Sea Turtles of India

A Comprehensive Field Guide to Research, Monitoring and Conservation

Dakshin Foundation, Bangalore

Madras Crocodile Bank Trust, Mamallapuram

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ABOUT THE MANUAL

This manual is a combined revision of a series of manuals produced by the Centre for Herpetology/Madras Crocodile Bank Trust in 2003 under the GOI-UNDP Sea Turtle Project. The purpose of the manual is to provide wildlife management authorities, coastal community groups, environmental organisations and other agencies with basic information on the biology, research and conservation of sea turtles and related coastal issues. The emphasis of the techniques and methods described in the manual is to promote standardised data collection for research programmes and the use of this information to inform appropriate and feasible conservation strategies and management practices. The recommended techniques and methods provided in the manual have been synthesised from a wide range of resources and are presented in a manner that is easily applicable by field practioners and is appropriate within the Indian context.

The manual is divided into three main sections. The introductory section provides basic information on sea turtle biology and evolution and the distribution of sea turtle species along the Indian coastline. It also carries a detailed identification key to the species that are found in Indian waters.

Information in the second section on research and monitoring is collated from existing research programmes in India with special emphasis on studying nesting sea turtles, studying sea turtle hatchlings, and tracing migratory routes through tagging and satellite telemetry. This section also provides brief information about other fields of research. For further details, readers are encouraged to look through recommended articles and handbooks, a list of which is provided in the bibliography. A major portion of this section is dedicated to census and monitoring of sea turtle populations on solitary nesting beaches. For arribada census techniques, please refer to Shanker *et al.* 2010 (see bibliography). The techniques discussed in this section are accompanied by sample data sheets; all data sheets are provided in Section 4 of the manual for easy access.

The third section on conservation and management provides information on designing and executing conservation programmes. In addition to a detailed description on running beach management and hatchery programmes, we provide some pointers on how to conduct developmental activities in a manner that is ecofriendly in general and sea turtle friendly in particular.

Additional features of the manual include a glossary for technical terms, a directory of organisations carrying out sea turtle conservation activities in India and a bibliography for further reading. Readers are also encouraged to visit the Sea Turtles of India website (http://www.seaturtlesofindia.org/) for further information and regular updates.

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1. INTRODUCTION

There are seven known species of sea turtles that inhabit the world's oceans. They include the leatherback, green, olive ridley, Kemp's ridley, hawksbill, loggerhead and flatback turtle. Sea turtles have remarkable life cycles which makes them fascinating to both biologists and wildlife enthusiasts. They are found in all major ocean basins, and typically inhabit tropical and subtropical waters, although individuals are known to have been found in the colder waters of the Arctic.

Once they leave the beach as hatchlings, females will return to land only to nest; male sea turtles never return to land at all. Most sea turtles undertake long distance migrations, as hatchlings and juveniles, during a long pelagic phase in the open ocean, and as adults between their feeding and breeding grounds. Loggerheads migrate over 12,000 km across the Pacific from their developmental habitats in Baja California to their nesting grounds in Japan. Green turtles migrate from their feeding grounds in Brazil to nest on Ascension Island, a speck in the middle of the Atlantic Ocean. On the east coast of India, olive ridley turtles that nest in Orissa are known to migrate to Sri Lanka and perhaps, beyond.

Most species of sea turtles are listed as threatened. Worldwide, sea turtle populations face increasing threats that need to be addressed through appropriate research and conservation measures.

There are a number of international, regional and national laws and regulations that offer protection to sea turtles; however, inadequate implementation and a growing conflict of interest with coastal development and expansion of the fishing industry have continued to take a toll on the species. Their global distribution and utilisation of diverse habitats makes sea turtles ideal flagships of the ocean, nearshore and coastal ecosystems.

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IN THIS SECTION > Evolution and biology of sea turtles > Life history of sea turtles > Sea turtle distribution in India > Identification of sea turtles (adults and hatchlings), tracks and nests

1.1. An introduction to evolution and biology of sea turtles

Sea turtles belong to the Class Reptilia and Order Testudines. The seven species of living sea turtles are a monophyletic group (derived from a common ancestor that has not given rise to other living turtles) of the suborder Cryptodira. Fossil records indicate that turtles first appeared on land about 200 million years ago. Sea turtles are believed to have originated in the lower Mesozoic era and evolved from land-based turtles. During the late Cretaceous period (about 65 million years ago), four distinct families of sea turtles are believed to have existed, of which two families survived into the current era: Dermochelyidae and Cheloniidae.

Anatomy of sea turtles

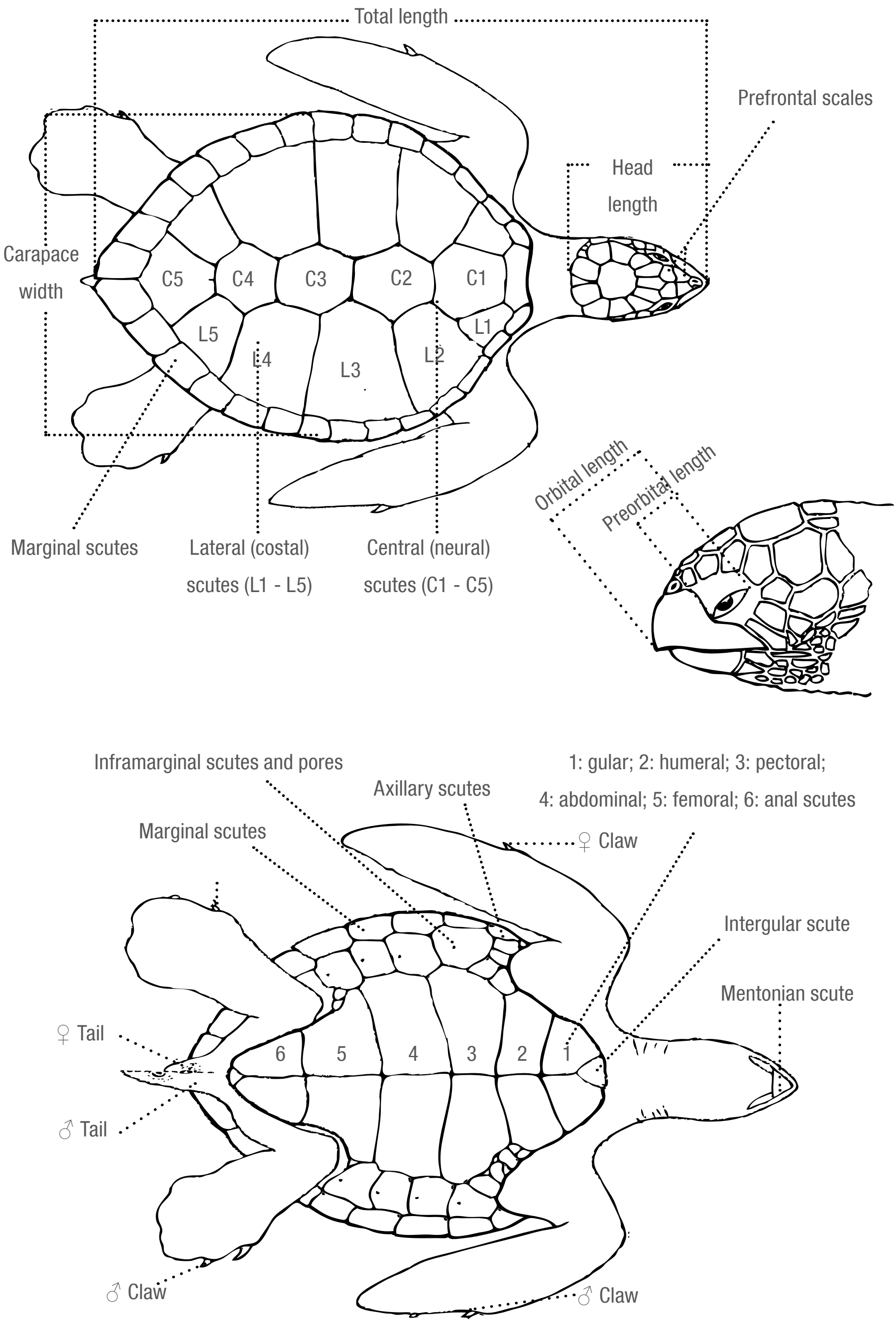
External morphological structures are important while identifying sea turtle species. The illustrations below depict easily identifiable morphological structures and taxonomic characters of sea turtles. These are useful terms to know while using the identification key and plates provided on pages 16-27 of this manual. The detailed anatomy of sea turtles is available in Wyneken (2001); a pdf of this publication is available online at: *http://courses.science.fau.edu/~jwyneken/sta/SeaTurtleAnatomy_Introduction_and_Terminology.pdf.*

Cheloniidae (hard-shelled sea turtles) are characterised by the scales on the head, carapace, and inframarginal scute patterns and numbers, as well as the numbers of claws on the flippers. The prefrontal set of scales are used in species identification. Leatherbacks have five dorsal ridges that run along the length of the carapace. They lack both distinctive head scales as adults and have minimal keratin covering on the jaws.

The primary scutes used as key characteristics are the marginals, laterals (costals), vertebrals, nuchal, and the inframarginal or bridge scutes. The plastron (bottom shell) also has distinct scute patterns. From anterior to posterior, they include: the intergular, gular, humeral, pectoral, abdominal, femoral and the anal scutes.

Adaptations

Sea turtles are distributed mostly in tropical and subtropical waters of the world's oceans and they depend on land only for reproduction. They are air breathing vertebrates like birds and mammals but have returned to a near complete life in the water. They are considered highly derived morphologically and have many adaptations for life in the sea.



Top: Schematic dorsal view of a sea turtle; Middle: Schematic lateral view of a sea turtle head; Bottom: Schematic ventral view of a sea turtle

Swimming: All species share features such as paddle-shaped limbs and a streamlined shape with an enlarged shoulder girdle and well-developed pectoral muscles which aid in swimming. Sea turtles are also excellent divers. Leatherbacks routinely dive to depths exceeding 1,000 feet in search of jellyfish. During long dives, blood is shunted away from tissues tolerant of low oxygen levels toward the heart, brain, and central nervous system. Unlike other cryptodires, sea turtles have a reduced ability to retract their heads; the shell adaptations necessary for retractile limbs would impede rapid swimming.

Respiration and metabolism: Sea turtles are known to have a reduced metabolic rate which allows them to stay underwater for long periods of time before needing to resurface to breathe. They are also equipped with enlarged lacrimal or tear glands modified to remove excess salt from body fluids. They are able to live in seawater without the need for a freshwater source as they can obtain sufficient water from their diet and from metabolising seawater.

Thermoregulation: A sea turtle's large size leads to a low surface area to volume ratio, so the heat exchange rate is low compared to total size. The thermoregulatory adaptations of leatherback turtles in particular, such as a counter-current heat exchange system, high oil content, and large body size, allow them to maintain a core body temperature higher than that of the surrounding water (up to 18°C above their surroundings), thereby allowing them to tolerate colder water temperatures.

Navigation: A wide range of theories have been suggested to account for the ability of some sea turtles to migrate in the open ocean between feeding and nesting grounds sometimes separated by thousands of kilometers. There is now evidence that when hatchlings emerge, they are "imprinted" on the earth's geomagnetic field. Using their ability to differentiate magnetic field intensities and inclination angles, they are able to migrate back to their natal beaches as adults.

1.2. Life history of sea turtles

Reproduction

Males and females begin the reproductive cycle by migrating from their feeding grounds to breeding grounds. Feeding and breeding grounds may be separated by several thousand kilometers. Courtship and mating occur primarily in the offshore waters of the breeding ground; the male mounts the female, holding her with claws in his fore flipper and proceeds to mate. Both males and females may mate with several different individuals.

Nesting

Several weeks after mating, the females come ashore to nest, mostly at night. They crawl above the high water mark, find a suitable nesting site, clear away the surface sand (making a body pit), and dig out a flask shaped nest with their hind flippers. This may be two to three feet deep depending on the size of the turtle. They lay about 100 – 150 eggs in the nest and fill it with sand; some species thump the nest with their body to compact the nest. Once the turtle starts laying eggs, they go into a 'nesting trance' and are less easily disturbed during this stage. They then throw sand around the nest to camouflage it and return to the sea. Beach selection is affected by accessibility of the beach as well as height and substrate. Different turtles prefer different types of beaches to nest. For example, olive ridleys and leatherbacks prefer wide beaches and sand bars at river mouths, while hawksbills and green turtles prefer small island beaches. Most turtles nest more than once during a season, with roughly two weeks separating each nesting event.

After they have completed nesting, they return to their feeding grounds until the next breeding migration, which may be a year or several years later.

Philopatry: Sea turtles usually travel 100s to 1,000s of kilometres from feeding to breeding grounds. It has long been believed that sea turtles return to their natal beach (the beach where they were born) or group of beaches to lay eggs as adults. Recent genetic studies have substantiated this; some species (like green turtles) show greater precision in natal homing than others (like leatherbacks and olive ridleys).

Nest site fidelity: Most turtles lay all their clutches within the same general area (0 to 10 km) during the nesting season. In some cases, such as with olive ridley turtles in Orissa, they may travel larger distances (a few 100 km) for re-nesting. Some leatherbacks have nested on beaches separated by more than 700 km.

Emergence of hatchlings

Hatchlings develop in their nest over a period of 7 to 10 weeks. They hatch simultaneously over a period of a few days and then emerge from the nest together (to swamp predators) usually at night. Predators include crabs, birds, jackals, feral dogs, and many fish once they are in the sea.

Hatchling emergence is nocturnal to avoid predators and sunlight. Sea finding is visual; the hatchlings seek a 'brighter horizon' which is usually the moon or starlight reflecting off the surface of the sea. They also use silhouettes of sand dunes and trees to orient themselves away from land and towards the sea. As soon as they enter the sea, they orient themselves to wave direction and start to swim against it. During this time, they also get imprinted on the earth's geomagnetic field. Hatchlings and adults are sensitive to both magnetic field intensity and magnetic inclination angle, and therefore have a compass sense that enables them to migrate to their natal beaches as adults. **Less than one in a thousand hatchlings is believed to survive to adulthood.**

Temperature dependent sex determination: The sex of a hatchling is determined by incubation (nest) temperature. Lower temperatures produce males, higher temperatures produce females. The pivotal temperature (i.e. the temperature that produces equal numbers of males and females) varies among species and populations, but is usually around 28–32°C. The sex of the hatchling is determined during the second trimester of development. Sex ratios are likely to vary over the course of a nesting season and also between nesting beaches. Influences on nest temperature (e.g. rise in temperature from impacts of climate change) can result in skewed sex ratios – more males than females or vice versa – which can lower the potential for reproduction.

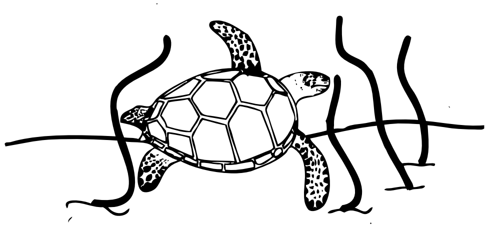
Development of hatchlings

Once in the sea, hatchlings spend the first few days of their lives in a 'swimming frenzy' when they use stored energy reserves to get into the open sea. Beyond this, they spend many years in a variety of juvenile habitats until they join other adults at feeding areas.

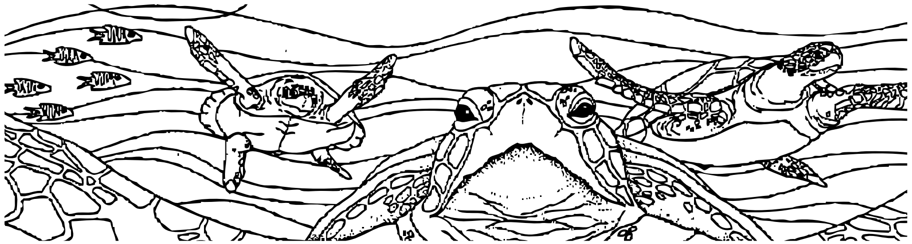
The lost year and beyond

Young turtles spend their lives in a variety of foraging habitats. The hatchlings are usually carried on trans-oceanic gyres and currents. Sargassum driftlines (seaweed rafts) and FADs (fish aggregating devices) have been found to be particularly important. Convergence fronts have also been found to be important foraging habitats for juveniles. Loggerheads are known to make trans-Pacific journeys (southern California to Japan) in the course of their development. For very long, this pelagic phase of their life was a complete mystery to biologists and was known as the 'lost year'. The juveniles and sub adults of some species spend many years in near- shore developmental habitats after the pelagic stage. Development to maturity may take 10 to 15 years in most turtles and maybe 30 years or more in the herbivorous green turtles. Once they have reached sexual maturity, these turtles will migrate to their breeding grounds during the mating season to breed.

LIFE HISTORY OF SEA TURTLES



Adult feeding grounds: Adult turtles remain in their feeding areas until they have accumulated sufficient energy reserves to migrate to breeding areas for reproduction. Adult males and females migrate to breeding areas to mate and, in the case of females, to nest.

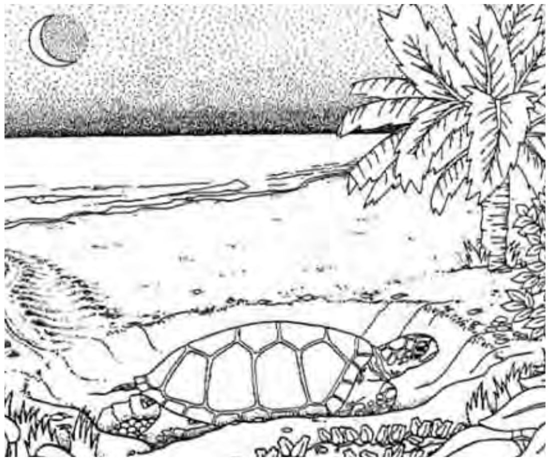


Shallow water developmental habitats for juveniles: The juveniles and sub-adults of some species spend many years in near-shore developmental habitats after the pelagic stage.

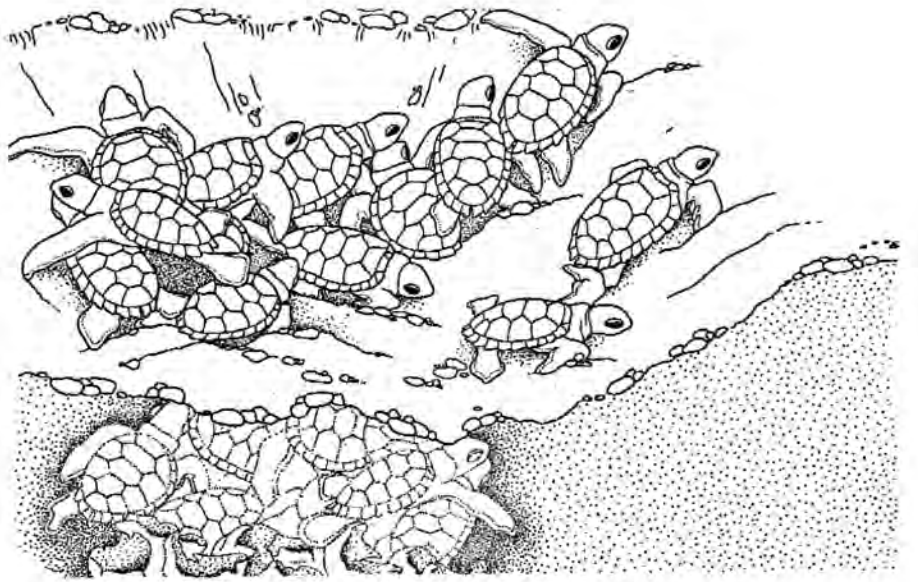
Development to maturity may take 10 to 15 years in most turtles and maybe 30 years or more in the herbivorous green turtles.

The lost year and beyond: Hatchlings drift and feed in seaweed rafts and fish aggregating devices. They spend many years drifting on gyres and currents across the ocean.

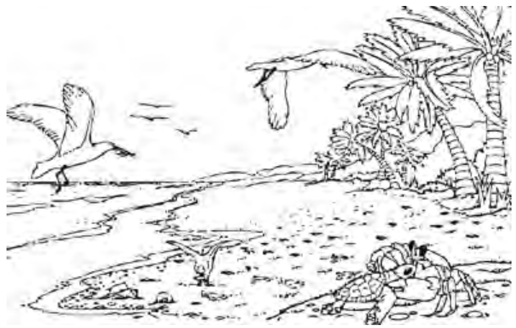
Breeding migrations: Breeding migrations can range from hundreds to thousands of kilometers. For example, green turtles that feed in Brazil nest on Ascension Island, 2,000 km away.



Reproduction and nesting: Courtship and mating occur in the offshore waters of the breeding ground. Within a few weeks of mating, females come ashore to lay eggs. Depending on the species, female turtles lay between two and seven nests in a single season. Once nesting is completed, females migrate back to their feeding areas.

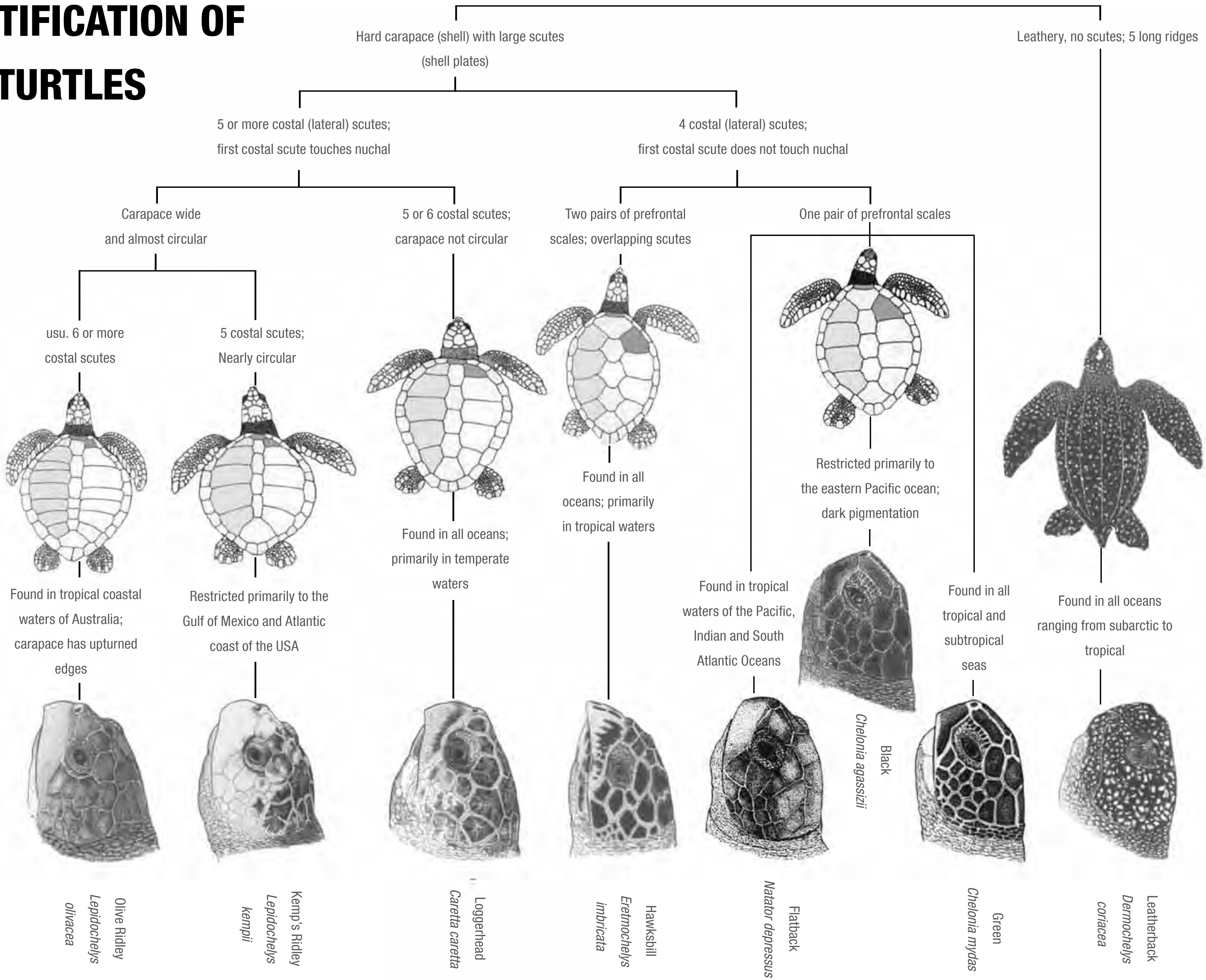


Incubation and emergence of hatchlings: Hatchlings emerge after 50-70 days of incubation. Incubation is regulated by metabolic heat and the heat of the sun. Sex is determined by incubation temperature; higher temperatures produce females.



Sea finding in hatchlings: Hatchlings find the sea using visual cues Many hatchlings are predated even before they reach the sea. Once in the water, hatchlings orient to wave direction. They swim continuously in a 'juvenile frenzy' for the first few days, which enables them to reach the open sea. They also imprint to geomagnetic cues.

IDENTIFICATION OF SEA TURTLES



1.3. Identification of sea turtles

1.3.1. Identification of adults and hatchlings

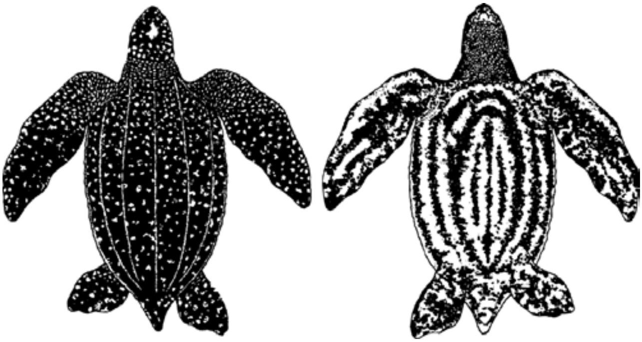
Only five species of sea turtles are known to occur in Indian waters. Identification therefore, is fairly straightforward. The distribution of nesting and feeding grounds of sea turtle species can also be a good aid to identification (see distribution on page 29). If a turtle or a carapace is seen, it can be identified from the features specified in the identification key. Carapace lengths, number of costal scutes and number of prefrontal scales are critical to the identification of the species. The shape of the central or vertebral scutes also provides clues to the identification of the species. In loggerheads and ridleys, these scutes are narrow, and hence the first costal (lateral) scute comes into contact with the nuchal scute. In green and hawksbill turtles, the vertebrals are rhomboid, and the first costal does not touch the nuchal scute. In case of doubt, a clear photograph of carapace and head should be taken.

Hatchlings can be identified using the same characteristics as adults (number of costal scutes, etc.) but one needs to be careful since coloration can vary considerably.

1.3.2. Identification of tracks and nests

Even though sea turtles can be identified by their tracks, this can be difficult even for experts, particularly with loggerheads, hawksbills and ridleys. Tracks can vary between populations and even between individual animals, and hence it is essential for field personnel to observe nesting turtles and note the characteristics of their tracks. Important features of a track are its width, body pit (see Page 34 for a detailed description), and symmetry. Track identification should be confirmed by checking for remains of hatchlings, egg shell sizes, and other, more concrete evidence. While loggerheads, hawksbills and ridleys make shallow body pits, green and leatherback turtles make large deep body pits. A symmetrical track is formed when the front flippers of the turtle move synchronously to pull the turtle forward (e.g. leatherbacks), while an asymmetrical track is formed when the front flippers move alternately (e.g. olive ridleys). Sometimes other animals (crocodiles, monitor lizards) leave tracks on the beach as well, but these can be easily distinguished by the pattern and size of the tracks.

If the hatching season has started, one must also be alert for hatchling tracks, which are, of course, small, but usually numerous as the hatchlings would have emerged and crawled to the sea simultaneously. One can follow hatchling tracks to a nest, which can be uncovered to examine nest contents and estimate hatching success.



