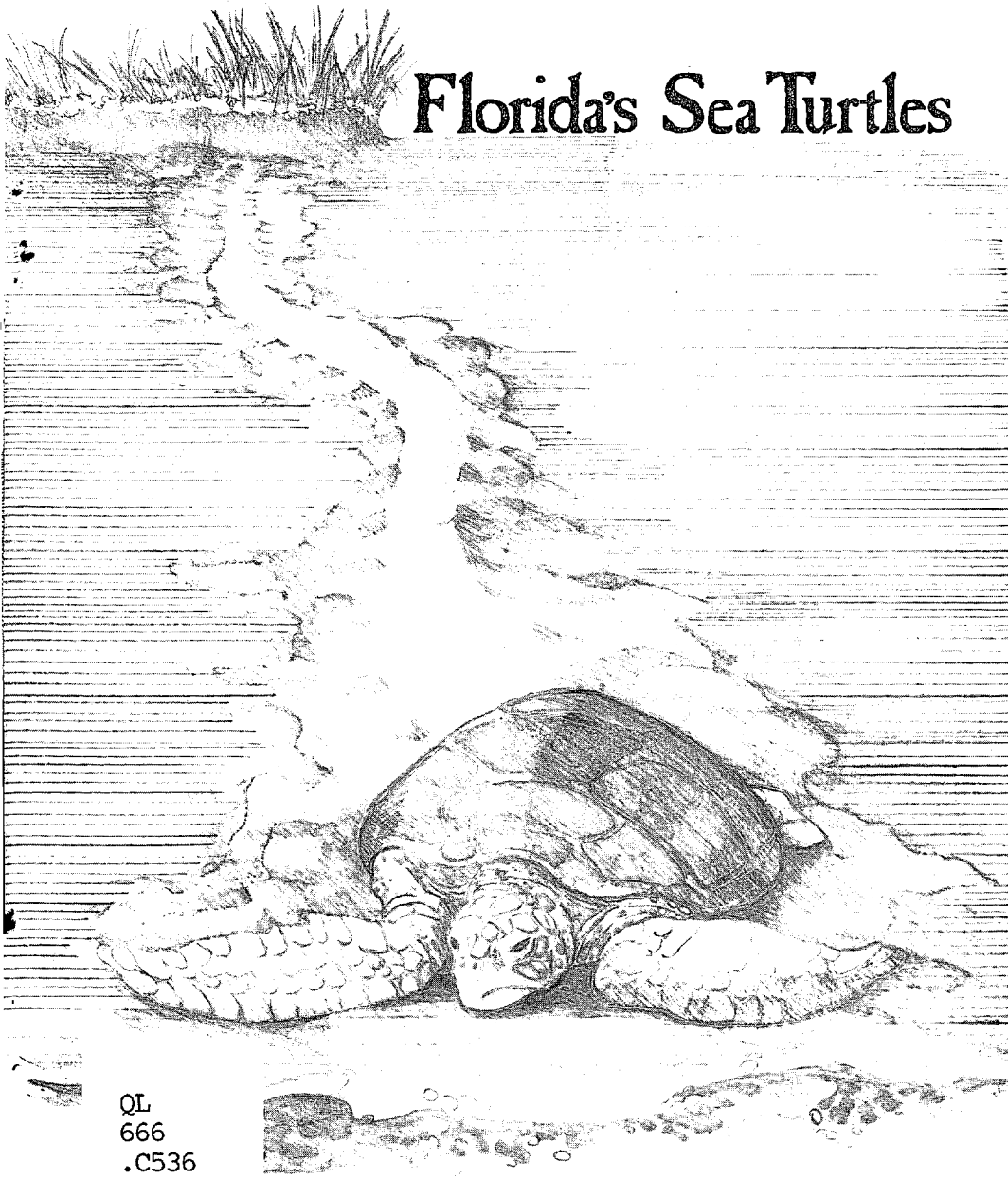
Florida's Sea Turtles



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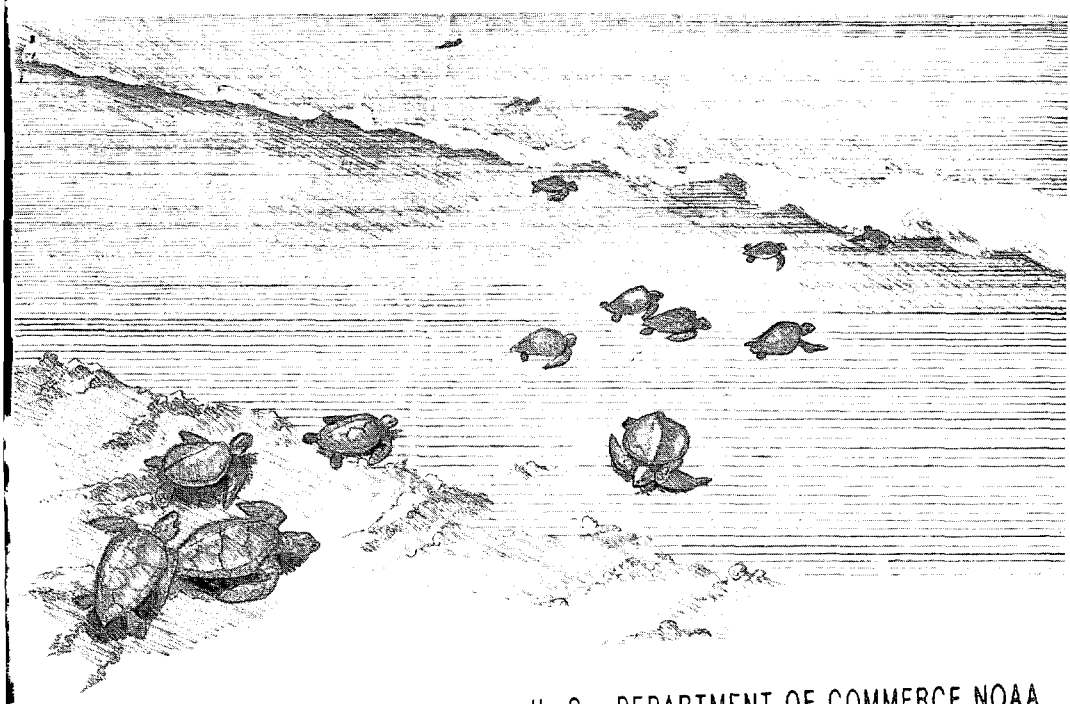
Florida's Sea Turtles



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Introduction

Sea turtles are large air-breathing reptiles that spend almost all of their life in the sea. Until recent times, these remarkable animals roamed the seas by the millions, but over the past few centuries their numbers have been decimated for meat, eggs, shell, oil, leather and decorative objects. Many countries have a stake in the future of sea turtles as either producers or consumers of sea turtle products. However, the divergent self interests of these nations have hindered the international cooperation needed to protect these vanishing animals.

Conservation efforts are further complicated by incomplete knowledge of the population dynamics and life history of sea turtles. These animals are difficult to study in the open ocean so most research has focused on nesting females and hatchlings emerging from their nests. Many of these studies consist of placing tags on turtles in the hope that information about their habits and movements can be learned through recaptures. After decades of research and the tagging of thousands of turtles, much has been learned but many questions remain.

For almost every generalization that can be made about sea turtles, there are exceptions, and much of what is written about turtles is based on limited information or professional speculation. One fact is clear, however, and that is that hundreds of thousands of sea turtles and millions of their eggs continue to be taken worldwide each year. If this exploitation continues unchecked, sea turtle populations will dwindle further and may ultimately disappear from the seas in which they have lived for millions of years.

Description

At first glance, sea turtles appear to be strange relics from prehistoric times that perhaps are obsolete and destined for extinction. This could not be farther from the truth. Sea turtles are remarkably adapted to life at sea and can be found in most of the major ocean habitats. The small number of sea turtle species is a reflection of the relative uniformity of the marine environment rather than an indication that sea turtles are unadaptive and in decline[1].

Sea turtles are strong swimmers capable of "flying" through the water with powerful strokes of long, paddle-like foreflippers

and by using the hindflippers as rudders. The development of the forelimbs and the need for streamlining resulted in the loss of the ability to retract the neck that serves as protection for other turtles. This is compensated for by the bony skull roof, a primitive characteristic in turtles[2]. Further protection from predators is provided by the shell and large body size; these features may also aid in heat retention in some species. Physiological adaptations to life at sea include the ability to dive, stay underwater for extended periods, and live in salt water without having to drink fresh water.

Like all turtles, the marine forms have no teeth, but the jaws are modified to provide crushing, biting and tearing surfaces that vary depending upon the diet of the species. Sea turtles are believed to be long-lived but no means of determining age has been perfected. Some studies suggest that it may be possible to age specimens by counting rings in the limb bones. Data are also accumulating on captive longevity and growth rates in the wild. Maturity is a function of size, not age, and once maturity is reached, growth slows considerably[3].

Male and female sea turtles do not differ externally until they approach maturity. Adult male sea turtles have longer tails than females and, in some species, the claw on each foreflipper of the male becomes elongated and curved. These features assist the male in grasping the female during mating.

The adaptations that make sea turtles at home in the sea make them slow and vulnerable on land. Individuals in some regions are known to haul out on beaches to bask but, for the most part, the only time sea turtles leave the sea is when females emerge to lay their eggs. Nesting usually occurs at night during the warmest months of the year. Some tropical populations nest year-round, although there is usually a seasonal peak. Other populations are strongly seasonal in their nesting, even in equatorial regions. The process of ascending the beach, digging a nest, depositing eggs, concealing the nest and returning to the sea takes about one to three hours. The nest is left unprotected and many eggs and hatchlings may be lost to predators, flooding and erosion. A large number of eggs is laid in each nest and a female may lay several nests during a season. Usually two to three years will elapse between a female's nesting seasons.

The eggs incubate in the sand for about two months, after which time the hatchling sea turtles emerge together from the nest and scurry down the beach to the sea. Many years will elapse

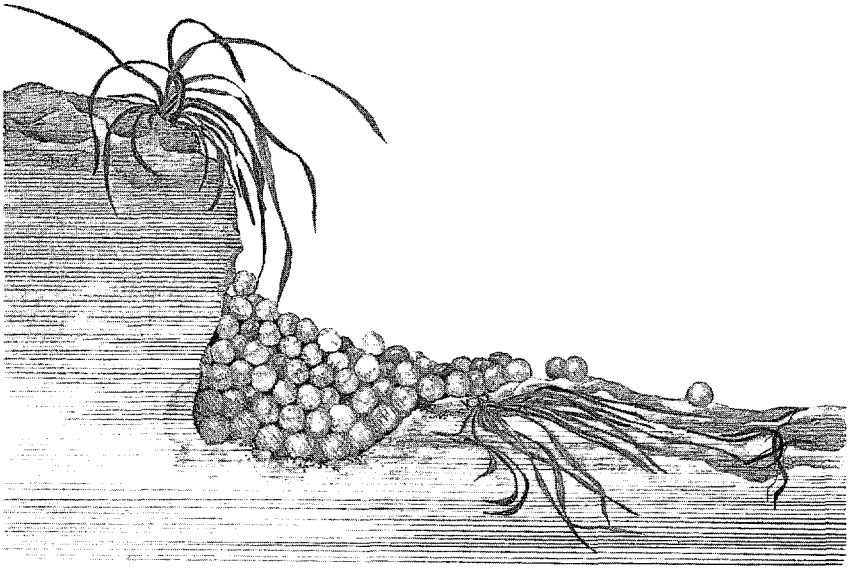
before the few hatchlings that survive to maturity return to reproduce.

