial view of the coral reef of Cahuita National Park, Costa Rica (600 hectares).

Photo: Proyecto Terra

In Gandoca, near the border between Costa Rica and Panama, a total of 17 hawksbills nests were reported in July 2000 and 14 nests in 2001 (Chacón, 2002b). The most recent surveys carried out in Cahuita National Park documented 68 hawksbill nests in 2001 and 34 and 73 in the 2002 and 2003 seasons, respectively (Chacón and Machado, 2003, Chacón *et al*., 2003).

Cuba. The importance of the Cuban feeding grounds for hawksbills has long been known. The Doce Leguas Cays (previously called Jardines de la Reina archipelago), off Cuba's southern coast, was one of the first centers to trade in tortoiseshell, and it is believed that this is where Cayman Island fishermen used to catch these turtles with nets (Parsons, 1972). Genetic research has revealed that feeding site populations contain 65% (estimated) Cuban-born turtles; the rest come from Belize, Costa Rica, Mexico, Puerto Rico, the US

Islands Virgin and Antigua (Bass, 1999; Caribbean Conservation Corporation, unpublished data).

The study by Moncada *et al.* (1999) suggests that although Cuba has an extensive coastline that appears suitable for the hawksbill nesting, most of the nesting activity is limited to small beaches on the outer islands. The most important nesting site identified to date is Doce Leguas, some 60 km off the island's southern coast (Camagüey province). In the past, the capture of hawksbills for commercial purposes in Cuba significantly reduced the populations (Carrillo *et al*., 1999). In 1990, fishing was limited to 5,000 individuals annually, and to 500 after 1994. The number of nests documented annually in Doce Leguas during the 1994-1995 to 1997-1998 seasons varied from 105 to 251 (Moncada *et al.*, 1999). The authors warned that these figures do not reflect all nesting activity and that the real total is undoubtedly higher. However, they also point out that hawksbill reproduction in Doce Leguas seems to have declined in the 1997-1998 period, compared with previous seasons, and attributed the decrease to human disturbance and beach erosion. In 1997-1998 a total of 403 hawksbill nests were found, representing around 101 females, in field inspections throughout the southeastern shore of Cuba (including Doce Leguas).

Since 1997, nine reference beaches have been monitored in Doce Leguas, where a total of 72 nests were recorded in 2001. The research effort increased on average to 45,9 +/- 5.1 (standard deviation) days per nesting season during 1997-2001, and the total of the nests counted in the course of these five years suggests an average annual increase of 20.2% (CITES National Authority- Cuba, 2002).

The hawksbill also nests in other areas of Cuba, though the scale of nesting in the country is still unknown. Therefore, it is not possible to make reliable population estimates and project trends. Nevertheless, an estimate of the total number of nests based on extrapolations from the reference beaches for the entire nesting season and for all the country's nesting beaches, reaches 2,000-2,500 (Meylan, 2001).

Dominica. Meylan (1999b) reported at least 6 nests in 1984.

Dominican Republic. This country has important nesting sites at San Luis and Bahía de las Aguilas, both located in Jaragua National Park. Nesting at each site varied from 0 to 50 nests annually (Leon, Y., personal communication).

Dutch Antilles. On the beaches along the northeast coast of Curacao a very low level of nesting of hawksbills was recorded (four nests confirmed in 1993; Debrot and Pors, 1995). The nesting of this species had not been previously documented on the island. In Aruba, nesting is estimated on a scale of 0 to 50 nests per site, on beaches such as Boca Gandi, Arikok National Park and Arashi beach; nests have been found from June to October (R. van der Wal, personal account).

Grenada. There is an estimate of more than 500 females, which Meylan (1999b) considers very high, probably an overestimate.

Guadalupe. This archipelago has around 565 km of coastline. On Trois Ilets beach in Marie-Galante, 117 nests were found for an estimate of 22-35 females and a total of 150 to 220 nests for the 2000 season. A total of 170-220 nests and 38 to 45 nesting females were estimated for the 2001 season. In 2001, 29 nests were found on Folle Anse beach and another 15 on Sucrerie beach. To summarize, Chevalier *et al.* (2003) have determined that nesting in this area may be around 200 nests, for a group of 30 to 40 females. Other important nesting areas on this island are Petit Terre, Ile Fajou, Anse a Sable, Galets Rouges and various sites on Les Saintes (Delcroix, E., personal communication).