Leatherback turtle: dorsal (left) and ventral (right) view

Common name: **Leatherback turtle**

Scientific name: *Dermochelys coriacea*

Distribution: All oceans, sub-arctic to tropical waters

Nests on: Tropical beaches

Beach type: Wide beaches with steep slope, rock free deep water approach. In India, nests in the Andaman and Nicobar islands mainly. Main nesting sites are Galathea on the east coast and several beaches on the west coast of Great Nicobar, Little Nicobar and Little Andaman Islands.

Weight (adult): 500 kg +

Carapace length: 140 – 170 cm

Carapace shape: Elongate and tapering with seven prominent dorsal ridges; scutes always absent.

Colouration: Mostly black with white spotting; pink or bluish pots on base of neck and flippers.

Costal scutes: Absent

Head shape: Triangular; two maxillary cusps (tooth-like notch on either side of upper jaw).

Prefrontal scales: None

Limbs: Forelimbs extremely long

Plastron: Relatively small and distensible with 5 longitudinal ridges.

Time of nesting: Night

Clutches per season: 4 – 6

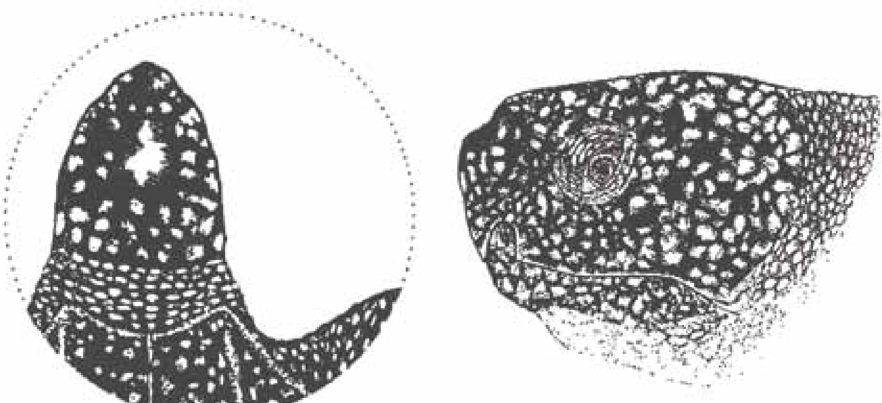
Clutch size: 80 – 100

Egg size: ~ 5 cm in diameter

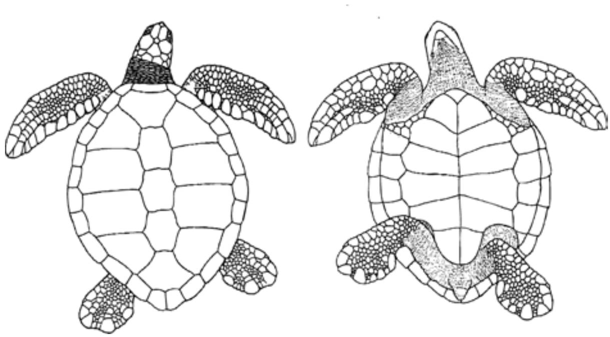
Re-nesting interval: 9 – 10 days

Re-migration interval: 2 – 3 years

Track: 150 – 200 cm wide, deep and broad, with symmetrical diagonal marks made by forelimbs, usually with a deep median groove from the long tail.

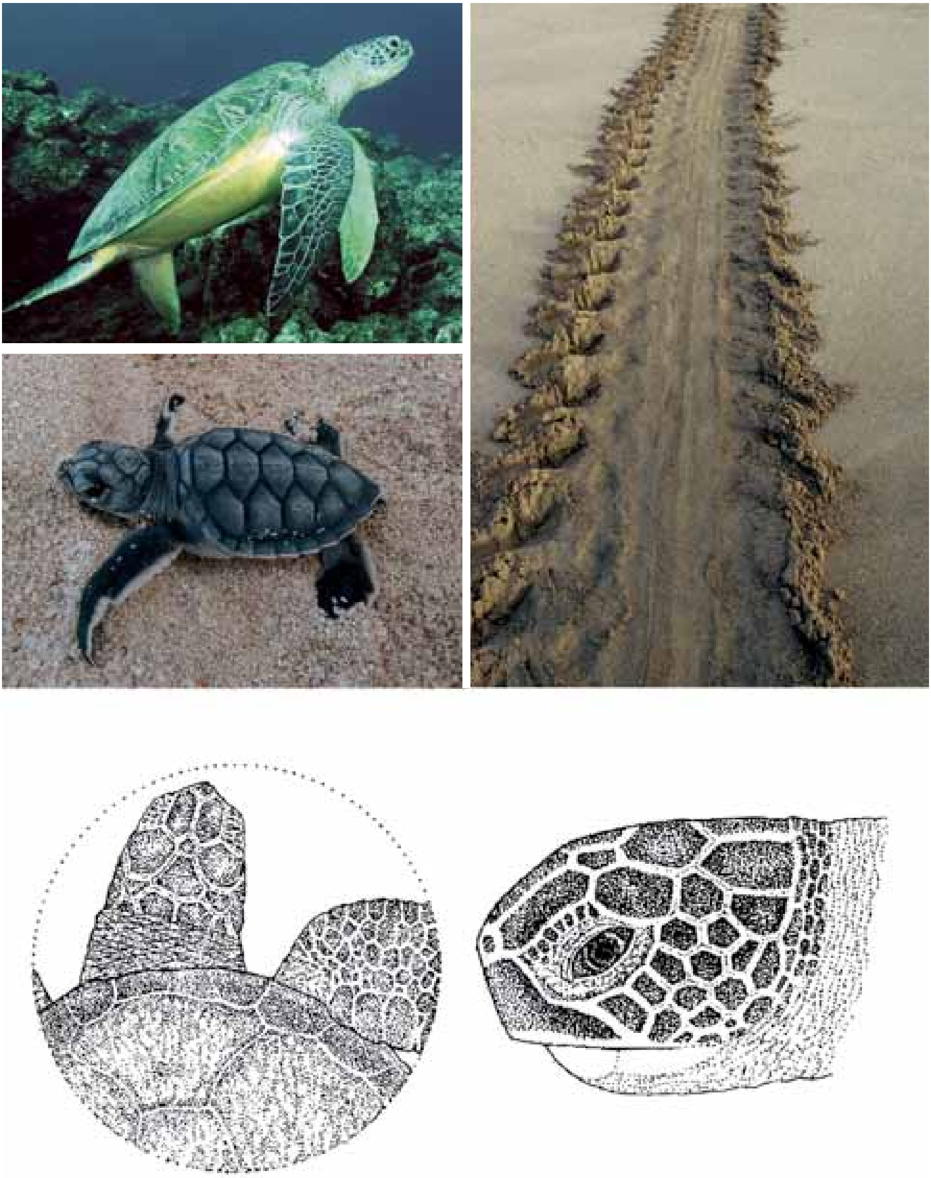


Clockwise from top-left: An adult leatherback; An adult leatherback's tracks; Adult leatherback head (detailed illlustration) profile and dorsal view; Leatherback hatchling

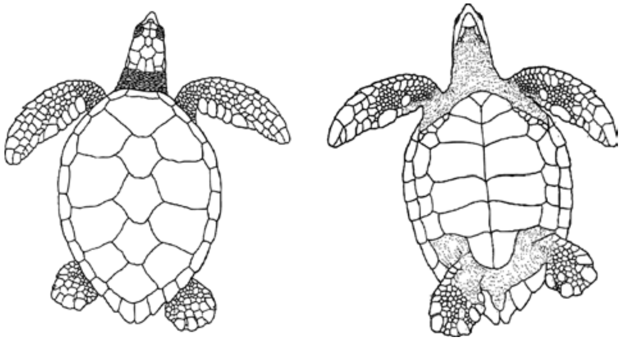


Green turtle: dorsal (left) and ventral (right) view

Common name: **Green turtle**
Scientific name: *Chelonia mydas*
Distribution: Tropical and subtropical waters
Nests on: Tropical beaches worldwide, mainland and remote islands.
Beach type: Large, open beaches to small cove beaches. Mainly Gujarat on the mainland, and beaches in the Lakshadweep and Andaman Islands.
Weight (adult): 250 kg
Carapace length: 90 – 120 cm
Carapace shape: Broadly oval; margin scalloped but not serrated.
Colouration: Brown with radiating streaks in juveniles, variable in adults.
Costal scutes: 4 pairs
Head shape: Anteriorly rounded
Prefrontal scales: 1 pair
Limbs: Single claw on each flipper
Plastron: White in hatchlings, yellowish in adults
Other features: Vertebrals (centrals) large, so that first costal does not contact nuchal scute.
Time of nesting: Night
Clutches per season: 4 – 6
Clutch size: 100 – 120
Egg size: ~ 4.5 cm in diameter
Re-nesting interval: 10 – 14 days
Re-migration interval: 3 – 5 years
Track: 100 – 130 cm wide, deep, with symmetrical diagonal marks made by forelimbs, tail drag solid or broken line.



Clockwise from top-left: An adult green; An adult green's tracks; Adult green head (detailed illlustration) profile and dorsal view; Green hatchling



Hawksbill turtle: dorsal (left) and ventral (right) view

Common name: **Hawksbill turtle**

Scientific name: *Eretmochelys imbricate*

Distribution: Tropical waters worldwide

Nests on: Tropical beaches worldwide, mainly remote islands.

Beach type: Narrow beaches on islands or mainland shores, with reefs obstructing offshore approach. Lakshadweep, Andamans, and few beaches in Nicobar such as Indira Point in Great Nicobar. Hawksbills often nest under overhanging vegetation (unlike ridleys which nest in open areas).

Weight (adult): 150 kg

Carapace length: 80 – 100 cm

Carapace shape: Oval, strongly serrated posterior margin, thick imbricate scutes.

Colouration: Brown, boldly marked with amber and brown variegations.

Costal scutes: 4 pairs (ragged posterior border)

Head shape: Narrow, straight bird like beak

Prefrontal scales: 2 pairs

Limbs: Two claws on each flipper

Plastron: Light yellow to white

Other features: Vertebrals (centrals) large, so that first costal does not contact nuchal scute.

Time of nesting: Night/Day

Clutches per season: 3 – 5

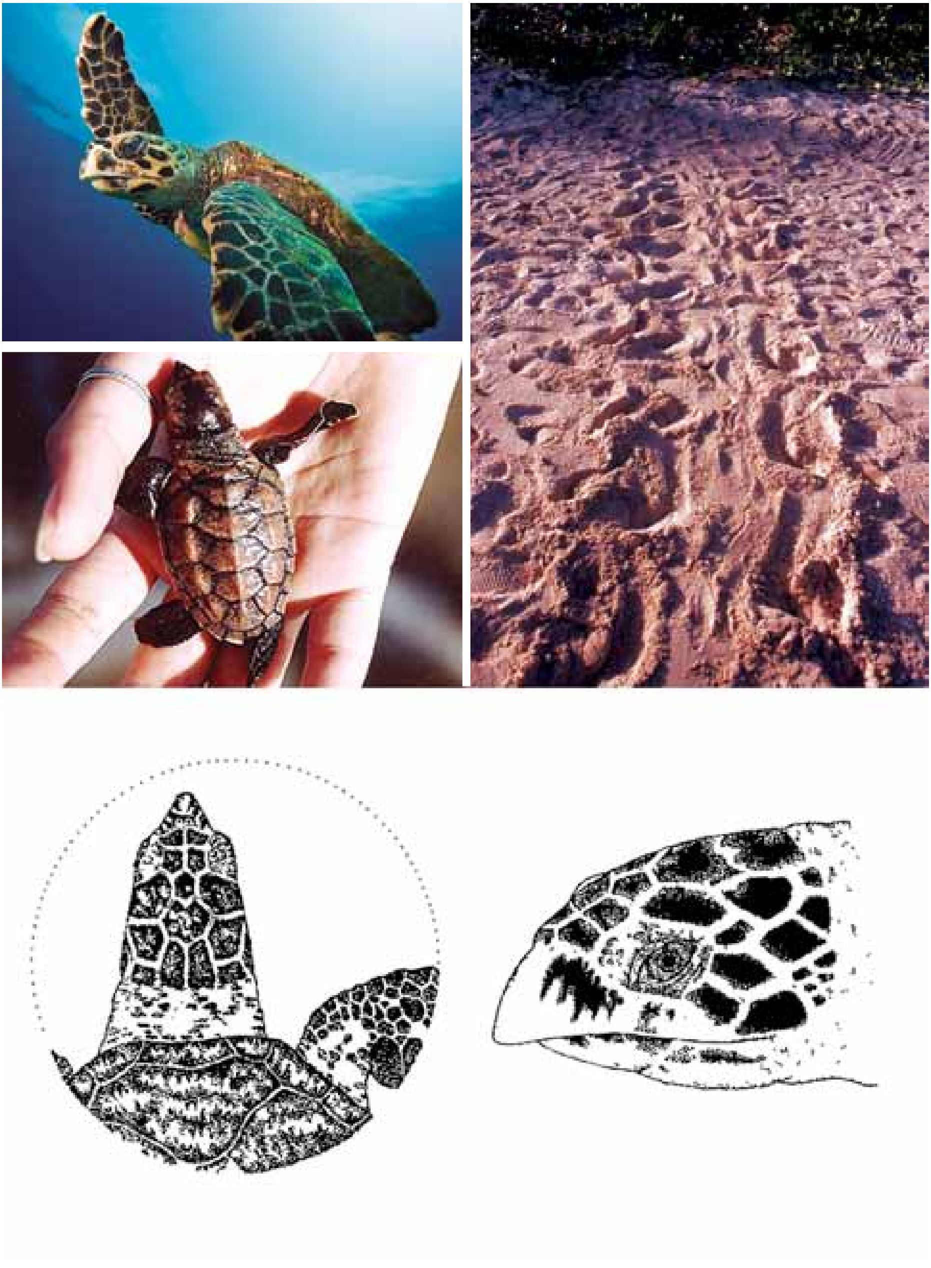
Clutch size: 120 – 150 (up to 180)

Egg size: ~ 3.5 cm in diameter

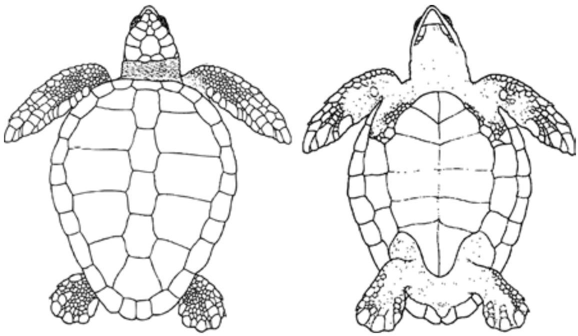
Re-nesting interval: 12 – 14 days

Re-migration interval: 2 – 5 years

Track: 70 – 85 cm wide, shallow, with asymmetrical (alternating) oblique marks made by forelimbs, tail marks present or absent. Often hard to distinguish from tracks of ridleys, but the two species nest in very different beach types.



Clockwise from top-left: An adult hawksbill; An adult hawksbill's tracks; Adult hawksbill head (detailed illustration) profile and dorsal view; Hawksbill hatchling



Loggerhead turtle: dorsal (left) and ventral (right) view

Common name: **Loggerhead turtle**

Scientific name: *Caretta caretta*

Distribution: Tropical waters worldwide

Nests on: Temperate, sometimes subtropical and tropical waters.

Beach type: Extensive mainland beaches or barrier islands.

Not known to nest in India, but does nest in Sri Lanka.

Weight (adult): 200 kg

Carapace length: 80 – 100 cm

Carapace shape: Moderately broad, lightly serrated posterior margin in immatures, thickened area of carapace at base of 5^{th} vertebral in adults.

Colouration: Generally unmarked reddish brown in subadults and adults.

Costal scutes: 5 pairs

Head shape: Large and broadly triangular

Prefrontal scales: 2 pairs

Limbs: Two claws on each flipper

Plastron: Yellow to orange

Other features: Vertebrals (centrals) narrow, so that first costal contacts nuchal scute.

Time of nesting: Night

Clutches per season: 3 – 5

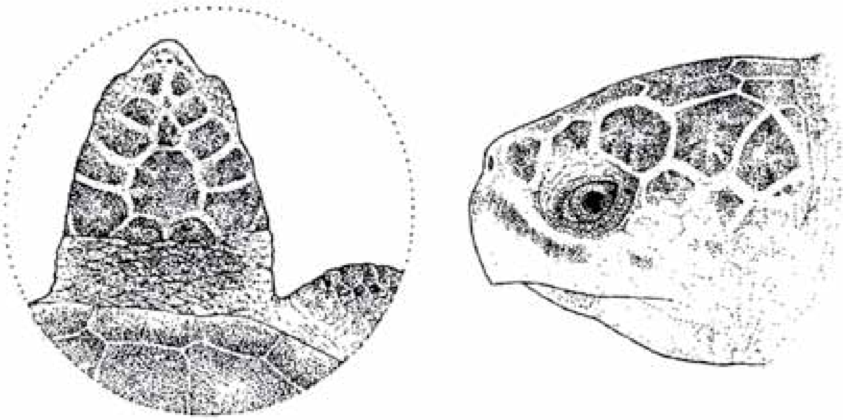
Clutch size: 100 – 120

Egg size: ~ 4 cm in diameter

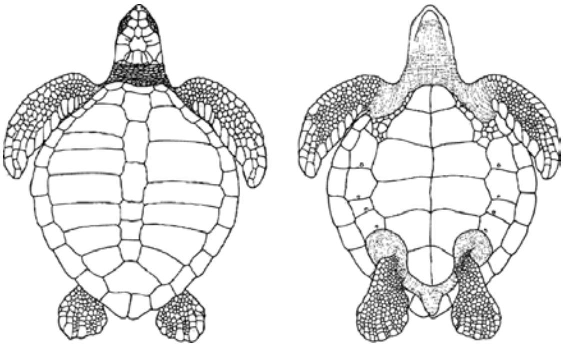
Re-nesting interval: 12 – 16 days

Re-migration interval: 2 – 3 years

Track: 70 – 90 cm wide, moderately deep, with asymmetrical diagonal marks made by forelimbs, tail drag mark usually absent.



Clockwise from top-left: An adult loggerhead; An adult loggerhead's tracks; Adult loggerhead head (detailed illlustration) profile and dorsal view; Loggerhead hatchling



Olive ridley turtle: dorsal (left) and ventral (right) view

Common name: **Olive ridley turtle**

Scientific name: *Lepidochelys olivacea*

Distribution: Tropical waters worldwide

Nests on: Tropical beaches worldwide

Beach type: Tropical mainland shores and barrier islands, often near river mouths.
Throughout mainland; also Andaman and Nicobar
and to a lesser extent, Lakshadweep Islands.

Weight (adult): 50 kg

Carapace length: 60 – 70 cm

Carapace shape: Short and wide, carapace smooth but elevated, tectiform (tent-shaped).

Colouration: Mid to dark olive green

Costal scutes: 5 – 9 pairs asymmetrical

Head shape: Large, triangular

Prefrontal scales: 2 pairs

Limbs: Two claws on each flipper

Plastron: Pore near rear margin of infra marginals; creamy yellow

Other features: Vertebrals (centrals) narrow, so that first costal contacts nuchal scute.

Time of nesting: Night

Clutches per season: 1 – 3

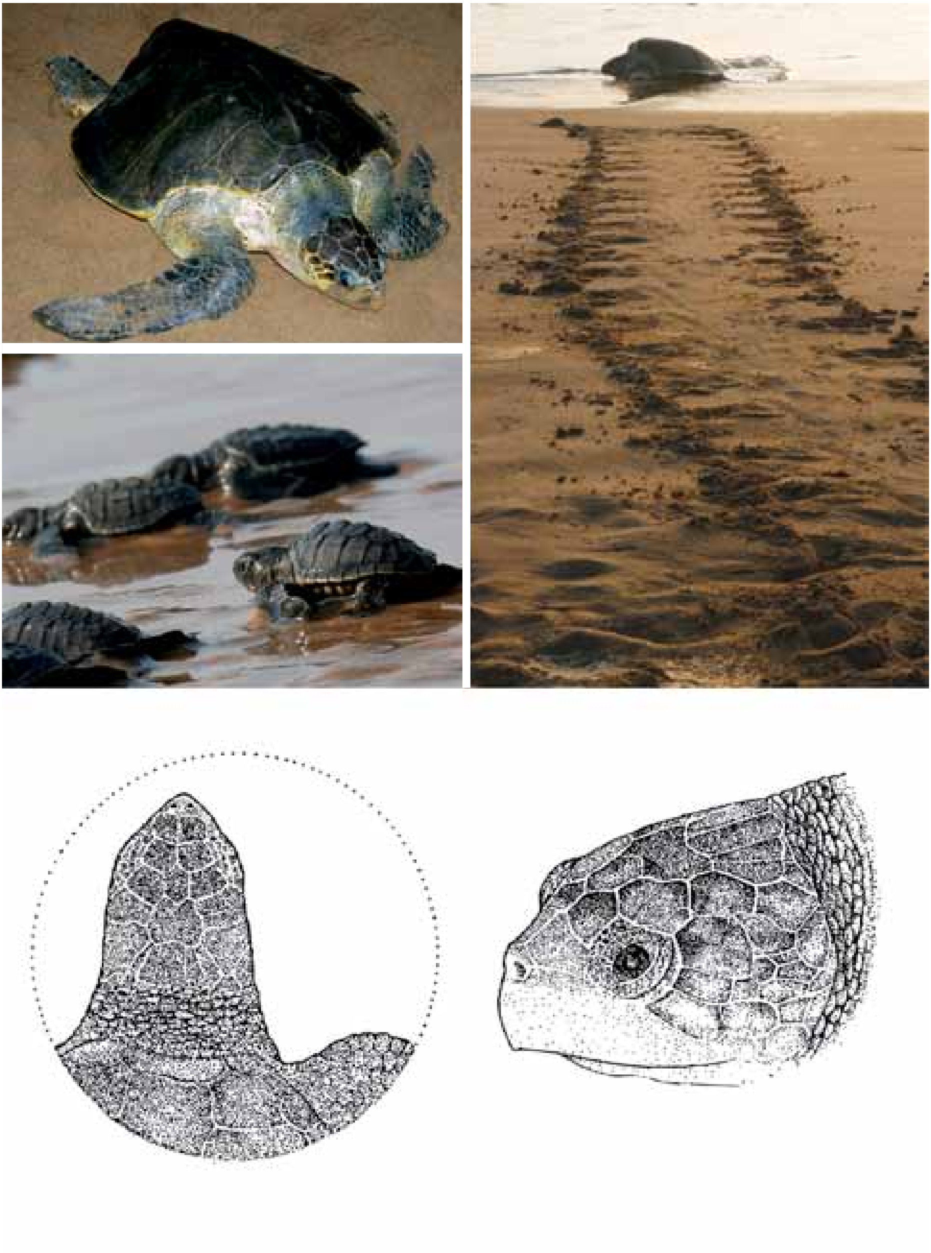
Clutch size: 100 – 120

Egg size: ~ 4 cm in diameter

Re-nesting interval: 20 – 28 days

Re-migration interval: 1 – 2 years

Track: 70 – 80 cm wide, light, with asymmetrical, oblique marks
made by forelimbs, tail drag mark lacking or inconspicuous.

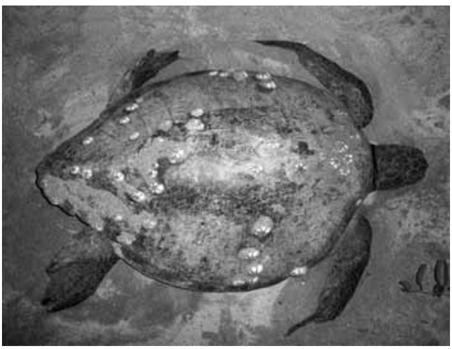


Clockwise from top-left: An adult olive ridley; An adult olive ridley's tracks; Adult olive ridley head (detailed illustration) profile and dorsal view; Olive ridley hatchlings

1.3.4. Other sea turtles of the world

The **Kemp's ridley** (*Lepidochelys kempii*) turtle is also known as the Atlantic ridley turtle and is found in the Atlantic Ocean and the Gulf of Mexico. Adults weigh about 50 kg and are about 60 – 90 cm in length and closely resemble olive ridleys. Females nest during the day and lay between 1 and 3 clutches per season. The re-nesting interval for the species is 17 – 30 days and the re-migration interval is 1 – 2 years.

The **Australian flatback** (*Natator depressus*) is endemic to the continental shelf of Australia and is so called because of its flattened carapace. Adults weigh about 200 kg. Females nest during the night and day and can lay between 2 and 4 clutches per season, each of a clutch size of about 50 – 60 eggs. The re-nesting interval for the species is 13 – 18 days and the re-migration interval is about 3 years.



The **east pacific green turtle** or **black turtle**, which is found in the East Pacific Ocean, is considered as a separate species (*Chelonia agassizii*) by a few turtle biologists but genetic studies indicate that it is a part of the Pacific green turtle population. Adults weigh about 70 kg (and up to 120 kg). Females nest during the night and lay between 1 and 3 clutches per season each consisting of 75 – 85 eggs. The re-nesting interval for the species is 17 – 30 days and the re-migration interval is 1 – 2 years.

1.4. Sea turtle distribution in India

Five species of sea turtles, namely the olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*), occur in the Indian coastal waters of the Bay of Bengal and Arabian Sea. All species except the loggerhead nest on the mainland coast and islands. The olive ridley nests on both coasts (primarily the east coast) and Andaman and Nicobar Islands. The green turtle nests in Gujarat, Lakshadweep and the Andaman and Nicobar Islands, the hawksbill in Lakshadweep and Andaman and Nicobar Islands and the leatherback in the Andaman and Nicobar Islands. In addition, practically all coastal states have sporadic nesting beaches and offshore congregation zones for sea turtles. Olive ridleys and leatherbacks, and hawksbills and greens often share nesting beaches in the Andaman and Nicobar Islands. Loggerheads are rare in India and known from very few records, mainly in southern Tamil Nadu. All five species nest in Sri Lanka.

State-wise distribution of sea turtle nesting sites along the Indian coast

Olive ridley Green Leatherback Hawksbill Olive ridley mass nesting site

2. RESEARCH & MONITORING

Sea turtles are clearly in need of conservation today. However, without data that provides knowledge of their biology, it is very hard to frame appropriate management strategies. Intensive research often needs extensive infrastructure and funding which may or may not be available to all field biologists. Fortunately, even the simplest of monitoring programmes can help collect basic data on various aspects of sea turtle biology, which could be crucial to their conservation.

Lack of knowledge about their biology has been a particular impediment to the conservation of sea turtles. For many years, conservationists incubated sea turtle eggs in styrofoam boxes to increase hatching success. But because the boxes were usually cooler than the nesting beach, and the sex of the hatchlings is determined by incubation temperature, these programmes had been producing and releasing only males. Other sea turtle conservation programmes involved 'headstarting' or maintaining hatchlings in captivity for months or years and releasing them when they were larger, so that their early mortality would be reduced. Unfortunately, this failed to take into account the imprinting of the turtles on their natal beach, which might affect their ability to remigrate to these beaches as adults. There is little evidence that headstarting, though labour and cost intensive, has had any significant effect on the conservation of sea turtles. Hence, the knowledge of an animal's biology is crucial to conserving it.

