# SEA TURTLE NATURAL HISTORY, HEALTH ASSESSMENT, CAUSES OF MORBIDITY AND MORTALITY, REHABILITATION, AND CONSERVATION-AN OVERVIEW

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## INTRODUCTION

Sea turtles of the coastal areas of the United States are either Federally Threatened or Endangered. Sea turtles are distributed globally. The primary causes of the marked decline of sea turtle populations worldwide include loss of nesting beaches to human development, excessive harvesting of sea turtles (especially green turtles) and eggs for food, and death of turtles entangled or ingesting marine debris (e.g. plastics, tar, discarded fishing gear). Incidental take in commercial fisheries (e.g. shrimp trawl nets, drift nets, long line fisheries, etc) poses another major threat to sea turtles worldwide. As human populations increase, additional threats of marine pollution, light pollution, and collisions with boats have increased. Infectious disease (fibropapilloma/herpesvirus) and pollution are also having a negative affect on sea turtle populations.

Along the coast of Georgia, a cluster of eight barrier islands, are separated from the mainland by an extensive system of salt marshes and sounds. Unlike other barrier islands of the east coast, Georgia's remain relatively undeveloped and retain much of their native wilderness. Five of the seven species of sea turtles are found in Georgia's coastal waters, but the loggerhead (*Caretta caretta*) is the only one to nest here in abundance with approximately 1,000 loggerhead sea turtle nests found annually. The green (*Chelonian mydas*) and leatherback (*Dermochelys coriacea*) sea turtles occasionally nest in Georgia and use the coastal waters as a foraging habitat and migratory pathway. Kemp's Ridley sea turtles *(Lepidochelys kempi)* migrate through and forage in Georgia waters as sub-adults. During the summer of 2005, the first Kemp's Ridley nest in Georgia was found on Wassaw Island, which is unusual because this species typically nests in large numbers (e.g. arribada) at Rancho Nuevo, Mexico. The hawksbill sea turtle *(Eretmochelys imbricata),* exploited for its beautiful shell in other parts of the world, is found only occasionally in Georgia waters.

## NATURAL HISTORY

### a) Taxonomy

- Green sea turtle (*Chelonia mydas)*
- Hawksbill sea turtle *(Eretmochelys imbricata)*
- Kemp's ridley sea turtle *(Lepidochelys kempi)*
- Leatherback sea turtle *(Dermochelys coriacea)*
- Loggerhead sea turtle *(Caretta caretta)*
- Olive ridley sea turtle *(Lepidochelys olivacea)*
- Flatback sea turtle (*Chelonia depressa*)

### b) Morphometrics

- Green: Adult approx 88-117 cm (SCL), 102-160 kg
- Hawksbill: Adult approx 63-91 cm (SCL), 80 kg
- Kemp's and olive ridley: Adult 65 cm (SCL), < 45 kg

- Leatherback: adult females weighing anywhere from 330 to 500 kg (660 to 1210 lbs) and males potentially approaching 2000 lbs. The SCL of the adult leatherback ranges from 135 to 175 cm (53 to 69 inches)
- Loggerhead: Adult approx. 92 cm (SCL), 113-150 kg
- Measurements commonly performed include straight and curved carapace lengths, straight and curved carapace widths, and straight plastron lengths, plastron concavity for debilitated turtles

**c) Distribution**

- Green: tropical areas of the Atlantic, Pacific, and Indian oceans
- Hawksbill: worldwide distribution in tropical waters
- Kemps ridley: limited distribution-found in the coastal waters of Gulf of Mexico (off the coasts of Texas, Louisana, and Florida), common species to strand live or dead in Georgia, first nest in Georgia and Florida in 2005
- Olive ridley: tropical waters of the Pacific, Indian, and southeastern Atlantic oceans
- Leatherback: Atlantic, Pacific, and Indian oceans
- Loggerhead: temporate and tropical waters worldwide
- Flatback: coastal waters of continental shelf off north and northeastern Australia

**d) Nutrition**

- Green sea turtle: herbivorous, feed primarily on **sea grasses** and algae
- Hawksbill sea turtle: feed primarily on **sponges**, tunicates, shrimp, and squid
- Kemp's and olive ridley: **various invertebrates** (crabs, shrimp, mollusks, jellyfish, and plants)
- Leatherback: feed primarily on **jellyfish**, tunicates, and other soft-bodied prey, spider crabs found incidentally due to symbiotic relationship with cannonball jellyfish
- Loggerhead: feed on a **variety of invertebrates**: crabs, shrimp, mollusks, jellyfish, and plant
- Fat is stored on mesenteries and organs, and marbled in muscle tissue, however, it is most apparent on the inner carapace and plastron and the SQ region of the inguinal space (good site for taking fat biopsies)
- Foraging grounds and breeding grounds are usually widely separated and both males and females make long-distance reproductive migrations. Do not feed on their breeding grounds, thus they must acquire and store the energy and nutrients required for an entire breeding season while on their foraging grounds.
- Sea turtles have some unusual anatomical adaptations for feeding. All turtles lack teeth, but they have various modifications to the beak to accommodate their preferred diet. Sea turtles have very prominent sharp projections coming from the surface of their esophagus (esophageal papillae) that function to hold prey items while salt water is expelled.