Evolution and Taxonomy

Sea turtles evolved from marsh-dwelling forms early in the history of turtles, possibly several times[4,5]. The earliest known marine turtle fossils are about 150-million years old. Sea turtles, as well as many other reptiles, flourished during this period of extensive shallow seas. In general, the living species of sea turtles are less specialized and diverse than earlier forms. The extinct sea turtle *Archelon* reached a length of 3.1 meters (10 feet).

The taxonomy of sea turtles is still under review, but at least seven species belonging to five genera are presently recognized. Five of these species, the leatherback, green, loggerhead, Kemp's ridley and hawksbill turtles, inhabit the coastal waters of the United States. The olive ridley is a widespread species but is not found along the coastline of the United States. The seventh species, the Australian flatback turtle, is found only in Australia.

Many populations of sea turtles of the same species do not interbreed and, therefore, have evolved independently.



Many sea turtle nests are lost to erosion caused by high tides, flooding and winds. Exposed eggs will not survive.

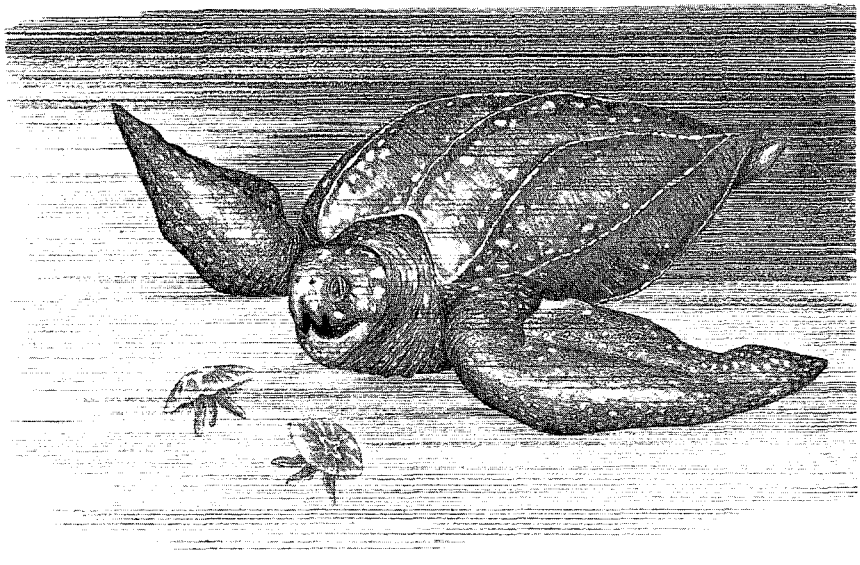
Some of the more strikingly-differentiated populations are under consideration as full species. The isolation of populations within a species has important implications for conservation because protection for one population will not insure the survival of others.

Sea turtle species share many characteristics because of their common ancestry and aquatic habits, but each species is adapted to different habitats, diet and behavior. In this way, turtle species do not directly compete with each other for resources and can coexist in the ocean environment[2].

Leatherback Turtle

Description

The leatherback turtle, *Dermochelys coriacea*, is the most unusual as well as the largest of the sea turtles. This species is so unique that it is placed in its own family, Dermochelyidae. Although the size at maturity may vary between populations[6], individuals can reach 1.8 meters (6 feet) in length and weigh up to 590 kilograms (1300 pounds)[2]. The leatherback is primarily black with white spots, and the eyes are almost vertical. The



The leatherback turtle is the largest of the sea turtles and feeds primarily on jellyfish.

top shell, or carapace, lacks the horny plates, or scutes, found on other sea turtles and is composed of a thick layer of oily, vascularized cartilaginous material, strengthened by a mosaic of thousands of small bones. The leatherback can be easily distinguished from other species by the presence of seven prominent longitudinal keels that divide the back into six sections.

Leatherbacks are particularly adapted to life in the open ocean. In captivity, however, they do poorly because they continuously swim into the walls of their tank and abrade their delicate skin. Powerful front flippers allow the leatherback to swim for long periods of time and cover great distances, and the keels on the carapace streamline the body for cutting through the water. The coloration of the leatherback, dark above and lighter below, is typical of open-water inhabitants. It is believed that the leatherback can dive to great depths; this view is supported by stomach content analyses that have revealed deep-water jellyfish species[7]. The large amount of oil found in leatherbacks may be important in avoiding decompression problems during diving and resurfacing[2].

Diet

Unlike the other species of sea turtles that feed primarily on the bottom, leatherback turtles feed in the water column where they eat jellyfish, sea squirts and other soft-bodied food items. In captivity, young leatherbacks can consume twice their weight in jellyfish daily[2]. The jaws are scissors-like and the mouth cavity is lined with stiff spines that project backwards and aid in swallowing soft prey. Food is probably sucked into the mouth by expanding the large throat[8]. It may seem unlikely that such a large animal could live on this diet, but jellyfish are abundant in many areas and few other animals feed on them[4].

Range

The leatherback turtle ranges throughout the Atlantic, Pacific and Indian Oceans, from as far north as Labrador and Alaska to as far south as Chile and the Cape of Good Hope[6,9]. Nesting occurs on tropical and subtropical mainland shores, especially in Malaysia, Mexico, Central America and the Guianas. A few leatherbacks nest each year in Florida and Georgia. Recently, a major nesting area was discovered along the southern Mexican Pacific shoreline[6]. The total number of breeding female leatherbacks in the world is estimated to be about 100,000[6].

The leatherback is known to travel as far as 5000 kilometers (3100 miles) from its nesting beaches[2]. It was once thought that leatherbacks spent most of their life far out at sea, but recent evidence suggests that they may also concentrate in relatively shallow coastal waters, including the east and west coasts of Florida[10,11] and off New England[9].

The presence of active, healthy leatherback turtles in cold regions has been of interest to scientists for many years because, as reptiles, their body temperature would be expected to be close to that of the water around them. The frequency with which leatherback turtles are seen in northern waters suggests that these turtles regularly migrate north in search of the large concentrations of jellyfish on which they feed. Active leatherbacks have been reported at water temperatures believed to be below 6°C (43°F)[12]; no other reptile is known to remain active at this temperature[9]. Research has shown that the body temperature of leatherbacks may be higher than that of the environment[13,14] and that a countercurrent circulatory system may provide a means of temperature regulation[15]. Additionally, the large size of the leatherback turtle favors the retention of heat produced by muscular activity[14].

Nesting Habits

Unlike other species of sea turtles, mating appears to take place away from the nesting beaches. This implies that males may mate with females from several nesting beaches[6], thereby reducing the genetic isolation of populations. Leatherback turtles are less faithful to nesting beaches than other species and may shift from one nesting beach to another within a season. Beaches adjacent to deep water and with a fairly steep slope seem to be preferred for nesting, probably because of the ease of access and the relatively short haul to dry sand above the high-tide mark[16]. Leatherbacks are rarely seen around reefs and rocky areas where their skin could be easily cut. Even the crawl up a sandy beach can be enough to abrade the leatherback's tender skin and cause bleeding[8].

Leatherbacks are not easily disturbed while nesting. Females nest at night at about ten-day intervals and six or seven nests may commonly be laid by an individual within a season[1]. Usually, two to three years will elapse before a female returns to nest again[6]. The track left in the sand by a nesting leatherback is very distinctive because, besides being very wide, it has a wavy appearance created by the turtle moving diagonally back and

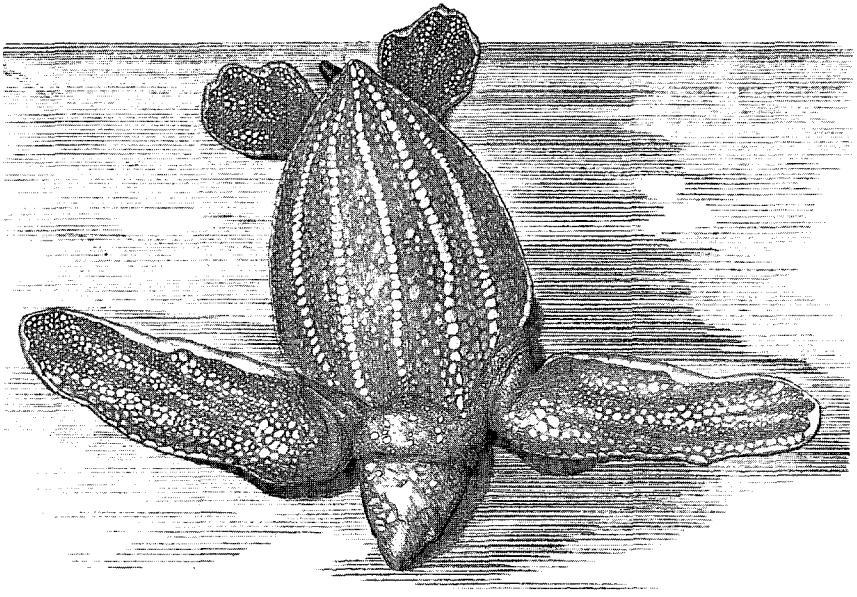
forth across the slope, perhaps to avoid a steep arduous climb[2]. The nest site can be recognized as that of a leatherback by the large, deep body pit and adjacent sand mound that together can span 2.4 to 4.8 meters (8 to 16 feet). About 60 to 100 eggs, many of them undersized and yolkless and therefore infertile, are deposited in each nest. Hatching occurs in 60 to 70 days. In general, leatherbacks produce fewer but larger eggs and hatchlings than most other sea turtles[17]. After laying her eggs, the female leatherback may turn in one or more complete circles before heading back to the sea.

Hatchlings

Hatchling leatherback turtles are about 60 millimeters (2.4 inches) in length. Their appearance is very distinctive because the foreflippers are as long as the shell and their dark color is interrupted by white stripes along the edges of the flippers and keels. Like the adult females returning to the sea, newly hatched leatherbacks frequently turn in circles as they head for water. Hatchlings grow quickly on a diet of jellyfish; a leatherback in captivity grew to 29 kilograms (64 pounds) in 22 months[2].

Threats to Survival

The primary threat to the leatherback turtle is egg



Leatherback hatchlings have distinctive white ridges along their dark shells.

collecting. On many nesting beaches nearly 100 percent of the eggs are taken[18]. As a result, egg production at some important nesting beaches has dropped precipitously[19]. The flesh of this species is not particularly palatable; nevertheless, leatherbacks are slaughtered for meat in many areas. In some countries, the oil of the turtle is rendered and used for caulking boats and for medicinal purposes.

Green Turtle

Description

The green turtle, *Chelonia mydas*, and the remaining species of sea turtles belong to the family Cheloniidae. Dr. Archie Carr, the world's foremost authority on this species, has called the green turtle "the most valuable reptile in the world" because of its economic importance. The name of this turtle comes from the greenish color of its body fat.

The green turtle is a medium to large sea turtle with a smooth olive-brown carapace marked with darker streaks and spots. This species can be distinguished from the other sea turtles by the single pair of scales on the front of the head. The bottom shell, or plastron, of the green turtle is white or yellowish and each paddle-shaped flipper usually has one claw. Adult males have a long prehensile tail tipped with a heavy, flattened nail. The size of adult green turtles varies in different parts of the world but a length of one meter (39 inches) and a weight of 150 kilograms (330 pounds) is typical[2].

The many non-interbreeding populations of green turtles often vary greatly in physical and even behavioral characteristics. Green turtles in the eastern Pacific are called black turtles, and some scientists believe this population warrants full species status as *Chelonia agassizi*[20].

Range

The green turtle is found in parts of the Atlantic, Pacific and Indian Oceans, primarily in the tropics. Sightings are also regularly reported in more northern areas, but it is not known if these turtles are stragglers or migrants. Green turtles now nest in small numbers along the Atlantic coast of Florida as far north as Cape Canaveral[1], and there are indications that the nesting population in Florida may be increasing[21].