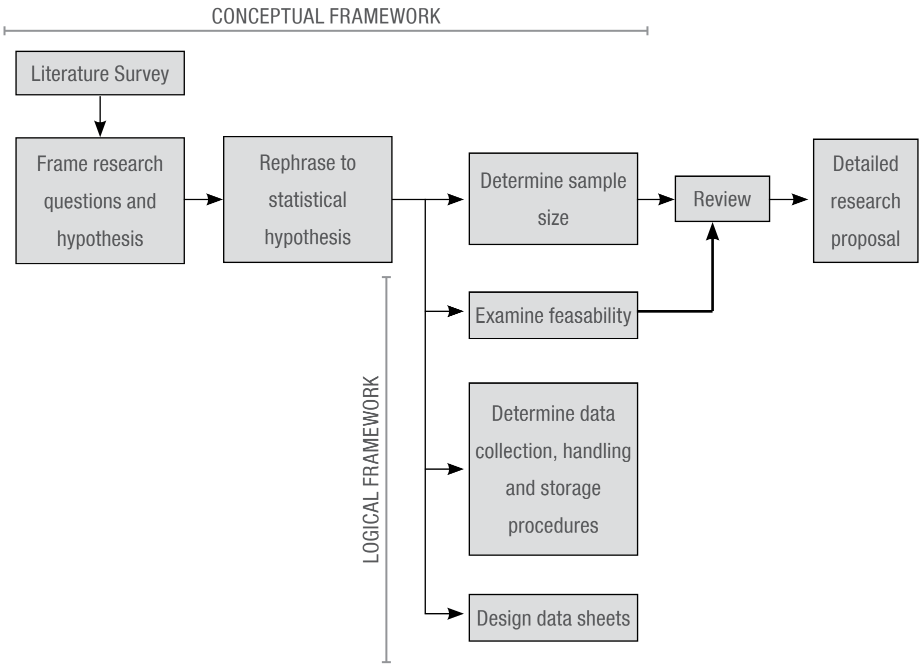
~

IN THIS SECTION > Designing a research programme > Studying nesting sea turtles > Studying sea turtle hatchlings > Tracing migratory routes > Studying evolution and behaviour > Measuring sea turtles > Other areas of research > Census and monitoring of sea turtle populations > Habitat surveys > Secondary data and market surveys

2.1. Designing a research programme

A good research project comprises both planning and execution. The framing of the research question (or questions) and the planning of the project before execution are important in determining its success.

First, the research question has to be framed in the context of existing knowledge, research and areas of interest. Second, the data required to answer the question must be identified. Finally, the data has to be collected, standardised and analysed carefully. An estimate of error is particularly important, as this helps us determine how precise our conclusions are. The following steps guide the design and implementation of a good research programme:



You can make use of a number of resources available for assistance with research proposal writing and project planning. See page 132 of the Bibliography for a list of these resources.

Both the historical perspective of a research topic as well as the current status of knowledge on the subject is particularly relevant to any research question. When placed in context, it becomes clear as to whether the research topic aims to fill lacunae in current information or address gaps in theory. Will this provide information that is completely new for the species? Or will it merely inform about a particular population? For conservation, research is needed to identify and quantify conservation challenges and evaluate the effectiveness of a management response or intervention. Therefore, while designing a research programme, it is also important to ask if the answer to the research question has any relevance to the conservation of the species.

Framing research questions and hypotheses

Once the general idea has been placed in the context of existing literature, a specific research question or set of questions has to be framed. This is followed by rephrasing the initial research question as a statistical hypothesis or statement that can be tested using data.

Sample size

Once a question is framed in a statistical context, it is important to have sufficient data to accept or reject the hypothesis with some measure of (statistical) confidence. The sample size required to achieve this will vary, but one must take this into consideration when planning the experiment and data collection.

Feasibility

Many research questions are of great interest to biologists, but some are not feasible for a variety of reasons. Feasibility is often a function of funds, and may influence sample size. For example, the number of islands visited, frequency of visits, or number of satellite transmitters deployed, is a function of **manpower**, **time** and **money**. Hence, the research design should seek to answer questions given the available resources. Variables that address the question must be identified, and data collected on these particular variables. It is also important to assess the error in the measurement of these variables.

Review

Finally, a research proposal should be reviewed by peers and colleagues, in this instance, other sea turtle biologists who have some expertise in the area of research.

2.2. Studying nesting sea turtles

Different species of sea turtles show differences during certain phases of their life cycle but also share many behavioural traits, especially those involved in reproduction. Methods for studying sea turtles at nesting beaches (and programmes to manage these populations) are therefore very similar for all species.

Nesting biology

Once the hatchlings leave their natal beaches, they return to land only to nest as adults. Males never return to land at all, except in some instances where they have been known to bask. Consequently, most research has been confined to that brief period in their life cycle when they do come ashore. However, this provides an important window of opportunity for studying nesting and reproductive biology, the knowledge of which is essential for the recovery and management of sea turtle stocks.

Left: Loggerhead turtle in shallow body pit. *Right*: Green turtle in deep body pit

Body pits (the depression dug by females during nesting) are characteristic of different species of sea turtles and range from shallow (e.g. olive ridleys) to deep (e.g. greens and leatherbacks). The depth of the nest depends on the size of the turtle and is typically between two and three feet deep. The egg chamber, into which the eggs are subsequently deposited is dug at the bottom of the body pit. The centre of the body pit does not usually indicate the location of the egg chamber. Once the nest is ready, the female turtle deposit a clutch of soft-shelled eggs. Clutch sizes vary between species, but average between 100-150 eggs. Once oviposition is completed, she will cover the nest with sand and return back to the sea. In a single season, female turtles may lay multiple nests. In some species, females visit more than one nesting site in a given season. Beach selection is affected by accessibility of the beach as well as height and substrate. Different turtles prefer different types of beaches to nest. For example, olive ridleys and leatherbacks prefer wide beaches and sand bars at river mouths, while hawksbills and green turtles prefer small island beaches.

Species	Period of nesting (Day/Night)	Re-nesting interval	Remigration interval	Clutch size	Egg size (diameter)
Leatherback	Night	9 - 10 days	2 - 3 years	80 - 100	~ 5.0 cm
Green	Night	10 - 14 days	3 - 5 years	100 - 120	~ 4.5 cm
Hawksbill	Night / Day	12 - 14 days	2 - 5 years	120 - 150	~ 3.5 cm
Loggerhead	Night	12 - 16 days	2 - 3 years	100 - 120	~ 4.0 cm
Olive Ridley	Night	20 - 28 days	1 - 2 years	100 - 120	~ 4.0 cm

2.2.1. Tagging sea turtles

Historically, sea turtle tagging has proved to be a valuable source of information on various aspects of sea turtle biology, including reproductive biology, growth, population size and migration. This involves marking animals with metal tags to recognise them when they return to the same beaches to nest, and hoping that others who encounter these animals in distant shores will return the tags or the information.

Tagging is particularly useful to study animals at the nesting beach. Identifying an animal uniquely enables us to estimate the number of clutches laid each season. If this is known, beach surveys that only include nest counts can be used to estimate the number of nesting females. Tagging also provides information on time intervals between nesting (inter-nesting interval) and distance between nesting sites (site fidelity).

When tags are returned from other areas by field biologists or fishers, it helps in identifying migration routes and foraging grounds of turtles tagged in breeding areas and vice versa. However, long distance returns of tags are usually very low compared to the number of tags applied.

Often, however, large numbers of tags have to be applied over many years before any useful results can be obtained. The study design also has to be suitable. If, for example, individual turtles nest at several adjacent beaches, tagging and monitoring at a single beach would probably not provide adequate data to estimate inter-nesting intervals or clutches per season. Considering that tags are also expensive, one must consider very carefully whether the money and effort to be spent on tagging are worthwhile. Finally, given that tagging causes a certain amount of disturbance and discomfort to sea turtles, it should be clear that the information obtained from a tagging programme is, in the long run, likely to provide commensurate benefits – either to our general knowledge of turtle biology or (ideally) to the turtle population itself.

Closeup of an olive ridley's flipper with a tag attached

In India, the Wildlife Institute of India tagged about 1,700 olive ridley mating pairs (both males and females) in the offshore waters of Orissa. The programme also tagged more than 10,000 nesting females between 1997 and 1999 at Gahirmatha, Devi River mouth and Rushikulya. Both males and females were recaptured within a season and between seasons. Ridleys that were tagged at one site were later encountered nesting at other sites, the distance between nesting sites varying from 35 to 320 km for individual turtles. There have been about 30 long distance returns of tags from the 15,000 turtles tagged in Orissa. All of these have been from Sri Lanka and southern Tamil Nadu. Here, metal tagging has provided some evidence that the turtles that nest in Orissa do migrate to the coastal waters of Sri Lanka and southern Tamil Nadu to forage.

A researcher applying a tag to an olive ridley's flipper

External tags

Most commonly, external flipper tags have been plastic or metal. A primary consideration is the longevity of the tag. Tag retention can depend on a variety of factors including the species of turtle, size class, geographical location, and where and how and by whom it is applied.

Metal tags used on turtles are usually made of Titanium (Stockbrands Company, Australia) or metal alloys such as Monel or Inconel (National Band and Tag Company, Kentucky, USA; http://www.nationalband.com). Metal tags require a special applicator for attachment, which is sold along with the tags. Generally, Titanium and Inconel tags are much more durable than Monel, but are also more expensive. Monel tags have highly variable rates of corrosion, showing great wear within a few years in some situations, while lasting decades in others. Tags are of variable sizes, but for adult sea turtles (barring leatherbacks) National Band and Tag Co. 1005-681 is a useful tag size, and is available in both Monel and Inconel. Monel tags cost about USD 200 per 1,000 while Inconel tags cost about USD 800 per 1,000.

In India, several tens of thousands of turtles have been tagged in Orissa using these Monel tags, and have been recovered in successive years in good condition. In some cases, tags have been retained for more than 20 years.

Monel tag in applicator

Applying the tag

The main problem with tagging is faulty application. The tag has to be placed correctly in the applicator, with the hole in the tag aligned with a groove in the applicator. When the applicator is squeezed, the tag pierces the flipper, and passes through the hole in the opposite end of the tag, where it bends over and locks (like a stapler pin). The initial force of squeezing the applicator only results in the tag piercing the flipper, and additional force has to be applied for locking, which is distinctive. All users should practice this first to ensure that tags are locked on application, and should also check each time they tag a turtle.

Ideally, sea turtles should be double tagged (once on each flipper) to minimise the problem of tag loss. If a turtle is given a single tag, and that tag is lost, it will lose its identity. A double tagged turtle, however, can lose one of its tags, and still be recognised by the researcher. In fact, the researcher can replace the lost tag, thus further extending the length of time the turtle will be identifiable in future encounters. Double tagging also helps to measure the rate of tag loss, which is important for population studies.

Tag position on the turtle

External tags should be applied to the front flippers of sea turtles at a proximate location, i.e. along the trailing edge near the junction with the body. Tags can also be attached to the hind flippers, and in fact, it may be preferable to tag leatherbacks on the rear flipper. If the tag is attached to the front flipper of the leatherback, the lock should end up on the dorsal side to prevent the tag from abrading the body of the turtle. Tagging can be slightly traumatic or painful for the animal, but a properly applied tag is probably no more painful than ear piercing in humans. During nesting, animals should be tagged immediately after oviposition.

Olive ridleys can usually be tagged during or after oviposition, but other species are best tagged after. Some turtles (like leatherbacks and hawksbills) may abandon the nest if tagged during laying, and though they will return later to complete nesting, it is best to avoid disturbing them. Studies have shown that there are no adverse effects of tagging on either re-nesting or survival (although there is a concern that contaminated tagging equipment may spread disease). Tagging can be preceded by the application of an antiseptic and topical anesthetic.

Tagging of a hawksbill turtle flipper

In all cases, it is useful to check all four flippers for tags, in case you come across a turtle that has been tagged by a different programme in a different location using a slightly different method.

Tag numbers and message

The size of the tag will dictate the length of the number and the message. The numbering must be unique to prevent confusion between tagging programmes. It is up to the research programme to find a unique combination of letters and numbers that are not being used elsewhere. Currently, a tagging database has been created where one can check which alphanumeric codes are already in use. The message on the tag must be concise ('WRITE TO:' or 'RETURN/SEND TO:') and the mailing address must be valid for at least a few years beyond the life of the project. Usually, tags are found by fishermen who come across them when they intentionally or accidentally catch the tagged turtles. Most fishermen will not return the tag unless they are aware of its significance. Sometimes, they are not concerned, but very often they may believe that they will get into trouble for catching a tagged animal, and hence dispose of the tag as quickly as possible. If they are inclined to return the tag, they will often pass it on to local conservation groups. Hence, it is important to spread information about the tagging programme in areas where it is suspected that these turtles might nest or forage. A decision also needs to be made with regard to whether the return of the tag will be rewarded. Rather than monetary rewards, it is suggested that posters, t-shirts and other such gifts serve the dual purpose of rewarding the finder and spreading awareness. Also, some thought should be given to the longevity of the project. If the tagging programme is short, and the tag offers a reward, there may arise a situation several years later when a person returning a found tag seeks a reward but the original project is no longer in operation.

Tagged flipper of a leatherback turtle

Tagging database

Since many programmes the world over tag sea turtles, there is some danger of using the same or similar tag codes. Furthermore, while most tags do carry a return address on them, information that reaches sea turtle field biologists (from perhaps local fishers) often includes only the tag number and not associated information on its origin, even if it was present on the tag. A tag inventory has been established at the Archie Carr Centre for Sea Turtle Research (ACCSTR) at the University of Florida in Gainesville, to keep a record of all tags used in sea turtle tagging programmes. This database can be accessed at **http://accstr.ufl.edu/taginv.html**. Tagging programmes should register their tag numbers and codes in this database. Field biologists who encounter or receive information on unidentified tags can search the database to locate the origin of the tag and provide the information to the tagging programme.

PIT tags

Passive Internal Transponder (PIT) tags are small inert transponders sealed in glass which passively transmit a unique identification number to a handheld scanner or reader at close range (approx. 1ft). PIT tags are generally about 10 – 20 mm long and 2 – 3 mm thick. These can be injected into the turtle in the shoulder or under the scales or between the digits of the front or hind flipper. The disadvantages of PIT tags are their greater cost, the cost of readers, problems associated with charging batteries in remote field stations, and the inability of personnel (either at the same or distant beaches, or at foraging grounds) to recognise tagged animals without the scanner/reader. PIT tags can also sometimes move inside the animal's body, if implanted too deeply. Generally, however, PIT tags have been found to be the most reliable with the best tag return rate, especially for leatherbacks, which have a particularly high rate of external tag loss. If PIT tags are used, it is best to also apply external tags, as this will lessen the possibility of total tag loss, can provide valuable information about the rate of retention of both PIT and external tags, and will enable other researchers and fishermen who capture the turtle to provide information about subsequent encounters with the turtle.

PIT tags, applicator and scanner

PIT tags are available from Avid, California, USA (http://www.avidmicrochip.com), Destron-Fearing, Minnesota, USA and Trovan Ltd, Koln, Germany. PIT tags are currently made in two transmitting frequencies (125 Hz and 400 Hz), but the latter are slowly being phased out. Tags and scanners made by different companies are not always compatible. PIT tags cost about USD 6 per tag and scanners cost up to USD 1,000. Universal scanners or readers which are cross-compatible and capable of detecting all types of tags are now available.

Location of PIT tags

There is a lot of variation in the tagging sites used by different researchers when they apply PIT tags, and so care must be taken when scanning a turtle for a possible PIT tag. Some attempts to standardise PIT tag sites have been made (e.g. for leatherbacks, injecting the PIT tag into the turtle's right shoulder muscle), although not everyone follows these standards.

Notching of scutes

The notching of a marginal scute or a combination of scutes has been attempted in an effort to identify year classes of hatchlings at rookeries. But, as the turtle grows older, these marks are often hard to distinguish from natural injuries. This, combined with the low rate of survivorship between the hatchling and adult stage, makes notching an unreliable marking technique. A better technique is to drill holes in the marginal scute. Such drill holes seem to be retained for many years and can be a useful way to mark juveniles and adults. These can be drilled in combinations to uniquely mark individual turtles, or simply to identify members as belonging to a group of marked turtles.

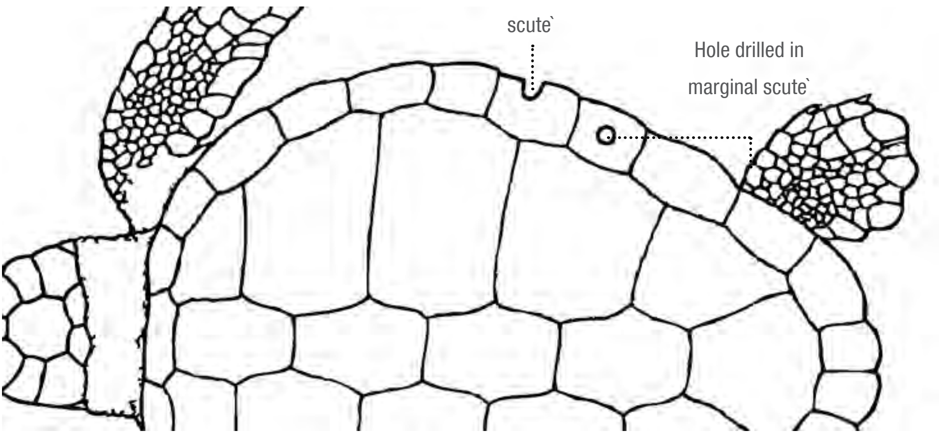


Illustration showing notched and drilled scutes

In the absence of tags, notching/drilling has been useful in some field programmes. Adult green sea turtles notched during late 1979 were identified during the 1998 nesting season in the Andaman Islands. Olive ridley and green turtles were notched each time they nested during the 1998-99 season in the Andaman and Nicobar Islands. During the subsequent season, if any marked turtles were encountered, notching was carried out on a different marginal scute.

While this did not provide information on individual turtles, some information on the number of nests per season and inter-nesting intervals was obtained. However, such data are usually not robust and cannot provide precise data on population parameters.

2.2.2. Examining sea turtle nests

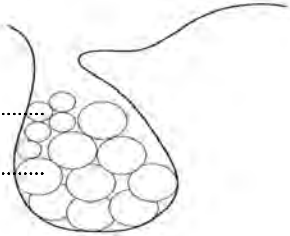
Information on nests is important for conservation and research. Data on nest depths determine hatchery relocation practice. Data on clutch sizes and hatching success can give important information about the reproductive biology of the species. In hatchery programmes, it is particularly important to determine hatching and emergence success so that one can evaluate if anything is drastically wrong, and then make appropriate modifications. This effort must be carried out for several years for inferences from the data to inform appropriate management decisions through a long term monitoring programme.

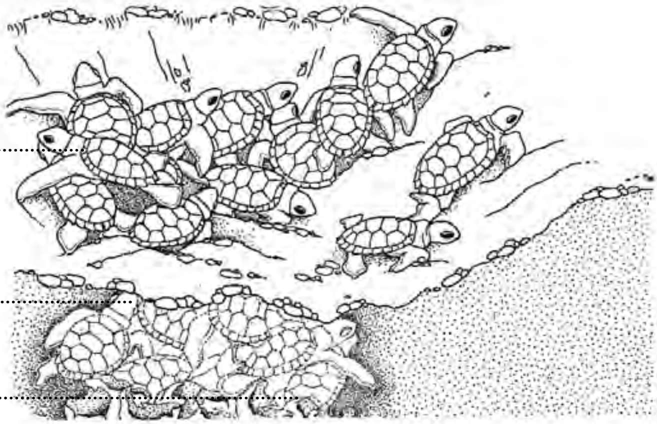
Weighing eggs from a leatherback nest

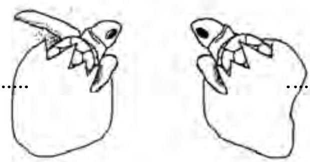
Clutch size

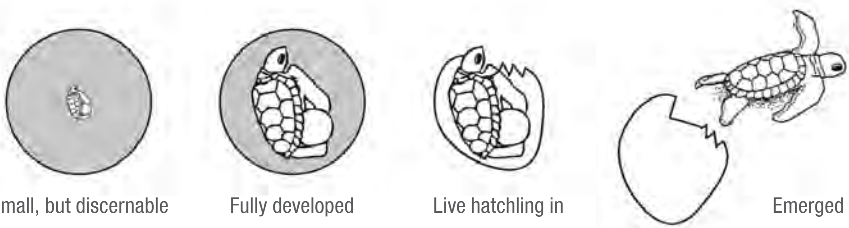
Clutch size is the number of eggs laid in a nest. Sea turtles (especially leatherbacks) lay some abnormal eggs, including yolkless eggs (which are much smaller than usual) and multi-yolked eggs. Yolkless eggs are not counted, while multi-yolked eggs are counted as single eggs. Clutch size must be determined at the time of oviposition. If the eggs are being collected for translocation to a hatchery, clutch size should definitely be determined at this time. If nests are in-situ, it is useful to determine the clutch size for some proportion of nests.

Clutch size can also be estimated after emergence by counting egg shells and other nest contents (see below). If some of the eggs that are collected are not included in the hatchery nest (perhaps because of breakage) this information needs to be recorded.


Yolkless eggs
Normal eggs


Hatchlings emerged
(E)
Live in nest
(N)
Dead in nest
(DIN)


Live hatchling in pipped egg
(LPE)
Dead hatchling in pipped egg
(DPE)


Small, but discernable embryo in egg
(UH)
Fully developed embryo in egg
(UHT)
Live hatchling in pipped egg
(LPE)
Shell
(S)
Emerged hatchling
(E)

Minimum data for each clutch

While examining a clutch, care must be taken to ensure that the data recorded contain the minimum set of information which includes:

Turtle species:	
Tag number (if any):	
Date and time laid:	*For nests laid before midnight, use the date of the following day; for nests laid after midnight, use that date)*
Location / Nesting beach:	
Clutch size:	
Fate of clutch:	*Predated / Left insitu / Relocated in hatchery*

Data can also be collected on:	
Nest location across beach:	*In relation to mean high tide line, dunes*
Nest habitat:	*In grass / under vegetation / in sand*
Nest depth top:	*Depth from surface to first egg*
Nest depth bottom:	*Depth from surface to bottom of the chamber*
Egg diameter:	*For 10 normal eggs*
Egg weight:	*For 10 normal eggs*

Measuring and weighing eggs

It is not strictly necessary to measure and weigh eggs, unless there is a specific research objective. A minimum of ten eggs should be chosen at random from the clutch, and wiped free of sand. The greatest and least diameter for each egg should be measured and recorded. These can be averaged to obtain the diameter of each egg. The same eggs can also be weighed using a spring or electrical balance. If the balance is not accurate enough to weigh single eggs, groups of eggs can be weighed together and averaged.

Excavation data

Collecting data on nest contents can help in identifying problems during incubation either in the hatchery or in situ.

Nest contents can be categorised as:

S = Shells = Number of hatched out empty shells
E = Emerged = Hatchlings that have emerged from the nest
LIN = Live in Nest = Live Hatchlings still within the nest
DIN = Dead in Nest = Dead Hatchlings within the nest
DPE = Dead hatchling in pipped* egg
LPE = Live hatchling in pipped* egg
P = Predated = Open, partial / nearly complete shell with egg residue/dead embryo

*Pipping: The breaking / opening of the shell by the hatchling

Unhatched eggs
UD = Unhatched, undeveloped eggs with no obvious embryo
UH = Unhatched egg with obvious small embryo
UHT = Unhatched egg with full term embryo

Shells: The number of hatched shells (shells are also left from predation) is difficult to count, and the accuracy often depends on the skill and experience of the worker. Only shells that are > 50% of the egg should be counted; small fragments must not be counted. All workers (both new and experienced) should calibrate their error by comparing egg shell counts in nests where the clutch size is known (though this may be affected if there is predation inside the hatchery).

Undeveloped eggs: Some of these may be infertile, but others may have a very small indiscernible embryo, which cannot be discerned without careful, detailed examination, and adequate equipment and training.

Calculating clutch size

Estimated total clutch = components without shells + components with shells
CS (Clutch size) = **(E + LIN + DIN) + (UD + UH + UHT + DPE + LPE) + P**

Where components without shells = Number of hatched shells (S) = Emerged (E) + Live in Nest (LIN) + Dead in Nest (DIN)

If the total number of hatchlings emerged is not known (i.e. if a few escaped and were not counted), **E = S – (LIN + DIN)**.

Calculating hatching and emergence success

If clutch size determined by counting hatchlings, then
Emergence success (%) = **(E / CS) x 100**
Hatching success (%) = **[(E + LIN + DIN) / CS] x 100**

If clutch size is determined by counting egg shells, then
Emergence success (%) = **[S – (LIN + DIN) / CS] × 100**
Hatching success (%) = **(S / CS) x 100**

Total clutch size must include eggs that were lost between collection and relocation due to breakage or predation inside the hatchery. Sample nest data sheets are provided on pages 125-127.

Monitoring incubation temperature

Incubation temperature is an important parameter in understanding incubation environment as it influences the duration of incubation and survival of the embryos, and determines hatchling sex. It also varies through the day and across a season. Monitoring incubation temperatures adds to the effectiveness of a hatchery programme and can also be used to study its influence on hatching success. Temperature data collected should be representative of the range of nesting sites on the beach. Sand temperature may be measured with the help of a field thermometer (which must be calibrated before use to account for error) or miniature data logging devices. Hobo pendant data loggers are popular temperature logging devices which cost approximately USD 40.

Marking nests

In order to be able to identify nests that have to be counted or relocated to a hatchery, a simple technique is to insert a coloured tape or rope into the egg chamber so that it extends to the surface. Once oviposition is completed and the turtle has left the nest, the nest can be located at a later time with the help of this marker. Nests left in situ on the beach or relocated to a hatchery can be identified by inserting a nest tag (a placard or tape) during the time of oviposition. The tag should contain information on the tag number (if any) on the female and the date and time of nesting. This enables the data collected at the time of hatching to be linked to a particular clutch (and nest site) and female. In areas where nests are likely to be poached, it is advised that the tags be made less conspicuous so as to attract the least attention.

2.3. Studying sea turtle hatchlings

Mortality is highest during the early phase of a turtle's life. It is important to understand the factors that affect egg and hatchling survival, especially on land, where they are most vulnerable to anthropogenic factors. Even under natural conditions, only one in a thousand hatchlings is believed to survive to adulthood.

Information about egg development, temperature dependent sex determination and hatchling development is discussed in some detail in the section on sea turtle life history on page 12.

2.3.1. Estimating hatchling sex ratios

Primary sex ratio

The sex ratio at birth in a population is an important and interesting demographic parameter. To determine this, the relationship between temperature and sex determination has to be established for a particular population. This can be done by experimentally maintaining nests at a particular incubation temperature and sexing a proportion of the hatchlings. In India, the pivotal temperature is known only for the olive ridley population in Orissa (~29.2°C).

Estimating the hatchling sex ratio of the population needs to take three factors into consideration: 1) **Spatial variation** in nesting results in nests being laid in beaches or zones with different temperature profiles, which will result in different sex ratios; 2) **Temporal variation** in nesting results in nests at different times of the year being subjected to different temperatures; and finally, 3) **Frequency of nesting** in different places at different times needs to be taken into consideration. The population under consideration itself may need to be defined, and genetic data may be required to achieve this. Sand temperatures cannot be directly converted into sex ratios since pivotal temperatures are usually derived from lab studies at constant temperatures, unlike field conditions. Moreover, the effect of metabolic heating needs to be taken into consideration. Also, inter-clutch variations in pivotal temperature may complicate the estimation of sex ratios.

Incubation times and sex ratio

If temperature data are not available and hatchlings cannot be sexed, incubation times can be used as a surrogate to estimate hatchling sex ratios for populations. Though this cannot be applied to individual nests, it is a useful technique for particular beaches or populations. Here the relationship between temperature and incubation (higher temperatures lead to shorter incubation times) is defined from known data. Hence, accurate data on incubation times yield rough values of temperature of incubation. The sex ratio can then be derived from the temperature profile for the beach for a particular season.

Sexing hatchlings

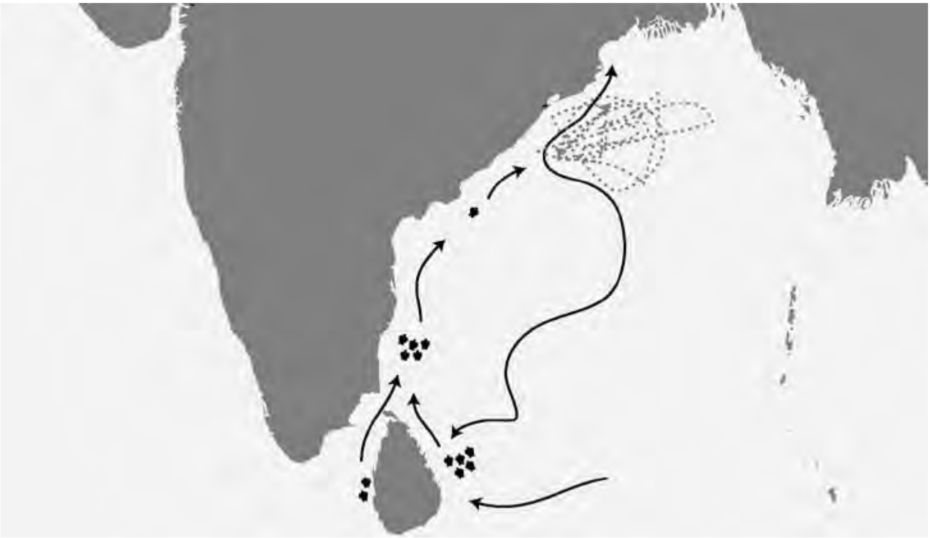
All the procedures available for sexing hatchlings involve dissection of the animals and examination of the gonads as there are no external morphological characteristics that may be used to determine the sex of a hatchling. Though experiments involving radioimmunoassays have been carried out, there are no conclusive results that support non-invasive methods of sexing hatchlings. The thermosensitive period, i.e. the period during the developmental stage during which the incubation temperature influences the sex of the embryo, is determined to be around the beginning of the second third of the total incubation time.