**e) Life stages of the loggerhead and sea turtle migration**

Over the last two decades, there has been a great broadening of the understanding of loggerhead life history and threats at the different life stages. The stages of the loggerhead life cycle and the habitat zones for each stage include (a) eggs, embryos, and hatchling stage occurring in the terrestrial zone, (b) hatchling dispersal/swim frenzy stage and the post-hatchling transitional stage (begins when turtle starts to eat) occurring in the neritic (open higher energy marine waters) zone, (c) oceanic juvenile stage in the oceanic zone (first 6.5 to 11.5 years of life), (d) juvenile transition stage from the oceanic zone back to the neritic zone, (e) juvenile stage and (f) adult foraging stage both occurring in the neritic zone, (g) breeding and migration (every 1 to 4 years as adults) occurring in both the neritic and oceanic zones, and (h) nesting and interesting movement (1-7 two week intervals) in the neritic zone. At each stage in this complex life cycle, the loggerhead faces a different host of natural and human induced threats.

The ability of sea turtles to navigate is legendary, and apparently done by sensing the declination and inclination of the earth's magnetic field. Recent satellite tagging data has shown that Pacific loggerheads migrate over 7500 miles between nesting beaches in Japan and their feeding grounds off the coast of Mexico. Leatherback sea turtles have been documented to swim up to 10,000 miles per year, making them one of the most migratory species on earth.

Loggerhead sea turtles are able to tolerate lower water temperatures than most other sea turtles with the exception of the leatherback. They are found as far north as Newfoundland and northern Europe, and as far south as Argentina; however, they have a predominantly temperate nesting distribution. This distribution intersects with major coastal human populations with beachfront development as a continued threat in the southeastern United States, the northeastern Mediterranean, and southern Japan. Most of the world's loggerheads nest in two places, southern Florida in the United States and on the Island of Masirah, Oman. Much of the genetic diversity of loggerheads comes from smaller nesting aggregations, many of which are known to be declining. Although South Florida hosts the largest number of nesting Atlantic loggerheads in the United States, the smaller northern subpopulation, which primarily includes those nesting along the Georgia, South Carolina, and North Carolina coasts, may be just as valuable genetically. Detailed studies are currently underway by researchers at the University of Georgia (UGA) to further define the genetic diversity of loggerheads nesting in Georgia.

Sea turtles migrate between their foraging areas and their nesting areas with high degree of accuracy. Tag return and satellite telemetry data have been instrumental in delineating the migratory pathways of sea turtles. Georgia's first sea turtle tagging project began on Little Cumberland Island in 1964, and is the oldest project of its kind in the United States and one of the longest running in the world. The Caretta Research Project (http://www.carettaresearchproject.org) on Wassaw Island has been tagging turtles since 1973. Long-term projects such as these provide valuable insights on trends that would otherwise remain unknown.

**f) Reproduction**

- Nest on beaches with deep loose sand that are above the high tide
- The gender of sea turtles cannot be determined by external evaluation until they are reproductively mature. Until that time, directly visualizing the gonad via a laparoscope or measurement of plasma testosterone levels are the only accurate means of obtaining this information. All species of sea turtle exhibit delayed maturity, the loggerhead becoming sexually mature at 30 yrs of age being the most extreme. The most distinguishing male characteristic at maturity is the elongated tail.
- Egg laying may occur year-round, with seasonal peak and trough periods or may be distinctly seasonal; the loggerhead sea turtles in Georgia lay eggs in May, June, and July and eggs hatch in July, August, September and occasionally in Oct.
- Migrate between their foraging areas and their nesting areas with high degree of accuracy
- Tag return data indicate that some turtles migrate greater than 2600 km, however, most travel less than 1000 km
- Breeding sea turtles return to the region of their birth
- Typically will renest in relatively close proximity (0 to 5 km) during subsequent nesting attempts within that season [e.g. loggerhead sea turtles renest up to 7 times (ave. 4.2) per season; leatherbacks renest up to 11 times
- Renest at approximately 2 week intervals (9-10 days for leatherbacks, 12-16 days for loggerheads, 10-14 days in greens, 13-18 days in flatbacks, 13-15 days in hawksbill, 20-28 for kemps ridleys, and 17-30 days for olive ridleys) between each nesting event]
- determining the number of times a turtle nests during a reproductive season is important, particularly if such data is averaged and used in calculations to estimate the number of female turtles in the population.
- In general, female sea turtles do not reproduce every year, with possible exception of *L. kempi*
- The duration of the period between reproductive seasons is defined as the remigration interval which varies from 1 to 9 years depending on the species, loggerheads in GA nest every 2-3 years
- Wildlife biologists from the GADNR and UGA have recently conducted a satellite and radiotelemetry study on nesting sea turtles in Georgia. Their research has confirmed significant site fidelity during the nesting season; however, an individual female may nest on several Georgia barrier islands over the course of one season. Additionally, post-nesting female turtles have traveled as far north as New Jersey and as far south as the Bahamas. More information on this study may be found at www.seaturtle.org. This information is critical for population management, because loggerhead females nesting in Georgia are exposed to a variety of fisheries

related industries (e.g. various types of gill nets, pound nets, scallop dredges, etc) not practiced in our state, during these migrations.

