INITIATIVES FOR THE CONSERVATION OF MARINE TURTLES

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Summary

All species of sea turtles are considered endangered and a number of conservation programs to save them are run throughout the world. Since turtles have a complex life cycle, the protection measures afforded vary greatly. Most efforts made so far are aimed at protecting the beaches where females nest and eggs develop. The creation of protected reserves and the related activities (limitation of human access, patrolling, and predation and poaching control) have produced positive results, helping the recovery of some nesting populations of turtles. The protection of eggs and hatchlings involves reducing predatory pressure and managing artificial lighting close to the beach; especially the latter is known to disrupt hatchlings' orientation. Egg translocation and incubation in protected enclosures (hatcheries) is sometimes carried out, but this practice usually determines a lower hatching success in translocated nests. Similarly, the procedure of growing turtles in captivity for some years before releasing them in the wild (headstarting) has not produced appreciable results, probably because turtles are deprived of early fundamental experiences. Unfortunately, the conservation of turtles

while at sea is less advanced, partly as a result of the limited scientific knowledge of at-sea turtle behavior. Establishment of marine reserves or areas where fishing is restricted is possible in some cases only, given the large areas usually involved in turtle movements. To prevent the detrimental effects of fishing activities, a few technical solutions are available, among which is a device allowing turtles to safely escape when captured in trawls. Finally, education is expected to provide a great contribution to turtle conservation, increasing the public awareness of the turtles' critical status and of their value as natural resources. In the future, turtle conservation is expected to benefit from a close cooperation with scientific research, providing the basic knowledge needed to plan well-suited conservation measures.

1. Introduction

Sea turtles have been swimming in the seas of the world from the early Cretaceous, ~110 million years ago. They can be considered an evolutionarily successful group, as they persisted through such a long span of time with little or no changes in their general plan of organization, surviving through major evolutionary events such as the extinction of great Mesozoic reptiles or the explosive burst of mammals. In the twentieth century, however, the exponential growth of human population and its impact on marine habitats have posed severe challenges to the seven currently living species of sea turtles. Many once abundant populations have declined or gone extinct, sometimes in few years, revealing a dramatic trend that might even jeopardize the survival of marine turtles on Earth.

Common name	Scientific name	Endangered Species Act	IUCN Red Book	CITES
Green turtle	**Chelonia mydas**	Endangered/Threatened	Endangered	Appendix I
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Critically endangered	Appendix I
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered	Critically endangered	Appendix I
Leatherback Turtle	*Dermochelys coriacea*	Endangered	Critically endangered	Appendix I
Loggerhead turtle	*Caretta caretta*	Threatened	Endangered	Appendix I
Olive ridley turtle	*Lepidochelys olivacea*	Endangered/Threatened	Endangered	Appendix I
Flatback turtle	**Natator depressus**	---	Vulnerable	Appendix I

Table 1. The seven living species of sea turtles and their legal status according to the three major conservation documents (U.S. Endangered Species Act, IUCN Red Book, and CITES lists)

Conservation biologists have long recognized the highly critical status of sea turtle species and the need to protect them, beginning with the works and activities of Archie

Carr, the pioneer of turtle biology and conservation. Already in 1966, a Marine Turtle Specialist Group was created within the World Conservation Union (IUCN), which in 1995 elaborated a general strategy for the conservation and recovery of declining turtle populations. Similarly, in 1988, the United States Congress mandated the National Academy of Sciences to review the causes of turtle decline in U.S. waters, which resulted in a most thorough study of threats to sea turtles and recovery hopes. The main international conservation organizations have also acknowledged the turtles' critical status. All sea turtle species, except the Australia-confined flatback turtle, are considered threatened with extinction or endangered by the United States Endangered Species Act and by the IUCN Red Book (Table 1). The Convention on International Trade of Endangered Species (CITES) lists them in Appendix I, meaning that trade of dead or live specimens is prohibited. Finally, they are listed as endangered migratory species by the Bonn Convention of Migratory Species. At a regional level, a number of conventions or conservation plans deals with turtles; among these, the Inter-American Convention for the Protection and Conservation of Sea Turtles is the only international treaty dedicated exclusively to sea turtles, which is expected to enter into force in the near future.

This international attention and concern have made turtles one of the best-known symbols of wildlife conservation and has produced a global effort to save marine turtles, with hundreds of management and conservation programs being currently run throughout the world. Turtles are subjected to protection measures at any stage of their life cycle, from eggs to adults, and, since individuals often change habitats at different stages, the kind of the implemented conservation activities widely vary.

2. Sea Turtle Life Cycle

Sea turtles are genuine marine animals, exhibiting a series of adaptations for life in the sea, such as streamlined carapaces, paddle-shaped limbs, and lacrimal glands to excrete excess salts. They are long-lived animals, late in reaching sexual maturity, moving widely between different habitats during all stages of their life. Figure 1, representing a diagram first proposed by Archie Carr and coworkers and then repeatedly elaborated, provides a useful framework to illustrate a generalized life cycle valid for all turtle species, and to highlight some differences between species in their general life style.

