<u>SELECTED CONSERVATION TOPICS</u>
<u>WITH A CONCENTRATION ON SRI LANKA</u>

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Module # 5

Coastal Conservation

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What is a Coastal Habitat?

For many the coast means one thing- beaches. Though this may be the simplest way of thinking of the coast, this fragile ecosystem is in fact a lot more than just beaches. Being a difficult area to define as it can encompass a whole variety of habitat types and ecosystems, coasts are often left unprotected. Coastal areas are essentially the interface between terrestrial areas and the deeper marine waters. The term "coast" can be broken down into four main types of habitat.

1. Terrestrial systems such as cliffs, beaches and sand dunes (fig.1).
2. Intertidal zones such as mangroves, tidal pools, coral reefs and sea grass meadows.
3. Coastal waterbodies such as estuaries and lagoons (fig. 2).
4. The shallow coastal sea that overlies the continental shelf.

Each is an ecosystem within itself and yet together they form the larger ecosystem of a coastal habitat.

Terrestrial systems:

Coastal terrestrial systems are largely barren and unproductive when compared to those systems occurring further inland. This is because the ground is usually unsuitable for life, consisting as it does of dry, nutrient-poor sand, crumbling unconsolidated cliffs or hard, sheer rock where plant life must cling to a relatively minor number of cracks and crevasses. In addition to this the constant salt spray makes conditions testing for even the most hardy of flora.

Cliffs

Created by the erosional powers of the ocean, cliffs form an abrupt transitional zone between the marine environment and its terrestrial counterpart. The type of rock as well as the situation of the cliff face in relation to the ocean, determines the specific qualities of each individual location. While all surfaces that are in contact with constant wave action are in a state of flux, softer more easily eroded surfaces display these changes more readily than harder rocks, which will erode at incremental rates very difficult to monitor. From a biological standpoint, cliffs are perhaps most noteworthy for their provision of nesting sites for a variety of sea birds (fig.3). Cliffs are chosen as breeding sites due to their security from interference either from terrestrial predators or human disturbance. However they are not necessarily the preferred choice and certainly not the exclusive one, as many birds prefer nesting on the ground when interference is not present. Sri Lanka does not have an impressive array of cliffs and the sea birds that typically nest on cliffs (gulls, auks etc.) do not nest on the island so their importance in the Sri Lankan coastal ecosystem is relatively minor.

Beaches

These geological features, so sought after by sun worshipping holidaymakers, are essentially the coastal accumulation of various types of sediment derived from rivers, streams and eroded rocks. The sand type that characterizes each particular beach is a result of the primary material being eroded. White sand originates with coral erosion, golden brown sand usually from inland rocks weathered by rivers and streams while unusual beaches of fine, black sand come from the erosion of silica rich cliff bluffs.

This sediment is then moved by tides and waves to form beaches whose characteristic profile forms are dependent upon sediment size and wave steepness. The constant pressure of wave movement ensures that beach areas are perpetually shape shifting, sometimes daily with the effect of the tides and sometimes seasonally.
Each wave has two distinct forces of movement, the swash and the backwash, and it is the relative strength of these forces, which affect the physical beach profile. Waves plunging downward on a vertical orientation have a much larger force of movement away from the shore (backwash) than towards the shore (swash). These waves are considered destructive as they erode beach sediment and drag it out towards the open sea. However waves that have a more horizontal plane of movement create a stronger swash than backwash and can actually move sediment up an incline. These are known as constructive waves. While in some areas erosion of land due to wave action is causing serious problems the global trend shows that more land is actually being gained around the world's coasts than is being lost.

Coastal vegetation has had to make numerous adaptations in order to survive in such a salt-rich, water deficient environment. Small, flat, luscious green and often prickly, the ground plants that edge many beaches form the primary fringe separating forest from sand. Possessing thick succulent leaves with the added protection of either fine hairs or thorns, these plants often line the beaches for some meters before giving way to the actual 'beach'. These hardy species provide an essential food source for many animals that frequent beaches. Used by crabs for shelter, by turtles for nesting areas and in certain area even by elephants and sambar for forage in a manner approaching that of a salt lick. Since sandy soils have difficulty retaining moisture, plants inhabiting these environments must develop methods to overcome the scarcity of freshwater. By storing water in their fleshy tissue beach plants have adapted to this problem while at the same time becoming attractive for human cultivation. Cabbages, lettuce, carrots and beets all occur as wild forms in dry, coastal areas.

The sloping shores of beaches are home to many crustaceans, the most commonly seen being the various crab species. Where the beach gives way to sizeable jungle patches sambar as well as leopards frequent sand dunes in the heat of the day, often resting in the shady hollow of the larger dunes or taking advantage of the cooling sea breeze combing the coastal grasses. In addition jackals and smaller cats frequent beaches in search of sea turtle eggs and of course the turtles themselves use it as nesting grounds.