- Males may breed yearly
- Males can be aggressive during courtship; females often have bites to her flippers, neck, head, and shell; male hooks onto female's carapace using enlarged claws on his front flippers and large claws on his hind flippers to hold himself in place, male curls his long tail to bring their cloacae into contact, penis is placed in cloaca
- Females are in reproductive readiness for the male for about 7 to 10 days; males appear to be sexually active for about one month
- Males mate with several females and females mate with several males; mating occurs in the month or two just preceding the first ovipositional cycle of the season
- Females do not store sperm between reproductive seasons
- Gait used by sea turtles on land fits one of two patterns: simultaneous (*Chelonia, Natator, Dermachelys)* or alternating (*Lepidochelys, Eretmochelys, Caretta),* can identify the species by the style and width of the track. These tracks are often the only clue that a sea turtle has nested and aid in finding the nest.
- Most sea turtles nest at night except *L. kempi* which nest primarily during the day, *N.. depressus* regularly nests during the day, and *L. olivacea*
- *L. kempi* and *L. olivacea* nests in arribadas
- General pattern of nesting consists of: emerging from the surf, ascending the beach, excavating the body pit, digging the egg chamber, oviposition, filling in the egg chamber, filling the body pit, and returning to the sea
- Debris and other obstacles (e.g. beach armoring to control erosion) may cause the female to change direction or even to abandon the effort
- Use hind flippers to excavate a flask-shaped chamber that has a narrow neck and a wider bottom
- The digging behavior is stereotyped so strongly that a turtle missing one hind flipper will move the stump in sequence with the flipper actually removing the sand from the chamber.
- During egg laying, all sea turtles species are relatively tolerant of a modest level of external disturbance
- Eggs are spherical with a flexible calcareous shell; in general the larger the sea turtle, the larger the eggs laid
- Average clutch sizes: loggerheads: 112.4; leatherbacks: 81.5; greens: 112.8, flat tail: 52.8, kemps ridley: 110, olive ridley: 109, hawksbill: 130
- Typically have high fertility-usually greater than 80%
- The sperm from all successful males are stored and mixed in the upper portion of the oviduct, the follicles ovulated to become yolks of the eggs in a clutch are fertilized by sperm from several different males
- Eggs are laid with the embryo at the middle of gastrulation. Once oviposited, development resumes in a few hours (4-8 hrs, depending on temperature)-movement of eggs after this time may results in death. The GA DNR recommends moving eggs before 12 hrs post laying and has not seen an appreciable increased mortality
- First sign of embryo development is a white spot on the uppermost part of the egg-the embryo is just underneath this area. The white spot becomes progressively bigger to eventually encompass the entire shell
- The energy and chemical components contained in the follicle were derived from food eaten in the foraging areas---any chemical analysis of the eggs reflects the situation in the foraging areas
- The nest environment must be within the limits of embryonic tolerance in 3 areas: gas exchange, moisture, and temperature
- Mortality is higher in drier conditions, sea turtle eggs are very sensitive to desiccation; inundation (flooding) for extended periods of time (hours) also increases mortality
- Eggs that incubate lower than 23 degrees C for the last third of incubation seldom hatch; eggs held at temperatures greater than 33 degrees C for extended periods do not hatch, higher temperatures cause a decrease in incubation time and lower temperatures cause an increase in incubation time; thus eggs from nests laid in Georgia have a longer incubation period at the beginning of the season

than at the end of the season; within the range of 26-32 degree C, a change of 1 degree C adds or subtracts about 5 days to the incubation; average incubation period is 60 days
- Temperature Sensitive Sex Determination (TSD): the sexual differentiation of sea turtle embryos is determined by temperature, pivotal temperatures varies among the species and between populations within a species; cooler temperatures produce males and warmer temperatures produce females holds for all species of sea turtle. There is a higher percentage of female loggerhead hatchlings in Florida than in Georgia due to the warmer temperatures on the Florida beaches
- Controlling depredation is the primary conservation tool used in Georgia for this life stage. Welded wire mesh fencing secured with steel pencil rods is placed over the nests to protect the eggs from depredations. On some islands, a combination of standard flat screen and wire cages are used to further deter raccoons and pigs. There is some evidence that the metal mesh fencing may alter the magnetic orientation abilities of the hatchlings. On Sapelo and Ossabaw Islands in Georgia, the GADNR has been using plastic screens as a part of a study to assess the effectiveness of nest protection techniques**.** Raccoons and feral hogs are generally controlled through hunting and trapping especially if found on the beach.

**Hatchlings**

- Hatchlings face numerous obstacles getting to the ocean from the nest
- Variety of predators: raccoons and other carnivores, feral pigs, various avian species, fire ants, ghost crabs
- Orientation of hatchling sea turtles from the nest to the sea: move to the brightest direction; short wave length light (near ultraviolet, blue, green) is more attractive to hatchling than long-wavelength light (yellow, red); horizon silhouette and/or shapes associated with the horizon also influence hatchling orientation; in highly directed light fields with brightness in one direction far exceeding that of competing directions, hatchlings move toward brightness; artificial sources near nesting beaches produce highly directed light fields that misdirect hatchlings-this is a major conservation problem
- Hatchlings use subtle visual cues related to the comparative brightness, under natural conditions of the open ocean horizon to orient down the beach to the surf line. As coastal Georgia becomes more developed, the presence of detrimental artificial light directed on the nesting beach, can be disorienting to both recently emerged hatchlings and nesting females. Hatchlings exposed to artificial light may use up their energy stores (e.g. internal yolk) wandering around on land and often leading them away from the ocean. Tybee Island, the northern most barrier island in Georgia has undergone rapid development, which threatens the small number of sea turtles that nest and hatch there. Recently, emerged hatchlings on the island were found disoriented due to excessive beachfront lighting and moving away from the ocean. The hatchlings were found in unusual places such as swimming pools and on the road, which predisposes them to numerous threats. The Tybee Island Marine Science Center has initiated a campaign to reduce light pollution on the island by educating businesses and homeowners on seasonal decreases or elimination of beach directed lighting and use of turtle safe lights, along with other preventive measures.
- After entering the sea, hatchlings depend on cues other than light to lead them away from land; at least 2 sets of cues direct swimming orientation: wave direction (orient into oncoming waves which establishes seaward movement in the near shore zone) and geomagnetic field (guide hatchlings as they travel off shore)
- Hatchlings acquire a magnetic directional preference during their initial swimming, sea turtles are the first animals to show an ability to determine latitude magnetically
- Once in the ocean, hatchlings swim offshore facing a new host of predators (fish, sharks, sea birds) and eventually associate with rafts of sargassum weed where the loggerhead is perfectly camouflaged. This floating algae provides refuge for a number of small marine organisms, which the young loggerhead feeds on. Predation is thought to lessen once the hatchling reaches oceanic waters (deeper than 200 m). Young loggerheads spend approximately a decade in a pelagic, and largely oceanic phase and become drift line inhabitants in the gyres and eddies of the main Gulf Stream. The life history of the hatchling from the time they leave the nesting beach, enter the sea, and become a part of the pelagic community until they return to coastal foraging habitats as juveniles were previously known as the “lost years” because turtles in this size range were not seen by early researchers. Major threats during

this decade of life include cold stunning, ingestion of marine debris, and mortality related to the long-line fisheries.