Guatemala. Surveys carried out during a 12-week period in the year 2000 along 10 km of nesting beaches on the Manabique peninsula near Jaloa documented 34 nests. In 2001 the surveys were extended to 12 km during a 14-week period and 22 nests were found (Meylan, 2001).

Haiti. The country's coastline extends for 1,535 km and the main nesting sites occur in the Gulf of Gonaive and certain southern areas in the regions of the Cays, Flamands Bay and some northwest regions. Meylan (1999b) reported at least three nests found during aerial surveys conducted from 1982 to 1983.

Honduras. Hasbún (2002) confirmed the existence of nesting sites on at least three beaches of the Cayos Cochinos archipelago (Dos, Paloma and Cordero beaches), between the months of June and October. Subsequent monitoring of the same beaches in 1999 and 2000 revealed 34 and 10 hawksbill nests, respectively (Aronne, 1999 and 2000). It is important to mention that this species also nests on the Bay Islands (Roatán, Guanaja and Utila), but monitoring only takes place on Utila, with around 20 nests per season reported (BICA, 2002).

Jamaica. Based on beach studies carried out during the period 1991-1996, 200 to 275 nests were estimated for Jamaica (Meylan, 2001).

Martinique. Between 245 and 375 nests have been found on this island (Meylan, 1999b).

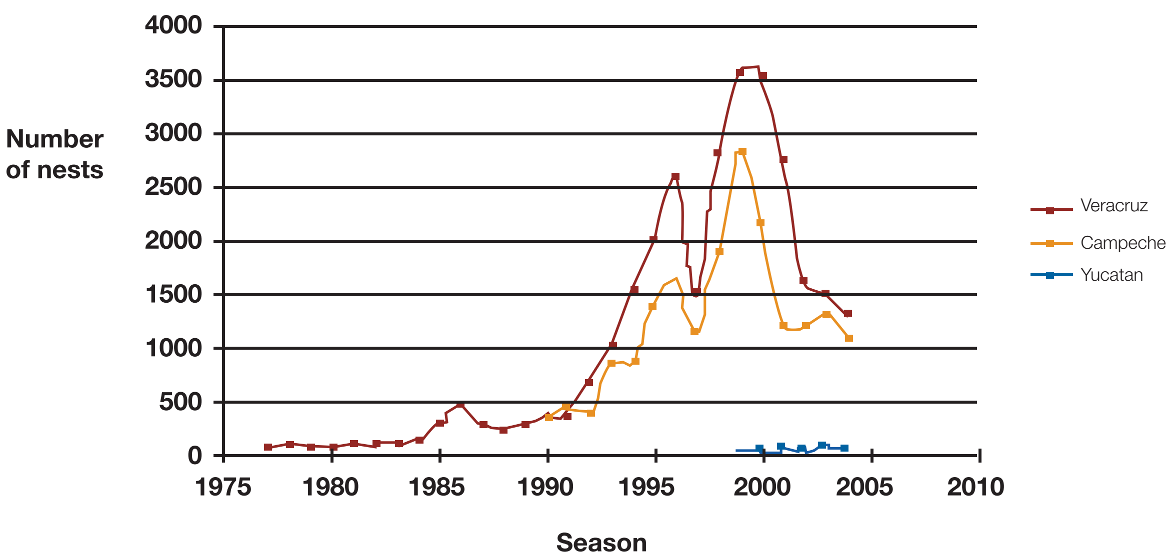
Mexico. Mexico is the only country of the Wider Caribbean with a relatively large and, until recently, growing nesting population (Guzmán *et al.,* 1995; Garduño- Andrade *et al.,* 1999). In 1996, a total of 4,522 nests were reported in the states of Campeche, Yucatan and Quintana Roo: 7 times more in the study area and 56 times more in comparison with the number of nests protected in 1977 (Garduño-Andrade *et al.,* 1999). These researchers believe that the higher nesting levels during the 1977-1992 period are explained mainly by increased surveillance efforts, but they feel that the increases between 1993 and 1996 are attributable to a real population shift. Guzman *et al.* (1995) reached the conclusion that the larger number of nests reported in Campeche in recent years indicated a gradual and effective recovery, and noted that the change in their status was the result of 17 years of beach protection. In 2000, a total of 5,595 nests were reported in Yucatan, representing from 1,119 to 1,865 females (assuming an average of 3 to 5 nests/female/season; Richardson *et al.,* 1989; Guzman *et al.,* 1995; Hillis, 1995), but that year not all the beaches monitored previously were included. Vázquez *et al.* (1998) report approximately 3,000 nests in one season from April to August along 260 km of beach monitored in the Yucatan peninsula, with a peak between May and June.