Sand Dunes

Simply stated sand dunes are raised formations created by wind-blown sand. On dry, clean sand beaches wind velocity over 16km/hour is enough to move individual grains of sediment away from the ocean. When these blowing grains are transported to the drift-line they encounter the salt tolerant plants growing there. These plants act as a windbreak causing the sand to settle and accumulate when the wind drops. The roots of fast growing coastal grasses often further anchor the gathered sand. This creates an even bigger windbreak thus allowing even more sand to accumulate. As long as the sand that is being removed from the beach to form the dunes is being replaced by wave action, dunes can continue to grow vertically. In rare instances coastal dunes can tower over 250m! Mostly however their supply of sand is cut off by the formation of smaller dunes closer to the ocean, resulting in a parallel series of dune ridges. Usually the older dunes are inland and have become stabilized by a cloak of vegetation while the immature dunes are closer to the ocean and generally lacking a vegetative cover. There are many variations on the general theme of sand dune construction depending on environmental circumstances.

A Note on Tides:
The vertical distance between the high tide mark and the low tide mark is known as the tidal range and it varies between spring (high) and neap (low) tides over a period of 14 days. Influenced by the gravitational pull of the moon the tidal cycle is in concert with the lunar cycle. Most tidal ranges are no more than a meter or two but they can increase dramatically when tides spread onto the shallower continental shelves. The largest tidal range in the world is around 15 m and is found in the Bay of Fundy on Canada's Atlantic coast.

Intertidal zones

Mangroves

Marshy areas in close proximity to tropical and sub-tropical oceans that get colonized by plant communities dominated by the genus' *Rhizophora, Bruguievia and Avicennia*. Instead of wind moving the sediment as in the case with sand dunes, this time it is water-borne suspended silt that gets dumped in protected tidal flats and muddy coasts. A steady accumulation of this sediment slowly raises the level of the shore allowing some of the seeds and fruits deposited with the rest of the muck to take hold and start to grow. The growth of these pioneer species increases the amount of sediment trapped out of the water subsequently speeding the process of colonization. Mangrove swamps are unique in structure in that many tree species in these areas produce seedlings viviparously (attached to the tree). These seedlings drop into the mud beside the parent tree and begin the next phase of growth. Other trees drop their seeds into the water where they bob along until they settle in quiet, muddy corners to germinate. Perhaps the most famous image of a mangrove swamp is the forest of aerial roots that are the speciality of the genus *Rhizophora*. This fascinating development is in response to the need to stabilize sizeable trunks with shallow root systems.
Communities of mangroves, called mangals, are highly productive ecosystems and play an important role on many tropical coasts. They support a multi-layered food chain beginning with dense amalgamations of algae and leading up through insects, fish, birds and crocodiles. Monkeys are also commonly found in mangrove areas using the latticework of aerial roots as a vast climbing gym. Being submerged for part of the day and effectively "dry land" for the rest it is no surprise that this zone sees a mixture of marine and terrestrial fauna taking advantage of the rich biomass. In addition to their importance as feeding and nesting grounds, mangrove areas offer protection against coastal erosion and the effects of storm surges.
Presently these wetland ecosystems are under severe pressure from human industry and development.
fig. 4 – a typical mangrove species with the characteristic aerial root system.

Tidal Pools

Tidal pools formed by wave action on surface rocks and old coral flats are literally the boundary between ocean and land. During high tide these pools are nothing more than slightly deeper areas of the near shore ocean environment while during the low tides they provide isolated aquatic systems within which thrive a multitude of saltwater creatures. Important habitats for urchins, crabs, starfish, jelly fish and numerous anemones they are pools that maintain life through the constant ebb and flow of the ocean. It is a microhabitat that is truly ruled by the magnetism of the moon and the resulting tide and with the exception of coral reefs is the richest of all intertidal microhabitats.

Coral reefs

A dazzling array of tropical fish dart from crevasse to nook while delicate corals sway in the slow-moving current. A sharply coloured Hawksbill turtle glides around the corner now obscured by the gossamar spread of a fan coral. A diverse and stunningly beautiful place, a coral reef is widely acknowledged to be the peak of the marine ecosystem. The corals that dominate reefs are colonial relatives of the sea anemone. They deposit an a cup-like external structure made of calcium carbonate from the protection of which they emerge to feed when submerged at night. This rock hard, skeletal calcium carbonate gets accumulated over many years and becomes the framework upon which the living reef is built. This means that in fact a coral reef is a varied collection of living creatures settled upon a massive structure of the skeletal remains of their ancestors. The distribution of coral reefs is controlled by environmental factors, most notably the clarity, salinity and temperature of ocean water. Most corals capable of forming reefs prefer temperatures between 18 and 33 degrees Celsius with apparent maximum development occurring between 25 – 29 degrees. The salinity best suited for coral formation is between 30 – 38 ppt while the water's clarity is vital to ensure that enough light penetrates the initial 10 – 30 meters (Wood 1985). These environmental conditions are met mainly between 30 degrees North and 30 degrees South latitude on mud free coastlines. As the eastern parts of the world's ocean basins experience zones of upwelling of cool water, coral reefs are almost exclusively found in the western portions of oceans or off the eastern coasts of large landmasses.