- Flipper tagging, genetic analysis, and satellite telemetry are being used to document specific movement patterns
- After 10 years in the open ocean, the loggerhead shifts to neritic and coastal habitats. They may move hundreds of kilometers between foraging grounds and further separate themselves by age. Large juvenile and adult loggerheads are largely benthic foragers (bottom feeding) that are distributed in coastal and neritic waters. These older loggerheads are among the few that survived the high mortality of the egg, hatchling, and oceanic stages and therefore have reached an age and size where they have a decent chance to live until they reproduce.

## REPRODUCTIVE ENDOCRINOLOGY

- Studies were initially conducted on large numbers of captive green sea turtles at the Cayman Turtle farm and on captive kemps ridley sea turtles and more recently on free-ranging sea turtles.
- FSH and LH are secreted simultaneously at ovulation.
- Thyroid hormone levels have been correlated to nesting, growth, migration and hibernation
- In wild turtles, progesterone levels peak with ovulation
- Ovulation may be affected by stress (corticosteroids)
- Estrogen is significantly elevated during the follicular development period prior to migration, while testosterone peaks dramatically (in female turtles) and estrogen drops as migration begins
- Testosterone used to sex hatchlings and juvenile turtles
- Estimate number of nests that a female has laid by the changes in testosterone levels
- Ultrasound and laparoscopy in conjunction with the reproductive hormones have been used to elucidate the reproductive cycles of the various sea turtle species
- Plasma calcium elevates during egg laying and slowly declines during the nesting season and can be used as one parameter to evaluate where the female is in the nesting cycle

## ANATOMY

**Anatomy guide to the sea turtle by J. Wyneken from Florida Atlantic University.** There is a CD rom version and a printed version. Recommend purchasing if you are involved with sea turtle necropsy or medical procedures.

**a)** **Esophogeal papillae:** prevent the loss of ingested items while extruding unwanted seawater
**b)** **Salt gland:** very large comparatively to other species, associated with nasolacrimal duct system, helps rid excess salt acquired during feeding

## EPIBIOTA

The loggerhead sea turtle is named for its relatively massive block-like head, which supports the powerful jaw muscles that allow this turtle to effectively feed on hard shelled prey. The carapace is reddish-brown, while the plastron is generally a creamy yellow color. One of the unique characteristics of the loggerhead is the community of organisms; called epibiota, that they carry on their shell. Eighty epibiotic species have been recorded as commensals or parasites of nesting loggerheads evaluated on Wassaw Island, Georgia. These epibionts include various species of invertebrates (such as barnacles, tunicates, sponges, corals, anemones, snails, sea slugs, bivalves, segmented worms, crabs) and algae.

## INDENTIFICATION TECHNIQUES USED IN SEA TURTLE

**a)** **loggerhead:** 5 vertebral scutes, 5 costal scutes, 11-12 marginal scutes, nuchal scute in contact with first costal on each side, 3-4 bridge scutes
**b)** **green:** 4 coastal plates, 1$^{st}$ not touching the nuchal, 1 pair of plates between eyes
**c)** **hawksbill:** 4 pairs costal scutes, 2 claws on each flipper posteriorly overlapping scute, 2 pairs of plates between eyes
**d)** **Kemp's ridley:** 5 pairs vertebral scutes, 5 pairs costal scutes, 12 pairs marginal scutes on carapace; bridge joining carapace and plastron has 4 scutes, each with a pore

e) **Olive ridley: INFO**
f) **Leatherback:** largest of the sea turtles, prominent ridges along back; no scutes, smooth skin

**ST. CATHERINES ISLAND SEA TURTLE NEST PROTECTION PROGRAM AND SCHOOL TEACHER EDUCATION PROGRAM**

Dr. Gale Bishop and Nancy Marsh coordinate the SCI Sea Turtle Conservation Program for sea turtle nest protection, relocation, and predator control. Additionally, the program integrates conservation of sea turtles with applied research and conservation education (**http://seaturtle.sdsmt.edu**). Teachers are trained for seven days in these techniques while in residence on the island. Teachers then impart their knowledge of these amazing reptiles to their students.

A Rapid Assessment Tool (RAT) was established by Dr. Bishop and colleagues to study the various habitats on SCI; these assessments indicate SCI currently hosts approximately 15% adequate nesting habitat. The RAT was modified by GADNR and has been used since 1999 for temporal study of potentially deteriorating habitat and for longitudinal assessment of Georgia sea turtle habitat.