History of Green Turtles in the Atlantic

Green turtles were once very abundant throughout the Caribbean. In 1503, on his fourth and last voyage to the new world, Christopher Columbus reported that his ship came

> "... in sight of two very small and low islands, full of tortoises, as was all the sea about, insomuch that they look'd like little rocks, for which reason those islands were called Tortugas..."

These islands, which were later renamed the Cayman Islands, were the site of a large green turtle rookery.

For 300 years the vast flotillas of turtles were a prime factor in the exploration and exploitation of the region by Europeans, including pirates. Turtle meat and eggs provided a seemingly unending supply of protein and turtles could be kept alive on ships for long voyages[22]. Turtle oil also was used for cooking, lamp fuel and as a lubricant[23]. The first rookery to be decimated was that of Bermuda and then, one by one, the turtles disappeared from their nesting beaches throughout the region. By the late 1700's, the Cayman Islands were no longer an important commercial source of turtles and, by 1900, the rookery was extinct. Turtle fishermen moved on to Cuba and then Nicaragua for new sources of green turtles[24].

Besides feeding the explorers and residents of the Caribbean, the green turtle was shipped to Europe, particularly England, where it was considered a great delicacy for its meat and the cartilaginous "calipee" found along the plastron that was made into soup. With the advent of steam travel, more turtles could be shipped alive. By 1878, 15,000 green turtles a year were being shipped to England from the Caribbean[23].

It is not clear if green turtles historically nested on the Florida mainland, although rookeries are reported to have occurred in the Florida Keys and the Dry Tortugas[21]. The rookery at Dry Tortugas was extirpated within 100 years of the start of commercial exploitation[24]. In the late 1800's, turtling was an active industry in Key West and, to a lesser extent, at Cedar Key on the Gulf and in the Indian River on the east coast of Florida[25].

Diet and Feeding Habits

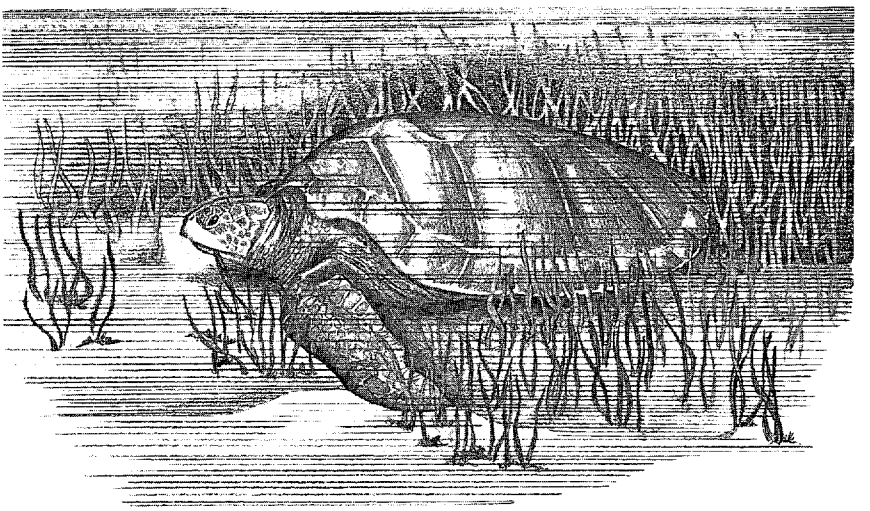
Green turtles are unique among sea turtles in being plant-eaters. As hatchlings, green turtles are primarily carnivorous but, at about a year of age, become mainly herbivorous. In

captivity, green turtles can thrive on fish or crustaceans but, in the wild, tend to avoid these food items. The vast beds of seagrasses found throughout the tropics serve as pastures for green turtles. However, some populations of green turtles feed on algae even if seagrass is available; these turtles are said to be less palatable than those that feed on seagrasses[26]. At one time, green turtles must have been a significant factor in the ecology of seagrass beds but, with the decimation of most turtle populations, the seagrass bed ecosystem lacks a major herbivore[27]. Research has shown that green turtles feeding on seagrasses produce a nitrogen-rich waste that provides food for other organisms[28].

Seagrass is high in fiber and relatively low in protein. As an adaptation to this diet, green turtles maintain "grazing plots" of young leaves by recropping in the same area. By eating young plants in the grazing plots, green turtles can avoid older leaves that are higher in fiber and thereby increase the percentage of protein in their diet. Additional nutrition is derived from cellulose through microbial fermentation in the hind gut[29].

Effect of Diet on Growth

Despite these adaptations, the diet of the green turtle is nutritionally limiting and results in a slow growth rate and delayed sexual maturity[29]. In captivity on a high-protein diet, green turtles have reached maturity in 8 to 10 years[30]. In the wild, however, it has been predicted that green turtles may not reach maturity until 15 to 20[31] or even 30 years of age[32,33].



Green turtles feed on the vast meadows of seagrasses found in the tropics.

Migrations

One of the most intriguing aspects of green turtles is their ability to migrate great distances between feeding and nesting areas and to locate these areas with remarkable precision. Some populations of green turtles nest and graze in the same region and others follow coastlines from feeding to nesting grounds and back. Other populations, however, travel great distances over open water. One of the best-studied migratory populations feeds on seagrass beds along the Brazilian coast and nests on Ascension Island, which is 8-kilometers (5-miles) wide and 2250 kilometers (1400 miles) to the east of Brazil over open ocean[34]. We can only speculate as to why turtles would make such an arduous journey and how they are able to make such an accurate landfall. Both male and female turtles must make this journey as mating occurs near the nesting beaches. To make this feat even more remarkable, these turtles must fast during the round trip and the stay at the nesting grounds because very little food is available[35]. In addition, a nesting female may deposit up to 500 eggs during a nesting season, a mass equivalent to about one-fifth of her body weight. The Ascension Island green turtles are about the largest in the world, which may partially account for their ability to make this trip[36]. Ascension Island female green turtles are believed to make this nesting voyage every 2 to 4 years with a 3-year cycle the most common[35,37]. The frequency with which males return to this nesting area is not known.

Nesting Habits

Extensive tagging programs have shown that green turtles will return to the same stretch of beach to nest during the breeding season and from one breeding season to the next, even though the beach topography may change[38,39]. In some Brazilian feeding grounds, populations share the same pasture but always return to their own nesting beaches[35].

The green turtle is the most sensitive of all the sea turtles to disturbances while nesting and can be deterred from leaving the water or completing the ascent up the beach by noise or lights. Once egg laying has started, however, turtles are less easily disturbed. The track left on the beach by a nesting green turtle is about 1-meter (3-feet) wide and marked with symmetrical diagonal lines made by the front flippers. The nest site can be identified as that of a green turtle by the deep body pit and large adjacent sand mound.

High energy beaches are preferred for nesting and a

successful nest requires sand at least a meter deep (3 feet)[1]. The number of nests laid during a season is quite variable with some individuals nesting only once and others as many as 8 times within a season[2]. The interval between successive nests is usually about 2 weeks. The number of eggs per nest ranges from about 100 to 140 and larger turtles may lay more eggs per nest than smaller turtles[17].

Incubation of the eggs takes from 48 to 70 days, depending on the temperature[1]. Because cooler temperatures prolong incubation, eggs may take longer to hatch during rainy weather[17]. A newly emerged hatchling is about 50 millimeters (2 inches) in length and has a black carapace and white plastron.

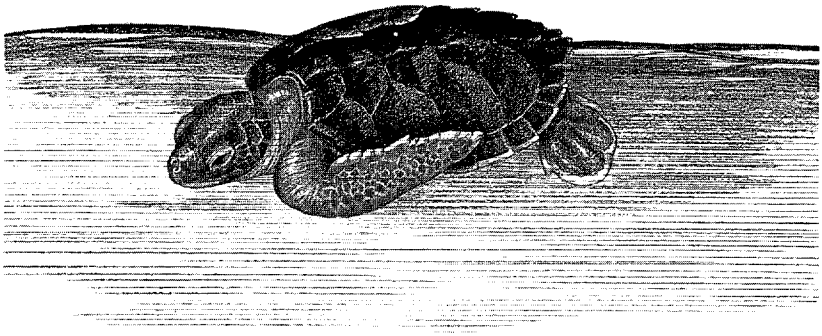
Threats to Survival

Throughout the world, green turtle populations are depleted or endangered as a result of exploitation for eggs, meat, leather and shells. Many green turtles and their eggs are consumed locally. An additional threat is the huge demand for meat and soupstock, primarily in Germany, England and Japan, and the market for turtle leather in France, Italy and Japan[40]. The high prices paid by these consumer countries has put heavy pressure on green turtle populations, particularly in underdeveloped countries. Many green turtles also are inadvertently drowned each year in shrimp trawls.

Loggerhead Turtle

Description

The loggerhead turtle, *Caretta caretta*, is a large reddish-



Hatchling green turtles often sleep at the surface with their front flippers folded over their backs.

brown sea turtle. Size at maturity varies between populations but, in the United States, adults range in size up to about a meter (36 to 38 inches) in length and weigh from 90 to 160 kilograms (200 to 350 pounds)[2]. The loggerhead is named for its large head, which may be 25-centimeters (9.8-inches) wide. The shell of this species is very thick, particularly towards the back, which may serve as protection from shark bites for this relatively slow swimmer.

Diet

The loggerhead is omnivorous in its diet, feeding on molluscs, crabs, shrimp, jellyfish, and vegetation[41]. The heavy head and jaw structure of the loggerhead are adaptations to a molluscan diet[4].

Range

Found in temperate and subtropical waters worldwide, the loggerhead nests farther from the tropics than other marine turtles[42]. Mainland beaches are the preferred nesting sites. The southeastern United States is one of the most important breeding areas for this species in the world[43]. The size of the Florida loggerhead nesting population is probably second only to that on Masirah Island, Oman, in the Middle East[44]. Almost all of the sea turtles that nest on the mainland of the United States are loggerheads. Major nesting concentrations are found on the coastal islands of North and South Carolina, Georgia, and the mainland coast of Florida. In Florida, most loggerhead nesting occurs from Volusia to Broward Counties on the east coast and at Cape Sable on the southwest coast[43].

During the nesting season, loggerhead turtles remain in inshore waters and estuarine areas near the nesting beaches[45,46]. At other times, however, loggerheads can range widely and have been found as far as 800 kilometers (500 miles) out to sea. Adult loggerheads travel up and down the southeast coast of the United States and, in winter, some may travel to the Bahamas. Immature Florida loggerhead turtles are thought to remain throughout the year in coastal and lagoonal waters[47].

Population Estimates

It has been estimated that about 28,000 female loggerhead turtles nest in the southeastern United States annually[48]. Loggerheads are believed to require at least 20 years to reach maturity in the wild[3].

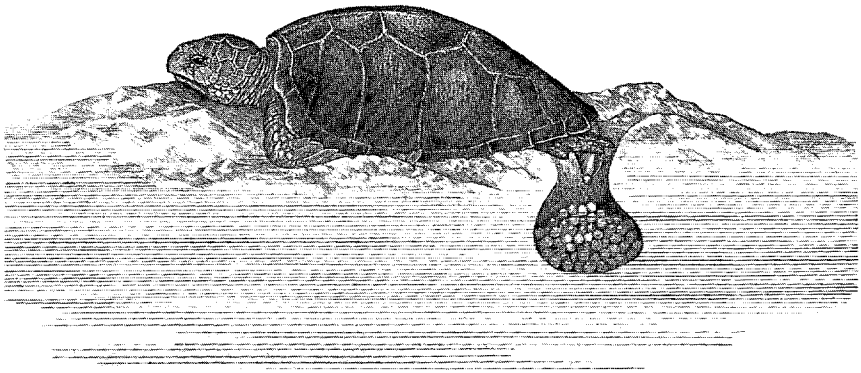
Nesting Habits

In the northern hemisphere, loggerhead nesting occurs from April through September, depending upon latitude and probably water temperature. In Florida, nesting peaks in late June and July. Studies have shown that loggerheads tend to make their initial nesting emergence during high tide if the beach has a wide tidal range. This behavior minimizes the distance that must be covered to reach a suitable nest site above the high-tide line[49]. The track made by a nesting loggerhead can be distinguished by the pattern of alternate flipper marks and the nest site by the very shallow or nonexistent body pit.