There are two main classes of reefs: Shelf reefs and Oceanic reefs. The former occur close to continental landmasses where the sea, being above the continental shelf, is mostly shallow with a gradual slope seaward to a maximum depth of 200m. The Great Barrier Reef off the NE coast of Australia is the most famous example. The latter develop in much deeper water far beyond the gently sloping continental shelf. The coral reefs of Hawaii and the Maldives represent the oceanic reefs.

Within the two classes of coral reef can be found five major reef types:

1. Fringing reefs: The most common of shelf reefs, fringing reefs occur where corals have colonized the shallow seas created by the submergence of coastal land. They grow close to shore and are typified by a vibrant, strongly growing fore reef on the seaward side which is generally deeper than the relatively poor, shallow back reef that makes up the landward side of the reef structure.
2. Barrier reefs: Similar in many ways to fringing reefs, it is thought that barrier reefs are the next stage in the evolution of reef formation. These are where the coastal reef is separated from the present coastline by a lagoon or calm sea that overlies inundated land. Often barrier reefs develop along the edge of the continental shelf where it falls sharply towards the ocean basin thus separating the shallow waters of the continental shelf from the deep waters of the open ocean. The back reef and fore reef of barrier reefs are

very different in both structure and species composition with the lagoon-facing back reef being of irregular shape and colonized by fragile corals while the ocean-facing fore reef tends towards a more consolidated and regular countenance and shows lively growth of sturdier corals.

3. Atolls: According to Darwin's theory of coral formation, atolls are the climax of reef development. Typically found in oceanic waters, an atoll is a reef that is roughly circular in shape and rings a central lagoon. This lagoon represents the position of the submerged island around which the reef must have originally grown. The top of the reef is jutting out of the water and it is here that small islands of accumulated coral sands and sediment, called cays, sometimes form. Only the very top of an atoll is alive and growing while it has been theorized that the basal structure is composed of old fringing reefs that originally formed around the ancient island millions of years ago.
4. Platform reefs: These are reefs that form on suitably solid, raised sections of the irregular continental shelf. Corals will settle on the upraised "platform" and proceed to grow vertically to form a reef. The top of the reef is usually exposed to the air and can allow for the development of a small cay.
5. Bank reefs: Similar to platform reefs, bank reefs are formed in deeper water and their top levels are never exposed and in fact, are often found as many as 40 meters below sea level. Since the uppermost part of the reef obtains the most filtered sunlight this is where the peak growth occurs. Bank reefs can be found both at continental margins and in oceanic water.

In addition to being remarkably productive and diverse ecosystems, coral reefs are also extremely important as barriers between the full power of the ocean and land areas prone to erosion. By breaking the force of the ocean waves reefs are the most effective protection against coastal erosion.

<u>Sea grass meadows</u>

While the plants comprising sea-grass meadows are not really grasses at all, they do fulfill the role of grass in the marine environment. They generally exist from the low tide mark to around 30 m of depth in enclosed and sheltered bays, reefs, lagoons and in the lee of offshore barrier islands. A number of marine creatures have developed specialized intestinal systems in order to digest the cellulose of the plants long, grass-like leaves. The gut-dwelling micro-organisms that break down the cellulose mirror those extant in terrestrial ruminants so it is perhaps appropriate that the largest of the ocean grazers – the dugong - goes by the moniker "sea cow". In addition to the dugong, manatees, sea turtles, sea urchins and even some fish find the sea-grass meadows attractive forage. In Sri Lanka the most noteworthy sea-grass beds exist around Mannar in the waters between the continental landmass of India and Sri Lanka. Here dugongs are relatively widespread as are sea turtles that come to the area not to nest but to feed.

Coastal Water bodies

<u>Estuaries</u>:

Where the wide mouth of a river meets and mixes with coastal seawater it creates a cocktail of unique biodiversity. Estuaries are not uniform, with salinity levels varying a great deal depending upon the amount of freshwater entering the system and the effect of oceanic tides. Most present day estuaries are in fact drowned river valleys. The faunal inhabitants of estuaries are essentially marine in nature as very few freshwater organisms can penetrate the waters that vary from low salinity near the source of the inlet to high salinity near the mouth. Not only must estuarine creatures be able to adapt to the possibility of water even more saline than seawater (when evaporation is greater than freshwater input) but they must also be able to adjust to the constantly fluctuating salinity levels.

<u>Lagoons</u>:

Lagoons differ from estuaries in terms of the physical connection between the water body and the open ocean. While estuaries possess broad mouths, lagoons are characterized by narrow channels connecting them to the ocean. They are generally elongated areas of very shallow coastal sea, almost isolated behind barriers of sand that have developed off-shore or as spits. In addition, lagoons have much less freshwater flowing through the system as they are not necessarily aligned with river systems. Since there is less "flow" in lagoon environments, they are more stable in terms of the fluctuation in salinity levels. Despite these differences in the salinity levels and degree of mixture many species inhabit both estuarine and lagoon environments.

Shallow coastal sea

The near-shore ocean waters overlying the continental shelf are by far the most productive part of the wider marine environment – in fact it has been estimated that coastal areas account for 25% of all marine productivity! Being shallow these waters receive sunlight that can penetrate all the way to the seabed at times. This in conjunction with the incredibly high nutrient content that finds its way from terrestrial runoff as well as deep ocean up-welling, means that the shallow coastal sea can support a diverse and very productive biological structure. This includes many species of commercially attractive fish, dolphins, porpoises and sea birds. Of course these are only there because the phytoplankton at the bottom of the food chain are in such abundance. It is due to this wealth of life in its dizzying array of colours, shapes and specializations that the near-shore ocean waters have been called the rainforests of the sea.