## EXAMPLES OF HEALTH RELATED RESEARCH CONDUCTED BY THE AUTHOR IN COLLABORATION WITH OTHER INVESTIGATORS ON FREE RANGING SEA TURTLE POPULATIONS

**GLOBAL SEA TURTLE HEALTH ASSESSMENT PROGRAM**

As sea turtle populations continue to dwindle, the more critical it becomes for scientists to ascertain their health status in the wild and to address the health–related problems that could decimate already fragile populations. In 1999, the Field Veterinary Program of the Wildlife Conservation Society proposed a sea turtle health assessment program in the Caribbean and Atlantic. The program was a coordinated effort between researchers from a variety of institutions. We applied standardized criteria for assessing the health status of sea turtles throughout the Caribbean and Atlantic. Field sites in the study included five key sea turtle nesting or foraging grounds in the Congo, Costa Rica, Gabon, Nicaragua, and the United States (Georgia). Turtles in the study were green, hawksbill, loggerhead, kemp's ridley, and leatherbacks. Biomaterials were opportunistically collected from nesting or foraging turtles in conjunction with on-going ecological studies, and all turtles were tagged at the time of sampling. These samples included blood, feces, biopsy samples of fibropapillomas, and epibiota from live animals, as well as complete necropsies and tissue preservation from eggs, hatchlings, and adult turtles that were found freshly dead. Additionally, physical examinations were conducted on all turtles and ultrasound and laparoscopy were performed on a select number of turtles. Laboratory analyses of blood samples included hematology, plasma chemistries, protein electrophoresis, genetics, hormones, toxins, and serological evaluation for a variety of infectious agents. Tissues were evaluated by histopathology and toxin levels were determined. The main study objective was to determine baseline health values for free-ranging turtles and to determine exposure to potential pathogenic toxins and infectious agents in the populations at the different sites. The baseline normal biomedical data is helpful when evaluating injured and ill turtles. Sea turtles are at the top of the food chain; thus, they may be useful bio-indicators of the problems occurring in the marine environment. For example, high mercury levels found in sea turtles from a specific area may lead to further investigations on risks to the human population.

**DEBILITATED LOGGERHEAD TURTLE (*Caretta caretta*) SYNDROME ALONG THE SOUTHEASTERN US COAST: INCIDENCE, PATHOGENESIS, AND MONITORING**

Excessive epibiota, especially barnacles and leaches on the skin, may be indicative of a debilitated turtle that has been spending excessive amounts of time on the bottom and moving around less. These turtles are usually severally emaciated, anemic, and have low plasma proteins. Heavy loads of barnacles and other epibionts may increase the energy costs of locomotion. Prior to 2003, approximately three emaciated barnacle laden turtles (often referred to as “barnacle Bills or Bettys”) were found stranded on Georgia’s beaches annually. In contrast, in 2003 twenty-five loggerheads were found stranded in a severely emaciated condition. Other states from Florida to North Carolina reported similar increases in numbers of debilitated turtles.

To investigate this situation further, the St. Catherines Island (SCI) Wildlife Center (SCIWC) and the Georgia Department of Natural Resources organized a workshop on SCI in November of 2003. Fifteen people attended including: turtle biologists from Florida, Georgia, South Carolina, and North Carolina, veterinarians, toxicologists, immunologists, and representatives from the National Oceanic and Atmospheric Administration (NOAA).

The group determined that there was an increasing trend in strandings of debilitated sea turtles from 1992-2002 (approximately 11% annual increase). The number of debilitated turtles appeared to increase substantially in 2003 (NC 3%, SC 22%, GA 10%, and FL 21-25% of the total turtle strandings). The species composition of debilitated sea turtle strandings was primarily loggerheads, but a few green (Chelonia mydas), Kemp's ridley (Lepidochelys kempii) and possibly in Florida, a hawksbill (Eretmochelys imbricata) turtles were affected. Temporally, the stranding of debilitated turtles occurred all year in Florida; however, strandings were found to be concentrated in the spring and summer (April through July) in the other states. Spatially, debilitated sea turtles were stranded across the southeastern US coastal region, there were areas of high stranding density in the southern part of North Carolina, the northern part of South Carolina (Georgetown and Horry Counties) and around Cape Canaveral in Florida (Brevard County). Many explanations for stranding patterns were discussed including ocean currents, winds, and cold-stunning events.

A debilitated turtle was defined as emaciated with small barnacles covering the skin. The flippers can also have lesions or be necrotic. While heavy epibiota can be a normal finding on the carapace and plastron of healthy loggerhead sea turtles, the skin is generally free of these commensals. Health assessment and necropsy data from these cases indicated the turtles were being affected by a wide range of secondary bacterial and parasitic infections with the primary cause still to be determined. Seven debilitated turtles showed significantly higher blood levels of polychlorinated biphenyls (PCBs) and organochlorine pesticides compared to apparently healthy turtles. In a separate study, mercury concentrations in blood and scutes were 2 to 3 times higher in dead stranded turtles compared to live, apparently healthy turtles although the sample size was small. It is still unclear at what levels these compounds become toxic to sea turtles. The high contaminant levels could be a secondary effect as debilitated turtles use up their fat reserves, causing organic contaminants to become concentrated in blood.

The group determined several areas that needed to be addressed in 2004 and 2005. First, a complete statistical analysis of debilitated sea turtle stranding trends (NMFS-Sea Turtle Stranding and Salvage Network Database) is needed to better define the extent of the problem. This analysis will assist in determining if there was a substantial and statistically significant increase of stranded debilitated turtles in 2003. Possibly the strandings correlate with overall increases in off shore populations. In the past, not all strandings were examined for signs of debilitation. Thus the percentage of debilitated turtles should be expressed as a proportion of turtles examined, not total strandings.

In order to provide consistent, standardized documentation on stranded debilitated turtles in 2004 and 2005, protocols were developed to include: visual assessment, physical examination, morphometric measurements, clinical pathology parameters (e.g. complete blood counts, plasma biochemistry, etc) , contaminant analysis, immune function tests, gross necropsy and histopathology (microscopic examination of tissues). Turtles undergoing rehabilitation, are sampled at four different time periods to follow their progress. Additionally, treatment protocols have been developed for these turtles. Significant findings to date from this ongoing study, include a high percentage of the turtles are sub-adult females and all turtles are severely compromised by heavy loads of Spirorchid trematode ova in tissues. All turtles have varying degrees of emaciation, anemia, and low blood protein. Several previously undocumented epibionts have been found on the skin and shell of these turtles. Contaminant analysis is currently being performed and hopefully data will be available in the near future.