Although nesting undoubtedly increased during the 1990s, two factors make it difficult to accurately estimate the extent of the increase in the number of females breeding annually in the Yucatan. Mexico imposed a total ban on the capture of all sea turtles in 1990, and captures for commercial purposes in the feeding grounds adjacent to Cuba have decreased considerably since 1993, after Japan, the main market for Cuban tortoiseshell, imposed a moratorium on hawksbill imports (Donnelly, 1991; TRAFFIC, 1994). Both measures have enabled immature turtles to survive long enough to nest, and have also allowed turtles that are already reproductively active to complete more nesting cycles. The Mexican populations are the only ones of this size in the Western Hemisphere.

During the Twelfth Regional Workshop on Conservation Programs in the Yucatan Peninsula, the Gulf of Mexico and the Caribbean, participants analyzed data from three Mexican states through the 2004 season, revealing a major decline in nesting in Veracruz, Campeche and the Yucatan (figure 20). The most striking aspect of this fact is that nesting trends are the same at each site, as though simulating a reflex, a situation that could indicate the effect of a phenomenon with regional impact.

Montserrat. This island forms part of the Lesser Antilles (Leeward Islands) in the eastern Caribbean, with a land surface of 104 km^2. Oldfield (1999) determined that the hawksbill is a common species in its waters and reported the following nesting sites: Yellow Hole, Rendezvous Bay, Little Bay, Bunkum Bay, Woodhand Bay, Limeklim Bay,

Figure 20: Nesting trends in the states of Yucatan, Campeche and Veracruz through the 2004 season. Data supplied by the Twelfth Regional Workshop on Conservation Programs in the Yucatan Peninsula, the Gulf and the Caribbean, authorized by SEMARNAT.



Old Road Bay, Fox´s Bay, Isles Bay; the feeding grounds identified are O´Garras, Bransby Point, Rendezvouz Bluff, Yellow Hole and Trant´s Bay. Godley *et al.* (2004), report limited nesting on this island and the presence of small numbers of adults and juveniles in the surrounding waters. With information from 12 beaches, these authors counted only 3 nests and 17 tracks for the 2003 season (mid-August to mid-September).

Nicaragua. In the year 2000, nest surveys were carried out at El Cocal along Nicaragua's southern coast. Monitoring was carried out every three weeks along 27 km of beach from April to October. A total of 75 hawksbill nests were reported, 73.3% of which were affected by egg poaching (Lagueux, Campbell and McCoy, 2003).

In the Pearl Cays, weekly inspections were carried out during the 1999 nesting season on 11 cays, and on a daily basis in 2000 and 2001, on 11 and 10 cays, respectively. The nest total for each of these three years was 99, 152 and 156 (Lagueux, Campbell and McCoy, 2003). It has been estimated that nest poaching 97% in 1999, decreasing to 30.3% in 2000 and 31.5% in 2001, thanks to conservation efforts. The peak nesting period is between July and August, while the season lasts from May to October.

Among other threats detected in this country we should mention the capture of nesting females and hawksbills of all sizes in the nearby mating sites, as well as habitat destruction or alteration. The most important feeding grounds are Pearl Cays (North Atlantic Autonomous Region, RAAN), the Miskito Cays (RAAN), Tyra Cays (RAAN), Kinas Cays (South Atlantic Autonomous Region, RAAS) and Morris Shoal (Department of San Juan), (C. Lagueux, personal communication).

El Cocal and the Pearl Cays are considered to be the ideal nesting sites for hawksbills on Nicaragua's Caribbean coast (González, 2001). This same author mentions 75 nests during the 2000 season on El Cocal beach.