The Importance of Coastal Conservation

The coastal areas of the world are as complex as they are varied resulting from millions of years of constant physical activity. As the margins between land and sea these areas of sharp transition are often overlooked in terms of the role they play in the functioning of the planets ecological systems.

It has been estimated that the earth's ecosystems provide US$33 trillion in services annually. These services range from direct benefits such as medications derived from plants, to psycho-spiritual benefits such as recreational usage to ecosystem services such as gas migration and soil formation without which life on earth would be impossible. Of this figure, which is almost twice that of global Gross National Product, some 63% is contributed by marine ecosystems. Approximately 80% of this comes from coastal marine ecosystems (Costanza et al. 1997). In terms of nutrient cycling alone the part played by coastal areas is impossible to overstate. It is beyond doubt that a healthy, functioning coastal environment translates into a stable and more secure world, however the threats to the health of coastal ecosystems are myriad. Due to the complex nature of coastal systems and the paucity of real knowledge regarding their interactions it is very difficult to plan ahead with regards to the effects of mismanaged coastlines. What can be comprehended are some of the short to medium term effects that certain practices can have.

One of the most pervasive problems for coastal conservationists is pollution. This can have a wide variety of sources ranging from oil spills to mid-ocean dumping to agricultural runoff to the direct discharge of industrial or household waste. When toxic chemicals from industrial sources enter the water system they can have widespread effects throughout the food chain. Often it is the predator species, including humans, higher up the food chain that reaps the worst of this kind of pollution. Toxins ingested by the primary herbivores get stored and often, magnified until they are in turn ingested by predator species feeding on those herbivores. Mercury runoff is one well-documented contaminant that acts in this way, resulting in massive die off of both larger fish and many raptors that feed on these fish, from mercury poisoning. Frequently the negative effects of pollutant runoff are far less direct. When chemical fertilizers are applied to agricultural areas high concentrations of certain components find their way, through runoff, to rivers and streams, which ultimately enter the world's oceans. Nitrogen-rich runoff of this kind causes a dramatic increase in the productivity of algae, which blooms to such an extent that is can actually choke a water body to death by blocking the sunlight necessary for photosynthesis to take place. This invariably has a far reaching and damaging effect on the ecosystem involved. Oil spills are another common maritime disaster that has the potential to wreak havoc on important aquatic environments like coral reefs, sea bird breeding colonies and of course marine animals. Often areas affected by oil spills will recover after a number of years but by and large their recovery will change the original balance of the ecosystem creating dramatic increases in some species and decreases in others, less able to bounce back. This unpredictability further complicates the scenario making it impossible to plan ahead for such eventualities.

It has been postulated that it is in fact not pollution that poses the greatest threat to the world's coastal marine habitat, but the process of reclamation. For centuries humans have been actively reclaiming sections of ocean in order to increase the surface area available for houses, factories, ports, agricultural land etc. however only in the last 50 or so years has the rate of reclamation become alarming. This is a problem throughout wetland ecosystems, coastal and non and is greatly reducing in size the area of these important coastal systems.

One final threat presently posed to fragile coastal environments is the destruction of coral reefs. As reefs are zones of such incredible biodiversity and therefore intense productivity they are vital parts of a healthy ocean. Many reefs around the world are under threat because of their special beauty and not in spite of it! Tourists by the thousands visit the Great Barrier Reef in Australia or the numerous cays and atolls off the coast of Belize, yet still too many are ignorant of the need for caution and care when observing these living aquatic gardens. Coral is very easily damaged and once it is destroyed can take a very long time to recover, if it does at all. Simply touching coral is enough to kill many of the more fragile organisms while dropping anchors or walking on the corals is certain to wipe them out. This accidental destruction is compounded in places like Sri Lanka where corals are purposefully destroyed and removed from the ocean for the production of lime. This lime, which is ultimately used in the construction process, does not need to come from coral at all. The result of this rampant extraction is increased erosion on beaches that were once protected by the barrier that the coral provided from the might of the open ocean.

Its Importance and application to Sri Lanka

An island with approximately 1,340 km2 of coastline, one of Sri Lanka's primary concerns should be coastal conservation. Erosion of the coastline would mean the erosion of this islands landmass, a seemingly straightforward concept ignored and/or misunderstood by many. Sri Lanka is also an island with many waterways flowing through to the ocean having originated from its central massif. As a result many delta systems, mangroves and lagoon ecosystems have been created over the centuries. A comprehensive coastal conservation plan incorporating all habitats within a coastal ecosystem therefore is necessary for an island such as this. It is inadequate to look simply at the more obvious beach environments.
It is hoped that with the increasing scientific knowledge of coastal environments governments will be more equipped to deal with the conservation of such a vast and complex ecosystem.