**PREVENTIVE MEASURE TAKEN TO REDUCE MORTALITY/MORBIDITY AND INCREASE NUMBERS IN FREE-RANGING POPULATIONS**

a) Preservation of nesting beaches
b) Turtle Extruder Devices (TEDs)
c) Public education
d) Predator control on nesting beaches
e) Nest protection

f) Relocation of nests in flood zones
g) Rehabilitation
**h)** Head start programs

## COMMON CAUSES OF MORTALITY AND MORBIDITY OF FREE RANGING SEA TURTLE POPULATIONS

### a) Traumatic injuries

Trauma is a common reason for sea turtle mortality and morbidity. Problems encountered in free-ranging marine turtles may include boat related injuries secondary to propeller or direct impact, encounters with predators such as sharks, entrapment in dredging equipment, dropping on a boat deck after incidental capture, and wounds created from fishing gear entanglement such as nets, fishing line, crab and fish traps and plastic rings from beverage containers. With increased coastal development in Georgia, interactions with motorized watercraft are on the rise. Propeller injuries occur when the turtle comes up to take a breath or is innocently basking or resting on the surface, thus the majority of wounds are found on the carapace and skull. Missing or amputated flippers may affect the sea turtle's general mobility, and nesting and breeding abilities. A female with stump on 1 front flipper and other missing at shoulder was still able to nest, male with same problem would not be able to breed, some females with only 1 rear flipper can nest, some cannot; this is important information when considering releasing or rehabilitation of a particular individual.

Traumatic injuries in sea turtles often involve the central nervous system (CNS) and need immediate attention. Consider cardiopulmonary resuscitation based on the severity of the case. Short-acting corticosteroids such as methylprednisolone (SoluMedrol), dexamethasone sodium phosphate, or prednisolone sodium succinate (Soludelta cortef) should be administered IV and then repeated in 12-24 hours. Supportive care, wound care, broad-spectrum antibiotics, and analgesics are indicated depending on the type of injury. Warm the pateint to ambient indoor temperatures (68 to 75 F) only when hemostasis is achieved, antibiotics are on board, and vital signs are stable. Warmed animals have higher O2 demands, increased potential for hemmorhage, and increased bacterial growth in contaminated wounds. Once the turtle is stabilized, radiographs can be taken to determine the extent of the injuries, prognosis and planning further therapy.

Uncontrolled hemorrhage should be addressed immediately. This can be accomplished by digital pressure, a pressure bandage or by surgical electrocautery ligation of vessels. Carapace injuries are common. After radiographic evaluation, clean the wounds and surrounding tissue with dilute chlorhexidine, betadine, or saline or place wet gauze over the fracture site until the patient is more stable. Foreign debris should be carefully removed from the wound. If the coelomic cavity is open, minimize contamination. Fractures or injuries over lungs put the patient at risk for bacterial and fungal pneumonia. After cleansing and drying the injured area, the wound should be dressed. Silver sulfadiazine (SSD) cream or triple antibiotic ointment may be applied to open shell fractures and wounds. The author used a silver-coated mesh (Acticoat with silcryst nanocrystals, Smith & Nephew, Inc., Largo, FL 33773 USA) on open wounds in chelonians including shell fractures with excellent results. This product provides 72 hours of antibacterial and antifungal activity if kept moist. DuoDerm or tegaderm can be used to cover various dressing materials and to keep the wound clean and dry. For a more waterproof bandage, apply tissue glue to the edges of these adherent bandages. Vet wrap can be used to keep the dressing in place and may assist in temporary fracture alignment if the turtle is dry docked. The patient should be kept in shallow water or may need to be dry docked until a waterproof bandage is placed over the wound or fracture or until final repair.

All skin wounds should be cleaned and debrided as described for shell injuries. Uninfected skin wounds can be sutured closed or left partially open for continued lavage and cleaning. Infected wounds should be left open to heal by second intention until infection is controlled. Reptiles produce thick caseous material that does not drain well, thus penrose drains are generally not used in wound care. In areas that are difficult to bandage, suture loops can be placed around the wound, the preferred topical treatment and dressing can be placed, and then umbilical tape can be placed through the suture loops and tied together like a shoelace to hold the dressing in place. This method allows for regular wound cleaning and bandaging.

**b) Marine Debris**

Sea turtles are very curious and often ingest non-biodegradable human waste such as plastic, balloons, metal, and glass that are dumped into the ocean. Sometimes these items are passed by the turtle without any problems; however, more often they may cause irritation or cut through the gastrointestinal tract, or actually lead to obstruction and potentially death. Some marine debris may be toxic to the sea turtle. Oil and tar may be found on the skin or shell or may be ingested by the turtle. Fishing hooks and line may be ingested with the hook caught in the mouth, esophagus, or lower down the gastrointestinal tract. The fishing line may hang out the mouth with the risk of entanglement or potentially may pass further down the gastrointestinal tract and lacerate through the tissue and eventually lead to fatal infections. If the hook is in the mouth, it may be relatively easy to cut and remove it. Hooks found in the esophagus, stomach, or intestinal tract require anesthesia and surgery for removal or may need to be left in place depending on the location and circumstances. .