Loggerheads may use more than one nesting beach within a season and so are more flexible in choosing nesting sites than green turtles[50]. Mating occurs off the nesting beach. Females can lay from one to nine clutches of eggs per season but most lay only two to three[1]. The average renesting interval within a season is 13 days, the average clutch size is 120 eggs, and the incubation period is about 60 days[1]. Usually two or three years will elapse between a female's nesting seasons. A maximum reproductive lifespan of 32 years has been estimated for the loggerhead turtle population of Little Cumberland Island in southern Georgia[3].

Hatchlings

Hatchling loggerheads are a little less than 50 millimeters (2 inches) in length and pale-tan to deep red-brown in color. Many hatchling loggerheads spend the first months of their life in floating seaweed and the coloration of the young turtles is similar to that of the weeds in which they hide[51].



This female loggerhead has dug a nest cavity with her rear flippers and is laying her eggs. Over 100 eggs may be laid in each nest and hatching will occur in about two months.

Threats to Survival

Loggerhead turtles and eggs are hunted extensively for food in many parts of the world. In the United States, however, the primary threat is probably predation on eggs by raccoons. On some nesting beaches almost every nest may be destroyed by raccoons[52]. Other threats to loggerheads are drowning in shrimp trawls and nesting beach alterations.

Kemp's Ridley

Description and Diet

Kemp's ridley, *Lepidochelys kempi*, has the dubious distinction of being the most endangered and, until recently, the most mysterious of the sea turtles. Kemp's ridley is a small turtle with a very broad carapace. Mature turtles range in length from about 56 to 76 centimeters (22 to 30 inches) and weigh about 40 to 45 kilograms (85 to 100 pounds). This species is omnivorous and feeds on crustaceans, swimming crabs, fish, jellyfish and molluscs[53].

Range

Adult and subadult Kemp's ridleys feed in the inshore waters along the Gulf coasts of Mexico, Texas, Louisiana and Florida. Kemp's ridleys are also regularly sighted in the Keys, the Florida east coast, Georgia and on up into New England. It is not known if the Kemp's ridleys found along the eastern seaboard are migrating[9] or if they are lost after being swept out of the Gulf of Mexico[4].

Although Kemp's ridleys were often seen in the Gulf of Mexico and southeastern United States waters, the whereabouts of their nesting beach remained a mystery for many years. Some researchers even suggested that this turtle was a hybrid between a loggerhead and a hawksbill turtle[54]. Then at a scientific meeting in 1961, a film was shown that stunned the scientists present. Made in 1947 by a Mexican engineer, the film documented the mass emergence of tens of thousands of Kemp's ridley turtles onto a remote sand-bar beach on the Gulf coast of Mexico near Rancho Nuevo in the state of Tamaulipas[55]. Tragically, the estimated 40,000 turtles recorded in this film have been so reduced that now only about 1000 nests are made annually by 400-600 females[56].

Nesting Habits

The reproductive strategy of Kemp's ridley, like that of some populations of its close relative the olive ridley, is to synchronize the emergence of nesting females. Unlike the olive ridley, however, the mass nestings that occur on this one Mexican beach represent virtually the entire reproductive effort of the species.

These mass nestings, called *arribadas* (Spanish for arrival), are remarkable but poorly understood events that occur at irregular times between April and June. Perhaps using cues such as wind direction or velocity, lunar cycles or water temperature, male and female Kemp's ridleys mass off a narrow strip of nesting beach to mate. Scent produced by secretory pores may enable the turtles to find each other once they are in the area. The beach in this region is hundreds of kilometers long, but the turtles seem to select stretches of beach backed by swampy areas or shallow water, possibly because backwaters exclude some predators. The location of successive *arribadas* may be several kilometers apart, even within a season.

Once they have mated, the females may stay offshore for days waiting for just the right conditions, which usually include a very high wind. The wind may help to eradicate the scent of the nests and thereby reduce predation. When conditions are finally right, the females emerge from the water to dig nests and lay their eggs, all within a few hours of each other and usually during daylight. Each nest contains an average of 110 eggs that incubate from 50 to 70 days[17]. *Arribadas* may be repeated several times during a season, and many females nest in successive years[53]. In recent decades, population reductions have resulted in the fragmentation of the *arribadas* into small groups or nesting by solitary individuals[57].

The reasons for mass nesting are unknown but it may serve as a form of predator saturation or swamping. Local predator populations may be bewildered by the sudden abundance of prey and, although some adults and many eggs and later hatchlings will be taken, many will survive. Predators seem able to anticipate the *arribadas*, as coyotes congregate in advance of the turtles' arrival[55].

Threats to Survival

Prior to the 1960's, the Kemp's ridley was extensively exploited for eggs. Mule trains would carry hundreds of thousands of eggs collected on the beach to market and

thousands of females were caught offshore and cut open just for their eggs[57]. The remaining Kemp's ridley population is now protected by the Mexican government and, since 1978, United States personnel have assisted in patrols to thwart poachers on the nesting beach. Additionally, eggs are moved to protected hatcheries to decrease losses to predators, particularly coyotes. Eggs from the nesting beach in Mexico are transferred to the National Marine Fisheries Service laboratory in Galveston, Texas where they are hatched, raised for nearly a year and released[58]. Raising Kemp's ridleys is difficult because the hatchlings are very aggressive and must be kept separated to avoid injuring each other.

Despite years of protection, the Kemp's ridley population still does not show signs of recovery. Years of exploitation combined with continuing losses of adults and juveniles in shrimp trawls contribute to this situation[57]. The catastrophic blowout of an offshore oil well near Campeche, Mexico, may have impacted the population, as this is an important feeding area for Kemp's ridleys[1]. Clearly, the Kemp's ridley is the most seriously endangered sea turtle species.

Hawksbill Turtle

Description

The hawksbill turtle, *Eretmochelys imbricata*, is a very agile, small to medium-sized sea turtle with a bird-like beak for which it is named. Mature females weigh about 45 kilograms (100 pounds) and range from about 75 to 90 centimeters (30-36 inches) in length. The heaviest hawksbill known weighed 127 kilograms (280 pounds)[59]. The shell of this turtle is prized for its use in tortoise-shell jewelry and ornaments and, because of the shell's value, the hawksbill continues to be hunted throughout the world. Despite its economic importance, it is probably the sea turtle we know the least about.

Range and Habitat

The hawksbill is found in tropical waters throughout the world, particularly near coral reefs and rocky outcroppings in shallow coastal areas. Many kinds of invertebrates and occasionally vegetation are eaten[60] and sponges may be an important part of the hawksbill's diet in Florida and the Caribbean[61].

Nesting usually occurs near feeding grounds, although some hawksbills may migrate from nesting to feeding areas[2]. Hawksbill nesting is spread diffusely on scattered islands and shores. This pattern of sporadic nesting may reflect population reductions resulting from hunting pressure[17]. Hawksbills nest in large groups in northern Australia where up to 100 hawksbills nest nightly on some islands[62]. Only a few nests have been documented in Florida but hawksbill turtles are observed on reefs off the coast of Florida and in the Florida Keys.

Nesting Habits

Mating occurs in shallow water off the nesting beach. Hawksbills are able to climb over reefs, rocks and rubble to nest among the roots of vegetation on beaches that would be inaccessible to other species of sea turtles. From limited studies, it appears that hawksbills nest several times during a season and lay about 70 to 160 eggs in each nest. Hawksbills in the Atlantic lay more eggs, on average, than any other turtle, and clutches of over 200 eggs have been reported. Larger females tend to lay more eggs per nest than smaller individuals[17]. Clutch size may decrease with successive nestings and a nest may contain some yolkless, infertile eggs[2]. It is thought that hawksbills nest every two or three years.

In some regions, hawksbill turtles hatched from one island differ markedly in shell pigmentation and pattern from hatchlings from a neighboring island. This suggests that hawksbills from each island are genetically isolated and that mating and nesting for each population is restricted to the natal island. If this is true, then, as with green turtles, each reproductive population must be considered independently in management plans[60].

Hatchlings

Hatchling hawksbills are about 40 to 45 millimeters (1.6 to 1.8 inches) in length[17]. Emergence from the nest occurs when the sand has cooled, either in late afternoon or at night. Once they have reached the sea, hatchlings swim by simultaneously stroking the foreflippers. Hawksbill hatchlings are uniformly dark, unlike hatchlings of some species of sea turtles that are dark on top and light underneath.

Threats to Survival

Hawksbill turtles are hunted for eggs, leather and occasionally meat. The greatest threat, however, is the market for

shell and for stuffed immature turtles that are sold to tourists[24]. Stuffed hawksbills and hawksbill shell fetch very high prices, particularly in Japan where the shell is used for decorative objects and has traditional ceremonial value. Japan imported 598,000 kilograms (1.3 million pounds) of hawksbill products from 1962 to 1981[63]. About 65,000 yearling and adult hawksbills are killed each year in southeast Asia alone to satisfy this market[64]. Almost 40 percent of the tortoiseshell imported by Japan now comes from the Caribbean[65]. By weight, tortoiseshell is now more valuable than elephant ivory, and trade in these shells has increased dramatically over the past few years. Because of the hawksbill's tendency towards isolated nesting, population declines are more difficult to document than for other sea turtles. However, hawksbill turtles clearly cannot continue to sustain this level of exploitation.

Olive Ridley

Description and Range

The olive ridley, *Lepidochelys olivacea*, is a small turtle, 60 to 71 centimeters (24 to 30 inches) in length, that is closely related to the Kemp's ridley. It feeds primarily on crustaceans. The olive ridley is a widespread species found in the tropical regions of the Pacific and Indian Oceans and in the southern and eastern regions of the Atlantic. In the western Atlantic, most nesting occurs in Surinam along a 0.8-kilometer (0.5-mile) long beach. Although it may be the most abundant sea turtle in the world today[39], this ridley is never seen in Florida and only occasionally in the northern Caribbean, including Puerto Rico. It has been suggested that olive ridleys are not found in much of the western Atlantic because they cannot co-exist with loggerhead turtles due to similarities in diet. Wherever olive ridleys are very abundant, as in the eastern Pacific, the loggerhead is virtually absent.

Nesting Habits

Like Kemp's ridley, some populations of olive ridleys synchronize their nesting so that thousands, and even tens of thousands, of turtles may emerge from the sea within a few hours of each other to nest. The sight of thousands of turtles on a beach is awesome, and an olive ridley *arribada* gives us an idea of how Kemp's ridleys must have nested before their decimation. A scientist studying olive ridleys along a remote stretch of the

Pacific coast of Costa Rica described the event like this[66]:

> "Six weeks after our arrival on Nancite, a day came when the expectancy in the air seemed tangible. The beach was quiet and deserted. Groups of buzzards sat still in the branches of trees, gazing fixedly out to sea...at midnight, the beam of my flashlight revealed along the surf edge a near-solid line of turtles. Thereafter, each receding wave left behind it a similar phalanx of new arrivals.
>
> In the next 30 minutes, the numbers on the beach had increased awesomely. But still they came, methodically plodding, deflected by nothing...they marched up the beach.
>
> Those returning to the sea, like those attempting to find a portion of clear sand in which to dig their nests, were forced to clamber over each other. So that, as the night wore on, the chances of finding an unused spot for a nest grew slim, and new arrivals dug up the eggs of earlier nesters...
>
> Against the background of Pacific surf could be heard the sighs and grunts of labor, the grind and squeak of shell against shell, loud slapping sounds as neighbor struck neighbor with wide sweeps of their foreflippers, and everywhere the dull thud, thud of turtles stamping hard the sand above their eggs."