<u>How you can help conserve:</u>

1. Do not pick and/or buy coral /coral products and large shells
2. If snorkeling take care to not step on the coral
3. Support seaside hotels and business that do not pollute (i.e have sewage treatment facilities and low- power inshore oriented beach side lights).

A Case Study of a Marine Mammal - The Sea Turtle

<u>History</u>

There is a good reason why present day sea turtles act to remind us of the long ago days of dinosaurs – they were there! For over 100 million years marine turtles have been roaming the Earth's oceans and in keeping with the dinosaur theme of big is better, the ancient ancestors of today's turtles were enormous with fossil remains indicating lengths of up to 12 feet and carapace width's of almost 7 feet! While contemporary sea turtles are more modest in size little else seems to have changed much in the intervening millenniums. Fossil records suggest that they evolved originally from large, terrestrial tortoise-like animals that for whatever reason were forced (or chose) to enter the saline world of the ocean. Centuries of adaptive evolution have allowed these creatures to restructure their anatomical designs in order to thrive in this different environment. Short, stumpy legs turned gradually into muscular, wedge-shaped flippers, the front set used like a pair of oars to propel the body while the back set adept at the subtle functions of a rudder. What once were high, domed shells became flattened to create a slight, streamlined curve that allows for increased speed in the water. The ability to retract head and legs into the shell disappeared along with teeth, the latter replaced by sharp, beak-like jaws used for crushing, tearing and ripping as necessity dictates.

Being reptiles, marine turtles are cold-blooded and must therefore rely upon the environment to determine their body temperatures. Often turtles will come to the seas surface in the morning in order to get enough sun to raise their body temperatures, still low after a night spent sleeping in underwater caves or crevices. While marine turtles possess lungs and therefore require air to breathe usually every half hour or so, when they are inactive they require very little oxygen so are able to spent entire nights below the surface.

Like most reptiles' marine turtles are long lived and while it is not known exactly how long they live it is widely accepted that they can survive for over 80 years. They become sexually mature and are able to reproduce only after approximately 30 years. Until that time it is very difficult to distinguish between male and female however once sexual maturity is reached the male develops both a long, powerful tail and a long, gripping claw on each fore flipper used during mating.

Species:

There are seven internationally recognized species of marine turtles presently extant in the world, all of which are threatened with extinction as a direct result of human interference.

Little is known about these ancient mariners as they spend the vast majority of their lives in the ocean deeps, well away from the curious eyes of researchers. When they do come close to shorelines it is for one reason and one reason only: Reproduction. Both male and female marine turtles come to near shore waters during the mating season, often spending hours bobbing at the surface locked in the act. Only the females undertake the next step of the cycle as they haul themselves out of the ocean and onto stretches of beach the world over to deposit their eggs and thus begin the amazing process of regeneration.

Remarkably five of the seven species come to the golden beaches of southern Sri Lanka to nest. In the world only Mexico and Australia are home to an equal variation of nesting sea turtle species.

The Leatherback turtle (*Dermochelys coriacea*)

The largest and most magnificent of the marine turtle species, the leatherback is named for its curious carapace. Unique in the realm of sea turtles the distinct black, five ridged shell is most unusual in that it is made up of thousands of minute, star-shaped bones which are covered not with the large, plate-like scales of most turtles but with a thick, leathery skin. The reason for this distinction can be implied from the leatherback's exclusive diet of jellyfish, the deep-sea varieties of which can live at a depth of 1600 meters. The tremendous pressure that occurs at such tremendous depths would crush the typical rigid shell of most turtles but the inherent flexibility of the leatherbacks carapace allows it to make such deep dives in pursuit of its prey. Relying on a single prey source has fostered other interesting adaptations for the leatherback turtle, one of which is the ability, again unique among marine turtles, to regulate its own body temperature without reliance on the elements. This, together with the fact that their bodies are insulated with layers of fatty tissue is the reason that these hulks have been observed feeding on jellyfish as far north as the Arctic Circle, almost 4500kms away from their tropical nesting beaches! It is not unusual for a mature leatherback turtle to measure 3 meters from head to tip of shell and exceed

600 kgs in weight. In fact the largest individual ever recorded washed up on a beach in Wales and at 916kgs was about the size of a small car! (Ranger et al. 1996)

The Green turtle (*Chelonia mydas*)

Next to the leatherback the green turtle is perhaps the widest ranging of all the marine turtles, existing throughout the tropical Indian, Atlantic and Pacific oceans. With an average length of over 1 meter and weighing up to 225 kgs, the green is also the second largest of the seven species. Its unique life cycle sees young turtles relying mainly on crustaceans and other living creatures for food while the adult of the species eats only vegetative matter. Unfortunately this turtle is renown for its flavour more than anything else and is the much sought after main ingredient in "turtle soup". The green turtle is so intricately linked with this restaurant fare that its name is derived not from its shell colour (although the shell is a mottled green) but from the colour of the fat layer found under the shell from which the soup is made. Needless to say the relentless hunting of these gentle giants for this speciality food has largely contributed to the downfall of the species. The shell is roughly oval and along with the Hawksbill turtle and Australian flatback, the Green turtle can be identified by four pairs of costal scales. With the exception of the Leatherback turtle, all marine turtle species possess these costal scales, which are the two sets of scales flanking the central band running down the "spine" of the shell (see Fig.5).