**c) Drowning**

Sea turtles have several unique adaptations for life underwater and deep diving. They have a very efficient oxygen transport system and have an extreme tolerance for low blood oxygen levels and require only a few breaths lasting less than 2-3 seconds to empty and refill their lungs even after being submerged for long periods. Unfortunately, they are frequently captured or entangled in shrimp nets, gill nets, or fishing lines and may be trapped underwater for extended periods of time. When a sea turtle is forcibly submerged and struggling, its oxygen stores are used up more rapidly. Capture of sea turtles in shrimp trawl nets remains a common problem in Georgia. Most turtles in this predicament drown and are subsequently found dead on the beach. Live turtles that have been submerged under water for extended periods of time may present in a comatose state without corneal or deep pain reflexes. Cardiopulmonary resuscitation may turn some of these cases around. Trawl-captured loggerhead sea turtles exhibit a marked acidemia and lactic acidosis when first brought on board. Blood gas and lactate levels should be monitored during the recovery process. Once intubated, the turtle should be placed with its head down to drain fluid from the lungs. Suctioning fluid from the endotracheal tube may be of some benefit. Limb and head pumping, intermittent positive-pressure ventilation (2-6 times per min), and doxapram administration (5 to 10 mg/kg IV) may assist in reviving the turtle. Aggressive therapy to correct acidosis, electrolyte imbalances, dehydration, and hypothermia may be necessary. Broad-spectrum antimicrobial therapy is usually indicated.

Occasionally a turtle can be treated and survive near drowning; however, prevention is the key to the problem. In 1978, the first Turtle Excluder Device (TED), a trap door in the shrimp net that allows the turtle to get out but not the shrimp, was developed in Georgia by local shrimpers and researchers. The use of TEDs has allowed for continued fishing while decreasing the number of sea turtles caught by as much as 97%. Since 1994, federal law has required TED usage by all vessels shrimping in US waters. Those fisheries trawling for whelk and cannonball jellyfish in Georgia waters are also required to install a TED in their trawl net. Unfortunately, there are no regulations for these two fisheries in federal waters. In May of 2004, approximately 70 healthy sea turtles were found dead on Georgia’s beaches. The cause of these turtles demise was illegal shrimping in federal waters. The shrimpers had several violations including small TED openings, steep TED angles, and TEDs were often lacking from try nets. Even today, TED regulations can be confusing and are difficult to enforce as demonstrated by this tragedy. Other management practices that reduce turtle mortality in Georgia and elsewhere include reductions in net-towing time for each shrimping run and seasonal and area closures of certain fisheries during peak turtle migration or nesting.

**d) Hypothermia**

Hypothermia, or cold stunning, in sea turtles is a wintertime phenomenon where the water temperature suddenly drops below 50 F (10 C). The turtles loose their ability to swim and dive, become buoyant and float to the surface. It is most common in juvenile sea turtles and has been documented to occur from Gulf of Mexico to New England and Western Europe. Secondary infections, especially bacterial pneumonias are not uncommon and may not be apparent until several weeks after the initial hypothermic event.

A classification system has been developed for hypothermic sea turtles based on a series of reflex responses such as the head lift, cloacal or tail touch reflex, eye touch reflex, and nose touch reflex. The degree of responsiveness will dictate the best approach to be taken and indicate a prognosis. The severity of secondary problems will depend on the length of time and temperature extremes the turtle was exposed to. Traumatic wounds, dehydration, corneal ulcerations, dermal, carapace and plastron lesions, flipper tip necrosis consistent with frostbite, and buoyancy disorders are frequent findings in severe cases.

Common abnormal clinical pathology findings in cases of hypothermia include an initial heterophilic leukocytoses with subsequent development of leukopenia and monocytosis, both regenerative and non-regenerative anemias, hypoglycemia or hyperglycemia, increased creatine phosphokinase (CPK), decreased blood urea nitrogen (BUN), hypocalcemia, hypoproteinemia, hypokalemia, hypernatremia, hyperchloremia, and metabolic acidosis. Electrolyte disturbances may be secondary to malfunctioning salt glands. Cultures of blood and other fluids often reveal localized and systemic bacterial and fungal infections. Radiographs often reveal changes consistent with pneumonia. Coelomic fluid evaluation may reveal evidence of inflammation or infection.

Important medical management considerations for hypothermic sea turtles include a slow increase in body temperature, gradual reintroduction to sea water from fresh and brackish water performed over a 2 week period, prophylactic antibiotic and antifungal therapy, nutritional support, and close monitoring of clinical pathology and acid-base abnormalities. Many turtles can have positive clinical outcomes with proper medical attention. Body temperature and heart rate are important parameters to obtain at time of presentation and to monitor until the rewarming process is complete. Less severe cases are placed in shallow water, while more severe cases are dry-docked and placed on foam pads. The water or room temperature should initially be only 2-4 degrees C warmer than the ambient water temperature where the turtle was found. Increasing the body temperature 5º F (3º C) per day until reaching 75º F (24ºC) has worked well for this author. In severe cases with apnea, CPR is recommended. Treatment of open wounds, corneal lesions, and supportive care should be started immediately. Broad-spectrum systemic antibacterial and antifungal therapy should be initiated when the turtle reaches 60-65º F (16-19ºC). Keep the skin and shell moist with bacteriostatic water-soluble lubricating jelly.

**e) Hyperthermia**

Reptiles are less able to compensate for elevated temperatures than mammals or birds. Temperatures over 100 ºF (38º C) are usually lethal for most chelonians. Ill or injured sea turtles stranded on a beach may become overheated. Early clinical signs of hyperthermia include increased activity, seeking cool areas, and skin becoming hyperemic. Eventually, the turtle develops open mouth breathing, rapid respirations, and may become comatose. Treatment involves administration of fluids and possibly, in severe cases, a short acting steroid to reduce brain swelling. Place the turtle in cool water (not cold) for a brief period to reduce core body temperature, while keeping the head out of water. Body temperature should be monitored carefully.