2.4. Tracing migratory routes

Sea turtles often migrate thousands of kilometers across international waters. Current knowledge of sea turtle life history suggests that individual turtles occupy a series of different habitats during the course of their life cycles. Various modern techniques are now being used to track sea turtles to study their long range migrations.

Tagging provides information about migration only as far as the sites of tagging and tag recovery, hence allowing inferences about the beginning and perhaps, the end points of the migration. For details of the migratory route, and behaviour during migration, one has to turn to a more advanced technique, namely telemetry. Radio telemetry is a widely used technique in wildlife studies, and has been used with limited results to study turtles within the breeding area. This involves placing a transmitter on the turtle and tracking it with a receiver. However, once a sea turtle begins its (often) long journey to its foraging area, it is impossible to track and follow these turtles.

Satellite telemetry solves this problem as the transmitter signal is received by a satellite, and the animals can be tracked wherever they go. This data can be used to trace the precise migratory route of the turtle, and collect associated information such as swim speed and travel rate. Transmitters can be fitted with equipment to provide information on water temperature and activity of the turtle.



Migratory routes of olive ridleys along the east coast of India

2.4.1. Satellite telemetry

Transmitters, also called Platform Transmitter Terminals (PPTs) are attached to the animal whose long distance movements are to be studied. Once they are turned on, the transmitters send high frequency signals which are received by polar orbiting weather satellites. ARGOS, a French company, has equipment on board these satellites for tracking animal movements. The transmissions are first decoded to identify the transmitter, each of which has a unique code and then the position of the transmitter is calculated. The data are then downloaded by ARGOS. Once the data are received, the latitudes and longitudes can be plotted on a map and the migratory routes of the animals can be traced. The data are classified by ARGOS depending on the quality of the data received by the satellite. LC 1, 2 and 3 are the best quality points and have an error radius of approximately 1,000 m, 350 m, and 150 m respectively.

For marine turtles, the transmitters also have a salt water switch which is turned on when the turtle is under water. The PTT sends transmissions only when the salt water switch is turned off, i.e. when the turtle surfaces. Transmitter specifications that need to be selected include repetition rates and duty cycles, which determine how often the transmitter will come on and how long it will stay on. This is to gain the maximum useful information out of the transmitter given the lifespan of the battery.

Applying satellite transmitters to turtles

STEP 1: The carapace of the turtle is first cleaned with alcohol; STEP 2: The bottom of the transmitter is cleaned with alcohol; STEP 3: Using a special gun, the two part epoxy is applied to the bottom of the transmitter; STEP 4: The epoxy is then applied to the carapace of the turtle and the transmitter is pushed onto it's back. The epoxy is smoothened around the transmitter; STEP 5: The turtle is released into the sea

In hard-shelled turtles, the transmitters are attached to the carapace of the turtles using Epoxy or fiberglass. In leatherbacks, transmitters are attached to the carapace directly by drilling a hole through the carapace ridges and running a wire or cable through it, to which the transmitter is then attached. Satellite telemetry is an expensive technique and can cost up to USD 2,000 for the transmitter and USD 2,000 for the data for each turtle.

For more information, log on to:

ARGOS - http://www.cls.fr
SIRTRACK - http://sirtrack.landcare.cri.nz
TELONICS - http://www.telonics.com
WILDLIFE COMPUTERS - http://www.wildlifecomputers.com

A tracking tool is also available at http://www.seaturtle.org. In India, satellite telemetry studies have been carried out on sea turtles in Orissa by the Wildlife Institute of India, Dehradun. The Centre for Ecological Sciences, in collaboration with the Andaman and Nicobar Islands Environment Team and the Andaman and Nicobar Islands Forest Department has initiated a long-term tagging, monitoring and telemetry programme on Little Andaman Island to monitor leatherback turtles.

2.5. Studying evolution and behaviour

For many years, sea turtle biologists have grappled with questions such as: Are black turtles and green turtles separate species? How closely related are olive and Kemp's ridleys? From which rookery does a group of foraging turtles derive? Do clutches have multiple paternity? And do turtles return to their natal beaches to nest?

Sea turtles have long been believed to nest on their natal beaches, i.e. the beaches where they were born. For many years, this remained mere speculation. Firstly, the hatchlings grow from a few centimeters in size to adults that are many times larger, ranging from the 80 cm ridleys to the 180 cm leatherbacks. Tags that would successfully last through till adulthood (which could take ten or more years) are not available. Secondly, considering that only one in a thousand hatchlings survives till adulthood, the number of tags that would need to be applied to get significant results would be astronomical. Finally, research would have to be carried out for decades to demonstrate natal homing through tagging.

However, in the early 1990s, a technique became available that could successfully address the question of natal homing in turtles – molecular genetic analysis. In simple terms, if turtles did not return to their natal beaches, the genetic markers of the populations would mingle. If however, turtles were faithful to their natal beaches, then markers in different populations would be distinct. In a first landmark study, scientists showed that the green turtles that foraged off the coast of Brazil had a mix of genetic haplotypes, but the haplotypes of the nesting beaches in Tortuguero, Costa Rica to the north and the Ascencion Island in the middle of the Atlantic were completely different. Hence the turtles were feeding together, but returning to their natal beaches to nest.

2.5.1. Genetic analysis and tissue sampling

- **Quantity:** Earlier, a large quantity of DNA was required for analysis, and hence blood sampling was essential. However, current techniques, which are mostly PCR (Polymerase Chain Reaction) based, require very small quantities, as can be obtained from small biopsies of tissue or skin. Blood may still be required for other studies (e.g. hormonal studies).
- **Contamination:** The most important aspect of sampling for genetic studies is avoidance of contamination. Equipment such as needles, forceps and scissors should be washed and cleaned thoroughly before re-use. Vials should be sterilised before use and sealed completely (with parafilm) after use. Vials should be labeled using permanent markers.
- **When to collect:** Often, genetic sampling is done opportunistically, i.e. during other field projects. It is wise to collect and store samples, because the opportunity to collect a sample may not always present itself. However, it is important to ensure that proper permits are acquired before collecting samples. Samples can be stored almost indefinitely, and hence genetic analysis can be carried out at a later date when funds are available.
- **What data to record:** Some basic data need to be recorded for each sample. These include: species of turtle, date, location where turtle was encountered, whether it is known to be an adult or juvenile, male or female, and whether the turtle was sampled at the nesting beach or its foraging ground.

Collecting and storing blood

Where to collect sample: Blood can be collected from the dorsal cervical sinus, which is located bilaterally in the neck close to the dorsal surface, about 1/2 to 1/3 way to the back of the head from the carapace (see figure below). Either a syringe and needle or a vacuum tube with needle (vacuutainer) can be used. For hatchlings and young juveniles, an insulin syringe with a flexible 26-29 gauge needle (12.7 mm) is used. For adult turtles (except leatherbacks) a 21 gauge needle (2.5-3.8 cm) can be used. For leatherbacks, 7.5 cm 18 gauge needles are required.

In leatherbacks, blood can also be collected from a sinus in the rear flipper. It is advisable to sterilise the skin prior to inserting the needle.

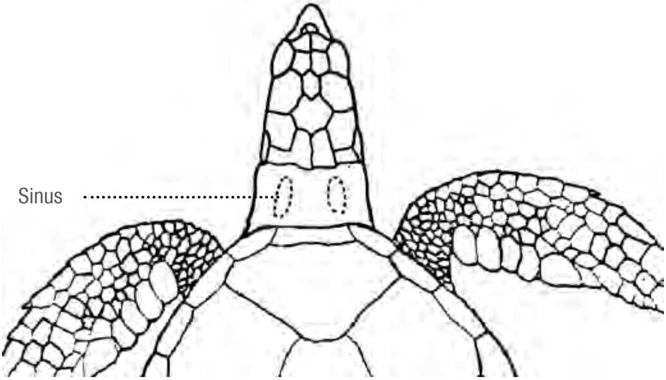


Illustration showing the location of the sinus on a sea turtle

How to collect a sample: The turtle should be restrained so that the neck is stretched and lower than the body which helps fill the sinuses. With nesting turtles, this is easily achieved during oviposition by scooping out sand from below the head. The needle is inserted about 1 cm from the dorsal cervical midline on either side of the line's midpoint. The needle should be inserted perpendicular to the surface to a depth of 1 – 3 cm, till there is a spurt of blood, at which point some suction can be applied to collect blood. The depth of insertion may need to be adjusted till the sinus is located, but the needle should not be rotated. The location of the sinus varies between individuals and it may be necessary to insert the needle a few times. If a few attempts are unsuccessful, the other side of the neck can be tried. 1 - 2 ml of blood can be collected from adults, while 0.1 - 0.5 ml only should be collected from hatchlings.

Storage of sample: Small blood samples can be dried on glass slides or filter paper, but these methods should only be used as backup. Blood can be stored in EDTA vacuutainers or in lysis buffer (100 mM Tris- HCl, pH 8; 100 mM EDTA, pH 8; 10 mM NaCl; 1-2 % sodium dodecyl sulphate, SDS). For blood samples, the buffer ratio should be 1:5 to 1:10.

Collecting and storing tissue

How to collect a sample: Tissue can be collected from live or dead animals. In either case, precautions must be taken to avoid contamination. A tiny piece of tissue can be taken from the flipper using a razor blade (single edge blades or double edged blades broken in half). The advantage of using razor blades is that they are easily available, reasonably sterile, and can be disposed of after collecting each sample, thus reducing the chances of cross contaminating samples. Razor blades must not be discarded in the field; they can be stored in an empty plastic bottle until they can be disposed of properly and permanently.

Storage of sample: The samples can be stored in a 1 or 2 ml cryovial. Tissue samples can be stored in absolute or 95% ethanol (alcohol). Tissue can also be stored in saturated salt (NaCl) solution with 20% DMSO (dimethyl sulfoxide). Salt solution is preferred because it is not volatile or inflammable and better for transport of material. (In the absence of the above, at a pinch, tissue can be stored in any alcohol, or salt, or salt solution, all of which are usually available in abundance in field stations).

Genetic analysis

In recent years, the development of molecular techniques has offered a new range of tools to answer questions of ecological interest. Genetic analysis can be carried out in laboratories which are suitably equipped. Primarily, mitochondrial DNA sequencing analysis is used for phylogenetic and phylogeographic studies, while microsatellite analysis is used for population genetics and paternity studies. For example, the study of the population structure of sea turtles along the coast is critical to assigning conservation priorities to particular nesting beaches or populations. Mitochondrial DNA haplotypes have been found to be unique to ocean basins and to particular geographical regions. The identification of genetic markers in all major populations across different ocean basins can provide a mechanism to trace migratory routes and identify populations affected by particular threats. Molecular studies of paternity can shed light on the reproductive biology of these turtles.

In India, genetic studies on sea turtles have been carried by the Wildlife Institute of Dehradun, India in collaboration with Centre for Cellular and Molecular Biology, Hyderabad. In one study, olive ridley turtles on the east coast of India were found to be ancestral to olive ridleys in the Pacific and Atlantic oceans, highlighting their evolutionary and conservation significance (Shanker *et al*. 2004). The Centre for Ecological Sciences at the Indian Institute of Science in Bangalore is currently involved in a research project that is documenting the mitochondrial DNA haplotypes to analyse population genetics and compare olive ridley populations along the east and west coasts of India.

2.6. Measuring sea turtles

Sea turtles are measured for a number of reasons – to relate body size to reproductive output, to determine minimum size at reproduction, and to monitor nesting female size at a rookery. Changes in nesting female size can, for example, be indicative of either a declining population or in some cases, an expanding population. At foraging grounds, they are measured to determine size classes of turtles, which in turn can provide important information about the demography of a population. Mark recapture studies in which turtles are captured, marked and released, then later recaptured, can provide estimates of population size. Repeated measurements of tagged turtles during mark recapture studies can provide estimates of growth rates.

As with all other data, measurements need to be as precise, i.e. free of error, as possible. Error can creep into the measurements in many ways. Different personnel may take measurements differently. They may measure the turtle from different points. Different tape measures can vary substantially from each other. The same tape measure can deteriorate over time (and stretch) and thus result in erroneous measurements. Hence, tapes and calipers should be calibrated regularly. Error should be measured by taking repeated measurements of the same animals (by the same and different personnel).

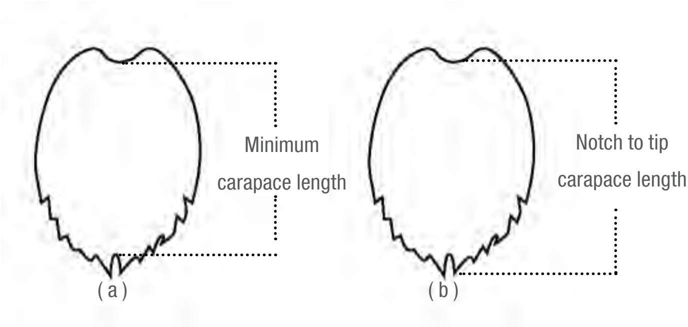
Though straight line measurements are more precise, calipers of the required size are unwieldy for field travel and use. Fiberglass tape measures are better than metal or cotton tapes, because they are flexible and do not stretch. The tape measure should be longer than the carapace, so that the reported length is the result of a single measurement. If any irregularity (such as deformity in the shell of the turtle) affects the measurement, it should be noted, and the measurements should not be used in the analysis.

2.6.1. Measuring sea turtle carapaces

Though carapaces are measured from different points both anteriorly and posteriorly, we will present two common methods of measurement here.

Carapace length

For hard-shelled sea turtles, minimum carapace length is measured from the anterior point at midline (at the point where the nuchal scute meets the turtle's neck) to the posterior notch at midline between the supracaudals (Figure a).



Illustrations showing the measurement of the carapace

The "notch to tip carapace length" is measured from the anterior point at midline to the posterior tip of the supracaudal. If the supracaudals are asymmetrical, then the measurement should be to the longer one (Figure b).

Generally, in **Straight Carapace Length (SCL)** measurements, SCL-min is preferred, but SCL-nt can also be recorded for comparison with other data sets. SCL-min may not be useful if there is substantial variation in the shape and length of the notch between the supracaudals. Either way, the measurement should be specified on the data sheet. **Curved Carapace Length (CCL)** is measured using the same points on the turtle's shell.

Carapace width

Carapace width is measured at the widest part of the shell. Both **Straight Carapace Width (SCW)** and **Curved Carapace Width (CCW)** should be measured with the turtle resting naturally on its plastron.

Tail length

Total tail length (TTL) is the distance from the midline of the posterior edge of the plastron to the tip of the tail following the curvature of the tail. Post cloacal tail length (PTL) is the distance from the mid cloacal opening to the tip of the tail. Both measurements are taken using a flexible tape measure. Since tail length is a secondary sexual characteristic in turtles, the ratio of TTL to PTL is greater in mature males than in mature females, and can also be greater in immature males that are beginning to show sexual characteristics.

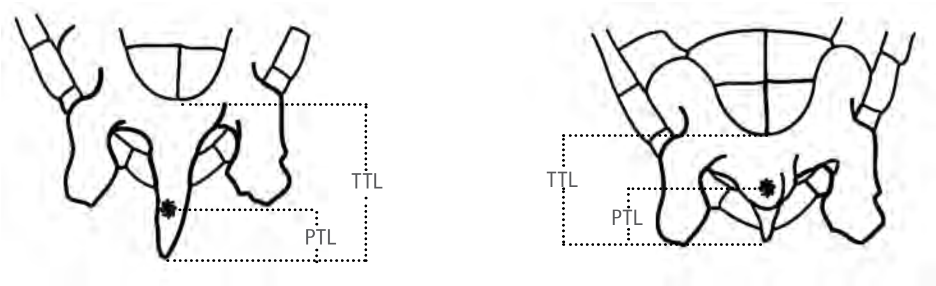
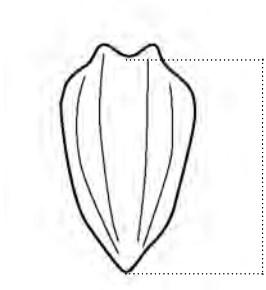


Illustration showing the measurement of TTL and PTL in males (*left*) and females (*right*)

Linear measurements of leatherback turtles

Both SCL and CCL are measured from the nuchal notch (anterior edge of carapace at midline) to the posterior tip of the caudal peduncle. CCL should not be measured along the crest of the ridge, but alongside the ridge, just adjacent to the apex of the central keel.



Linear length of a leatherback carapace

Carapace width

As there are no anatomical reference points, carapace width is measured at the widest point. SCW is measured with calipers and CCW is measured with a flexible measuring tape; the measure does not follow the curvature of the ridges, but spans from the first ridge crest to the furthest ridge crest across the width of the carapace.

2.6.2. Measuring sea turtle hatchlings

Hatchlings should be measured as described above, using calipers. Care should be taken not to distort the shell of the hatchling, which is very flexible.

Measurement of a leatherback carapace length

2.6.3. Weighing sea turtles

Though body mass is an important variable, it is often difficult to weigh adult turtles. When weighing adult females on the nesting beach, it is important to record whether the weight was taken before or after the turtle laid her eggs. A portable tripod with a pulley can be constructed to weigh turtles.

Hatchlings can be weighed using a spring balance. Depending on the accuracy of the scale available, it may be better to weigh groups of hatchlings together and determine the average weight.

As there are variations in the methods to measure turtles, it is important that the type of measurements and degree of precision of the measurements used be noted and reported in any publication.

2.7. Field equipment

Basic necessities:

- Data sheet or field notebook (You may use the sample data sheets provided in Section 4 of this manual)
- Pen / pencil
- 2m tape
- Watch or stopwatch
- Bags for transport of eggs
- Depending on the objective of the conservation or research programme, you may need:
- Vernier calipers* (to measure eggs or hatchlings)
- Weighing scales*
- Scissors, forceps and vials (with ethanol) for collecting and storing tissue samples
- Permanent marker pens for vials and nest markers
- Tags and applicators

*Calipers are cheap and can be purchased easily. Good weighing scales (or spring balances) are more expensive and purchase of these will depend on the availability of funds. Pesola spring balances are available from the Forestry Supplies Inc. and cost about INR 2,000 each.

2.8. Other areas of research

Today, the development of new tools and technology have opened up many avenues of research. For example, GIS and remote sensing can be used to study nesting and foraging habitats and anthropogenic impacts on these habitats. Listed below are a few other traditional areas of research on sea turtles, and there are many more.

Foraging ground studies

Studies are being carried out at foraging grounds, both on population size and structure (age and size classes), mixed stock analysis (genetic analyses to determine which nesting beaches these turtles are derived from) and foraging ecology. Foraging studies can include behavioural observations of feeding, diet analysis and local movements.

Diet sampling and diet component analysis are important aspects of studying nutrition and foraging. Combined with information on growth rates, these can offer important insights into the nutritional ecology of sea turtles. Currently, new methods such as stable isotope analysis are available to study diet in sea turtles.

In the case of herbivorous green turtles, their impacts on foraging habitat – namely seagrass – have also been studied through experiments and observations. In India, Lal *et al.* (2010) studied the impact of green turtles on seagrass meadows in the Lakshadweep Islands.

Reproductive cycles and endocrinology

Various techniques such as hormone radioimmunoassay, laparoscopy and ultrasonography can be used to study reproductive cycles and endocrinology in sea turtles. However, these methods require equipment, expertise and training. Useful data can also be obtained from autopsies of dead turtles. The state of the ovaries can be a fund of information on the reproductive stage and status of the turtle.

Orientation and navigation

Studies have been carried out on visual stimuli and sea finding of hatchling sea turtles. What wavelengths and intensities of light are they most sensitive to? How do landward silhouettes affect sea finding ability? This information can help design turtle friendly beachfront lighting. Experiments have also been conducted on the sensitivity of hatchling turtles to geomagnetic stimuli, to understand their ability to navigate.

In India, one study has been carried out on the effect of lighting on olive ridley turtle hatchlings in Rushikulya, Orissa (Karnad *et al.* 2009).

Diseases

Studying diseases is an important component of monitoring the health of sea turtle populations. Given the high rates of organic and inorganic pollutants in many waters that sea turtles inhabit, they could be susceptible to a wide range of diseases. Fibropapilloma, in particular, affects many sea turtle populations, and has been the focus of research in recent times. Fecal samples and blood samples are used to study parasites and pathogens. Serodiagnostic tests have been conventionally used to study blood borne pathogens, but today, many molecular diagnostic tests are also available.

2.9. Census and monitoring of sea turtle populations

How many individuals comprise a population? What is the age structure of the population (are there many young animals or many old animals)? What are the trends over time – is the population increasing, stable, or decreasing? Since this is impossible to calculate precisely for sea turtles (given our limited knowledge of various aspects of their biology, such as their remigration intervals, sex ratios, numbers of animals in the age classes before reaching reproductive age, etc.), we often use surrogates or indices such as number of nests / nesters per year. Even a simple index such as this can be hard to quantify unless the study design is carefully planned.

One of the most important questions for conservation is with regard to trends: is the population increasing, decreasing or stable? To answer this question, reliable data on the population size (or index) are required for a number of successive years. Given the amount of year-to-year variation, the long time to maturity, and the long life spans of sea turtles, it is necessary to gather systematic data for many years or even decades. These data should be comparable in that they should have been collected by the same method (and hence be comparable with regard to considerations such as error and bias) and even better, the data should have an associated measure of error, so that one can not only judge whether differences are due to errors in measurement or actual changes in population size, but also to verify if perceived trends are significant or not.

Population trends in sea turtles are particularly hard to pin down because of the yearly variation in nesting populations. Some sea turtles, like ridleys, nest annually or once in two or three years. On the other hand, the remigration interval for leatherback and green turtles can be three or four years or even as much as 11 years. This means that the proportion of the total population that is nesting each year can vary substantially. Hence, yearly variations in nesting population size may not be a good index of population dynamics unless data are collected for a sufficiently long period – which is usually decades.

Because nesting females are the only part of the population that are readily accessible – they crawl out on to nesting beaches where they can be counted or their tracks can be counted – nearly all estimates of population size in sea turtles are based on nesting beaches. This means that we are ignoring all the members of the population that are not reproducing, all of the males (regardless of age) and those reproductive females that do not nest during the period when we carry out our beach surveys. Hence, population estimates are based on a relatively small part of the total population.

Even with these caveats, good information on population sizes is critical to conserving and managing wild populations. In this section, we discuss basic methods* used for monitoring sea turtles:

- Population surveys on nesting beaches
- Habitat surveys
- Market surveys

What is a population?

For sexually reproducing animals, a population is defined as a 'set of organisms capable of freely interbreeding with each other under natural conditions.' It is generally understood to be a group of individuals belonging to the same species occupying a geographically delimited area. In genetic terms, one can define a population as a group of individuals amongst which there is gene flow on an ecological time scale, i.e. within a few generations. Most importantly, it is necessary to be consistent in the use of term.

2.9.1. Population surveys

Nesting beach surveys are most widely used for monitoring sea turtle populations. Surveys may be conducted on a single day (a 'snapshot' of a nesting beach) or may be intensive, long term structured monitoring of sites during the whole nesting season for several decades. Since methodologies vary widely, it is often difficult to compare surveys conducted at different sites, or even surveys of the same site carried out by different methods at different points in time. Hence, it is of utmost importance to use a standardised method that is clearly understood by anyone who reads the reports and that is repeatable and comparable.

Nesting surveys often begin with beach assessments, which identify potential nesting sites, seasons and the species nesting. Often, preliminary beach surveys can be combined with preliminary nesting assessments, as long as the survey is carried out during the nesting season (if this information is available).

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*Census methods for arribadas are provided in the manual: *Census techniques for arribadas - Monitoring olive ridley sea turtles in Orissa* (Shanker *et al.* 2010)

a. Nesting versus non-nesting emergence

Sea turtles emerge frequently on nesting beaches and return without laying eggs, sometimes having constructed several nests. **Scoring non-nesting crawls as nests can give a false account of nesting density.** The best way to identify a nesting crawl is to locate the nest and eggs. This may not always possible and other signs can be used to identify nesting crawls that are successful.

It requires considerable experience to determine a successful nesting crawl from the tracks, and given the importance of distinguishing them from false crawls, personnel should expend considerable effort on first familiarising themselves with the species and its nesting habits and field signs (track and nests) by direct observation of the nesting process.

Field signs of a nesting crawl

- **Backstop:** An approximately 45° incline made in the sand as sand is pushed back with the rear flippers during the excavation of the primary body pit (not distinctive in smaller species)
- **Crawl:** Tracks made by the sea turtle (not sufficient evidence of succesful nesting)
- **Egg chamber:** Cavity into which the turtle deposits the eggs (not sufficient evidence of succesful nesting)
- **Escarpment:** Perimeter of the secondary body pit where the front flippers have cut away a small cliff into the surrounding sand (not always distinctive)
- **Body pit**: Excavation made by the turtle prior to digging the egg chamber. Ridleys make practically no body pit at all, while loggerheads and hawksbills make very shallow body pits, which may be difficult to detect. Green turtles and leatherbacks usually make deep body pits.

Successful nesting crawl

Observing the direction in which sand was pushed will help identify the up track (track leading to the nest) and down track (track left while turtle returned to the sea). In ridleys, the flipper mark is comma shaped, and the direction of the tail of the comma indicates the direction in which the turtle moved.

One can follow the crawl to the nest to look for the above signs of nesting. Ridleys and hawksbills do not create large body pits, but the backstop may be evident if the sand has not been disturbed. Even it if is present, this is not certain proof that there was a successful nesting.

The nesting area is usually a smoothed out expanse of sand resulting from the throwing of sand by the front flippers following egg laying. This needs considerable experience to be able to detect with an acceptable degree of certainty.

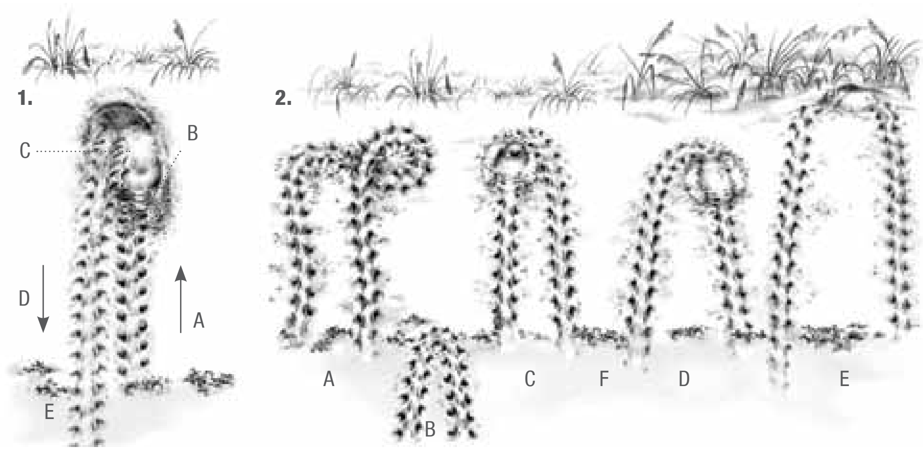
False crawl

A false crawl can be determined from the following signs:

- Very little or no sand disturbed apart from the crawl itself
- Considerable sand disturbed but with the crawl exiting from the disturbed area
- Considerable sand disturbed and an uncovered egg chamber

For olive ridleys, false crawls can usually be determined from the complete absence of a nesting area or from half or fully excavated nest chambers that have not been covered.