There has long been heated debate in the scientific community regarding the species designation of what is locally known as the Black turtle. Many researchers consider this Pacific Ocean dwelling turtle as merely a colour variation of the Green turtle while others are adamant about it being a distinct species (*Chelonia agassizii*). It has the same habits and life cycle as the Green but is differentiated by its darker carapace that also exhibits a slightly pointed anterior portion.

The Loggerhead turtle (*Caretta caretta*)

This sturdy turtle is known to nest in the tropical environments typical of all marine turtle species, but also lays its eggs in some more temperate climates both further north (the Northern Mediterranean) and south (South Africa) than any other species. A large, thick-set turtle the Loggerhead grows to a carapace length of 1 meter and can weigh as much as 180kgs (Ranger et al.1996). The five pairs of costal scales, which adorn a distinctive tapering shell, can identify them. Reddish-brown to brown in colour, this rugged reptile is not easy to mistake. The imaginative name comes from its heavy, squarish head that encompasses a powerful set of jaws used to crush the crustaceans and mollusks that make up its carnivorous diet.

The Hawksbill turtle (*Eretmochelys imbricata*)

Hawksbills are relatively small by sea turtle standards with typical individuals having carapaces 90 cm long and weighing 50kgs. What they lack in size however they more than make up for in beauty with delicately patterned yellow and green shells that overlay one another to form a remarkable composite. It is the young of the species that posses the most alluring carapaces and for centuries these exquisite shells have been sought after for the making of "tortoiseshell" jewelry and ornaments which is why these turtles are today highly endangered. As if this curse of the beautiful was not enough, Hawksbills are also at a crossroads with man regarding their eating habits. They subsist on a large variety of marine animals including jellyfish, sponges and crustaceans, however most of their diet is gleaned from in and around tropical, coastal coral reefs – in fact their name comes from their narrow, raptor-like beak used to snatch animals out of crevasses in the reefs. These reefs are being destroyed at an alarming rate around the world either directly for the making of construction lime, unplanned development and misguided tourists or indirectly from runoff chemicals from agricultural industries such as banana plantations. Luckily for Hawksbills they do not need to worry about being hunted for food because they have the peculiar ability to store toxins in their flesh. This allows them to eat such things as toxic sponges without getting poisoned and also ensures that nothing can eat them without the threat of acute food poisoning.

The Olive Ridley turtle (*Lepidochelys olivacea*)

The omnivorous Olive Ridley turtle is the smallest marine turtle of all weighing less than 40 kgs with a shell measurement of around 65cms. They can be identified by their grey green (or olive!) colour in addition to the six or more pairs of costal scales on their rounded carapaces. The Olive Ridley inhabits the tropical Indian and Pacific oceans and is renown for its curious mass nesting habit. On a select few beaches in the world thousands upon thousands of these turtles come ashore during the few weeks of the nesting season in what is known as an Arribada. This is Spanish for "the arrival" and accurately sums up the grand event when one cannot walk down the beach at night without tripping over dozens of nesting females. While the numbers seem staggering – 600 000 Olive Ridleys nesting on a single stretch of beach in India, 400 000 in Costa Rica – the species is endangered because of the inherent fragility of relying so heavily on so few locations.

The Kemp's Ridley turtle (*Lepidochelys kempi*)

Slightly larger than the Olive Ridley turtle, the future of the Kemp's Ridley turtle is more precarious still. Like its smaller cousin these turtles have been known to nest in huge numbers however they are now restricted to a single stretch of beach in Rancho Nuevo, Mexico. Just over 50 years ago as many as 60 000 of these turtles came ashore at this beach to lay their eggs but now the population has been reduced to such a degree that no more than 2000 females struggle ashore every year to carry on the species legacy. This critical situation has forced drastic conservation measures in Mexico and the surrounding waters including armed guards patrolling the beach during nesting season. These actions have allowed the numbers to gradually increase; however the situation is far from stable.

The Flatback turtle (*Natator depressus*)

Once known as the Australian flatback because of the fact that they nest only in Australian waters, the Flatback turtle is limited in its distribution to the far western Pacific and Indian oceans. They are medium sized turtles with carapace lengths of 90cm and weights up to 70kgs recorded. Flatbacks are omnivorous and are known to eat seaweed and cuttlefish amongst other marine life. They owe their name to their distinctive low domed carapace that flares up at the edges giving the shell the appearance of a surrounding rim.

Nesting Behavhiour:

It is during the annual nesting season that these gentle giants are at their most conspicuous to human eyes for while sea turtles spend their entire lives in the vast ocean expanses they all begin their lives firmly entrenched in terra firma. The nesting season of each species varies to a certain degree according to location but they are consistent year after year.