The *arribada* described continued for five nights and was followed by two more during the season. In three and one-half months an estimated 290,000 nests had been dug and 29 million eggs had been laid. However, it has been estimated that only 0.2 percent of the eggs laid hatch[67]. Very high predation on the beach and in the ocean permit even fewer hatchlings to reach the open sea.

Threats to Survival

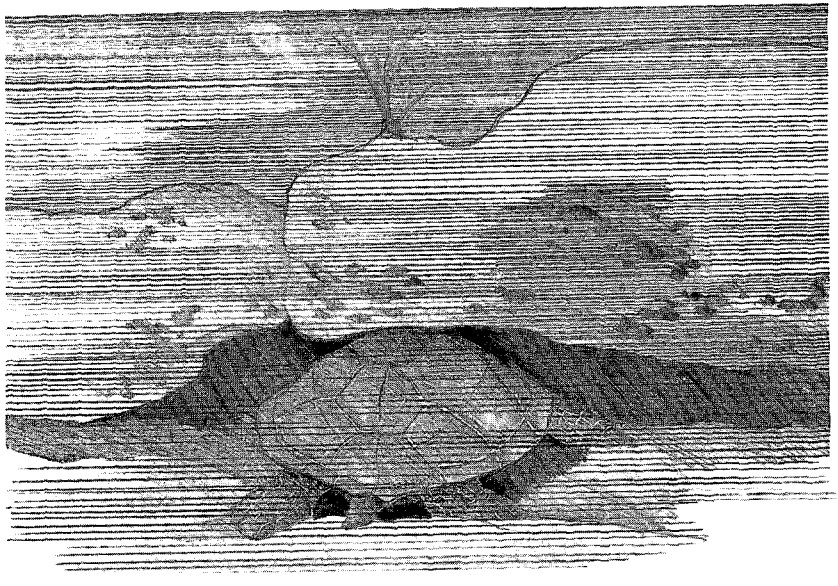
The olive ridley is slaughtered for meat, eggs and leather. Wherever the ridley gathers in numbers to nest, it is vulnerable to exploitation. In Mexico, the sea turtle fishery has been industrialized and millions of ridleys have been killed and processed for pet food, frankfurters and, more recently, leather. The olive ridley fishery in the Mexican Pacific is the largest turtle fishery in the world, spurred by the high prices offered by Japan and some European countries for the skin of the neck and foreflippers[64]. The demand for turtle leather has grown over the last two decades with the decline in the availability of other

reptiles such as crocodiles[40]. In addition, poachers continue to take millions of eggs and thousands of animals each year. In recent years, olive ridleys have failed to nest at many of their traditional nesting beaches, and populations in other areas are collapsing[68]. In the Atlantic, the greatest threats to the olive ridley are accidental take by shrimp trawlers and a build-up of mud in front of the only significant nesting beach[56].

Behavior

Activity Patterns

Sea turtles are usually active during the day and sleep at night. The exception to this rule is nesting, which, in most populations, occurs at night. Most of what we know about non-nesting turtles comes from observations of captives and, more recently, radio or satellite tracking of individuals. In captivity, turtles were observed to rest at sundown and become active again as dawn approached[69]. Sea turtles sleep at the surface in the open ocean and on the bottom or under ledges in inshore waters. Loggerheads have been observed sleeping under ledges in 27 meters (90 feet) of water off Palm Beach, Florida[61].



Loggerhead turtles sleep under ledges along Florida's coastal reefs.

Hatchlings sleep floating at the surface with their flippers tucked over their backs. Green turtle fishermen in the Caribbean catch turtles at night by setting nets over the rocks where the turtles sleep[22].

During the day, turtles feed and rest intermittently. Tracking studies in the southeastern United States have shown that, at least during the nesting season, loggerhead turtles follow regular routes between inshore and estuarine areas and offshore rocky areas or wrecks. Presumably the turtles travel to the offshore areas to feed[45,46].

Swimming

Sea turtles are powerful swimmers and move through open water by stroking the foreflippers simultaneously as if they were flying. The hind flippers are used as rudders. In shallow water, sea turtles sometimes paddle with alternating strokes of the foreflippers. When startled, turtles exhibit amazing bursts of speed. Sea turtles are also remarkable long-distance swimmers. An adult loggerhead turtle tagged at Melbourne Beach, Florida, was captured eleven days later in northwestern Cuba. This turtle must have traveled at least 70 kilometers (43 miles) a day and crossed the powerful currents of the Gulf Stream[70].

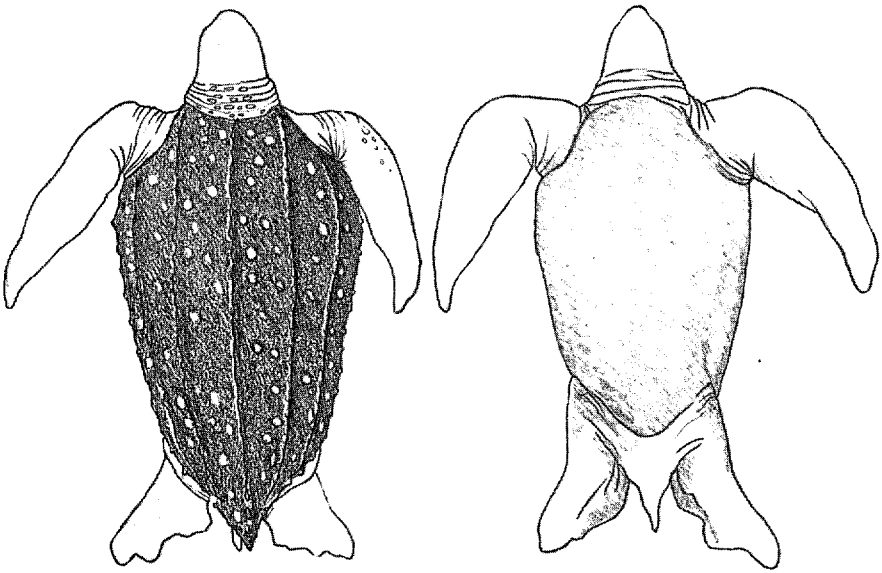
Courtship and Mating

Courtship and mating rituals vary between species and even populations within a species. In general, courtship and mating occur off the nesting beach, which means that populations from different nesting areas do not interbreed. Furthermore, for species that migrate, males as well as females must make the long journey from the feeding grounds to the nesting beach and back.

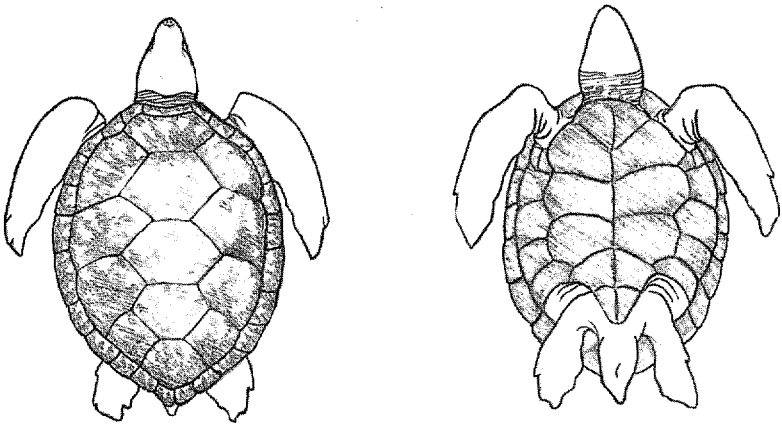
Interesting courtship behavior has been observed among green turtles. Studies conducted in Australia revealed that a non-receptive female will avoid a male by folding her hind flippers together or by assuming a "refusal position" in which she remains vertical in the water facing the male with her limbs widespread. This study also noted an underwater "reserve area" where females rested but which males appeared to avoid[71]. Other researchers have observed that a male may nuzzle the head of a female and gently bite her neck and rear flippers. If the female does not flee, the male will then attempt to mount her[72]. While mating, the male grips the female by hooking his long front claws over the front of the top shell and folding his long tail under the female's plastron. Males may fight with each other aggressively, pursue large moving objects, and even attempt to

Florida's Sea Turtles

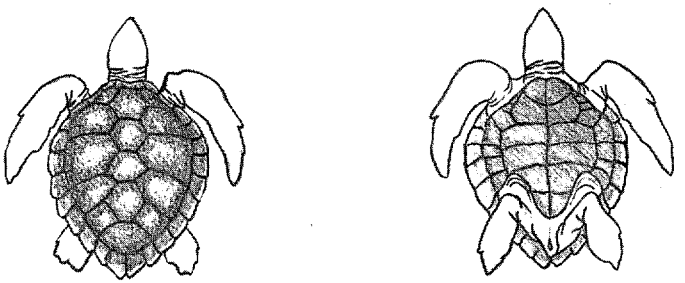
Top and Bottom Views of Adult Turtles



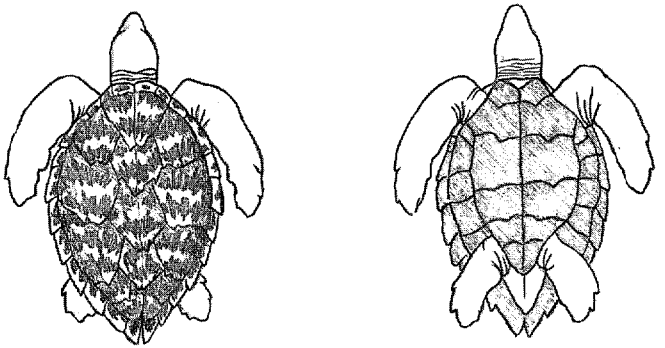
Leatherback



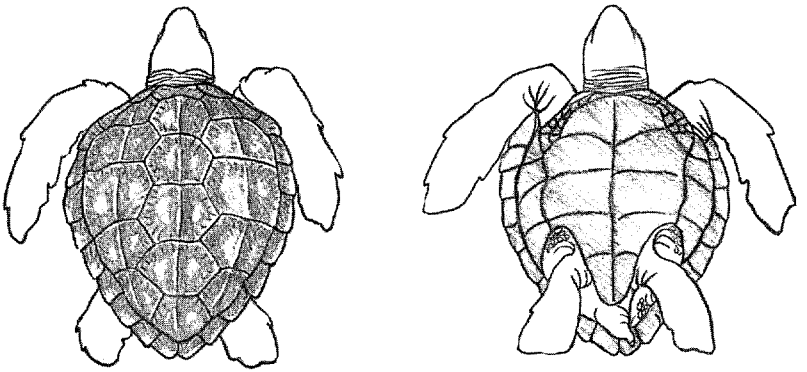
Green



Kemp's ridley



Hawksbill



Loggerhead

dislodge mating males. However, the tendency to fight over females may be the result of changes in sex ratios caused by the selective killing of nesting females. In some places, females have been reported to fight over males[2].