In addition, one may encounter depredated nests. These will usually be surrounded by eggshells and partially consumed eggs and must be counted as successful nesting crawls.



1: Stages of successful nesting, with emerging crawl (A); sand misted or thrown back over the emerging track (B); a secondary body pit and escarpment, with sand thrown in the vicinity (C); and returning crawl (D). (E) marks the high tide line. 2: Examples of false crawls (non-nesting emer gences) include extensive wandering with no body pitting or digging (A); U-shaped crawl to the high tide line (B); considerable sand disturbance and evidence of body pitting and digging and no evidence of covering (D); and considerable sand disturbance, evidence of body pitting and digging with a smooth-walled egg chamber and no evidence of covering (C). (E) marks the site of a crawl where the relative lengths of the emerging and returning crawls are the same. (F) marks the high tide line

2.9.2. Beach surveys

a. Extensive surveys (Preliminary survey of extensive coastlines)

Often, information is needed for hundreds of kilometres of coastline. Obviously, the entire coast cannot be monitored on a daily basis. Surveys of such extensive coastlines are best conducted by covering the entire coast at least once, and often, it is effective to partition the coast into sectors and sample them at different levels according to their importance and accessibility. For example, the coast can be divided into 50 km sectors and a random stretch of 10 km could be evaluated for each sector. For a finer scale of resolution, one could sample 2 out of each 10 km. In both these cases, 20% of the coastline is covered. The proportion of coastline that needs to be sampled to get a clear picture of nesting along a coast will vary between sites.

This often depends on the logistics and accessibility. If transport is available, and the beach is accessible from the road, one can motor to different sectors and sample them by foot. If driving on the beach is possible (by cycle or motorcycle), the entire coast can be covered fairly quickly. Combined with interviews, surveys of extensive coastlines seek to identify:

1. Proportion of the coastline comprising potential nesting habitat
2. Locations with occurrence of sea turtle nesting
3. Species of sea turtles nesting
4. Seasonality of sea turtle nesting
5. Relative intensity of sea turtle nesting
6. Index beaches for intensive monitoring
7. Potential threats to habitats, eggs, hatchlings and adult turtles
8. Potential beaches for conservation activities
9. Potential conservation activities and partners

While # 1 and # 6-9 can be evaluated at any time, only surveys conducted during the nesting season can evaluate # 2–5 from direct observation, and surveys conducted outside the nesting season will depend on interviews with locals for information on these questions. Example data sheets for beach profiles and beach surveys are provided in Section 4 of this manual.

The proportion of nesting habitat along a coast can be assessed from satellite imagery, aerial photographs, or up to date maps, and although it is preferable to do the initial planning before field work, these resources may not be available or accessible. In any case, ground surveys should be conducted, for they give the most reliable results. First, what constitutes a potential nesting beach needs to be defined. Once this is clear, the extent of these beaches can be measured at either a coarse or fine resolution.

b. Intensive surveys (on nesting beaches)

Often, the results of preliminary or extensive surveys provide some indication about important nesting sites and the species nesting. However, more data are needed to obtain reliable estimates of population size and trends. Intensive surveys can be carried out during an entire nesting season to quantify the amount of nesting at a beach. If only a part of the nesting season is monitored, it necessary to have clear and standardised methods for deciding when to start and stop monitoring. Since it may not be feasible to survey the entire coastline throughout the season, it might be necessary to choose a few sites to represent the entire coast.

The sites used for intensive surveys can serve as index beaches that can be used to estimate total sea turtle nesting effort over a larger region. Long term monitoring of these index beaches will also provide much needed information on population trends. Index beaches may either be important nesting beaches which support a large proportion of a region's nesting, or they may be representative of nesting in the region. For systematic and regular monitoring, they must be of a length that can be surveyed daily, and be accessible to project staff.

c. Frequency of surveys

Daily versus periodic surveys

Daily surveys (whether conducted at night or day) during the nesting season can obviously provide the most detailed information on species, nesting activity and nest density from both direct observations of nesting females as well as from track and nest counts (i.e. indirect counts based on spoor). However, periodic surveys that are conducted less frequently (weekly, fortnightly or monthly) can also provide useful data. Both daily and periodic surveys, however, must be careful not to double-count tracks. To this end, tracks can be raked out or otherwise marked to ensure that they are counted only once.

Surveys that are carried out at periodic intervals must attempt to evaluate track longevity. Fresh, old and false crawls must be enumerated separately. Surveys must be carried out at regular intervals with consistency for all sites under study. For an example of a survey method, see Godley *et al.* (2001), Tripathy *et al.* (2003) and Bhupathy and Saravanan (2002). It is very important to distinguish nests, tracks and other field signs that are associated with successful nesting attempts. In some beaches, more than half the nesting emergences made by females are unsuccessful. These unsuccessful attempts, known by various names such as false crawls, half-moons, etc., can result from various causes. However, including counts of these unsuccessful attempts in the overall results of the study can completely invalidate efforts to estimate population size and trends.

d. Types of data collected

Track counts versus direct observations of nesting turtles

When nesting intensities are particularly high, track counts alone are unlikely to be a reliable method of estimating nesting, much less successful nesting. It may be quite difficult to erase 50 – 100 tracks each night over a small stretch of beach during peak nesting, or even 10 – 20 leatherback tracks. Moreover, in cases where nesting occurs in high density, turtles that nest later can obscure the tracks left by earlier turtles, making it difficult to accurately count the total number of turtles that nested. In such instances, direct counts at night offer the most reliable method of counting turtles.

Both methods can be combined, so that track counts are used during periods of lower intensity of nesting and direct observations are used during peak nesting. However, it is necessary to test the correspondence of indirect counts with direct counts.

Fresh versus old crawls

Some surveys count fresh crawls (i.e. crawls made during the previous night) while others count all visible crawls, regardless of age. The age of a crawl is usually very hard to determine, given the variety of factors that can affect the persistence of a track. Ideally, one should record four categories of tracks: a) very fresh successful crawls; b) very fresh false crawls; c) successful crawls more than one day old; and d) false crawls more than one day old. Doing so will enable more flexibility during analysis.

Counting fresh crawls

A particularly effective way of enumerating fresh crawls is to conduct a pre-survey. One day prior to the survey, all existing tracks on the stretch of beach are covered or raked over (or driven over) or otherwise obliterated or marked, so that fresh crawls can be readily identified and enumerated during the survey.

Estimating proportions of false crawls

It may be difficult to distinguish between successful and false crawls. Another approach to resolving this is to carry out observations during the night to determine what proportion of emergences result in nesting. Thus, nesting can be estimated from counts of total crawls during surveys. However, this may vary substantially between species, site and season. For the same site and species, it may vary across years. Hence, it will need to be estimated separately for each survey.

e. Variables affecting data collection during track counts

Observer / surveyor accuracy / experience

The ability of the observer to identify and distinguish different types of tracks depends upon the expertise and experience of the observer. The observer must be able to distinguish different species and also whether tracks are fresh/old and are successful nesting crawls or false crawls. Hence, observers should be adequately trained in advance of any serious data collection.

Turtle species

Different turtle species leave different kinds of tracks. When old crawls are being considered, this is of particular relevance, since the persistence of the tracks of different species can vary substantially. Hence, a count of the old crawls of green turtles and olive ridleys are not likely to give an accurate account of relative abundance since the crawls of green turtles will remain on the beach much longer, and hence represent nesting from a much longer time period.

Nesting density

Track counts are not very useful when nesting densities are very high, and crawls overlap extensively with one another.

Beach type

Sand texture and compaction can affect the crawls and cause difficulty in identifying the species or differentiating nesting and non-nesting crawls. It will also affect the persistence time of crawls.

Rainfall, wind and human activity

Rainfall, wind and humidity can obscure crawls and confound identification, in addition to affecting the persistence time of crawls.

Time of day

Apart from affecting sighting of crawls (which may not be a significant factor in ground as opposed to aerial surveys), time of the day will affect the freshness of the crawl, especially when human activity is present. Hence, it is recommended that surveys are carried out early in the morning for best enumeration of fresh crawls. This works better when the sun is in a low position on the horizon as it is easier to distinguish the characteristics of the crawl.

Stratification of the beach

Sometimes, different kinds of beaches may have different nesting densities. For example, beaches on islands or sand bars, or beaches adjacent to river mouths may have different densities from other mainland beaches. Hence, beaches may need to be classified on the basis of characteristics that affect nesting. However, some preliminary information is required before such stratification can be carried out. Once the beach has been classified, the different classes need to be sampled independently.

The index beach (or sample beach) can be divided into zones (of 1 km or less) to obtain fine resolution data on nesting density, nesting site fidelity, nesting success or habitat alteration. The zones can be marked using posts or by the presence of other permanent structure or markers. However, regular verification of index beaches is necessary, since in more dynamic areas of the coast, turtles may move to different areas.

Substituting time for distance to calculate location of nest/track/observation

Sometimes, it may not be possible to physically mark the sectors on the beach. In this case, if the surveyor walks at a standard pace, time can be used to measure distance. First, the surveyor's standard walking speed needs to be estimated. The time of the individual observations relative to start time can then be used to calculate the distance of the track or the nest from the starting point.

Track persistence

Trac persistence can be measured by monitoring a track over several days/weeks. Several measurements (15 – 30) need to be obtained to derive an average. Since this may vary with time and place, track persistence needs to be evaluated for different seasons and different sites/beaches separately.

f. A recommended ground survey methodology

- Conduct an extensive survey of the entire study area.
- Locate a series of index beaches that represent different densities of nesting, nesting by different species, and span the entire coast.
- Conduct daily or weekly surveys on each of the index beaches during the nesting season. Periodic surveys need to be at consistent intervals.
- Count fresh, old and false crawls separately. If surveys are not carried out daily, conduct a pre-survey so that the number of fresh crawls is estimated accurately.
- Obtain an estimate of track persistence

2.9.3. Estimating population sizes (from indices such as nest counts)

Nest counts conducted throughout the nesting season are often used as an index of population size. However, if nest counts need to be converted into population size, two parameters are required. To estimate the annual number of turtles nesting, data are required on clutch frequency of a turtle. These can be derived from estimates in literature or can be estimated for a particular population, if such data are available. Intensive tagging and monitoring studies are required to estimate the seasonal clutch frequency, which can vary from 1 – 6 clutches per season.

Average clutch frequency can sometimes be derived from data on tagged turtles. However, this is possible only if the entire nesting population is adequately sampled. Otherwise, multiple nesting emergences of large numbers of turtles are likely to be missed when they renest at sites not being monitored. The nesting periodicity and inter-nesting interval can again be derived by tagging turtles, but only with adequate coverage.

Annual nesting population size = Total no. of nests in a season / Average number of egg clutches laid per female per season

Not all the turtles in a population nest each year. Remigration rates vary from annual remigration (in some but not all ridleys) to once in 3 – 5 years, or longer in leatherback and green turtles. The average remigration interval can only be obtained from long term studies.

Total population size = Annual nesting population size × Remigration interval
Or
Total population size = Seasonal nest count × Remigration interval / Average number of egg clutches laid per female per season

Where:

Remigration interval – average number of years between nesting migrations (this should not be confused with the interval between nests in a single season, which is about two to three weeks and referred to as inter-nesting interval)

Seasonal nest count – total number of nests per season (ideally an average across several seasons)

2.9.4. Habitat surveys

Though there are vast areas that appear to be potentially suitable for nesting and foraging, this does not necessarily imply the presence of sea turtles. In order to identify important habitats for sea turtles, one must conduct a broad scale survey to locate potential habitats, and then conduct intensive surveys at these sites to determine the nesting and foraging population size.

a. Nesting habitats

Interviews: Substantial local knowledge exists on many aspects of turtles as well as other wildlife. Most coastal fishing communities are aware of sea turtle nesting if it occurs in their region, and are likely to have even more specific information if they consume the meat or eggs. The precision of species identification varies from region to region and must be carefully evaluated.

Preliminary habitat surveys: Preliminary habitat surveys can take into account habitat features that are required for nesting, i.e. the presence of sandy beaches, the nature of the offshore approach, the level of disturbance in offshore waters, and the level of disturbance on land. Beach characteristics include the width of the beach, dominant beach vegetation, grain size and texture, sand compaction, moisture, beach profile, wave conditions, and presence of rivers and estuaries (beach preferences for different species are provided in the identification plates on pages 18-27).

Intensive surveys: Intensive population surveys can be carried out to evaluate the species and intensity of nesting as well as to determine the total habitat available and threats. Since it is not feasible to conduct population surveys to determine total nesting across several hundreds of kilometers, the nesting from index beaches can be extrapolated to the entire coast if the total available habitat is evaluated.

This will differ from coast to coast for a variety of reasons. For example, in Orissa, 400 out of 480 km of coastline is suitable for nesting, the remainder being unsuitable because of mud flats and rocky coast. In Kerala, only 100 out of 600 km is suitable for nesting, the rest having been blocked by beach armouring to prevent erosion. Hence, habitat suitability can be affected by both natural and human factors, which need to be evaluated thoroughly.

A leatherback nesting beach in Little Andaman Island

b. Foraging habitats

Interviews: Again, interviews can provide much valuable information about the occurrence of sea turtles in offshore waters. The Coast Guard, fishermen and ship crews can provide information based on sightings.

Preliminary surveys: Surveys need to be carried out using visual observations from boats, SCUBA or snorkelling to ascertain the presence of foraging turtles. Sea turtle presence can also be evaluated from indirect evidence such as the presence of food items specific to particular turtles such as sponges for hawksbills, sea grasses for green turtles, and crabs and other crustaceans for ridleys and loggerheads.

Intensive surveys: This can include transects and mark recapture studies to estimate population size in offshore waters and foraging habitats. For long term data, one can set up sighting networks where observers (coast guard, fishermen) can send in information on a regular basis.

2.9.5. Secondary data and market surveys

While primary data may be the best way to collect information on turtle populations and threats, there are several constraints, including time and money. Further, secondary data can provide clues to long term trends, for which primary data cannot be collected in a short period of time. Secondary data may include collection of data from published and unpublished (or grey) literature, or collection of information from stakeholders.

a. Literature surveys

It is often rare that no information is available on a subject such as nesting of turtles on a particular beach. Often, the problem lies in the fact that the information is in unpublished reports, or in papers in journals that are not widely accessible. Researchers should first check whether such reports are available with enforcement agencies (forest and fisheries departments) and conservation groups (NGOs) and research groups associated with the area in question. Methods of data collection vary, and may not always be clearly outlined in such reports, and hence, the data may not be directly comparable; one should therefore exercise caution in arriving at conclusions based on these data. However, this information can usually provide a baseline for planning and designing a study for the collection of primary data.

b. Interviews

Interviews are useful to collect information quickly and inexpensively, summarise the experience of knowledgeable people and communities, compile information otherwise available only orally, and supplement data collected by direct observation. Though the data collected in interviews may not be standardised and cannot usually be used for quantitative comparisons, they synthesise a body of knowledge available within a community collected over several years or even generations, and thus have a value that primary data cannot easily provide.

Conducting interviews

Interviews can be conducted in several different ways. However, a common theme to all interviews is that the observer must ensure the quality of the information collected. In order to do this, the interviewer must understand the politics of the information to be collected, the people being interviewed and his own position. For example, fishers may not reveal the magnitude of incidental mortality if they feel threatened by the interviewer. Mainly, the interviewer must be prepared to be courteous, listen carefully, and be respectful of the interviewee. One must know the language, or be certain that the translator is entirely objective with regard to the issues and the people.

Interviews should be carefully designed to get the most accurate understanding of the interviewee's knowledge. Questions can be framed in two or three different ways to obtain the same information, so that concordance can be used as a quality check. Questions should be objectively framed, so as not to reveal the bias of the interviewer. Thus one should ask 'Has the number of nesting turtles changed?' or 'Are there more or less turtles than before?' rather than 'Has the number of nesting turtles decreased?', which reveals the expectation of the interviewer. If the interviewer needs to understand how the interviewee arrived at a conclusion, he should investigate it carefully, but courteously.

One more important consideration is the ethics of information collected by interviews. In the context of intellectual property rights, one must acknowledge the value of information collected during interviews. Mutual gain and equitable exchange must be the expected outcome of an interview. In some cases, interviewees may require and request anonymity which must be fully respected.

Types of interviews

Interviews can be conducted using questionnaires, prompting a discussion using lead questions, or through completely open-ended discussions. Questionnaire-based interviews are the most structured format and result in the data most amenable to statistical analysis. However, open-ended discussions often provide an understanding of complex issues, that may not have been previously known to the interviewer. Ideally, a combination of these methods should be used.

Recording information

Information can be recorded by hand, tape recorder, videography, or even memory. The method chosen should best suit the interviewee so that they are comfortable and not threatened in any way by the mode of recording.

Reply paid post cards

In India, a number of surveys have used reply paid post cards to collect information, especially from state agencies and NGOs. An advantage of this method is that a large number of individuals and agencies can be contacted without visiting them personally. However, this precludes any evaluation of the sociopolitical standing of the interviewee, and hence makes it difficult to assess the quality of the information.

c. Market surveys

Market surveys can compile information on levels and types of sea turtle use, organisation of market structure, increase or decrease in product availability and demand, role and importance of turtles in the diet and income of people in an area, cultural connections, people's attitudes to turtles, and ecological information. Such surveys can collect information using interviews or direct observation of the market and associated disposal sites.

Information that can be collected during interviews

On biology, status and distribution

- What species of turtles are seen? How are they identified? Do they have local names?
- How many turtles are seen (per distance or area unit)? How many turtles nest (per distance per time)? Which turtles are the most common (relative or ranked abundance)?
- Where are the species of turtles found? What are they doing (foraging or nesting or migrating)?
- What times of the year are they encountered? What sizes and sexes are found and where and when?
- How many turtles were found in the area (nesting, foraging or captured) 10/20/50 years ago? Has there been a change? Why?

On utilisation

- Do people consume turtles or use their products? How are turtles used? Are eggs and meat consumed?
- How many turtles (species, size) are caught? How, where, when?
- What are turtles used for? Are they caught intentionally or opportunistically?
- What proportion of the diet/income do the turtles form?
- What proportion of the community uses or depends on turtles?
- What are the selling prices of turtles and their parts? How long have they been used?

On threats

- What are the main threats to the eggs? What are the main threats to the hatchlings once

they emerge from the nest? What are the main threats to adult turtles?
- Are hatchlings caught in nets or fishing gear? What kind? Do many hatchlings die before they reach the sea? Why?
- Are adult turtles caught in nets or fishing gear? What kind?
- What is needed to protect the eggs, hatchlings or adults?

On laws and conservation programmes

- Are there local agreements or laws concerning the use of turtles? Are they working?
- Who enforces them? Are they necessary? Are they fair?
- Are eggs/hatchlings/adults protected by law?
- Are there conservation programmes being run in the area? What do they involve? Who conducts them? Are local communities involved? What do local communities think of these programmes? Do they benefit?
- Are government agencies involved in turtle conservation or management? What do they do? What do local communities think of these programmes and how are they affected?
- Do either government or conservation agencies share information with each other or with local communities?
- Do you think conservation is necessary? What action are you willing to take? Have flipper (or other) tags been encountered? What is done with such tags? What is the perceived purpose of these tags?

On fishing

- Do you fish? For how long have you fished?
- Do you use a boat? What kind/size?
- Do you use nets? What kind/size? How far offshore do you fish?
- How often (days/week, hours/day)?
- What is the most important fish that you catch?

Information on the locality

- What is the spoken language?
- What communities live in the area?
- What is the population size?
- What are the common livelihoods? What facilities and infrastructure are available (hospital, school, water, sanitation, electricity)?

Information source

- Name and address
- Sex, age, occupation
- Date and location of interview

Market survey information

- Name and location of market
- Date, day of the week, time visited
- Number of vendors (selling turtles, turtles parts and turtle products)
- Number of turtles, species, size and sex
- List of items, seasonality, popularity, prices
- Sources of turtles, parts and products, locations of collections, livelihoods of collectors
- Organisation of market and vendors
- Number of vendors surveyed or interviewed

3. CONSERVATION & MANAGEMENT

Threats to sea turtles and their habitats, including harvest of adults and eggs, incidental catch in fisheries, beach erosion, sand mining, beach armouring, artificial lighting and predation by feral animals, have had severe negative impacts on many turtle populations. In order to address these threats and to minimise or mitigate their impacts, it is necessary to design appropriate and effective conservation programmes. However, in order to do this, it is important to first identify the source of the threat and then evaluate the best approach to conservation. Basic biological data can be collected without much extra effort as part of ongoing conservation activities, and these often provide important information about the species.

The priority for a conservation intervention on a nesting beach involves protection of nests and hatchlings (when they emerge). Depending on the nature of the threat and the objective of the programme, either in situ or ex situ approaches have to be adopted.

This section discusses hatchery and beach management programmes in some detail and provides an introduction to some important threats related to sea turtles and their nesting habitats. It recommends standard methods for identifying and evaluating these threats and proposes simple methods to help monitor and conserve turtle populations. While some threats and mitigatory actions have been elaborated upon in detail (for example, effects of beach lighting and installing turtle friendly lamps), others have only been outlined to indicate the possibility of varied threats, and addressing specific threats should draw upon general information, lessons learned elsewhere and context or location specific parameters.

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IN THIS SECTION > Designing a conservation programme > Beach management and hatchery programmes > Threats and mitigation

3.1. Designing a conservation programme

Prior to initiating a conservation programme, the threats to populations and habitats have to be assessed. Conservation actions will depend on the nature and intensity of these threats. One must keep track of habitat quality and population trends to evaluate the success of the programme.

Sea turtle conservation programmes must include the following components:

Population size and trends: It is important to accurately determine whether populations are increasing or decreasing or stable. Hence, even if the main focus of a programme is conservation education, it is essential to keep records of details like the number of nests laid on a particular beach each season.

Assessment of habitat: The nesting habitat should be assessed periodically to evaluate threats such as sand mining, beach armouring and lighting.

Sources of mortality: These will essentially determine the main/priority actions to be taken towards conservation. For example, if the main threat is from fishery related mortality, conservation action will need to be directed towards reducing this by implementing no-fishing zones or the use of Turtle Excluder Devices for trawlers.

Involving local communities: It has become increasingly clear that successful conservation programmes need to involve local communities, i.e. the people who are most directly in contact with the animals in question. This involves:

- Identification of stakeholders
- Promoting bottom-up as against top-down management
- Integration of communities into conservation programmes
- Development of socio-economic alternatives for local communities

Research and data management: Basic research often provides useful insights into the biology of a species, which can have important implications for conservation. Data should be collected systematically on nesting season, abundance (number of nests / beach / season), adult mortality (source and magnitude), clutch sizes and hatching success in situ and in the hatchery. It is important to identify and quantify threats before addressing them and ensure standardised and periodic data collection and adequate training of field staff.

Public awareness and education – Public support is required for successful conservation, and hence education and awareness must form a central part of conservation programmes.

Most importantly, the communities must play a major role in the identification and development of alternatives, and participate in decisions about the use and conservation of their resources.

3.2. Protecting sea turtles on nesting beaches

3.2.1. Beach management and hatchery programmes

Given the high densities of human populations along the Indian coast, nests are vulnerable to predation by humans and feral animals, mainly dogs. Hatchlings are also vulnerable to predation and are disoriented by beachfront lighting. Since it is often not possible to have complete protection for nesting beaches, it is important to weight the costs and benefits of in situ (on site beach management) versus ex situ (hatchery management) approaches which will depend on the nature and degree of the threat, the objective of the conservation programme and the resources (financial and personnel) available.

In general, eggs should be allowed to develop without disturbance as far as possible. It is only when the relative merits of moving eggs far outweighs leaving them on site that they should be moved. Ex situ conservation (with hatcheries) usually involves greater intervention, but offers additional value in terms of education and awareness.

Many state forest departments (West Bengal, Orissa, Goa, Gujarat and Andaman & Nicobar Islands) and NGOs (in Andhra Pradesh, Karnataka, Kerala, Gujarat, Maharashtra and Tamil Nadu) already run hatchery programmes.

Practicalities of beach management and hatchery programmes

Both beach management and hatchery programmes have merits and demerits. Beach management programmes are often much harder to initiate and need the support of local communities, and those who make use of the beach, to succeed. Sometimes these programmes require as much effort and personnel as hatcheries, which offsets some of the supposed advantages.

On the other hand, hatcheries can often have negative impact on populations because of their limitations. It is only when other options are ineffectual, and funds, personnel and suitable sites for a hatchery are available, should this option be considered.

3.2.2. Hatchery management programmes

Advantages of hatcheries

- A certain proportion of eggs is guaranteed protection from risks on the nesting beach, such as predation by feral dogs, crabs and other animals, extraction by people, beach erosion, flooding by high tides and so on.
- The number of eggs protected and hatchlings released is documented; hence there is some known measure of "success".
- Involvement of volunteers and other personnel in conservation related action has a positive effect on spreading awareness.
- The hatchery provides a physical focus for conservation activity related to the coast, which can be used for public education and awareness activities.
- Hatchlings are available at a known time and place for use in education and awareness programmes.

Disadvantages of hatcheries

- Hatcheries are often relatively expensive as they require investment in fencing, nest enclosures, and personnel.
- Hatcheries require trained personnel for collection, relocation and reburial of eggs, as well as to guard the hatchery against people and animals.
- Hatching success in hatcheries is regularly lower than in the wild.
- Sex ratios in hatcheries may be skewed.
- Improper methods of hatchling release leads to high rates of mortality, either while on the beach or at sea. For example, releasing hatchlings at the same site each day may create fish and sea bird feeding stations. Unattended, or inadequately constructed, hatcheries can be attacked by predators (including people), resulting in total or near total loss of eggs and hatchlings. Holding hatchlings for too long before release may lead to injuries or make them too lethargic to survive after release into the sea.

How to set up a hatchery

Location of the hatchery

The best location for a hatchery is at a site that is as similar as possible to the habitat of the nesting site of the turtles. Hence, hatcheries should be located on the nesting beach, and if the beach is sufficiently long, several hatcheries should be established. This makes the transport of eggs less labour intensive, and makes it possible to transplant eggs into hatcheries relatively quickly. Several programmes have failed only because eggs had to be transported to hatcheries several kilometres away. One alternative that combines aspects of in situ and ex situ practices, is to simply transplant a clutch of eggs several metres up the beach from where the nest was originally laid.

Hatcheries also need to be located close to the nesting beach to minimise trauma during transportation of eggs, to reduce the time between collection and relocation, to provide an opportunity for the hatchlings to imprint on their natal beach and to facilitate hatchling release. The hatchery should be located well above the high tide line, but not too far inland as to be in heavily shaded areas, or in sand with a very high humus/organic soil content. The hatchery can be enclosed by chain link fence or wire mesh. Inexpensive wooden poles, cane and bamboo or slats can also be used. To prevent the entry of crabs and other burrowing predators, chicken wire mesh (or any small mesh material) can be buried to a depth of 0.5 metres along the inside of the fence. This measure is often essential to ensure the success of the hatchery.

A hatchery set up by SSTCN in Chennai, Tamil Nadu

Ideally, the hatchery should be located and oriented in such a manner to provide the greatest diversity of microhabitats for the nests. The shape of the hatchery often depends on local conditions. If the beach is narrow, then the hatchery perforce has to be rectangular with the long side parallel to the sea. Circular shapes provide the greatest area for a given perimeter, and hence a polygon provides more space to relocate nests especially if availability of perimeter fencing is a constraint.

To prevent infestation from fungus and bacteria, the hatchery should not be located at the same site during two consecutive seasons.

Collection and transport

Sea turtles are very sensitive and may return to the sea without nesting if they are disturbed while stranding or excavating the nest. During this period, workers should be very careful not to disturb the turtle with lights or movement. Once egg laying (oviposition) begins, the turtles go into a 'nesting trance'. During oviposition, the turtle will usually not react even if she is handled gently, though some species (and individuals) are more sensitive than others. Collection of eggs, tagging and tissue sample collection can all be carried out during this time, or if possible, after she has finished laying eggs.