The process begins shortly after the actual mating occurs in the wave tossed near shore waters, when the female turtle drags herself ashore onto the nesting beach. It is believed by researchers that turtles return to their natal beaches to breed, led by a still poorly understood magnetic compass. What is known is that a female will return to the same beach – and very often to the very same *stretch* of beach – every year of her life cycle. Over the course of the nesting season she can deposit a nest of eggs – ranging in number from 120 to 250 per nest depending on the species – as many as half a dozen times, roughly once every two weeks. The turtles come ashore during the night as the temperatures are more moderate in the tropical nesting sites and also possibly because of the need for secrecy from potential predators that are hindered by the cover of night. The nesting females usually make a beeline for the vegetated dunes – usually bypassing the open, sandy areas of beach – where they carefully select a nesting site. While it is unknown to what degree the female turtles actively select one spot over another it is believed that their selection considerations include sand temperature, moisture content and grade of sand. Once the ideal location has been found the turtle will use her powerful front flippers to dig out a shallow "body pit" in which to lie. These pits are usually no more than one or two feet deep and roughly the shape of an irregular saucer. Upon completion of the "body pit" she will get down to the serious business at hand by using her smaller, more dexterous hind flippers to scoop out an "egg chamber". This chamber is usually around 1 ½ to 2 feet deep, narrow necked at the surface and opening out into a large circular hollow at the bottom. Sometimes females will dig out their "body pit" and "egg chamber" and then, deciding something is not quite right, fill them in and start the whole process over again. This initial work that occurs before the actual egg laying can take anywhere from half an hour to two hours and it is during this period that the females are at their most wary. Lights, sudden movements or noise during this delicate time can easily send a female back into the ocean before her eggs are laid. Once the "egg chamber" is prepared and the female begins to deposit her batch of eggs she enters a trance-like stage during which she seems completely unbothered by the same disturbances that would, a few minutes earlier have sent her lumbering back into the surf.

Turtle eggs are soft shelled and round – except for the larger Leatherback eggs they look much like table tennis balls! - So they do not break as they drop down from the prone turtle to the bottom of the "egg chamber". Even so some turtles prefer to guide their precious cargo onto the chamber floor using their curved hind flippers. The egg laying complete the female turtle now fills in the "egg chamber" with her hind flippers before showering sand on the entire area with her front flippers as she slowly moves away from the nest. This last event is an effort to camouflage the exact location of the nest so as to make it more difficult to locate for predators. This exhausting process can take over three hours from emergence to the time that the hulking reptile re-enters the ocean. Now that the eggs are safely laid the female has no more to do with the process leaving her carefully deposited nest to the elements and chance.

The Hatching Process:

During the 60-day incubation period the nests are vulnerable to a number of potential hazards including predation by any number of predators from foxes to mongooses, snakes to humans. If the nest is poorly placed there is even the chance that it will become inundated with water during periods of high tide, thus destroying the nest. If all goes well during this incubation period the baby turtles will begin to hatch and move around in the nest. After around 2 days almost all of the eggs will have hatched and their combined movements will cause sand from the roof and walls of the nest to fall down forming a platform for the hatchlings. In this curious manner the baby turtles ride the sandy elevator, level after level up to the surface of the beach. Similar to the nesting females the hatchlings tend to wait until nightfall before emerging to the surface. Upon escaping the nest their instincts tell them to move in the direction of the most light, which under natural conditions is the moon or starlit surface of the ocean.

However at this point the process is far from over and in fact is just entering its most dangerous stage! The freshly hatched turtles, while fully formed and exquisite in their miniature detail are seen by patrolling dogs, crabs, crows, gulls etc. as nothing more than a bite size meal. Once the water is reached safely the turtles immediately begin swimming in an effort to clear the predator filled inshore waters for the relative sanctuary of the deeper ocean currents. The young turtles have been well provided for this danger fraught trip as they each posses a yolk sac in their stomachs upon which they rely for sustenance during the trip. This 48-hour period of swimming has been termed the "juvenile frenzy" and is known to be an essential part of the breeding process. Once they reach the open ocean the hatchlings relax somewhat and it is thought that they hitch rides on clumps of floating seaweed called "rafts" where they begin feeding on the tiny sea animals that will sustain their next few months. Unfortunately very little is known about the lives of sea turtles from the time they hatch until they are ready to return to their natal beaches to lay eggs of their own, however it has been estimated by comparing hatchling numbers with nesting female numbers that only 1 in 1000 eggs will eventually grow into a reproductive, adult sea turtle.

The Human Threat (Sri Lanka and beyond):

Direct Threats:

- The ways in which human activities directly and indirectly threaten sea turtle populations are numerous and varied. The most obvious and direct threat is the poaching of turtles either for their meat (Green turtles, *Chelonia mydas*) or their shells (Hawksbill turtles, *Eretomochelys imbricata*). The eggs of all species are seen by many, including Sri Lankans in both the north and south as delicacies and are routinely dug up and eaten. Many erroneously believe that the eggs increase sexual virility and as a result they are eaten raw by hopeful men the world over. This belief is thought to have developed because of the marathon mating sessions in which sea turtles routinely partake.