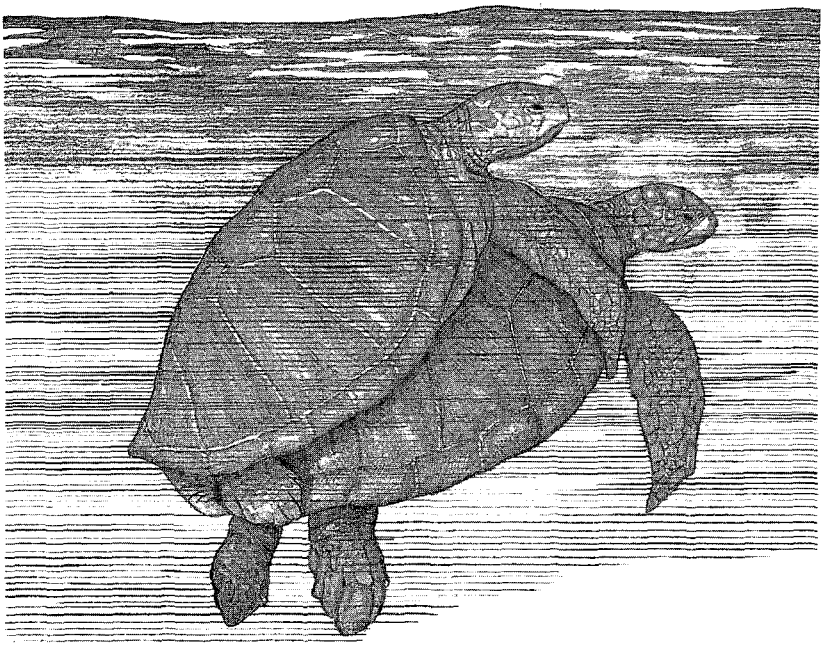
In captivity, female green turtles are receptive for two to four days. Copulating pairs may float at the surface, lie on the bottom, or even crawl up on the beach. Green turtles may remain mounted from a few minutes to over several hours. The duration of mounting may determine if a female will lay eggs that season[30].

It is now believed that mating occurs prior to a female's first nesting emergence and that most females mate only once a season. However, female sea turtles, like freshwater turtles, probably can retain sperm until a subsequent nesting season[73]. Water temperature and day length are believed to be important factors in determining nesting cycles[74]. Egg laying appears to be independent of mating as females that have not been observed mating can lay eggs, though these are infertile[75].

Nesting

Preparatory Behavior

Female loggerhead turtles tracked in South Carolina swam



While mating, the male green turtle grasps the female by hooking his front claws over the top of her shell and folding his long tail under her.

within 3 km (1.8 miles) of the nesting beach for varying lengths of time before nesting. In the late afternoon and early evening before a nesting attempt, the females moved into the turbulent surf zone immediately off the nesting beach to wait for nightfall. If an emergence onto the beach did not result in a successful nest, the females would return to the water and swim parallel to the beach in the surf zone until another emergence was made or until sunrise. If nesting was successful, the turtle would swim away from the beach to a shoal area to await dawn[45].

Beach Selection

Beaches with open-water access are usually preferred, especially by larger sea turtles such as leatherbacks and loggerheads. The beach must be high enough to prevent flooding by tides, rain or ground water, and the sand must allow for gas diffusion yet be moist enough to prevent collapse during digging. Other factors that may determine if a turtle nests or not are beach slope, sand texture, offshore reefs, dune vegetation, artificial lighting, and human activity on the beach[76].

Nesting

Sea turtle nesting behavior does not differ much from one species to the next because all sea turtles have similar anatomical and habitat constraints. For all species, the nesting process requires a great expenditure of energy. On land, the loggerhead, hawksbill and both species of ridleys move with a lizard-like gait in which the diagonal limbs move simultaneously. The leatherback and green turtle, however, haul themselves forward by moving the opposite limbs together. The tracks made by each species of sea turtle are distinctive and can be used to census nesting activity.

As they emerge from the water and proceed up the beach, many turtles will stop several times to dig into the sand with their snouts, as if testing the sand. These turtles may be following a temperature gradient from the cool wet sand to the warmer dry beach zone in order to select a suitable nest site[77]. This burrowing behavior may also be a way of appraising the smell, texture or water content of the sand[2].

Once a site has been chosen, the area is cleared by sweeping with all four limbs and a body pit is excavated by digging with the limbs and rotating the body. The green turtle digs a deep body pit, whereas the ridleys only take a few swipes at the sand. When the body pit is complete, an egg cavity is dug using the cupped rear flippers as shovels. The depth of the egg cavity,

therefore, is determined by the length of the rear flippers. Sea turtles are rigidly stereotyped in always alternating their hind feet as they dig[78]. After one rear flipper removes a scoop of sand, the other rear flipper shoots forward to spread the sand to the side and front. The egg cavity is flask-shaped and usually tilted slightly. When the cavity is complete, the turtle proceeds to lay her eggs, often two or three at a time with brief rest periods in between. Leatherbacks and green turtles extend their rear flippers behind them during egg laying, while the other species spread the rear limbs beside the nest.

After the eggs have been laid, the egg cavity is filled with sand by raking and packing with the rear flippers. Ridley turtles finish their nests by rocking laterally and slapping the sand, whereas the leatherback pivots with its weight to the rear of the body to pack the sand. During the nesting process, the viscous tears that are shed continuously to eliminate excess salt serve to cleanse the eyes of sand and prevent drying. Lastly, the body pit is filled, the nesting site concealed with swipes of the front flippers, and the turtle moves slowly back down the beach and into the surf.

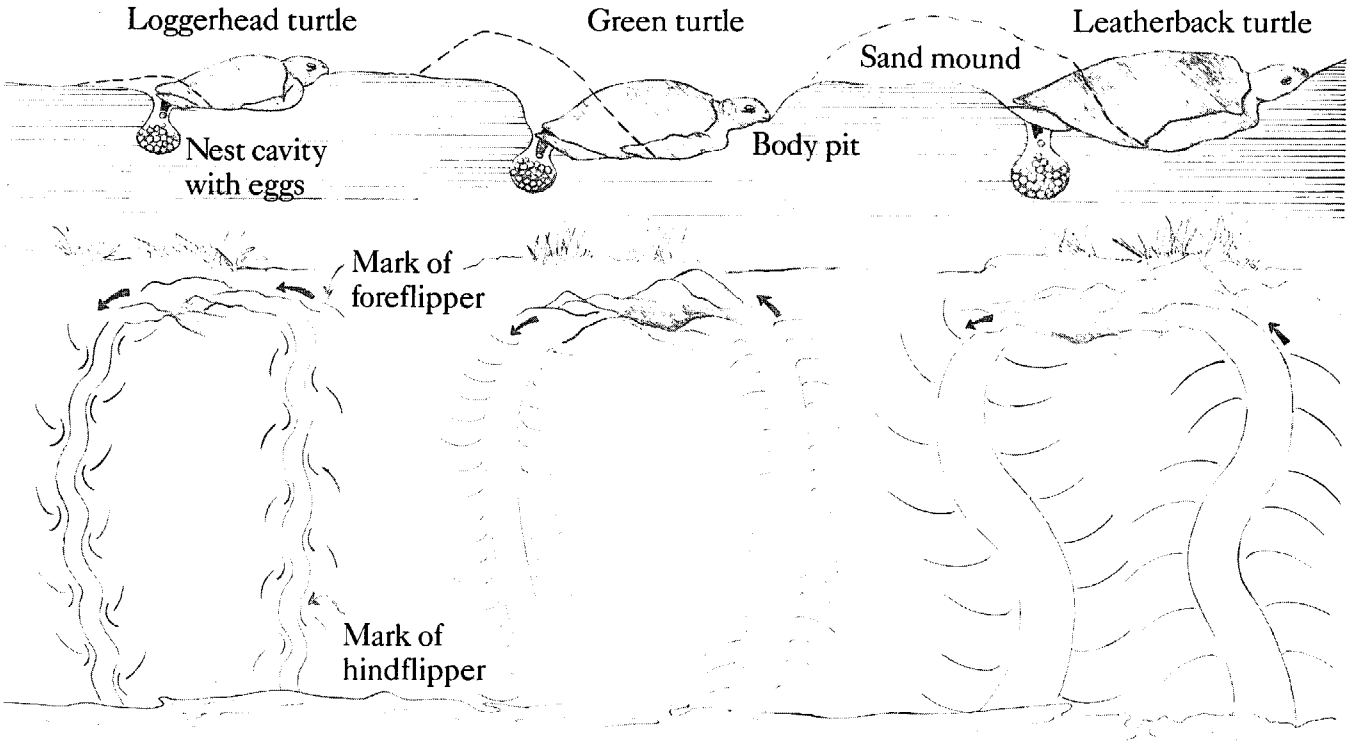
Once egg-laying has begun, turtles usually are not easily disturbed, but turtles about to emerge from the water or ascending the beach may turn back if they are bothered by lights, noise or unusual activity. A turtle will sometimes abandon a nest site if, in digging, she encounters a root, a rock or obstacle, or if the sand does not have the correct consistency or moisture content. Occasionally, for no apparent reason, a turtle will ascend the beach but fail to nest and return to sea without laying her eggs.

Hatchlings

Escaping From the Nest

Emergence from the nest is a group activity that may take several days. Newly-hatched turtles do not actually dig upward but, instead, thrash about. The activity of one turtle triggers the movement of others so that, as a group, the hatchlings move together towards the surface. As the ceiling and walls of the chamber collapse, the floor rises until the hatchlings are near the surface. Turtles hatching alone or in a small group have little chance of escaping from the nest[79].

Hatchlings usually emerge from the nest at night when the sand is cooler and they are less visible to the many waiting predators. How hatchlings can know if it is night or day while



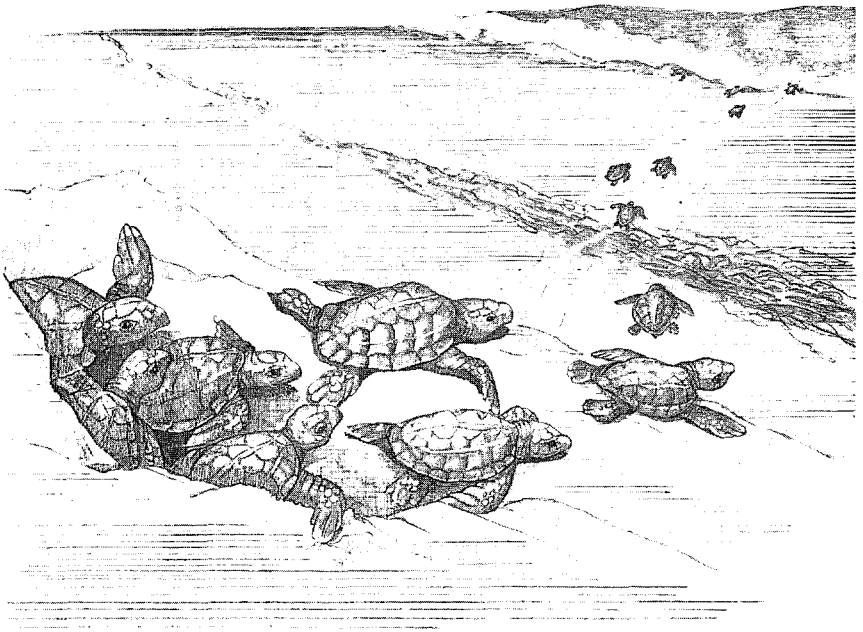
Each species of sea turtle can be distinguished by its tracks and nest site characteristics. The track made by a loggerhead as it ascends the beach to the nest site and then returns to the sea is wavy and punctuated by alternating flipper marks. The nest site is characterized by a shallow body pit and small sand mound (dotted line). The track of a green turtle is marked by symmetrical flipper marks and the nest site has a deep body pit and large adjacent sand mound. The track of a leatherback turtle is very wide and usually curves across the beach slope rather than straight up the beach. The large body pit and adjacent sand mound of a leatherback turtle can span 3 to 5 meters (9 to 15 feet). (The dark arrows in the illustration indicate the direction of travel.)

buried in the sand is an interesting puzzle. It appears that if the first turtles to get near the surface sense high temperatures, they become almost comatose. Their lack of activity has a dampening effect on the other hatchlings who wait quietly for the top hatchlings to emerge[80]. Occasionally, turtles will emerge after a rainstorm, even if it is daytime, because the temperature is cooler[81]. When conditions are right, the hatchlings emerge explosively from the nest so that a hundred turtles may break out together and head for the sea.