Ideally, eggs should be collected, transported and placed in the hatchery within 2 hours of egg deposition. Eggs collected within 8 - 10 hours (i.e. same night as deposition) generally have a good chance of survival, if handled carefully. If eggs are collected more than 10 hours after laying, great care should be taken during collection, transport and relocation.

Only nests that are threatened by flooding, erosion or high levels of predation by humans and feral animals should be collected. Eggs can be collected in a plastic or cloth bag, either directly from beneath the turtle while she is laying eggs, or dug out from the nest after she has laid and left the nest. The bags or buckets need to be clean and not contaminated. For smaller turtles like ridleys and hawksbills, eggs are fairly easy to locate. However, with larger turtles, although nests are easy to find, the eggs can be difficult to locate once the turtle has covered up the nest, and if a nesting turtle is found, it is best to collect the eggs during or immediately after oviposition. Alternately, a small rope or coloured tape can be inserted into the nest so that it extends to the surface, and once the turtle has completed nesting, the nest can be located by following the tape.

Collection of leatherback turtle eggs

If eggs are transported and relocated more than 10 hours after laying, they should be handled very carefully and should not be rotated or jarred. This can be done by marking the eggs on top with a pencil and placing them in a rigid container (i.e. bucket or tray, not a bag) with some moist sand from the nest to ensure that they do not move during transport.

Relocation

Each clutch should be relocated within the hatchery in a microhabitat as similar as possible to the natural nest. They should be buried at the same depth as the natural nest, which can vary depending on the species of turtle. The nest should be constructed in the shape of the natural nest, i.e. with a narrow neck and a flask shaped bottom. The eggs should be carefully placed in the nest and then covered first with moist and then dry sand on the very top. The latter should not contact the eggs. Nests should be relocated in low densities in the hatchery, with at least 1 metre between nests (and up to 2 metres if space permits) so that they do not affect each other during development and so that hatchery workers can move about without stepping on the nests.

Left: Basket enclosures. *Right:* Mesh enclosures

Each nest should be numbered and recorded in a data sheet or book (in particular, the date of laying and number of eggs), so that the date of emergence can be estimated with accuracy, and for other research purposes. A sample hatchery data sheet is provided on page 127. Data such as clutch size, nest location, date of collection need not be posted on the signboard near the nest. Rather, each nest should have a place marker with a number, and associated data can be entered in a data book. The marker can be a wooden stick (with or without a small signboard) placed beside the nest.

Nest enclosures in the hatchery

Some hatcheries use mesh enclosures for each nest to restrain hatchlings after they emerge to facilitate data collection and release. However, hatchlings should be released immediately after they emerge from the nest. Unless hatcheries are constantly manned, hatchlings may remain within the enclosure for extended periods, which can cause exhaustion or death, especially if there is bright sunlight. Chicken wire mesh should not be used for these nest enclosures. Hatchlings are easily cut by the wire when they put their flippers and heads through the mesh. Thatch baskets work better, and also shade the nest towards the end of incubation, which can help to reduce mortality especially during summer. However, the nests should not be shaded too early during incubation, as this could affect sex ratios. In populated areas, thatch baskets can be stolen from the hatchery, and this can been countered by making a hole at the bottom of the basket, hence making them useless for any other purpose. If enclosures are used primarily to restrain hatchlings for data collection and release, they only need to be placed during the end of incubation.

Excavation of relocated nests in a hatchery

Hatchling release

Hatchery personnel should anticipate hatching for each nest. Expected dates of hatchling emergence can be estimated from date of collection (and will vary depending on species and time of year), and can also be predicted by the caving in of sand surface above the nest when hatching begins. Hatchlings will usually begin to emerge from the nest two to three days after hatching begins. Hatchlings should be released into the sea in groups immediately after emergence, but at different times of the night and at different points to prevent the creation of feeding stations (fish will learn that hatchlings are released at a particular point and may wait for them). Hatchlings should be allowed to crawl across the beach to allow imprinting. However, it is best not to subject them to this if there is bright sun or hot sand.

If and when immediate release is not possible, hatchlings should be kept in a soft, damp cloth or sack in a cool and dark place. They should not be placed in buckets of water as they will engage in swim frenzy behaviour and exhaust their yolk reserves. They need both the yolk reserves and swim frenzy behaviour to help them to swim past the breakers. Hatchlings should not be retained in containers with water; they should be released as soon after emergence as possible.

3.2.3. Beach management programmes

Hatcheries are obviously not always an ideal solution for the conservation of sea turtles since they involve substantial manipulation of natural events. They require considerable manpower and hatching success of nests may be much reduced. An alternative is to implement measures to protect the nests on the beach where they are laid. Some might suggest that one should simply remove all the people and associated predators, but this may be neither ethical nor possible. Alternative methods of beach management or in situ protection include a variety of measures.

Beach patrols and disguising nests

The very presence of monitoring and surveillance personnel or even just researchers is often enough to deter egg collectors to some extent. This, of course, is if the collectors know that the collection of eggs is illegal, which is not the case in many areas. In this case, it is first necessary to acquaint them with the wildlife laws. All five species of sea turtles found in Indian waters are classified in Schedule 1 of the Indian Wild Life Protection Act (1972), which affords complete protection for the turtles and eggs. Offenders can be sentenced to imprisonment for a maximum of seven years. Egg collectors can also be deterred by removing the evidence of nesting by wiping out the track and smoothing over the nesting site. Another method is to leave a lot of foot prints around nests and create poke marks with a 1 to 1.5 inches diameter stick. Egg collectors often use sticks to probe for nests and this makes it look like the eggs have already been taken. Nests can also be disguised from predators using masking scents (e.g. urine) but there is no evidence that this is effective.

An alternative is to relocate the eggs to a site close to the original nest. In addition to being effective in thwarting egg collectors and predators, this does not require the infrastructure of a hatchery. Relocation protocols are the same as those for the hatchery as described above. The location of nests needs to be carefully determined using local landmarks. However, if beach front lighting is present, the hatchlings will be disoriented when they emerge, necessitating monitoring during the period of emergence as well.

For in situ nests, an aid to locate the nest is to use a coloured tape, extending just to or just below the surface. This is a good way to mark nests on the beach without attracting the attention of egg collectors or curious passersby.

Buried mesh and caging

Eggs need to be protected immediately after laying when they are most susceptible to predation. Again, after about 30 days, when the nest temperature reaches a certain level (due to the metabolic heat generated by the developing embryos), the predated eggs start to rot and smell. Predators (like dogs) which rely on smell will learn quickly to locate these nests. Of course, fresh nests are also susceptible to these predators. Hatchlings are obviously susceptible during emergence, especially if artificial lights are present which disorient them. In such cases, the nests need to be protected throughout incubation. The placement of mesh or caging surrounding each individual nest is possible on beaches where the main threat is from predators such as dogs and pigs. The mesh should be buried deep enough to protect the egg from burrowing by predators. Mesh size should be big enough to allow hatchlings to crawl through after emergence, if the nests are not going to be monitored during that period.

Predator control

Sometimes, the best way to deal with predators is to eliminate them. However, this is an option to be exercised only with semi-domestic, feral, introduced and widespread species. Elimination of native predators can negatively impact the coastal ecosystem. Further, this would be ineffective in many parts of the Indian mainland, where there is an endless supply of predators such as feral dogs. However, this is an alternative for isolated beaches such as in the Andaman and Nicobar Islands. Aversive conditioning (use of chemicals which create unpleasantness on consumption) has unfortunately not been shown to have great success, but could be useful if the right chemicals for particular predators are discovered.

3.2.4. Data collection

The collection of accurate data is a very important part of any conservation programme. Information on the number of nesting turtles per season, or at least the number of nests (with eggs) on a given nesting beach provides information on population trends, though effort needs to be standardised between years and research teams. Data on nest depths determine hatchery relocation practice. Data on clutch sizes and hatching success can give important information about the reproductive biology of the species. In hatchery programmes, it is particularly important to determine hatching and emergence success so that one can evaluate if anything is drastically wrong, and then make appropriate modifications.

Page 43 in the previous section (Research and Monitoring) provides information about data collection for monitored nests.

3.2.5. Education and awareness

Hatchery and beach management programmes offer excellent opportunities for education and awareness. They allow wildlife enthusiasts and school and college students to participate in and contribute to conservation programmes, and help in giving them exposure to key conservation issues and to learn the basics of wildlife research.

Education

If funds are available, some material or handout with basic information should be provided to visitors to the hatchery or participants on turtle walks. During turtle walks, clear instructions (verbal or written) must be provided on behaviour, especially with regard to nesting turtles. A sufficient number of volunteers should be present to guide the group.

Children release hatchlings into the sea in Chennai, Tamil Nadu

Hatchling release

Hatchling release is an exciting activity for students and children, and really anyone. Hatchlings should be released at night or early in the morning, and be allowed to crawl on the beach prior to entering the surf. Each participant can be assigned a few hatchlings to guard until they enter the surf and swim away. For large groups, one can cordon off a section of the beach, effectively keeping people behind parallel lines, in the middle of which the hatchlings crawl to the sea.

Volunteers and participants

Volunteers and participants or new personnel must be acquainted with the particulars of sea turtle biology, conservation and management techniques. They should be encouraged to read general articles and manuals on sea turtles, and directed towards more literature and websites. They must be acquainted with the necessary techniques required for the conservation programme.

Community based conservation

It is ideal when the conservation programme can be run, or co-managed, by a local community. The youth of the fishing community should be encouraged to protect turtles and nests near their villages. This can work in tandem with other community programmes as well as synergistically with other sea turtle conservation programmes on the coast.

3.3. Threats and mitigation

3.3.1. Estimating threats to sea turtle populations and habitats

In many parts of the world and in India, sea turtle populations are affected by a wide variety of threats. Even under natural conditions, survival rates are low, and eggs and hatchlings are predated by small carnivorous mammals, birds, lizards and crabs. Once they are in the sea, a variety of predators plague them through their immature stages. Only large sharks, and perhaps killer whales, predate adults. In some locations, humans also catch and consume adults. At a few sites, nesting turtles may be killed by large predators such as jaguars and tigers. Human induced threats are increasingly problematic for turtle populations. These threats can be broadly classified into direct and indirect threats.

Direct threats include:

- Incidental catch in mechanised fisheries
- Consumption of adults – not very common in most parts of the Indian coastline
- Egg depredation by feral animals and humans

Indirect threats include:

- Loss of marine habitats (due to pollution, aquaculture, coastal tourism, etc.)
- Loss of nesting beaches (due to erosion, sand mining, beach armouring, pollution, exotic plantations, etc.)
- Artificial lighting (disorientation of both adults and hatchlings, mainly the latter)

3.3.2. Direct threats

a. Incidental catch in fisheries

Fishing is a major occupation along the coast of India. A majority of fishers along the coast are artisanal fishers who use traditional methods or a combination of traditional and modern methods. However, since the 1970s, there has been a dramatic increase in mechanised fishing with thousands of motorised boats and trawlers operating in each state. The interface between marine fisheries and marine turtles has been a major concern not just for the wellbeing of sea turtle populations all over the world, but also for local and international commerce, artisanal fisheries, by-catch reduction policy, marine fishing ground health and the development of eco-friendly fishing gear.

Olive ridleys entangled in a fishing net

Several thousand turtles are killed in fisheries along the coasts of Orissa, Andhra Pradesh, Tamil Nadu and the Andaman and Nicobar Islands.

How fisheries affect turtles

Sea turtle mortality occurs primarily in gill nets and in trawl nets by drowning. Although sea turtles are capable of staying submerged for half an hour or more, the stress of being trapped for many hours in gill and trawl nets usually results in drowning. Some turtles trapped in trawl nets are not dead, but comatose, and if they are thrown back into the water immediately, they are likely to die. On the other hand, if they are kept on board the ship, they may recover. Turtle Excluder Devices (TEDs) can substantially reduce the mortality of turtles in trawl nets, without reducing fish catch.

In Orissa, more than a hundred thousand dead turtles have been counted since the 1990s, and ten to fifteen thousand dead turtles are washed ashore each year, predominantly due to trawlers. Researchers have documented that ten to twenty turtles can be trapped and killed during a single trawl. In 2002, researchers and conservationists also documented gill nets with 100 – 200 dead turtles trapped in each net. The real mortality rate may be even higher, since not all the turtles killed are washed ashore.

In addition, the operation of trawlers in offshore waters during the breeding season may disrupt breeding congregations and prevent the onset of mass nesting. Along the shore, many fishers operate zero mesh nets to catch shrimp seeds. These can interfere with the nesting of turtles and prevent hatchlings from reaching the sea.

Mitigation measures

No fishing zones

Many maritime states already have laws to prevent mechanised fishing in certain zones, including all states on the east coast of India. Marine turtles are protected in Orissa by the Orissa Marine Fisheries Act (1982) and Rules (1983) which prohibit all mechanised fishing within 5 km of the coast. Fishing is also prohibited in the Gahirmatha Marine Sanctuary within 20 km of the Gahirmatha coast (~ 35 km). Currently, fishing is also restricted in the offshore waters of Devi river mouth in Rushikulya during the breeding season.

The Andhra Pradesh Marine Fishing (Regulation) Rules (1995) states that 15 m mechanised vessels may not operate within 8 km of the coast and vessels above 15 m in length may not operate within 25 km of the coast. Similarly, mechanised fishing is prohibited within 5 km of the coast in Tamil Nadu, and in the Gulf of Mannar Marine National Park. Similar laws exist for mechanised vessels in the state of West Bengal. However, implementation of these laws remains poor, and as a consequence, artisanal fishers, fish stocks and sea turtles all suffer.

Seasonal fishing ban

Many maritime states including Kerala, Tamil Nadu and Andhra Pradesh have seasonal fishing bans. These are currently during the southwest monsoon (May and June) to allow the replenishment of fish stocks. These bans could be extended for particular areas to the turtle breeding and nesting season as well.

Turtle Excluder Devices (TEDs)

A TED is a frame consisting of a grid of bars installed before the cod end of the trawl net at an angle leading upward or downward to an escape slit. Small animals such as shrimp slip through the bars and are retained in the cod end, while large animals, such as turtles, large fish and large elasmobranches are stopped by the grid bars and can escape through the opening. Many different kinds of soft and hard TEDs are available.

In India, the Central Institute of Fisheries Technology, Kochi, has developed an indigenous TED, called CIFT TED. The production of this TED is currently being funded by the Marine Products Export Development Authority. CIFT TEDs have been distributed in West Bengal, Orissa and Andhra Pradesh, but are not being used at any of the sites.

The use of TEDs has been made mandatory for trawlers in Orissa, and other states are following suit. The use of TEDs will be helpful, since they will prevent bycatch of many marine organisms, not just sea turtles. However, sea turtles and other fauna are also killed by gill nets. Furthermore, the livelihoods of poor artisanal fishers must also be protected. In India, as in many parts of the world, the implementation of TEDs has been poor, as enforcement is difficult and the politics of fishing is complex. Hence a combination of TEDs and community supported seasonal and area wise fishing bans will probably give the best results.

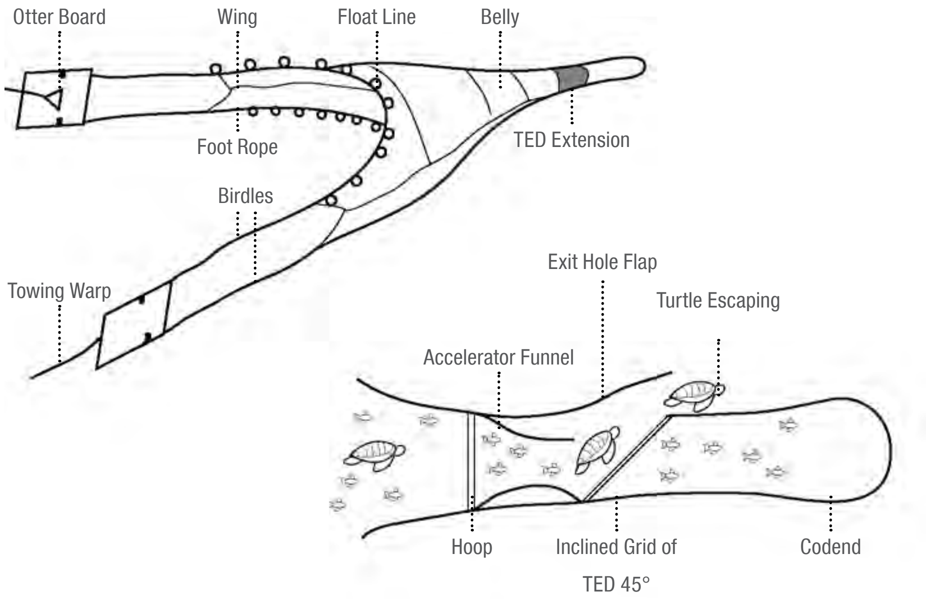


Illustration showing the working of a Turtle Excluder Device (TED)

b. Consumption of adults

Along the Indian coastline, the take of adults and juveniles for consumption is not as common as in some other regions of the world. However, the practice does exist in many coastal villages. Although such take and trade of turtle parts is in contravention of national (and international) legislation, often it is the ignorance of the law or the lack of support to, and understanding of, conservation initiatives that perpetuates the practice. It has been suggested that the involvement of the local community in conservation efforts by making them aware of the importance and benefits of such efforts will reduce their dependence on adult sea turtles as sources of food or income. It is important that the initiation of such programmes takes into consideration the socio-cultural dynamic of the area to ensure that they do not negatively affect the socio-economic structure of the community. Inclusion of the resource user community's interests is likely to increase the chances of their supporting the programme.

c. Egg predation

Predation of sea turtle eggs is a common threat in nesting beaches around the world. Eggs are predated by natural and subsidised predators, and in many instances by humans. Details of mitigation practices for egg predation are provided under Beach and Hatchery Management Programmes on page 83.

Feral dogs and crows are common predators of sea turtle eggs

3.3.3. Indirect threats

a. Threats in offshore waters

With the onset of the breeding season, sea turtles leave their foraging areas and arrive in the coastal waters of breeding grounds. Species like olive ridleys congregate in large numbers in the coastal waters off nesting beaches and spend nearly six months in a year in this habitat. Green and hawksbill turtles use shallow water lagoons as their developmental habitat during the juvenile and sub-adult stages of their life.

These nearshore waters are often subject to heavy use by humans in terms of marine fishing, aquaculture, coastal tourism and other recreational activities. These coastal zones are also susceptible to indirect pollution from industrial or agricultural run-off. These activities impact sea turtles during various crucial stages of their life cycle.

Pollution of offshore waters

Coastal waters and beaches are under constant threat from pollution originating from landward activities as well as from the sea. Such pollutants have often proved to be the primary cause of death of marine plants and animals. Impacts of pollution on sea turtles have been less severe, although accidental ingestion of plastics has been documented to indirectly cause death due to poisoning or starvation because of the inability to swallow food due to the blockage of the food passage by these materials. Further, changes in water temperature and quality results in changes in their offshore breeding congregation locations. Changes in salinity profile and levels of organic and inorganic pollutants in the vicinity of mass nesting sites will impact adults and hatchlings.

The following pollutants are known to impact sea turtles directly or indirectly through their food chains or altering their preferred offshore/onshore habitats:

Discharge of sewage, nutrients and fertilisers: In sheltered lagoons, organic sewage, nutrients and fertilisers tend to accumulate and hasten the process of algal bloom and seaweed growth, changing the food chain composition.

Heated water from power stations and industrial plants: In lagoons and offshore waters, release of heated water from power plants and other industrial installations changes the water temperatures significantly altering the distribution pattern of microorganisms. This in turn impacts the distribution of organisms at various trophic levels and also that of sea turtles.

Petroleum hydrocarbons and crude oil from oil spills: Oil spills cause severe damage to marine life worldwide due to oil pollution along the coasts. Sea turtles are exposed to the harmful effects of oil pollution in many ways. Floating crude oil in the immediate offshore waters gets coated on the eyelids, nostrils and mouths of sea turtles, often leading to death. This has been recorded along the west coast of India. On nesting beaches, oil deposits could interfere with proper aeration of the turtle nests and impair normal development of the embryos. The crude encrusted hard substrate also does not allow the embryos to successfully emerge from the nest. Onshore oil deposits are high along the west coast of India, particularly along the Gulf of Kutch where the presence of many oil refineries have resulted in chronic crude oil spills into the sea.

Oil deposits on nesting beaches from spills impact both nesting turtles and nests

Chemicals and synthetic paints, pesticides and herbicides, and heavy metals: These may selectively destroy or damage phytoplankton and zooplankton of reef and lagoon communities as well as planktonic larvae. Such accumulation has severe physiological effects on filter feeding animals and reef fish and may be accumulated in animals like the sea turtles. Pesticides and other industrial chemicals have been identified as "environmental estrogens". These can impact the reproductive system of animals including turtles if the beach sand becomes contaminated with these types of chemicals.

Radioactive waste: In recent years, research has shown marine turtles exhibiting carcinogenic growths and deformities attributed to radioactive residues. There is also a suspicion that radioactive waste may result in long term and largely unpredictable effects on the genetic nature of the biological communities in the sea, including sea turtles.

Debris: Marine debris is prevalent in nearshore habitats, and there are numerous reports of the occurrence of marine debris in the digestive tracts of hatchling and adult sea turtles. The list of materials found in the digestive track of sea turtles is extraordinary. Plastic bags, sheets, beads, pellets, lines, rope, strapping, pieces from bottles and hard pieces of unknown origin are commonly ingested by sea turtles. If sufficient material is swallowed it can cause complete stoppage of the gut and result in death. Leatherbacks feed principally on jellyfish and are known to swallow plastic bags by mistake, often leading to their death.

Mitigation measures

Options to minimise pollution include:

- Monitoring of levels of pollution both onshore and offshore, particularly in sea turtle congregation areas
- Prohibition of discharge of crude oil, pesticides, heavy waters, heavy metals and other poisonous effluents to estuaries and coastal areas and near turtle nesting beaches
- Prohibition of discarding of fishing lines, nets, plastic bags and other trash into the water or on the beach which results in ghost fishing and incidental mortality of sea turtles
- Introduction of organised clean up of beaches and nearshore waters by local forest and fisheries departments and other governmental agencies in collaboration with non-governmental organisations, coastal communities, and school and college students. This should particularly be taken up prior to the breeding season of sea turtles in an attempt to clean up the habitat as well as to educate people about marine turtles

b. Threats to nesting beaches

i. Sand mining

The coastal and nearshore marine environment, sea sand in particular, is a source of a variety of minerals of geological and biological origin that have been extracted and utilised by man for centuries. In general, marine sand used for building and construction are utilised locally, whereas those products that have a world market, such as jewelry and industrial metals, may be largely exported in one form or other. The mining or extraction of these minerals, however, tends to be unplanned and unmanaged, causing severe and long lasting detrimental impacts to the environment.

Beaches are dynamic landforms and are constantly subject to erosion and/or accretion. The sand on the beach is subject to storms, waves, and buffeting from the force of waves. This in turn results in the movement of sand from one part of the beach by erosion, and accretion of the same sand in another part. The condition of a beach is a reflection of the local balanced or unbalanced gain due to deposition or loss due to erosion. While natural beachfront and sea erosion does occur, anthropogenic alteration of the beach has significantly contributed to beachfront erosion. Therefore, beach conservation should be based on the premise that any removal of sand can have adverse impacts by disrupting the natural cycle.

Sand mining on a beach a beach in Tamil Nadu

Impact of sand mining on sea turtle nesting beaches

Coastal sand mining can change the entire beach geomorphology. Restoration of the beach often takes years, resulting in loss of available habitat for marine flora and fauna. The immediate deleterious impact of beach sand mining on sea turtles is the uncovering and destruction of nests. Raking can also leave ruts and ridges that disrupt hatchlings' sea finding behaviour. Beach nourishment is one solution to counter the impacts of sand mining, but it can negatively impact sea turtles if the sand is too compacted for nesting. If the sand imported is drastically different from native beach sediments, it may affect nest-site selection, digging behaviour, incubation temperature, gas exchange and moisture content of nests, all of which can ultimately impact the reproductive fitness of sea turtles.

In India, there is severe damage to the nesting beaches of olive ridley turtles along the coast of Orissa (sand mining for rare earth metals), Andhra Pradesh (sand mining for minerals), and Kerala (sand mining for building constructions). In the Andaman and Nicobar Islands, in the absence of riverine sand, large scale sand mining from narrow fringes of sandy coastline impacts nesting beaches of olive ridley, green, hawksbill and leatherback turtles.

Guidelines for coastal sand mining

The Government of India, in 1991, issued the Coastal Regulation Zone (CRZ) Notification under the Envrionment Protection Act (EPA) of 1986 to regulate development activites such as sand mining, lanscaping and construction along coastal stretches of mainland India. The notification has since been amended numerous times and the latest amendement was was officially passed in 2011. The Andaman and Nicobar and Lakshadweep Islands are governed by a recent notification (also issued under the EPA) titled Island Protection Zone (IPZ) Notification. Coastal areas which include the nesting and breeding grounds of endemic and endangered species are categorised under both the CRZ and IPZ notifications as requiring a high degree of protection, and as such, no mining of sand is allowed at these sites. Both notifications contain a list of activities that are permitted and prohibitted along designated coastal stretches and contain provisions for coastal planning through the preparation of Coastal Zone Plans. Under the CRZ 2011 and IPZ 2011, mining of sand, rocks and other sub-strata materials is prohibited, except for rare minerals not available outside the CRZ area and for exploration of oil and natural gas.

Before taking up any coastal sand mining activity, the concerned agencies must ensure that the targeted areas are not important habitats of any marine fauna. Sensitive coastal stretches need to be identified, properly marked with site boards and labels, and removal of sand from such zones or primary dunes should be completely prohibited. Even where sand mining may be allowed, the actual mining must be preceded by proper impact assessment studies conducted by the development agencies in collaboration with the coastal resource management authorities including environment, forest and wildlife agencies. If sand extraction from the landward side of the berm is permitted, it should be carefully conducted avoiding the main nesting season of sea turtles and other rare and endangered fauna, and hard engineering exercises must be stopped at night.

Sand mining activities must ensure adequate control to prevent sedimentation of watercourses from spoil deposits and other disturbance on the land surface. Sand fill and other restoration processes need to be monitored to confirm whether such measures actually rehabilitate sand dunes, and whether the new fill is compatible with the needs of nesting sea turtles and other coastal fauna and flora.

ii. Beach armouring

The deliberate 'armouring' of the coast with the sole purpose of protection of upland structures is rapidly degrading sea turtle nesting habitats in many parts of the country. Coastal armouring takes many different forms such as bulkheads and seawalls, revetments, sandbags and geotextile tubes, soil retaining walls and dune reconstruction. Beach erosion has been a problem especially along the west coast of India. To mitigate erosion, beaches have been armoured with concrete tetrapods and sand bags along the Kerala and Karnataka coasts, Lakshadweep and Andaman and Nicobar Islands. Wherever coastal development has been planned and the area is subjected to some degree of erosion, concrete armouring has been carried out without conducting any impact assessment studies on marine flora and fauna (see Namboothri *et al.* 2008a, b; Rodriguez *et al.* 2008).

Beach armouring in the Lakshadweep Islands

Possible impact on sea turtles

There are four broad consequences to the beach/dune system that can result from coastal armouring.

- Coastal armouring structures cause reflection in wave energy, which can increase erosion seaward of these structures.
- The intensity of long shore currents can be increased, moving sand away from the site more rapidly and in greater quantities.

- The natural exchange of sand between the dune and the beach is prevented; the wave energy is concentrated at the end of armoring structures, which can exacerbate erosion at an adjacent, unarmoured beach.
- These structures physically block female turtles from reaching suitable nesting sites, or the presence of these structures may be aversive to nesting females. These structures may also disrupt sea finding of hatchlings once they emerge.