Panama. Panama's Caribbean coast has at least three major recognized nesting areas: Bocas de Toro to Escudo de Veraguas, the Colon and Portobello area and the San Blas archipelago. In 2003, several hawksbill nesting sites were located in Bocas del Toro; 275 nests in Rio Caña, 118 in Rio Chiriquí, 19 in Escudo de Veraguas, 45 in Little Zapatilla Cay and 42 in Big Zapatilla Cay, for an overall total of 495 nests between May and November (Ordoñez *et al.,* 2003).

Puerto Rico. It is estimated that the breeding population of hawksbill at Mona Island is increasing, with a count of 541 nests in 2000, representing between 108 and 180 females (C. Diez and R. Van Dam, personal communication). These authors consider that the island is the largest breeding ground for hawksbills in the Caribbean basin and attribute the recent increase in nests to protection efforts at Mona Island and to the reduction of fishing in the Caribbean region. In 2001, 549 nests were counted at this same site during the main phase of the nesting season. In 2000, other nests were also reported in Puerto Rico, namely: Caja-de-Muerto (58), Viequez (50), Humacao (145) and Culebra (20) (C. Diez, personal communication, in Meylan, 2001). Tallevast and Morales

(2000) reported 280 nests for the period 1993-1997 in Culebra.

St. Kitts and Nevis. According to Butler (2002) there were 84 hawksbill nests on this island in July 1999. The best-known sites are on the southeastern peninsula, in places such as Major Bay, Banana Bay, Cockleshell Bay, Mosquito Bay, Sand Bank Bay, Conaree and Belle Tete. In Nevis the nesting sites are Pinneys Bay, Red Cliff and Indian Castle (Eckert and Honebrink, 1992).

St. Lucia. According to Meylan (1999b), at least 11 females nested on this island, although their numbers were considered to be declining. This population may have laid eggs in some 30 to 40 nests.

St. Vincent and the Grenadines. On these islands there were an estimated 20 females, representing around 60-70 nests (Meylan, 1999b).

Trinidad and Tobago. On the island of Tobago, nesting occurs on some beaches of the northwest (L'Anse Fourmi) and the southwest (Pigeon PT), near Crown Point. Feeding occurs in the coastal zones of the southwest (Bucco Reef), in the area around Mt. Irvine, Culloden, Arnos Vale; towards the northwest there are other feeding grounds close to Charlotteville, St. Giles Island and the rocky formation called the "Sisters" (W. Herron, personal communication).

Turks and Caicos. This island group is located in the extreme southeast of the Bahamian archipelago and consists of more than 40 islands, but only six of the main islands and two small ones are inhabited by humans. The total land area of this island group is 500 km^2. The hawksbill is considered moderately abundant but in decline, as well as bring predominant in comparison with other species. The most important feeding grounds are: Big Ambergis Cay, Little Ambergis Cay, Fish Cay,

Figure 21: Known hawksbill nesting sites in the Caribbean.

Highas Cay, Grand Cay, Gibas Cay, Cotton Cay, East Cay, SALT Cay, Grand Caicos and North Caicos (Oldfield, 1999). Godley *et al.* (2004) report adults and juveniles in the surrounding waters; in some zones the numbers of juveniles are significant. Fletemeyer (1983) reported between 125 and 275 nesting females for this group of islands.

United States of America. From 1979 to 2000, only 1 to 4 nests were reported annually in Florida (Meylan *et al.* 1995, database of the Study on Turtle Nesting Beaches of the State of Florida).

US Virgin Islands. The breeding population found at the Buck Island Reef National Monument, in the US Virgin Islands appears to be static, with a maximum of 135 nests in 1995. Chevalier *et al.* (2003) noted an average of 106.25 nests per season for the period 1987-1997, while Garland and Hillis (2003) reported 150 nests between July and October.

Venezuela. It is estimated that the Paria peninsula in the state of Sucre is the main hawksbill nesting site on the continental territory (Buitrago and Guada, 2001). In partial surveys, 33 nests were reported in 1997 and 65 in 1998 (Guada, 2000). The Roques archipelago is an important offshore nesting site, with 31 nest s per year during the 1979-1983 period and 32 nests confirmed in 1998 (Guada, 2000; Mata *et al.,* 2002). It is believed that the information from both localities underestimates the total number of nests. Despite the lack of data, Buitrago and Guada (2001) calculated some 120-150 nests per year in this country.

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