Finding Water

The mechanism by which newly-emerged hatchlings find the sea has been studied extensively but is still not completely understood. Hatchlings can find the sea even if the surf is not in view by discriminating between light intensities and selecting the brightest and most open horizon[82,83,84]. A tendency to move down a slope as well as the interaction of cues may also help hatchlings locate water[85].

The trip down the beach may be facilitated by the same interaction that enabled the hatchlings to escape the nest. The activity of one hatchling moving down the beach seems to stimulate others in the group to move[86]. Once at the water's edge,



Hatchling turtles emerge from their nest as a group, usually at night. As they scramble to the sea, many hatchlings will fall prey to waiting crabs and birds.

the hatchlings must negotiate the surf. As the turtle touches the water, the crawling stroke is replaced by a swimming stroke and, as a wave approaches, the turtle dives to the bottom and rides the undertow[78]. This diving response prevents the hatchling from being thrown back onto the beach. When waves are small or absent, hatchling swimming appears more random[87]. Once in the open water, the principal instinct is to swim away from land toward the open and brightest horizon[84,88,89].

Out to Sea

Hatchling turtles remain very active for up to 24 hours after entering the water. This "swim frenzy," which may vary between different populations of the same species[90], serves to get the hatchlings into deeper water and away from predators. Hatchling green turtles released from a beach were clocked at an average speed of 1.57 kilometers/hour (1 mile/hour)[88]. These turtles maintained a non-random course even when they could no longer see the shore.

The whereabouts of turtles between the time they first enter the sea and about a year of age is somewhat of a mystery because turtles of this size are rarely seen. This phenomenon is called the "lost year." It is presumed that hatchlings swim out to sea where they disperse with the currents. Loggerhead hatchlings have been found in seaweed thrown up on the beach during storms[91] and many have been found in the weedlines that form at the edge of the Gulf Stream[92]. Apparently, hatchlings find both food and shelter in the weedlines. Stomach content analyses of loggerhead hatchlings from weedlines have revealed large numbers of terrestrial insects. It is believed that these insects are transported by high winds and collect in weedlines along current convergences[92].

A great unknown with important management and conservation implications is what makes turtles select certain beaches for nesting. One theory is that turtles may learn the identifying characteristics of their beach while in the nest or during the hatchlings' trip to the sea. Some of the cues that could be learned include smell, low-frequency sound (surf noise), magnetic orientation, and the characteristics of seasonal offshore currents. Conversely, it may be that first-time nesters learn the location of nesting beaches, not by recognizing cues they learned as hatchlings, but from experienced adults[93].

Sociality

Sea turtles interact with each other during some phases of

their life, but, in general, are solitary animals. No parental care is given to eggs or hatchlings and contact between adults is limited, for the most part, to courtship, mating and the *arribadas* of the ridleys. Hatchlings, however, must work together to escape from the nest and cross the beach.

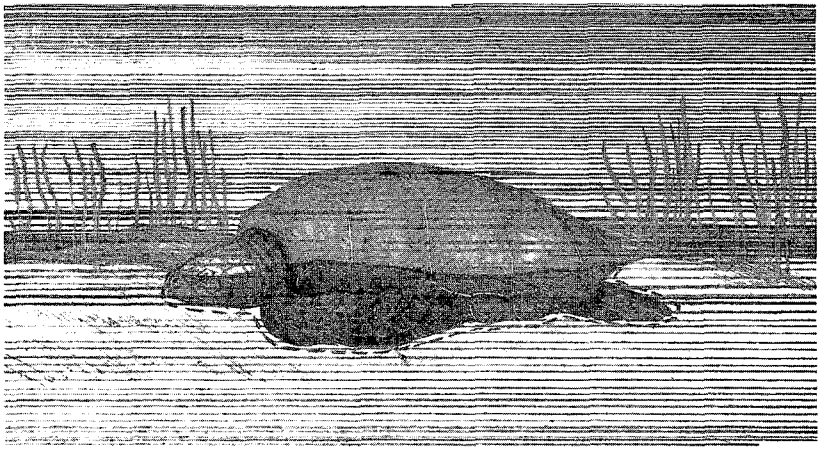
In captivity, sea turtles have been reported to defend territories[69] but, in the wild, seem to ignore each other while feeding or resting in the same area[61]. Turtles will return to preferred nonbreeding areas year after year. A male loggerhead turtle has been seen each fall at the same rock formation in 15 meters (50 feet) of water off Palm Beach for seven years in a row[61].

Basking

Freshwater turtles often haul up on land to bask in the sun but this behavior is rare in sea turtles. However, green turtles are known to bask on several islands in the Pacific. Many reasons have been suggested for basking including escape from sharks, heat regulation and vitamin D production[78,94].

Hibernation

Sea turtles that range into subtropical areas where cold winter temperatures may occur must either migrate to warmer water or find a means to adjust. Some green turtles may be taking refuge in the warm-water discharge from a power plant in San Diego Bay[78]. Recently, it has been documented that some turtles hibernate during cold weather. For years, fishermen reported that



Some sea turtles hibernate during cold spells by burying themselves in the mud. The Port Canaveral Ship Channel is an important hibernation area for loggerhead turtles.

dormant Kemp's ridley and green turtles could be found buried in the mud in the Gulf of Mexico. These claims were never documented and now these dormant turtles cannot be found[78]. Dormant sea turtles were once hunted by local Indians in the Gulf of California during the winter months[95], but this population has also been extirpated by commercial exploitation.

Recently, it has been discovered that large numbers of mostly subadult loggerhead turtles hibernate in the Port Canaveral ship channel when water temperatures drop below 15°C (59°F)[96,97]. In deep water, bottom substrates are usually warmer than the surface water so, by burying themselves in the mud, turtles can avoid extreme temperatures. Many of these dormant turtles were killed by dredging activity in the channel before protective action was taken. For unknown reasons, loggerhead aggregations are common in this channel year round.

Physiology

Effect of Temperature

Temperature affects many phases of a sea turtle's life because, as a reptile, its body temperature is usually within a few degrees of that of the environment. As an example, the temperature at which sea turtle eggs are incubated determines the number of days they take to hatch. A 1°C (1.8°F) decrease in temperature from shading or excessive rain may add 5 days to the incubation period[98,99]. More remarkably, incubation temperature influences the sex ratio of the hatchlings. Green turtle eggs incubated at temperatures above 29.5°C (85°F) produced almost all females, while below 28°C (82°F) almost all of the turtles were males[100]. In other words, the sex of a turtle may be environmentally rather than genetically determined.

Temperature extremes affect the activity of turtles. High temperatures inhibit the emergence of hatchlings from the nest[81] and slow their swimming speed[84]. In captivity, Kemp's ridley, green and loggerhead turtles stopped feeding at temperatures below 10°C (50°F) and died at 5.0° to 6.5°C (41° to 44°F)[101]. Cold-stunned loggerhead and green turtles were found floating immobile in the Indian River region when water temperatures fell below 11.5°C (53°F)[47].

Water temperature is believed to be important in determining the onset of the nesting season and the interval between nesting emergences. Daylength may also be an

important factor in reproductive periodicity as there is evidence that it affects hormone levels[74].

Diving Ability

Sea turtles routinely stay underwater for several hours at a time, surface for a minute or two to breathe and then submerge again[102]. Under laboratory conditions, turtles have survived for up to 5 hours without breathing[103]. During a prolonged dive, the metabolic rate slows and the heart rate drops to as low as 1 beat in 9 minutes[104].

Sight, Hearing and Sense of Smell

Sea turtles can see well underwater but are extremely nearsighted in air[105]. As would be expected for an animal that lives in the sea, sea turtles are particularly sensitive to blue and green light[83]. Tests on green turtles have shown that they hear well, particularly in the low frequency range[106]. Some turtles make sounds while nesting such as groans and belches. The sense of smell is acute in sea turtles and hatchling green turtles will orient to the scent of shrimp[107].

Mortality Factors

Almost all populations of sea turtles are in decline. Turtles no longer frequent many former nesting beaches and the number of turtles using the remaining sites is greatly reduced. As adults, the sea turtle's large body size discourages most natural predators. Hatchlings and young turtles, on the other hand, are subject to heavy predation. In undisturbed populations, this high rate of predation is compensated for by the large number of eggs laid during a nesting season and a long reproductive lifespan. Man and his activities, however, have greatly increased the mortality rate of turtles during all life stages. This section discusses some of the natural and man-related mortality factors.

Natural Causes

Eggs can fail to hatch as a result of flooding from heavy rains or tidal inundation and nests are often washed away by beach erosion. Many animals, including ants, ghost crabs, foxes, coyotes, buzzards and man-introduced pigs, dogs and mongooses, prey on turtle nests. In the southeastern United States, the major predator is the raccoon. On some South

Carolina beaches, raccoons were destroying over 95 percent of the loggerhead nests until protective measures were taken[108]. Hatchlings moving across the beach are subject to many of the same predators as well as several kinds of birds. Once the hatchlings reach the water, fish become the major predators.

Adult turtles may die while nesting if they are caught in vegetation or wedged between rocks because they cannot crawl backwards to escape. They may also become disoriented and unable to find the water. Death results from heat exposure and desiccation. Occasionally, in Central and South America, large land predators such as jaguars will kill a nesting female[109]. In the ocean, turtles are attacked by sharks and killer whales. Sharks are probably the major natural predator on adults, judging from the number of individuals seen nesting with mutilated shells or missing flippers.

Man-induced Mortalities

Commercial Exploitation

Turtles and their eggs have long been an important source

The raccoon is the major predator of sea turtle eggs in Florida.

of food for many people throughout the tropics because turtles are easy to catch, palatable and, until the past few centuries, abundant. Turtle eggs are valued for their supposed aphrodisiac value in many countries. In some cultures, turtles are an important part of the local culture, and conservation practices, such as protecting nesting females, are built into the local tradition[64]. Unstressed turtle populations can withstand some cropping for local consumption if human population growth has not outstripped local resources. The real threat to turtle populations is the commercial exploitation of turtles for luxury items[18]. Worldwide, hundreds of thousands of adult turtles and millions of eggs are taken each year. This commercial exploitation, coupled with threats from pollution and the loss of nesting areas from development, has resulted in unsustainable population losses.

Fishing Gear

Each year thousands of turtles drown in fishing gear, particularly in the nets used for shrimp trawling. In areas where shrimp trawlers work offshore, many turtles wash up dead on the beaches[50]. Many turtles found dead in the southeastern United States have intestines filled with fish, shrimp and squid remains, items that a turtle ordinarily would not encounter[110]. This suggests that turtles may concentrate near trawlers that dump their bycatch and refuse overboard. Underwater observations show that turtles will try to outdistance a trawl rather than swim to the side to avoid the oncoming net[111]. The development of an excluder device for trawls called the Trawling Efficiency Device (TED) has proved very encouraging. This low-cost device allows turtles to escape from the net and may even increase the shrimp catch slightly. The National Marine Fisheries Service is providing funds to promote the use of TEDs on a voluntary basis, but so far only a few hundred of the thousands of trawls in use are equipped with excluders. It is hoped that use of this equipment will spread throughout the industry in other countries as well as the United States.