- The fishing industry is responsible for a great deal of the pressure on sea turtle populations. Irresponsible fishing practices the world over see an enormous amount of what is called "by-catch". This is the term given to the thousands of untargeted species that routinely get caught in fishing nets and traps along with the commercially targeted species. Sea turtles are often snared due to their size and the fact that they range throughout the oceans and at various depths. As the turtles often damage nets with their struggles to break free it has become standard practice for fishermen to simply cut off the entangled flippers and throw the turtle back into the water where it slowly dies. For obvious reasons the actual numbers of turtles that are killed in this manner is unknown. There are some positive responses to this problem that have resulted from extensive lobbying on the part of concerned conservation groups, the most notable of which is the development of the Turtle Excluder Device (TED). This is a mechanical device, which is fitted onto shrimp trawlers that allows the bulky sea turtle to escape from the shrimp cages without releasing any of the desired catch. They are now mandatory in many parts of the world, and is certainly a step in the right direction.

In heavily trafficked areas during breeding season when turtles mate near the surface in the inshore waters they fall victim to motor boat propellers.

Indirect Threats:

- While these direct threats are devastating indirect threats have an equally widespread impact on turtle populations. The destruction of coral for the production of construction lime as well as from improperly managed tourism reduces the feeding grounds for various sea turtle species, most notably the Hawksbill that relies a great deal on the bounty of the world's reefs. These reefs and the inshore waters in general are also adversely affected by chemical pollution from the pesticides and herbicides of agricultural activities. Coastal crops like banana plantations that use large amounts of these chemicals produce run off during times of rain, which brings high concentrations of these harmful solutions into the ocean via streams and rivers. The toxic mixtures concentrate in the near shore waters where they get incorporated into the food chain destroying the marine life in the vicinity. Industrial activities produce similarly destructive run off.
- Garbage, particularly polythene, is another cause of distress to marine turtle populations as they often ingest it. It tends to line their stomachs resulting in starvation. This problem is particularly potent with regards to Leatherback turtles as they frequently mistake floating plastic bags for their traditional prey species, jellyfish.
- Rampant development in all of its guises is another cause of decline in sea turtle numbers. Many prime nesting beaches have been destroyed by the development of tourist hotels or beachfront housing development around the world. The pollution created by these structures often gets deposited directly into the ocean leading to even more hazards for marine life. One of the most overlooked and silent threats to turtle populations come from a seemingly innocuous source – lights. Many beachfront properties have lights that illuminate the beach, which has a doubly detrimental effect for the nesting process. Many female turtles will get driven away from the lights causing them to place their nests in less optimal locations decreasing the chances that their nest will successfully hatch. Once the hatchlings do emerge they instinctively migrate towards the brightest horizon which is usually the ocean, however when artificial lights are in the vicinity the baby turtles will turn the wrong way and clamber inland away from the ocean and their only chance of survival.
- A final threat that is widespread in Sri Lanka is from a seemingly unlikely source: Turtle Hatcheries. It is natural to think on the surface that these hatcheries which dot the South coast of the island are working towards the conservation of sea turtles, however due to unscrupulous management or

sometimes plain ignorance these operations are causing more harm than good. Often nests are unnecessarily moved to fenced off artificial hatcheries in order to increase the tourist potential at the site. This in itself is not necessarily very harmful provided that care is taken with the translocation of the nest, however due to the fact that little is known about the incubation period the fewer disturbances the better. It is known that the sex of emerging hatchlings depends upon the temperature of the nest in which they are incubated so the potential to create artificial sex ratio imbalances by moving nests to a hatchery needs to be taken into consideration. Furthermore many hatcheries keep the baby turtles in concrete tanks for extended periods in order to enable tourists to view them. This ensures that the hatchlings deplete their vital yolk sacs before even reaching the ocean! As a result they are unable to partake in the 48-hour "juvenile frenzy" when they do reach the ocean and must instead begin feeding right away. This greatly increases their exposure to predators, which abound in the rich near shore waters. If the hatchlings are kept longer than a couple of days they begin to bite each other due to hunger, often inflicting nasty injuries, which greatly reduce their chances of survival once, released. Another harmful practice that occurs in many hatcheries is the direct release of hatchlings into the water. Again this is usually done for the benefit of ignorant tourists who want to actively participate in the whole process. It is believed by researchers that the hatchlings undergo an imprinting process as they make their way from nest to ocean, which provides them with the ability to navigate back to their natal beach when it is time for them to nest 30 years down the road. By releasing baby turtles directly into the water this potentially vital imprinting process is sacrificed.

Concerned individuals can make a great deal of difference to the overall protection of marine turtles by observing some simple rules:

1. Never purchase turtle products such as meat, eggs, or articles made with turtle shell.
2. Don't dispose of garbage, particularly polythene near waterways or the ocean and encourage others to do likewise.
3. Encourage beachfront property owners to aim their lights away from nesting beaches at night.
4. Lobby for more environmentally sustainable sewage treatment practices for beachfront properties.
5. Never purchase products made from coral and educate others about the matter.
6. Lobby local govt. to initiate methods of reducing by-catch in the fishing industry.
7. Do not frequent turtle hatcheries that undertake any of the above-mentioned practices and encourage changes if they do.
8. Support turtle conservation projects that actively and sensibly work towards the preservation of marine turtles.

Note: *All hatcheries in Sri Lanka do not adhere to conservation ethics and are mostly tourist attractions causing further decline in turtle numbers around the world.*

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