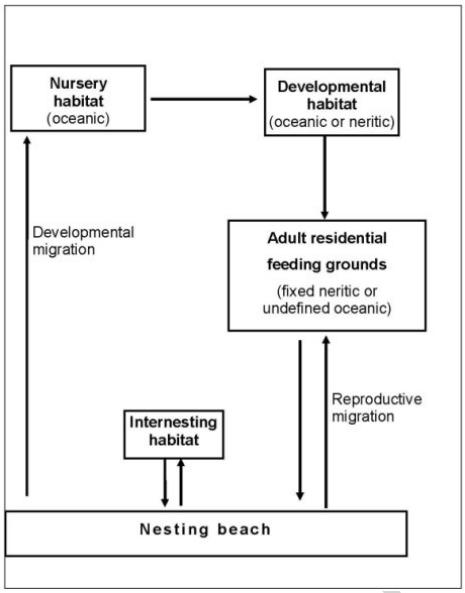

Figure 1. Diagrammatic view of the generalized life cycle of sea turtles
Redrawn from Carr A., Carr M.H., and Meylan A.B. (1978). The ecology and migrations of sea turtles. 7. The West Caribbean green turtle colonies. *Bulletin of the American Museum of Natural History* **162**, 1–46.

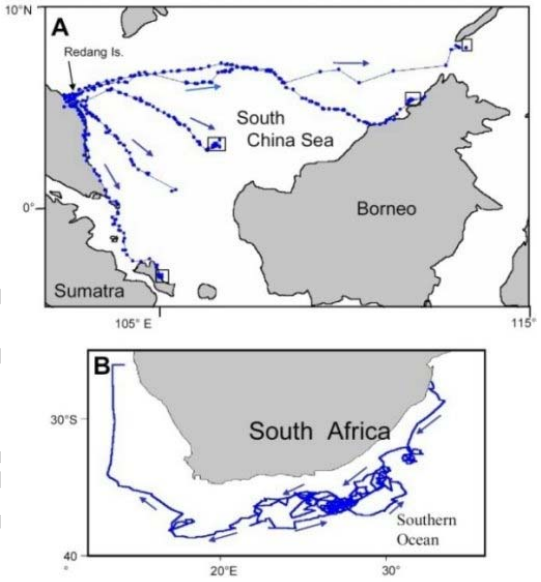

Figure 2. Examples of sea turtle migratory journeys reconstructed by satellite telemetry
(a) Tracks of five green turtles nesting at Redang Island, Malaysia, and migrating towards their specific feeding grounds located in different parts of the South China Sea (rectangles at the end of four tracks; the tracking of the fifth turtle ended prematurely). Dots indicate Argos fixes. Redrawn from Luschi P., Sale A., Mencacci R., Hughes G.R., Lutjeharms J.R.E. & Papi F. (2003) Current transport of leatherback sea turtles (*Dermochelys coriacea*) in the ocean. *Proceedings of the Royal Society of London B* 270 Supplement 2: 129-132.
(b) Long-distance wandering movements in open ocean of a leatherback turtle leaving her nesting grounds in South Africa (indicated by the asterisk). The whole reconstructed

journey was ~14 000 km long and lasted nearly eight months. (Luschi P., Papi F., and Hughes G.R., *unpublished data*).

Female turtles lay their eggs on a tropical or subtropical nesting beach, which is most probably the same where they were born, at least 10–15 years prior. Eggs are left in an underground egg chamber and their development is extremely dependent on the environmental conditions: most noticeably, sex determination is dependent on the temperature encountered during a sensitive phase of the development. After a couple of months, hatchlings emerge from the underground nest and crawl across the beach to reach the sea, where they start to swim vigorously, heading away from the beach. In this way, they reach the open sea, where they are caught by sea currents transporting them away to their oceanic nursery habitats. Juveniles tend to stay in oceanic areas that are rich in food (such as areas of convergence between different water masses at the edge of major sea currents) where they feed while drifting passively over large oceanic areas (developmental migrations). They are sometimes carried thousands of kilometers away from the natal beach by large-scale movements of oceanic currents. In most species, baby turtles are thought to leave their oceanic nursery habitat only after a long time (two to ten years), when they, now larger and closer to sexual maturity, recruit to neritic developmental habitats, often shared with adults. Juveniles may change several of these developmental habitats before settling in their residential feeding grounds, where they will pass all the inter-reproductive periods of their life. In these species, the adult residential grounds are specific neritic areas, fixed in space, which can be more or less distant from the nesting beach (Figure 2). Conversely, in the leatherback turtle and in the olive ridley, there are no such well defined neritic developmental or feeding areas; both juveniles and adults continue to wander in the open sea without settling in any specific site and feed on pelagic preys (Figure 2). Flatback hatchlings are thought to display a further pattern (common to some hawksbill hatchlings), lacking a pelagic phase and settling in coastal waters soon after leaving the natal beach.

Upon reaching sexual maturity, both males and females are thought to leave their feeding areas (whether they are undefined pelagic areas or coastal feeding grounds) and migrate towards their (natal) nesting beach, where mating mainly occurs. Females (and possibly males as well) remains for some weeks in the nesting area, where they lay multiple clutches of about one hundred eggs each, every 10–14 days. Between successive egg-layings, they remain in the waters close to the nesting beach, together with males (internesting habitat). At the end of the reproductive season, both males and females migrate back to the residential feeding area or to the oceanic environment (Figure 2). The extent of the reproductive migration can range from a few kilometers (as in many hawksbill populations) to hundreds or thousands of kilometers (especially in leatherback, green, and loggerhead turtles), and can include movements at rather high latitudes in cool waters. When these long-distance migratory journeys are directed to reach fixed targets, reliance on sophisticated orientation and navigation mechanisms has to be supposed, enabling turtles to find their way even in the open sea.

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Biographical Sketch

Paolo Luschi was born in Leghorn, Italy, on 10 October 1965. He graduated in biological science at the University of Pisa in 1989 and got the PhD degree in ethology in 1997. Since 1990 he has been doing research on animal behavior at the Department of Ethology, Ecology, and Evolution of the University of Pisa. Since 1993, he has been working on sea turtles, especially on their migrations and orientation abilities, studied by means of satellite telemetry.