Other kinds of fishing gear, such as pound nets, long lines, and sturgeon nets also are responsible for drowning turtles. The use of nonbiodegradable (nylon and monofilament) fishing nets is another threat because nets lost during fishing operations continue to pose a hazard to turtles and other wildlife for many years[112].

Boats

Boats are hazardous to turtles traveling or resting near the surface. Many dead turtles have been found with extensive propeller wounds. This is particularly a problem during the nesting season because turtles concentrate near shore where boat traffic is usually heaviest.

Habitat Alterations

Human activities on beaches can disrupt nesting turtles, nests and hatchlings. Sea walls, jetties and erosion-control structures can make beaches unsuitable or inaccessible to nesting turtles. Artificial lighting along beaches, particularly if directly visible from a nest site, often disorients hatchlings and causes them to head toward buildings and roads instead of the ocean. Many of these hatchlings are then crushed by cars or die from exposure. People on beaches at night may deter turtles from nesting, although in some areas it has been shown that green and loggerhead turtles do not necessarily avoid lighted, developed beaches[113]. At Hutchinson Island, on the east coast of Florida, an increase in the percentage of non-laying crawls may be related to human disturbance and development[114]. Off-road vehicles, beach cleaning equipment and even horses can dig up or collapse nests or leave ruts in which hatchlings become trapped. Tar and oil also harm turtles, particularly young ones, at sea and on the beach[115].

Many turtles die each year from ingesting floating trash that they mistake for food. In particular, plastic bags may be mistaken for jellyfish, a common food item. Plastic can block the intestines and cause death by starvation. A ball of plastic was removed from the gut of an emaciated leatherback turtle that, when unraveled, measured 9 by 12 feet. Off the coast of Costa Rica, many green turtles reportedly died as a result of eating plastic banana bags[112].

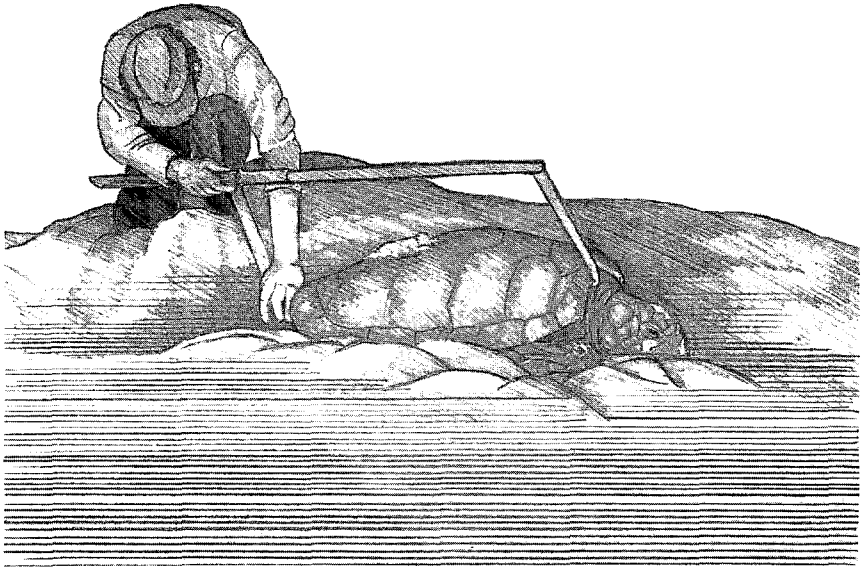
Conservation

Legislation and Agreements

In the United States, sea turtles are protected by many laws. In 1969, the Lacey Act was amended so that, for the first time, federal restrictions were placed on the importation of sea turtles. In the same year, the Endangered Species Act was passed which specified prohibitions on the importation of species listed as

endangered. This law was later replaced by the Endangered Species Act of 1973. As amended, this federal law makes it a violation to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect endangered species." In addition, this law "provides for acquisition and/or protection of turtle nesting habitat, establishment of marine sanctuaries for turtle protection and funding of sea turtle research and protection through grant-in-aid to the states." Currently, the hawksbill, leatherback and Kemp's ridley are listed as endangered, the green turtle is listed as endangered in Florida and threatened throughout the rest of its range, and the loggerhead is listed as threatened. Sea turtles are also protected by other federal and state laws including Florida statute. Without a proper scientific permit, it is illegal to import, sell or transport turtles or their products in interstate or foreign commerce. This law applies to tourists bringing in turtle curios as well as commercial operators.

Many federal, state, local and private groups are now working to protect sea turtles and promote population recoveries. At the federal level, the National Marine Fisheries Service has jurisdiction over sea turtles in the water and the Fish and Wildlife Service has jurisdiction over them on land. In Florida, the



Scientists use large calipers to measure nesting turtles. This information is used in population studies.

Department of Natural Resources, in cooperation with federal agencies, administers turtle programs. Throughout Florida, local governments, conservation groups, and corporations are sponsoring programs to involve local citizens in protecting turtles. Florida Power & Light Company is promoting the conservation of sea turtles and other endangered species by funding educational programs and research.

Because sea turtles are migratory, protection at the national level is not enough. Worldwide, there are over 70 conservation laws and regulations that apply to sea turtles[116]. Two of these are global in scope. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), drafted in 1973, controls international trade in endangered and threatened species. All sea turtles as well as many other endangered species are addressed in this agreement, which has been signed by over 70 countries. However, a few European and Asian countries have taken exception to the inclusion of some species and continue to trade in large quantities of turtle products. Many countries that are party to the agreement also have large-scale illegal trade because of lack of enforcement.

The second global agreement is the Convention on the Conservation of Migratory Species of Wild Animals. This agreement, drafted in 1979, specifically addresses endangered species that travel from one governmental jurisdiction to another. The convention provides a framework on which to base future conservation agreements as well as a mechanism for governments to unilaterally conserve endangered migratory species.

The Law of the Sea Treaty being finalized by the United Nations will also affect sea turtles and many other species because nations will be able to claim jurisdiction over resources within 322 kilometers (200 miles) from shore. This treaty does not provide guidelines for the conservation of marine species and serious problems may arise with these new jurisdictional boundaries.

Management Methods

Methods for conserving sea turtles have, by necessity, been implemented without an understanding of many fundamental aspects of turtle ecology. As a result, the development of conservation measures has sometimes been based on intuition and common sense, rather than on sound knowledge. Given the slow maturation time for sea turtles in the wild, it will be many years before we know if conservation efforts are working.

Currently there are five major categories of conservation methods being pursued[117]. These are:

1. Banning international commerce in sea turtles and their products through laws and agreements;
2. Protecting nesting females on beaches by means of beach patrols;
3. Raising eggs in protected hatcheries;
4. Raising hatchlings in captivity until they are large enough to avoid some predators — this procedure is called "head-starting";
5. Releasing hatchlings from a beach other than where they were laid in hope that, when mature, these turtles will return to establish or reestablish a nesting colony at the new location.

One controversial aspect of turtle conservation is that of turtle farming. The practice of hatching wild eggs and raising turtles to marketable size has been conducted on a small scale many times but, in the 1960's, a large green turtle mariculture operation was begun in the Cayman Islands. It has been proposed that raising turtles in captivity would satisfy market demand and reduce the pressure on wild populations. However, so far this operation has been unable to produce a second generation in captivity. Furthermore, it can be argued that farming operations encourage a demand for turtle products and makes the policing of turtle products more difficult[40].

So far, there is no hard evidence that turtle populations are responding to protective measures, but some of the more optimistic researchers feel that there are signs of a comeback in some areas. Green turtle nesting appears to be increasing in Florida where turtles are protected and a head-start program has been releasing turtles since the mid-1960's[21]. An increase in the number of loggerhead turtles nesting on Cape Island in South Carolina may be the result of raccoon control programs there in the 1960's[118]. Hopefully, these indications will be followed by more evidence that the hard work of sea turtle conservationists over the past decades is beginning to bear fruit.

A sea turtle hotline has been established by the National Marine Fisheries Service and the University of Miami by which the public can report turtle sightings or report marked, injured or stranded turtles. The number in Florida is 1-800-432-6404 and operates 24 hours a day.

How You Can Help

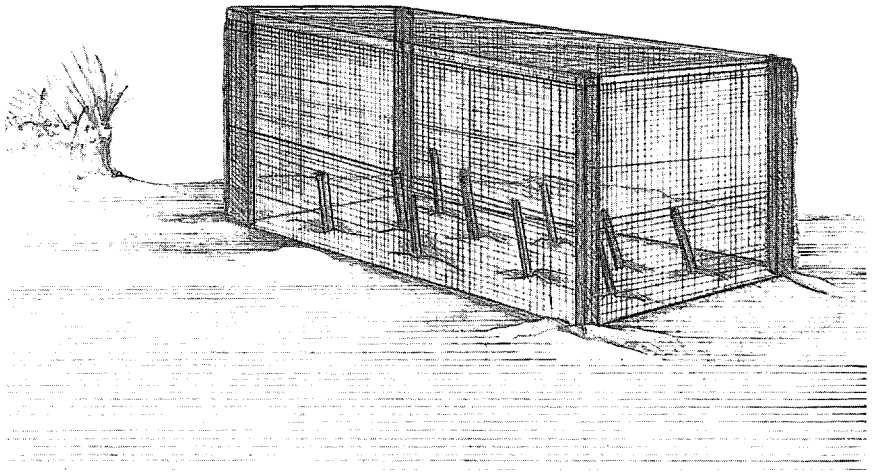
Sea turtles are fascinating animals uniquely adapted to life at sea. Their extinction would mean the irretrievable loss of some of the most interesting of the ocean's inhabitants.

As citizens, there are many things that we can do to ensure the survival of sea turtles. First of all, we must remember that we share the beach and ocean with many other creatures. Never disturb or harass nesting turtles by making noise, shining lights or trying to ride them. Watch out for hatchlings or turtles that may be disoriented by lights and lured onto the road. Be careful while boating to avoid collisions with turtles and never throw trash in the water or on the beach. Find out about turtle research and conservation programs in your area and inform others and, if you find an injured or dead turtle, call the sea turtle hotline. The information gathered may prevent further losses.

It is possible for man and turtles to coexist but it requires commitment and effort on our part. Hopefully, future generations will also have the opportunity to enjoy these unusual animals.

Acknowledgements

I would like to thank Dr. J. Ross Wilcox of the Florida Power & Light Company for providing the stimulus and direction for



To reduce loss to predators such as raccoons, sea turtle eggs can be relocated to protected hatcheries. Each nest is marked by a stake.

developing educational materials concerning endangered species in Florida, of which this booklet is a part. Dr. Wilcox also reviewed this manuscript. I would also like to thank Dr. Peter C.H. Pritchard of the Florida Audubon Society, Andreas Mager of the National Marine Fisheries Service and David J. Herrema of Applied Biology for reviewing this manuscript and providing many helpful technical and editorial comments.

The illustrations for this booklet draw on photographs and illustrations from a variety of sources. These include: Florida Power & Light Company photographs; Pritchard et al. 1982 (reference 20); the poster "Sea Turtles of the World," sponsored by the National Marine Fisheries Service and the Center for Environmental Education, Marvin Bennett, Jr., artist; Booth and Peters. 1972 (reference 71); and a South Carolina Wildlife and Marine Resources Publication on the loggerhead turtle.

Additional Information Available From FPL

Publications

The West Indian Manatee in Florida
Boater's Guide to Manatees

16-mm Films

Silent Sirens: Manatees in Peril
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