Mitigation measures

Guidelines for ecofriendly armouring:

- All important sea turtle nesting beaches of moderate intensity must be identified and should be free from beach armouring as sea turtles normally prefer gentle sloping seaward sand dunes rather than beaches which are subject to regular erosion.
- Beach changes must be measured and monitored on a regular basis; this information should be used by planning agencies and others to reduce the problems caused by coastal erosion and to effectively manage coastal development.
- Construction of temporary sand trapping fences: A typical sand fence consists of vertical slats joined with wire/rope or supported with sand posts. Such structures have proved to be more effective in controlling beach erosion and are relatively sea turtle friendly. Caution must be exercised when selecting the placement of these fences so as to avoid impacting nesting females. In general, sections of fence should be less than 3 m in length with a 45° angle relative to the high tide line. The sections of fence should all be parallel to each other.
- Sand trapping fences may be constructed in destroyed, eroded beaches during the non-nesting season and once the sand is trapped sufficiently and a dune is created, it should be planted with appropriate vegetation. This will further reduce erosion and remove the need for armouring. Depending on availability, the fence can be constructed with discarded coconut branches, dry wood and logs, and other materials. The fence must be stabilised with vegetation.
- Coastal vegetation promotes the large scale trapping of sand. The stems of beach grasses reduce the wind velocity near the surface resulting in deposition of sand. The plant roots also serve to bind and consolidate the sand. Therefore, re-vegetation is a suitable option for eroded beaches where armoring is planned. However, this should be area specific and depend upon the characteristics of a particular site. For example, olive ridleys prefer wide sandy beaches, and no vegetation should be planted up to a distance of 50-100 m from the high tide line. On the other hand, green turtles prefer to nest in coastal undergrowth vegetation rather than on open sandy beaches.

iii. Highways and marine drives

In the process of construction of highways, coastal geomorphology is considerably altered. Engineering actions are often geared towards the highways rather than towards the natural coastal geomorphology and ecological processes. Deltaic drainages, coastal vegetation and the shore sand dunes often get impacted irreversibly. Apart from reducing natural coastal habitat, a highway also brings in new impact factors not present in the area before the construction of the highway. In the context of marine turtles, coastal highways on sand dunes have invaded sea turtle nesting sites, and highway illumination and vehicular traffic illumination have impacted marine turtles directly. With increasing access to the coast, human settlements crop up on the coast and along with humans, accompanying livestock and pets (dogs) cause considerable damage to the coastal ecosystem. Predation on adults and hatchlings gets enhanced significantly as the presence of subsidised predators increases.

A highway running along a nesting beach in Gujarat

Impacts of roads on sea turtles

Roads that are constructed on the dune and/or very close to the high tide line of the sea, directly impact sea turtles by:

- Reducing the space available for them to nest
- Disturbing their egg laying activities (due vehicular traffic during the night)
- Increasing human and other biotic disturbance on the nesting beach
- Removing beach sand for road construction, thereby eliminating significant amounts of nesting habitat

- Altering the geomorphology of the sand dunes and reducing the natural nesting beach over a period of time

Mitigation measures

The impacts of coastal highways can be reduced by:

- Locating the road sufficiently far away from the coastal sand dune habitat, preferably on the landward slope of the sand dunes rather than the seaward slope
- Plantation of indigenous species on the seaward side of the highway to reduce lights on the beach from vehicular traffic and marine drives and also to safeguard the highway from sand deposition
- Closure of vehicular traffic at night, at least during nesting season at prime sea turtle nesting areas
- Creation and restoration of degraded sand dune habitats caused by highway construction

iv. Exotic plantations

While the beach itself is devoid of any vegetation due to the constant action of waves, the sand dune zone above the high tide line has various types of natural vegetation despite being subject to wind action. Sand dune grass and other spiny vegetation trap blowing sand and help stabilise, maintain and elevate dune structures. There are also other salt tolerant creepers that help bind the sand.

Most sea turtles prefer open sandy beaches for nesting. Coastal sand dunes with natural vegetation such as *Ipomea pes-caprae* and *Spinifex littoreus* are ideal nesting sites for sea turtles in India. The natural dune vegetation and sand dune structures are closely interrelated and have coevolved to support floral and faunal communities obligate to the coastal sand dune habitat.

However, in recent years, as a measure of control of beach erosion, creation of vegetation shelterbelts against cyclonic storms and afforestation of the coastal zone, large scale plantations of alien and exotic plant species have been taken up, without any impact assessment studies.

One of the exotics that has been planted along most of the Indian coast is the Australian screwpine *Casuarina equisitefolia*. Casuarina plantations were also widely established on the east coast of India (especially Andhra Pradesh and Tamil Nadu) following the December 2004 tsunami. However, studies have shown that these plantations, unlike natural mangrove forests, can hardly withstand cyclones and storm surges (see Mukherjee *et al.* 2008a, b; Namboothri *et al.* 2008a,b; Shanker *et al.* 2008; Chaudhari *et al.* 2009).

Casuarina plantation along the East Coast Road, Tamil Nadu

Impact of coastal plantations on sea turtles

Exotic coastal plantations have proved to be detrimental to the nesting of sea turtles in more ways than one.

- Plantation of exotic beach vegetation drastically alters the beach profile and may often be a deterrent for sea turtle nesting
- Since all coastal plantations are taken up on either side of the sand dune berm, there is significant loss of sea turtle nesting habitat between the high tide line and the berm on the seaward side
- Alien vegetation such as Casuarina with its superficial root growth and thick litter fall renders the beach unsuitable for turtles to nest
- Dense Casuarina and other plantations cause excessive shading of the nesting beach. Nests laid in shaded areas are subject to lower incubation temperature, which alters the natural sex ratio of turtle hatchlings, producing more males
- Plantation of exotic vegetation on the beach also affects the natural beach formation process
- Dense vegetation on the coastal sand dunes provides shelter for both natural (jackals, hyenas, monitor lizards, wild pigs, etc.) and subsidised predators (dogs, pigs, etc.) to breed and add additional predation pressure on nesting females, eggs and hatchlings

In India, some of the important mass nesting beaches of olive ridleys along the coast of Orissa have been drastically altered with dense Casuarina plantations. Some nesting beaches of Gahirmatha and Devi river mouth that were used by olive ridleys in extremely large numbers in the early 1970s and 1980s have been completely abandoned by sea turtles after dense strands of Casuarina were planted.

Guidelines for ecofriendly coastal vegetation

The biological and ecological significance of the beach is often overlooked while undertaking developmental activities or afforestation programmes. The following guidelines are therefore suggested for ecofriendly revegetation of the coastal sand dunes.

- As a policy, no exotic species should be planted in CRZ areas so as to prevent unknown/ unforeseen ecological impacts
- Environmental and ecological impact assessment studies must be conducted before taking up any afforestation programmes along the coast, with provisions set up to evaluate any post-project impacts on sea turtles
- Plantation of exotic vegetation should be clearly avoided on beaches that are known to be sea turtle nesting grounds
- Apart from the high priority sea turtle nesting beaches where no plantation should be taken up, in sporadic sea turtle nesting areas, plantations should be carried out beyond 200 m from high tide line (HTL) and on the landward side slope of the berm, thereby setting aside enough space for sea turtles to nest
- In historically known sea turtle nesting sites, alien and exotic plantations should be gradually removed to restore the nesting beaches to their former state

v. Artificial illumination

The emergence of adult females to successfully nest on a particular beach depends on many factors, including the natural suitability of the nesting site and presence or absence of abiotic and biotic disturbances. With increasing use of the coast for developmental activities, nesting sites are often abandoned by sea turtles due to human induced activities, including artificial coastal illumination.

Hatchlings use visual cues to find the sea when they emerge. Both nesting adults and hatchlings therefore, are susceptible to changes brought on by the use of artificial lighting on the beach.

Lights on Marina Beach, Chennai, Tamil Nadu

Impact of coastal illumination on sea turtles

Impact on adults:

Artificial illumination on nesting beaches impacts adult sea turtles by disrupting nest site selection, abandonment of nesting behaviour, disruption of sea finding ability and disorientation following unsuccessful nesting. The most clearly documented effect of artificial lighting on sea turtle nesting beaches has been the non-emergence of adult females to the nesting beach. Dramatic reductions in nesting attempts by sea turtles at brightly lit nesting beaches have been documented for all species of sea turtles. Along the Indian coastline, conservationists have attempted to reduce artificial illumination near Gahirmatha and Rushikulya in Orissa during the nesting season, to prevent disruption of nesting by olive ridley turtles.

Sea turtles are particularly sensitive to disturbance during the initial phase of nesting. Generally, female turtles will abandon egg laying and return to the sea if disturbed by lights and other activities. After nesting, sea turtles may move towards the brightly illuminated landward side of the seashore rather than going back to the sea. Such bright illumination along the seashore often comes from highways, beach resorts, industries, coastal village street lights and townships, ports and jetties and in recent years, coastal aquaculture farms.

Impact on hatchlings:

Sea turtle hatchlings orient themselves towards the sea as soon as they emerge from the nest. Under natural conditions, the hatchlings recognise the direction of the ocean almost exclusively by visual stimuli, detecting the brightness of the open seaward horizon, due to the reflection of stars and moonlight on water. Sand dunes and vegetation along the nesting beach also help create a darker horizon on the landward side. However, on beaches where artificial lighting is clearly visible, the hatchlings' journey to the sea is disrupted. Hatchling sea turtles emerging from nests at night are strongly attracted to visible light sources along the beach. Consequently, hatchlings move toward the source of artificial illumination and away from the ocean. They thus fail to find their way to the sea, and succumb to predators or exhaustion or dehydrate in the morning sun. Their orientation towards the artificial lights is so strong that even a small torch light left on the beach can attract hundreds of hatchlings towards it.

Sea turtle hatchlings are attracted to bright sources of light

Some of the major nesting sites of olive ridleys in India like Rushikulya in Orissa are now subject to heavy artificial illumination. This has resulted in heavy mortality of turtle hatchlings. At the Rushikulya mass nesting beach in some years, hundreds of thousands of hatchlings have strayed into the fields and vegetation behind the beach. These are collected in the morning by conservation volunteers, state Forest Department staff and local communities, for release into the sea. With the present trend in coastal development, artificial illumination is going to pose a serious impediment for sea turtles along the entire mainland coast, and even if they nest successfully, the hatchlings may stray onto land and die.

Guidelines for coastal illumination

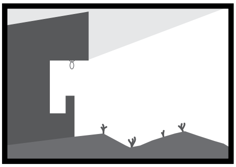
Any light that is visible to the human eye at turtle level on a beach affects the nesting turtles and/or hatchlings. The most direct and complete way to resolve the problem of lights near sea turtle nesting beaches is to put off all artificial lights visible on the nesting beaches during the breeding season. Unfortunately eliminating all the beach front lighting is not always possible. Under such circumstances, following a few simple measures can help mitigate impacts.

- Artificial illumination along important sea turtle nesting beaches during the nesting season must be turned off (depending on the species, the peak nesting season at any particular location usually does not exceed three months of the year).
- The number of lights near sporadic and secondary nesting beaches must be reduced to the minimum necessary and switched off during peak nesting nights.
- Illumination reaching the nesting beach can be reduced by lowering, shielding, and redirecting light sources onto immediate land rather than towards the sea. Even the glow on the horizon can affect sea turtles. Low mounted lights are better than lights that shine upwards from a high pole.
- An easy means to reduce the influence of light on turtle beaches is to screen them on the seaward side. This can be done by applying dark tinting to windows visible on the beach and by drawing curtains after dark to shield lights.
- Care in placement and orientation of light fittings on coastal buildings and infrastructure will considerably reduce the impact of direct and scattered lighting on turtle nesting beaches. Orienting light towards land or by directing lights downwards and by using lamp shades is an easy and effective solution.
- Studies have shown that fluorescent, mercury vapour, high pressure sodium vapor, metal halide and white incandescent lighting disorient sea turtles the most. Further studies need to test which lights affect sea turtles the least (and this may be species specific). For loggerheads, low pressure sodium vapor lights (not to be confused with high pressure sodium vapour lights) that emit a pure yellow light seem to work best. Similar studies need to be carried out for olive ridleys which nest along much of the Indian coast and are most affected by artificial lighting.
- Security lighting can be placed on motion sensitive switches that keep lighting off when it is not needed. Lights that come on only when approached can be quite effective for security purposes.
- Vegetation can suitably “block” artificial lighting from reaching the beach. This might not be applicable in all situations, but may work in specific cases (see Karnad *et al.* 2009).

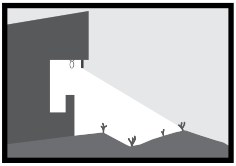
There is a definite need for a Coastal Illumination Act to define appropriate beachfront lighting, to set standards, apply regulations, and deal with offenders. Compared to other kinds of coastal development, light pollution is probably one of the problems that can be solved with relative ease, if the government and local residents are committed to conserving sea turtles.

The following illustrations (adapted from Witherington & Martin 2003, see bibliography) depict factors to be considered for suitable lighting near sea turtle nesting beaches, including mounting position, light distribution, and overall suitability.

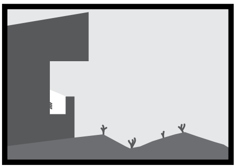
Options for balcony/porch lighting near sea turtle nesting beaches



Poor: Poorly directed balcony lighting can cause problems on sea turtle nesting beaches

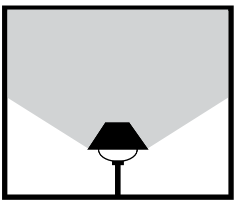


Better: Completely shielding fixtures with a sheet of metal flashing can reduce stray light reaching the beach



Best: Louvered step lighting is one of the best ways to light balconies that are visible from nesting beaches

Options for low level lighting near sea turtle nesting beaches

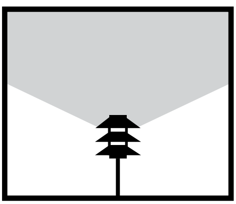


Low level "Mushroom" lighting

Mounting suitability: Good if mounted at foot level

Directional suitability: Poor

Overall suitability: Fair. Good to excellent if used so that vegetation and topography block its light from the beach.

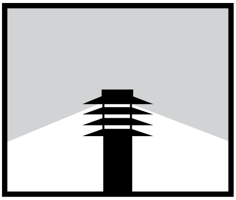


Low level "Tier" lighting

Mounting suitability: Good if mounted at floor level

Directional suitability: Poor but can be good if the fixtures have louvers that eliminate lateral light

Overall suitability: Fair. Good to excellent if used so that vegetation and topography block its light from the beach.

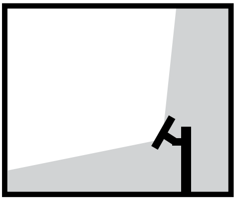


Light bollard with louvers

Mounting suitability: Good if mounting height near 1 m

Directional suitability: Good

Overall suitability: Good



Ground-mounted floodlighting

Mounting suitability: Poor because of its upward aim

Directional suitability: Fair to good

Overall suitability: Fair to poor if directed away from the beach. Very poor if directed towards the beach.

Options for pole-mounted lighting near sea turtle nesting beaches

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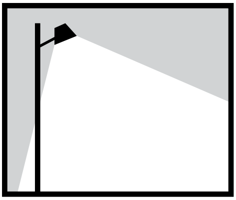
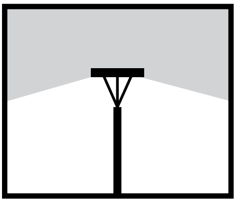


Pole-mounted flood lighting with full visor

Mounting suitability: Good if directed downward and away from the beach

Directional suitability: Good

Overall suitability: Good if directed downward and away from the nesting beach and if light does not illuminate objects visible from the beach.

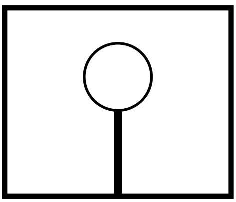


Pole-top-mounted cutoff lighting, "shoebox" fixture

Mounting suitability: Good to poor, depending on mounting height

Mounting height should be no more than 5 m within 100 m of a nesting beach

Directional suitability: Fair to good, as determined by reflectors

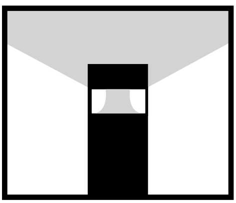


Decorative globe light

Mounting suitability: Fair if mounted at height lower than 2 m. Poor if mounted higher

Directional suitability: Very poor

Overall suitability: Very poor. This fixture is difficult to shield and should not be used near nesting beaches.



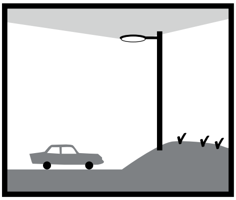
Lighting bollard with hidden lamp

Mounting suitability: Good if mounting height is near 1 m

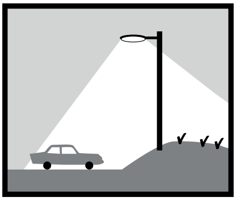
Directional suitability: Poor to fair

Overall suitability: Fair. Good if additional shields on the beach side of the fixture are used.

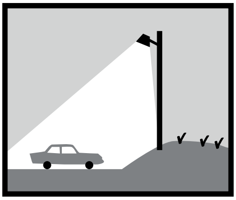
Options for parking lot lighting near sea turtle nesting beaches



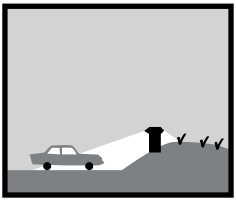
Poor: Poorly directed parking lot lighting can cause problems on sea turtle nesting beaches



Better: Fixtures with 90^{0} cutoff angles can reduce the amount of stray light reaching the beach



Much better: Fully hooded floods can direct light accurately and reduce stray light even more



Best: Low-mounted, louvered bollard fixtures are the best way to light parking lots near nesting beaches

vi. Ports, harbours and jetties

Port, harbour and jetty development facilities on the coastline are required for the shipping industry, offshore oil and gas development, marine fisheries operations, naval and other military operations, and navigation. Major impacts of such developments are 1) shrinkage of natural coastal habitats; 2) dredging and destructive disposal of dredge spoils; 3) obliteration and destruction of nearshore benthic ecology; 4) increasing spills and pollution; and 5) increased coastal illumination.

A jetty on the Nagapattinam coast in Tamil Nadu

Impact of ports, harbours and jetties on sea turtles

Ill-planned locations of ports, harbours and jetties close to, or on, marine turtle nesting sites and breeding congregations directly impact their populations, in addition to permanent loss of their nesting and congregating habitats. Sea turtles also lose important foraging grounds when large scale dredging operations destroy the sea floor. The increased navigation of ships, boats and other vessels directly interferes with the migratory routes of marine turtles. Since marine turtles are known to have strong affinity and fidelity to their natal nesting beaches, any infringement on their migratory route will have an impact on their reproductive cycles and will disorient them from their breeding and congregating grounds. Other impacts that directly affect sea turtles include injuries due to collision with propellers of marine vessels.

Guidelines for ecofriendly ports, harbours and jetties

- No ports, harbours and jetties should be planned within a range of at least 25 km from any important sea turtle nesting and congregating sites.
- Environmental impact assessment studies and alternate site locations to eliminate such impacts should be a mandatory regulation for the establishment of ports, harbours and jetties.
- Existing ports, harbours and jetties must develop protocols and strictly implement them to reduce impacts on sea turtles. Based on such practices, ports, habours and jetties can be given a green rating.

vii. Aquaculture

In recent years, marine and brackish water aquaculture has spread all along the coastline of maritime states. In most cases, aquaculture activities use either the land along the beach (shrimp, brackish water fish farming) or shallow sea beds (for artificial reef, and other mariculture practices). Aquaculture also causes environmental problems such as local eutrophication and depletion of benthic fauna through the accumulation of food residues and excrement, and also toxic pollution through the escape of chemicals and antifouling products.

Coastal aquaculture farms often encroach upon sea turtle nesting and foraging habitats

Impact of aquaculture on sea turtles

Intensive and uncontrolled aquaculture expansions along the coast have resulted in the loss of sea turtle nesting and foraging habitats. In addition, aquaculture farms along the coast have become a major source of light pollution for marine turtles.

Shrimp culture facilities are largely dependent on good quality juvenile prawn seed. Instead of producing them in shrimp hatcheries, in many parts of India, coastal communities are encouraged to scoop out prawn seedlings from nearshore waters. Lured by the lucrative opporunity, thousands of fisherfolk use shore seine nets and enclose stretches of nearshore water adjacent to nesting beaches, resulting in blocking the nesting females' approach towards land as well as movement of hatchlings to the sea. A fairly large number of adult turtles also get killed in such improvised non-target fishing practices, especially along the coast of West Bengal, Orissa, Andhra Pradesh and Andaman and Nicobar Islands, even though such practices are illegal.

Guidelines for ecofriendly aquaculture

- Delineation of proper aquaculture zones away from important sea turtle nesting sites.
- Total ban of prawn seed collection from the immediate offshore waters using any kind of scoop net.
- Ban on the use of bright illumination oriented towards the beach during the nesting and hatching seasons.
- Total prohibition on the release of chemicals and effluents from aquaculture farms and hatcheries into marine and coastal riverine systems.

viii. Tourism

The beachfront and the immediate adjacent land, lagoons and offshore waters are preferred locations for coastal tourism. One of the major impacts of such development is the drastic alteration of the natural landscape often completely stopping, or interfering with, ecological processes. An ecofriendly coastal tourism strategy and action plan should seek to optimise developmental benefits while preserving the natural environment and the socio-cultural scenario upon which the sector depends.

Impact of coastal tourism on sea turtles

Tourism infrastructure: Physical alteration and loss of nesting beaches comes about as a result of erection of structures such as hotels, apartments, restaurants, mobile shops, etc., on the beachfront. They also disorient adults and hatchlings due to artificial illumination. Shadows from buildings close to the high tide line can alter sand temperatures and thus affect the sex ratios of hatchlings.

Removal of vegetation, sand, corals etc.: Removal of vegetation, sand and other materials for recreational tourism results in erosion of sand from nesting beaches and makes the beach unsuitable for sea turtles to nest. Green and hawksbill turtles prefer to nest in the shade of coastal vegetation and if vegetation is removed, they may not use such beaches for nesting.

Speedboat movement and anchoring: Small propeller driven recreational and other commercial boats used by inexperienced boat handlers often cause considerable physical damage to shallow marine habitat including reefs, particularly at low tide. A large number of marine turtles succumb to propeller related injuries. Anchoring of boats in shallow water areas, particularly in corals and seagrass beds, damages these habitats. Plough anchors are known to be particularly destructive. Oil spillage and chronic leakages from tourist and other boats are also a major source of pollution in lagoons and nearshore waters.

Beach chairs, sun beds, umbrellas, etc.: Beach chairs, umbrellas etc. on the beach stop female turtles from reaching suitable nesting locations. Installations of such artifacts can also damage the nest on the beach and/or interfere with incubation temperatures due to increased shade.

Mechanical cleaning: Mechanical cleaning of the beach contributes to the compaction of sand and destroys turtle nests. Further, mechanical cleaning changes the beach slope and configuration thereby deterring adult female turtles from using the area for nesting.

Joy rides on the beach using animals: Use of heavy animals for joy rides on the beach can destroy turtle nests by trampling, and continuous movement of these animals on the beach also results in compaction of beach sand which makes the beach unsuitable for nesting and emergence of hatchlings.

Littering of beach by tourists: Trash and debris on the shoreline not only threaten the health and safety of beach users but also entangle marine animals, including sea turtles. Debris such as plastic sheets, scraps of nylon nets and ropes often cause entanglement of nesting turtles and hatchlings.

Snorkeling and scuba diving: Snorkeling and scuba diving by tourists in turtle congregation areas disrupts the foraging and breeding activities of turtles. Since such activities are often near coral reefs, they also cause unintentional damage to corals and other reef biota resulting in significant loss of sea turtle habitat.

Lagoon/coral bed fishing: Recreational fishing in lagoons and coral beds, harpooning, use of explosives, collection of ornamental fish, live corals, shells, seagrass and seaweeds not only hampers major activities of sea turtles but also reduces forage availability and causes considerable damage to these habitats.

Guidelines for eco (turtle) friendly coastal tourism

- Seasonal closure of coastal tourism activities in nesting beaches and lagoons should be adopted.
- Tourism infrastructure development should only be permitted beyond 200 m from the high tide line or on the landward slope of the sand dune berm rather than the seaward slope.

- All illumination must be made sea turtle friendly. Green ratings, and punish and award systems can be adopted to encourage turtle friendly infrastructure.
- A total ban on joy rides on nesting beaches using animals or heavy vehicles should be enforced.
- Beach leveling and removal of natural vegetation should only be permitted in consultation with conservationists or coastal zone management authorities.
- Foot traffic on sea turtle nesting beaches should be controlled during the daytime to avoid compaction of sand, and at night to avoid disturbing nesting turtles, in those areas where tourists are not taken under well organised sea turtle watch programmes.
- The tourism department, beach resorts and other beneficiaries of beach tourism can involve local communities and schools to adopt a particular sea turtle nesting beach and demonstrate turtle friendly practices.

Installation of permanent or temporary structures impact turtle nesting beaches

The following provisions must be made on sea turtle nesting beaches where tourism is also an important focus: provision of litterbins, installation of warning notices and boards, demarcation of turtle sensitive areas, and display of guidelines for lagoon and offshore habitat users. Innovative methods can be used to promote sea turtles as a coastal tourism resource, for example, by adopting turtle friendly tourism such as turtle watch in lagoons, nesting turtle watch, turtle egg collection, hatchery operation and release of hatchlings and voluntary nesting turtle counts. Such activities are not only educative but also generate a great deal of interest and support for sea turtle conservation.

4. SAMPLE DATA SHEETS

BEACH DATA

Turtle encounter

Date of encounter:	
Time of encounter:	
Beach name:	
GPS coordinates of beach:	
Beach zone where found:	*Relative to HTL: Low I Medium I High*
GPS coordinates:	
Turtle species:	
CCL (cm):	
CCW (cm):	
Sex:	*Male I Female I Not determined*
Activity of turtle:	*Nesting I False crawl I Other*
Injury:	*Yes I No*
Type of injury (if any):	
Primary tag no. (if any) and flipper:	
Secondary tag no. (if any) and flipper:	
Tag type:	*Metal I Other*
Address on tag:	
Genetic sample collection:	
Blood (vial no.):	
Tissue (vial no.):	
Remarks/Observations:	

BEACH DATA

Mortality survey

Date of encounter:	
Beach name:	
GPS coordinates of beach:	
Beach zone where found:	*Relative to HTL: Low I Medium I High*
Survey time start:	
Survey time end:	
Time of encounter:	
GPS coordinates:	
Species:	*Male I Female I Not determined*
CCL (cm):	
CCW (cm):	
State of carcass:	*Fresh I Decomposed*
Injury:	*Yes I No*
Cause of death:	*Evidence of: Physical injury I Drowning I Disease I Not determined*
Primary tag no. (if any) and flipper:	
Secondary tag no. (if any) and flipper:	
Tag type:	*Metal I Other*
Address on tag:	
Remarks/Observations:	

BEACH DATA

Beach profile

Date of survey:	
Beach name:	
Length of beach (km):	
Width of transect (m):	
Length of transect (m):	
Data for each transect:	
GPS coordinates:	
Width of beach (m):	
Height (m):	
Slope:	
Sand texture:	*Fine I Medium I Coarse*
Beach is backed by:	*Natural vegetation I Casuarina plantation I Habitation* *Dunes I Road I Village/town I Other*
No. of villages:	
Threats:	
Lighting disurbance:	
Intensity:	*Absent I Low I Medium I High*
Source:	*Industry I Resort I Village I Town I Other*
Plantations:	*Yes I No*
Sand mining:	*Yes I No*
Beach armouring:	*Yes I No*
Other:	
Remarks/Observations:	

BEACH DATA

Daily beach survey

Date of survey:	
Survey time start:	
Survey time end:	
Beach name:	
GPS coordinates of beach:	
Data for each transect:	
Length of beach (km):	*Distance covered in survey*
Average width of nesting beach (km):	
Nest encounter data:	
No. of nests encountered:	
No. of nests poached:	
No. of nests relocated:	
No. of nests left in situ:	
Turtle encounter data:	
No. of turtles encountered:	
Turtle mortality data:	
No. of dead turtles encountered:	
Remarks/Observations:	

Overall beach survey data for a season, or over a number of seasons can be collated from beach survey data over the specified time and length of nesting beach

NEST DATA

Nest encounter

Beach name:	
GPS coordinates of beach:	
Date of encounter:	
Species:	
Date laid:	
Time laid:	
Age of nest:	*Fresh I Old*
Distance from HTL (m):	
Distance from beach backing (m):	
Nest depth (top) (cm):	
Nest depth (bottom) (cm):	
GPS coordinates of nest:	
Nest habitat:	*In grass I Under vegetation I In sand*
Clutch size:	
Threats to nest:	*Good position I Inundation I Erosion I Obstacles: Vegetation Rocks I Tree trunks I Sea walls/beach armouring*
Fate of clutch:	*Predated I Poached I Inundated I Left in situ I Shifted to hatchery*
Turtle encountered:	*Yes I No*
Remarks/Observations:	

NEST DATA

Nest temperature monitoring

Hatchery (Ex situ)

Species:	
Data logger no.:	
Date of data logger deployment:	
Time of data logger deployment:	
Date of removal of data logger:	
Position of nest in hatchery:	*Centre I Periphery I Intermediate*
Remarks/Observations:	

On site (In situ)

Species:	
Hatchery nest ID:	
Data logger no.:	
Date of data logger deployment:	
Time of data logger deployment:	
Date of removal of data logger:	
Remarks/Observations:	

Hatchling collection

Species:	
Date of collection:	
Hatchling collected from:	*In situ nest I Hatchery nest*
Hatchery nest ID:	
Hatchling bottle no.:	
Tissue sample bottle no.;	
Remarks/Observations:	

HATCHERY DATA

Nest ID (if any):	
Date laid:	
Time laid:	
Date of relocation:	
Time of relocation:	
Date of hatching:	
Clutch size:	
Emerged:	
LIN:	
DIN:	
DPE:	
LPE:	
UD:	
UH:	
Total:	
HS:	
ES:	
Egg diameter (cm):	
Egg weight (cm):	
Total depth (cm):	
Neck depth (cm):	
Neck width (cm):	
Chamber width (cm):	
CCL (cm):	
CCW (cm):	
Remarks/Observations:	

For explanation of the above terms, refer to page 46.

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6. GLOSSARY

Adult: A member of the population that has reached sexual maturity. Sea turtles may reach sexual maturity at different sizes rather than after a certain number of years; hence, the age at sexual maturity may be quite variable and dependent on a number of factors, such as amount and quality of food sources.

Anthropogenic: Effects or processes that are derived from human activities, as opposed to natural effects or processes that occur in the environment without human influences.

Aquaculture: The process of raising aquatic organisms in a controlled environment for commercial purposes.

Arribada: The emergence of an aggregation of ridley turtles onto nesting beaches. Copulating pairs congregate in large numbers followed by mass nesting of females, generally over a period of several days. Olive ridley turtles exhibit mass nesting behaviour in India along the Orissa coast.

Axillary notch: The notch in the front part of the shell into which the front leg fits.

Basking: A behaviour that exposes the body, or a portion of the body, to the warmth of the sun.

Biodiversity: In an ecosystem, variability among living organisms from all sources, sometimes measured by the total number of species or other taxonomic groupings, and their relative abundances.

Body pit: The depression dug by the female turtle during nesting. Body pits are characteristic of different species and range from shallow (ridleys) to rather deep (greens and leatherbacks) and may persist for months under certain conditions. The center of the body pit usually does not indicate the location of the egg chamber.

Bycatch: Organisms caught incidentally, or by accident, during fishing operations for which the organism is not a target. Bycatch can be fish with no commercial value, juveniles of marketable species, sea turtles and birds, marine mammals such as seals, dolphins and whales, and many other forms of ocean life. See also: Incidental capture.

Carapace: A bony shield or shell covering all or part of the dorsal (top) side of an animal.

Carnivore: An organism that primarily eats other animals. See also: Herbivore.

Caruncle: A temporary egg tooth. The horny tubercle on the snout of a hatchling is used to cut through the eggshell.

Caudal: Pertaining to the tail.

Cheloniid: Cheloniids are hard-shelled sea turtle species (green, loggerhead, olive ridley, Kemp's ridley, flatback and hawksbill) that are members of the Cheloniidae Family. The leatherback it is the sole living member of the Dermochelyidae Family. See also: Dermochelyid.

Cloaca: The common cavity into which the intestinal, urinary, and reproductive tracts open in reptiles and other animals; the opening through which sea turtle eggs are laid.

Clutch: A group of eggs laid at the same time. Clutch size refers to the number of eggs produced by a turtle/deposited in a nest at one time.

Conservation: The preservation and careful management of the environment and of natural resources.

Costal bones: The bones of the carapace lying between the neural and the peripheral bones. The lateral (also called pleural or costal) scutes roughly overlie these bones.

Crawl: The tracks of a turtle on the beach. "Track" is used synonymously with crawl. See also: False crawl.

Curved carapace length: Length of the turtle's carapace measured with a flexible tape measure. CCL can be measured in one of two ways: (i) CCL minimum – from the notch at the anterior of the carapace to the notch at the posterior end of the carapace where the last two marginal scutes meet, and (ii) CCL n-t – from the notch at the anterior of the carapace to the tip of the last posterior marginal scute. See also: Carapace.

Curved carapace width: Width of the turtle's carapace measured with a flexible tape measure. A variety of start and stop points are used by different research groups, but the maximum widest measurement is usually taken. See also: Carapace.

Data Deficient: An IUCN category for listing endangered species. A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. (For precise criteria, visit: www.iucnredlist.org).

Dermochelyid: Leathery-shelled sea turtle species (the leatherback turtle is the only Dermochelyid sea turtle). All other sea turtle species are Cheloniids. See also: Cheloniids.

Disorientation: The lack of directed movement towards a specific area or goal. Sea turtle hatchlings on the beach can be disoriented at night when confronted by bright lights on a nesting beach. Also called: Misorientation. See also: Orientation.

Dorsal: On the upper or top side or surface.

Drift lines: Elongated masses of seaweed, debris and other floating objects that often form where ocean currents converge. Hatchling sea turtles take refuge in drift lines.

Ectothermic: An animal, including most reptiles, whose body temperature is determined largely by ambient (outside) temperature, as opposed to generating heat within its own body. With the arguable exception of the leatherback, sea turtles are ectothermic.

Egg chamber: A hole dug by an adult female turtle using her rear flippers, into which she lays her eggs.

Embryo: This stage of development spans the period from the time of first cell division until hatching.

Emergence success: The relative number of eggs in a clutch that produce live hatchlings that leave the nest chamber.

Emergence: (a) Female: The action of the female turtle leaving the water and coming onto land to nest. (b) Hatchling: The emergence of hatchlings on the beach surface above the nest cavity (emergence occurs a variable number of hours or days after hatching from the egg).

Endangered: An IUCN category for listing endangered species. A taxon is Endangered when it is considered to be facing a very high risk of extinction in the wild. (For precise criteria, visit: www.iucnredlist.org).

Environmental sex determination: Environmental sex determination (ESD) is the phenomenon when the sex of the offspring is determined by the environment. TSD (temperature-dependent sex determination) is a special case of ESD. See also: Temperature-dependent sex determination.

Ex situ: Meaning "out of place" and the opposite of in situ. Ex situ conservation is the practice of protecting wild animals/plants outside of their native habitat. In sea turtle conservation, an example of ex situ conservation is the practice of relocating nests to a hatchery.

False crawl: The track left by a sea turtle that has ascended a beach but returned to the sea without laying eggs.

Foraging: The process of looking for food. Areas where turtles feed are referred to as foraging/feeding habitat or foraging/feeding grounds.

Feral: Animals (typically pets or livestock) that have reverted to a wild condition after escape or release from captivity. Feral dogs, for example, are important predators of sea turtles along some parts of the Indian coastline and in the Andaman and Nicobar Islands.

Fibropapillomas: Lobulated tumors that grow on the skin, eyes, in the oral cavity, and on the viscera of sea turtles. This disease is life-threatening as these lesions can impair the turtle's ability to swim, eat, see, and even breathe.

Fidelity: In sea turtles, nest site fidelity refers to adult females returning to the same beach to lay their eggs clutch after clutch, year after year.

Genus (or genera): A taxonomic division that generally refers to a group of animals which are similar in structure and descent but are not all able to breed amongst themselves. For the seven species of sea turtles, there are six different genera: Genus *Caretta* - Loggerhead turtle; Genus *Chelonia* - Green turtle; Genus *Dermochelys* - Leatherback turtle; Genus *Eretmochelys* - Hawksbill turtle; Genus *Lepidochelys* - Kemps ridley and olive ridley turtle; Genus *Natator* - Flatback turtle.

Gill net: A fishing net set vertically in the water so that fish swimming into it are entangled by the gills in its mesh.

Habitat: The specific place in the natural environment where an animal or plant lives.

Hatchery: A man-made structure or enclosed (e.g. fenced) area constructed for the incubation of eggs.

Hatching success: The relative percentage of eggs in a nest that produce live hatchlings. See also: Emergence success.

Hatching: The process of leaving the egg after development is completed.

Hatchling: A turtle that has recently emerged from the egg.

Head-starting: The experimental practice of raising hatchling turtles in captivity for the first several weeks or months of life.

Herbivore: An animal that eats mainly plants or parts of plants. Green sea turtles are primarily herbivores. See also: Carnivore.

Home range: The area in which an animal normally lives, whether or not it defends the area from other animals; the area that an animal learns thoroughly and habitually patrols.

Imbricate: To be arranged with regular overlapping edges. The scientific name for hawksbill turtles - Eretmochelys imbricate - denotes the overlapping arrangement of scutes on the carapace

Immature: An animal that has not reached sexual maturity. See also: Juvenile.

Imprint: Impress on or fix in the mind memory of a thing or person. In the case of sea turtles, hatchling turtles are thought to imprint on the beach or coastal area from where they hatched, enabling them to return to this site to breed. See also: Natal homing.

In situ: Latin term meaning "in place" or "not removed". With sea turtles *in situ* is often used to refer to nests that are left in place as opposed to nests that are relocated or moved to a hatchery. See also: Ex situ; Relocation; Hatchery.

Incidental capture: The unintended capture of non-target species during fishing activity. For example, sometimes sea turtles are incidentally captured during fishing activities for shrimp or swordfish. Also called: Incidental catch; Incidental take. See also: Bycatch; Take.

Incubation: The process of development between egg-laying and hatching. In sea turtles, incubation typically lasts 50-75 days depending on the ambient temperature and the species involved.

Inframarginal pores: Pores located near the rear of the inframarginal scutes. These pores are only found in the ridleys (*Lepidochelys* sp.).

Internesting (interval or period): The period of time between a successful nest and the next nesting attempt (sea turtles of all species lay several clutches of eggs during a nesting season). Typically this is 10-18 days in most species and up to 28 days for ridleys.

Juvenile: Not at full size or strength; a sexually immature sea turtle. Inasmuch as wild sea turtles may take up to 50 years to reach sexual maturity, and that different species and even populations within a species have different growth rates, the distinction between a juvenile and subadult is not well defined. This distinction is further complicated in that there is little or no correlation between size and age in sea turtles. See also: Immature; Subadult.

Laparoscopy: Surgical procedure to examine and/or treat abdominal and pelvic organs through a small surgical viewing instrument (laparoscope) inserted into the abdomen.

Management: The science of working with the characteristics and interactions of habitats, wild animal populations, and humans to achieve specific goals.

Marginals: The scutes lying around the margins of the carapace. These more or less overlie the peripheral bones.

Migration: The directed movement of animals from one place to another. Sea turtle migrations usually involve feeding and nesting activities.

Misorientation: See: Disorientation.

Natal homing: The behaviour by which an animal returns to the place where it was born. For sea turtles, adult females return to lay eggs in the general region where they were born.

Navigation: The method by which an animal orientates and finds a location.

Necropsy: Dissection of a dead body to determine to determine the cause of death. Also called: Postmortem; Autopsy.

Nest: A container or shelter in which birds, reptiles, fish, insects, or other animals deposit eggs or keep their young.

Nesting population: A group of adult female turtles that tends to nest in a specific and defined region or beach.

Nesting: The process of depositing eggs in a nest cavity on a beach. This is often used interchangeably with breeding.

Oceanic: The open ocean where depths are greater than 200m.

Orientation: A species ability to be aware of its environment and its position within that environment with reference to time and space. A species cannot navigate unless it is oriented.

Oviposition: The process of depositing eggs.

Papillae: The esophagus of sea turtles is lined with keratinised projections that point inward towards the stomach. The papillae end where the esophagus joins the stomach and are presumed to trap food while excess water is expelled prior to swallowing.

Pelagic: An organism, such as a young sea turtle, living in the open ocean. Organisms are pelagic if they occupy the water column, but not the sea floor, in either the neritic zone or oceanic zone. Leatherbacks are considered to be the most pelagic species of sea turtle.

Peripheral bones: The bones around the edge of a turtle's carapace that lie beneath the marginal scutes.

Phalanges: The elongate finger or toe bones in the flippers.

Philopatry: Derived from the Greek for "home loving", philopatry refers to the drive or tendency of an individual to return to, or stay in, its home area. Sea turtles display philopatry by migrating from a feeding area to a breeding area and then back again.

Phylogeny: The evolutionary history or genealogy of a group of organisms.

Pivotal temperature: Pivotal temperature is the constant incubation temperature of eggs that will produce equal numbers of males and females. The pivotal temperature is a characteristic of TSD (Temperature-dependent sex determination). Also called: Threshold temperature. See also: Temperature-dependent sex determination.

Plastron: The ventral shell covering the underside of a turtle.

Pollution: The presence of a substance in the environment that because of its chemical or biological composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects.

Population: A group of organisms belonging to the same species that occupy a fairly well defined locality and exhibit reproductive continuity from generation to generation. Genetic and ecological interactions are generally more common between members of a population than between members of different populations of the same species. See also: species.

Predation: When one species feeds on another species. The predator species feeds on the prey species. See also: Predator.

Predator: An animal that hunts and eats other animals. Sea turtles are important predators in the ocean food web.

Prefrontal scales: Thin, flattened, plate-like structures between the eyes that can be used to help distinguish sea turtle species.

Relocation: The removal of an organism from one site and placing it in another. Sea turtle nests that are laid too close to the ocean or in a dangerous section of beach are often relocated to safer areas (either on the beach or into a hatchery). See also: Ex situ.

Remigrant: In sea turtles, this term refers to a nesting female turtle that has been recorded nesting at a particular nesting beach before and has returned, or remigrated, to the nesting beach in a different subsequent year to nest again.

Remigration: The return of adult sea turtles to a particular breeding area in succeeding years. Depending on the species involved, remigration usually occurs on a one (ridley), two, three, or four (most other species) year cycle.

Rookery: The nesting location of populations of sea turtles. Rookery may refer to one species or to a general area of sea turtle nesting.

Scale: Thin, flattened, plate-like structures that form the covering of certain animals, including turtles and other reptiles.

Scutes: The horny scales covering the bony carapace and plastron, except in the leatherback sea turtle. The shape of the scutes does not mirror the shape of the underlying bones and they are named differently from the bones. Both are of taxonomic importance.

Sex ratio: The number of males divided by the number of females (sometimes expressed in percent). It can be specified as "primary sex ratio" that is the sex ratio of the hatchlings, "secondary sex ratio" that is the sex ratio of adults, or "operational sex ratio" that is the ratio of reproductive males to females.

Site fidelity: Being faithful to a particular location. Many sea turtles show nest site fidelity, returning to the same beach to lay their eggs clutch after clutch, year after year.

Species: A taxonomic term to describe a type of plant or animal which can interbreed successfully with members of the same type; these are reproductively isolated from members of all other types (or species). They may mate with similar organisms which are in the same genus and bear considerable resemblance to them but either cannot produce offspring as a result, or the offspring are sterile, or the offspring have distinct survival disadvantages. In some cases, they simply cannot mate because of morphological, behavioural, or physiological differences.

Stock: A management term which refers to a harvestable portion of a species living within a certain geographical area. A stock may include a portion of a biological population or several populations.

Straight carapace length: Length of the turtle's carapace measured with a pair of large calipers. SCL can be measured in three ways: (i) SCL minimum – from the notch at the anterior of the carapace to the notch at the posterior end of the carapace where the last two marginal scutes meet, (ii) SCL n-t – from the notch at the anterior of the carapace to the tip of the last posterior marginal scute, and (iii) SCL maximum – from the anterior edge of the carapace to the tip of the last posterior marginal scute. Usually measured to whichever scute is longer. See also: Carapace.

Straight carapace width: Width of the turtle's carapace measured with a large pair of calipers. There is no standard point to measure to, but the maximum widest measurement is usually taken. See also: Carapace.

Subadult: A turtle approaching sexual maturity. See also: Juvenile.

Survival rate: The percentage of individuals surviving from one developmental stage, year class, or life stage to the next stage, or succeeding period.

Sustainable use: The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

Take: Refers to any activity that might result in the following actions that impact a protected species: harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect. When a species is accorded protection under law (for example, all species of sea turtle are listed under Schedule I of the Indian Wildlife (Protection) Act of 1972), the listed species is protected from "take". See also: Incidental capture.

Taxonomy: Referring to the science of hierarchically classifying animals by groups (e.g. genus and species) which share common features and are thought to have a common descent.

Telemetry: The use of electronic equipment to monitor the movements of animals. With regard to sea turtles, sonar, radio telemetry and satellite telemetry are most often used. Typically, an electronic device which emits a signal at a characteristic frequency is attached to the turtle's carapace.

Temperature profile: Refers to the various temperatures encountered on a beach at different times of the day. Temperature profiles of the sand may be considered in both horizontal and vertical dimensions. The temperature profile may influence nest site selection and surely affects sex ratios and duration of incubation of eggs.

Temperature-dependent sex determination: Temperature-dependent sex determination (TSD) is the condition where the sex of the offspring is influenced by the prevailing temperatures during embryonic development. In sea turtles, warmer temperatures produce more or all females, cool temperatures produce more or all males, and the pivotal temperature is the constant incubation temperature that produces equal numbers of males and females. TSD also occurs in other reptiles (crocodilians, some freshwater and land turtles, some lizards), some types of fish, some types of invertebrates, etc. See also: Pivotal temperature; Environmental sex determination.

Threatened: The term is used in the 1994 IUCN Red List of Threatened Animals to refer collectively to species categorised as "Endangered" (E), "Vulnerable" (V), "Rare" (R), "Indeterminate" (I), or "Insufficiently Known" (K) and in the 1996 IUCN Red List of Threatened Animals to refer collectively to species categorised as "Critically Endangered" (CR), "Endangered" (EN), or "Vulnerable" (VU). (For precise criteria, visit: www.iucnredlist.org).

Tracking: Following the spatial movements of an animal. Typical tracking methods employ satellite, radio, sonic or passive (i.e. flipper or PIT tags) telemetry. See also: Telemetry.

Trawl: A large tapered fishing net that is towed along the sea bottom to catch benthic animals (shrimp, prawn, squid, etc.).

Turtle Excluder Device: A gear modification used in shrimp trawls for the purpose of excluding sea turtles caught in the trawl net before they drown.

Ventral: On the lower or bottom side or surface. In several species of sea turtles, the ventral side (plastron) is lighter in color than that dorsal side (carapace). See also: Plastron; Dorsal.

Vertebrals: The scutes of the carapace which overlie the backbone of the turtle (absent in the leatherback). Also called: central or neural scutes.

Vulnerable: A species or population that is considered to be facing a high risk of extinction in the wild (for precise criteria, visit: www.iucnredlist.org).

Year class: All the animals in a population that hatched during a particular nesting season. The sizes of a particular year class can vary substantially after a few years depending on quantity and quality of food sources.

Yearling: A turtle that has survived one year from the time of hatching. Depending on amount and quality of food, and the species involved, yearlings may vary in size.

Yolk sac: The residual yolk that remains inside a hatchling turtle is contained within the yolk sac.

Adapted from:

Sea Turtle Glossary: Seaturtle.org:
http://www.seaturtle.org/glossary/

Glossary of Sea Turtle Terms: WIDECAST:
http://www.widecast.org/Resources/Docs/Biology_Terminology_Glossary.pdf

7. SEA TURTLE CONSERVATION ORGANISATIONS IN INDIA

Alacrity (Orissa)
Contact: Kalpana Mallik. Postal address: At/PO: Kapaleswar, District: Kendrapada, Orissa
Email: alacrity34@yahoo.co.in; kalpanamallik@gmail.com.

Andaman and Nicobar Environmental Team (Andaman and Nicobar Islands)
Contact: Tasneem Khan. Postal address: Post Box- 1, Jungli Ghat P. O., Port Blair - 744103, Andaman and Nicobar Islands. Email: info@anetindia.org. Website: www.anetindia.org.

Action for Protection of Wild Animals (Orissa)
Contact: Bijaya Kabi. Postal address: Hatapatana, P.O. Kadeliban, Kendrapara District - 754222, Orissa. Email: bijayakabi@apowa.org. Website: www.apowa.org.

Canara Green Academy (Karnataka)
Contact: Ravi Pandit. Postal address: No. 163, Shrikrishna, Shree Vananagara Chipgi, Sirsi - 581402, Karnataka. Email: mail@canaragreenacademy.org; ravi.kfd@gmail.com.

Centre for Ecological Sciences, Indian Institute of Science (Karnataka)
Contact: Kartik Shanker and Naveen Namboothri. Postal address: C.V. Raman Avenue, Bangalore - 560012, Karnataka. Email: kshanker@ces.iisc.ernet.in; naveen.namboo@gmail.com. Website: www.ces.iisc.ernet.in/kslab.

Dakshin Foundation (Karnataka)
Contact: Kartik Shanker, Naveen Namboothri and M. Muralidharan. Postal address: Flat No 8, Dwarakamai Residency, # 2278, 24th Cross, Sahakarnagar C Block, Bangalore - 560 092, Karnataka. Email: info@dakshin.org. Website: www.dakshin.org.

Field Services and Inter-Cultural Learning (Karnataka)
Contact: Dayanand Salins. Postal address: East End residency, East block road, Kundapur, Udupi District- 576201, Karnataka. Email: daya@fsl-india.org.
Website: www.fsl-india.org/kundapur_center.html.

Green Habitat (Kerala)
Contact: James N.J. Postal address: Pavaratty P.O. Thrissur District – 680507, Kerala.
Email: jamesnjj@gmail.com.

Green Life Rural Association (Orissa)
Contact: Sovakar Behra. Postal address: Gundalaba (Devi Coast), Post – Kusumber, Via Astarang, Puri District - 752109, Orissa. Email: wildlife_sovakar@yahoo.co.in.

Green Mercy (Andhra Pradesh)
Contact: K.V. Ramana Murthy. Postal address: Plot No. 7, Collector Bunglow Area, Srikakulam - 532001, Andhra Pradesh. Email: green333mercy@gmail.com.

Greenpeace India (Karnataka)
Contact: Sanjiv Gopal and Ashish Fernandes. Postal address: 60, Wellington St., Richmond Town, Bangalore - 560025, Karnataka. Email: sgopal@dialb.greenpeace.org; ashish.fernandes@gmail.com. Website: www.greenpeaceindia.org.

Gujarat Institute of Desert Ecology (Gujarat)
Contact: Wesley Sunderraj. Mundra Road, Post Box No. 83, Bhuj - 370 001, Kachchh, Gujarat.
Email: wesley.s@rediffmail.com. Website: www.gujaratdesertecology.com.

Lakshadweep Marine Research and Conservation Centre (Lakshadweep Islands)
Contact: Jafer Hisham. Postal address: Pittiyathala, Sandy Beach, Kavarathi Island - 682555, UT of Lakshadweep. Email: jaferhisham@gmail.com.

Madras Crocodile Bank Trust (Tamil Nadu)
Contact: Gowri Mallapur. Postal address: Post Bag No. 4, Mamallapuram - 6031104, Tamil Nadu. Email: mcbtindia@gmail.com. Website: www.madrascrocodilebank.org.

Naithal (Kerala)
Contact: Sudheer Kumar. Postal address: Thaikadappuram P. O. Nileshwaram, Kasargod District - 671314, Kerala. Email: sudheer_nlr@yahoo.com; naythal@gmail.com.

Orissa Marine Resources Conservation Consortium (Orissa)
Contact: Mangaraj Panda. Postal address: O/o United Artists Association, PO/Dist. Ganjam - 761026, Orissa. Email: uaaorissa@gmail.com. Website: www.omrcc.org.

Podampeta Ecotourism and Olive Ridley Protection Club (Orissa)
Contact: D. Himanshu. Podampeta P.O., Via Humma, Ganjam District – 761027, Orissa.

Prakruti Nature Club (Gujarat)
Contact: Dinesh Goswami. Postal address: Marutinagar Society, Opp. Kanya Chhatralay, Veraval Road, Kodinar - 362725, Gujarat. Email: dineshgoswami2008@gmail.com.
Website: www.prakrutinatureclub.org.

Rushikulya Sea Turtle Protection Committee (Orissa)
Contact: Rabindranath Sahu. Postal address: Purunamandha, Palibandha Post, Ganjam District - 761026, Orissa. Email: turtle_rushikulya@yahoo.co.in.

Sahyadri Nisarga Mitra (Maharashtra)
Contact: Bhau Katdare. Postal address: Near Laxminarayan Temple, Chiplun, District Ratnagiri, Maharashtra - 415 605. Email: snmcpn@rediffmail.com. Website: www.snmcpn.in.

Salim Ali Centre for Ornithology and Natural History (Tamil Nadu)
Contact: Dr. S. Bhupathy. Postal address: Anaikatty P.O., Coimbatore - 641108, Tamil Nadu.
Email: sacon@md3.vsnl.net.in; sb62in@yahoo.co.uk.
Website: www.envfor.nic.in/saconh/saconh.html.

Sea Turtle Action Programme (Orissa)
Contact: Bichitrananda Biswal. Postal address: Gundalaba, Post-Kusumber Via Astarang, Puri District - 7520109, Orissa. Email: bichi_devimouth@yahoo.com.

Students' Sea Turtle Conservation Network (Tamil Nadu)
Contact: Akila Balu and V. Arun. Postal address: 8/25, 2nd Street, DP Nagar, Kotturpuram, Chennai - 600085, Tamil Nadu. Email: sstcnchennai@gmail.com. Website: http://sstcn.org.

Theeram Prakruthi Samrakshana Samiti (Kerala)
Contact: Suresh Kumar. Postal address: Iringal Beach, Kolaavipalam, Payyoli, Calicut, Kerala.

TREE Foundation (Tamil Nadu)
Contact: Supraja Dharini. Postal address: 63, First Avenue, Vettuvankeni, Chennai - 600 041, Tamil Nadu. Email: treefoundation2002@yahoo.com. Website: www.treefoundationindia.org.

Visakha Society for the Protection and Care of Animals (Andhra Pradesh)
Contact: Pradeep Kumar Nath. Postal address: 26.15.200 Main Road, Visakhapatnam - 530001, Andhra Pradesh. Email: vspcadeep@yahoo.co.in. Website: www.vspca.org.

Wildlife Institute of India (Uttarakhand)
Contact: B.C. Choudhury and Suresh Kumar. Postal address: Post Box 18, Chandrabani, Dehradun - 248001, Uttarakhand. Email: bcc@wii.gov.in; suresh@wii.gov.in.
Website: www.wii.gov.in.

Wildlife Protection Society of India (New Delhi)
Contact: Belinda Wright. Postal address: S-25 Panchsheel Park, New Delhi 110017.
Email: wpsi@vsnl.com. Website: www.wpsi-india.org.

Wildlife Society of Orissa (Orissa)
Contact: Biswajit Mohanty. Postal address: TULEC Building, Link Road, Cuttack 753012, Orissa. Email: kachhapa@gmail.com. Website: www.wildlifeorissa.org.

WWF-India (New Delhi)
Contact: Sejal Worah. Postal address: 172 B, Lodhi Estate, New Delhi - 110003.
Email: sworah@wwfindia.net. Website: www.wwfindia.org.

This is a list of organisations currently active in the field of sea turtle research and conservation and is by no means exhaustive. A majority of the organisations listed above are also members of the Turtle Action Group (for more information, visit www.seaturtlesofindia.org/tag).

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