**f) Ileus, Obstruction**

Vomiting or regurgitation in chelonians is usually indicative of a poor prognosis. A thorough diagnostic work up should be performed to make a definitive diagnosis. Some causes of vomiting include foreign body or other gastrointestinal obstruction, noxious tasting materials, dehydration and debilitation, gastric stasis, gastrointestinal yeast, and parasitism. Turtles should be rehydrated and stabilized and then tube feed with an easily digestible elemental diet such as Peptamen (Nestle USA, INC., Deerfield, IL 60015 USA). Keep the neck extended and elevate turtle for a period of time after the tube is removed. Gradually introduce a higher caloric diet.

Heavily parasitized turtles may become partially or completely obstructed with dying nematodes after deworming with relatively low doses of fenbendazole (30 mg/kg given once). Rehydrate and stabilize these patients so they regain their normal gastrointestinal motility. Then treat them with lower doses of anthelmintics (fenbendazole or pyrantel pamoate) and gradually increase to the recommended dose of 50 mg/kg over several weeks. This gradually increased dose reduces the chance of obstruction by reducing the number of parasites affected per treatment. Fenbendazole, although effective in chelonian species should be used with caution based on recently described bone marrow suppression effects in reptile and avian species.

Gastrointestinal stasis or ileus is a common cause of morbidity in debilitated chelonians and must be differentiated from obstruction. Gastrointestinal stasis is precipitated by dehydration, systemic disease, and malnutrition. Diagnosis is challenging because of difficulties in palpating the chelonian coelomic cavity and the normally slow GI transit time of chelonia. Without appropriate treatment the condition may progress to impaction and obstruction requiring intensive medical or surgical therapy. Debilitated sea turtles often develop a secondary gastrointestinal stasis and become obstructed with chitinous and shell prey item parts. Radioopaque material and gas in the gastrointestinal tract are visible radiographically. The condition is resolved with fluid therapy, mineral oil, enemas, and gastrointestinal motility modifiers. Resolve the obstruction prior to feeding or tube feeding the patient. Motility modifying drugs such as metaclopromide and cisapride are clinically effective in chelonians.

Foreign body ingestion is a common emergency presentation in chelonians. Occasionally foreign bodies are found incidentally on whole body radiographs. Fishhooks with attached fishing line may become anchored in the oral cavity, esophagus, or other parts of the gastrointestinal tract and lead to intestinal plication or coelomitis secondary to hook penetration of the serosal surface of the gastrointestinal tract. A variety of foreign materials, such as plastic bags, metal, and glass, have been found in sea turtle gastrointestinal tracts and may be an incidental finding or lead to an enteritis or obstruction. The radiographic hallmark sign for intestinal obstruction is the accumulation of radiopaque material in a dilated segment of intestine. A prominent obstructive gas pattern is not always observed. Conservative medical treatment, with enemas, parenteral fluids, petroleum laxatives and water given with stomach tube at 15 ml/kg, and other supportive care, may be all that is necessary for clinical resolution of these patients. However, surgical removal of the foreign body or material may be required in some cases.

**g) Contaminants/Toxicosis**

Sea turtles may encounter waters that contain chemical pollutants, such as petroleum products from oil spills and present with oil or tar on skin and shell or systemic signs of toxicity due to ingestion. An increased stranding rate of sea turtles in Florida has been associated with red tide blooms of the dinoflagellate *Karenia brevis*. Central nervous system signs are most common.

A diagnosis of toxicity in a chelonian is usually based on a thorough history, clinical signs, physical examination, and various diagnostic tests. Diagnostic testing that may be helpful includes contaminant analysis of blood, plasma, stomach contents or tissue, and radiographs may reveal metallic foreign bodies.

Fluid therapy, CPR, wound care, and other supportive measures previously discussed are utilized frequently in chelonians presented for intoxication. Activated charcoal or psyllium may be used to bind and decrease absorption of toxins ingested orally. Calcium EDTA has been used to treat lead toxicity in chelonians. Midazolam or diazepam may be used to control seizures. Atropine may be used to treat organophosphate toxicity.

Ivermectin has been used successfully and safely in a variety of reptiles, it is toxic to many species of chelonians. There are species differences in susceptibility to the toxic effects; however, **the drug should be avoided in all chelonians.** Clinical signs associated with ivermectin intoxication are primarily related to general neuromuscular weakness with death usually occurring because of respiratory paralysis.

Metronidazole (Flagyl) is used to treat anaerobic bacterial infections and amoebiasis in reptiles. Tortoises are prone to developing side effects from this drug and may not tolerate the relatively high doses or duration of therapy necessary to treat amoebiasis effectively. Metronidazole treatment regimens in chelonians need to be tailored to the individual with close monitoring for clinical signs of toxicity. Clinical signs of metronidazole toxicity include anorexia, head tilt, circling, dysequilibrium and signs of hepatotoxicity. Although potentially fatal, supportive care may reverse some cases.

**h) Buoyancy disorders**

Aquatic turtles, especially sea turtles are often presented with buoyancy disorders, where they are unable to float normally at the surface or submerge . Any condition leading to gas or air accumulation in a body organ or in the coelomic cavity may cause abnormal buoyancy. Common causes of this condition include 1) pneumonia, 2) gastrointestinal disease (e.g. motility disorders, spinal cord injury, foreign body and other obstructive processes leading to gas accumulation), and 3) free air in the coelomic cavity, which may occur from respiratory or intestinal leakage or microbial fermentation. Efforts should be directed towards diagnosing the primary problem, which may include blood work, radiology, endoscopy and laparoscopy. Initially the turtle should be stabilized and then attempts should be made to treat the primary disease. Laparoscopic surgery has been used to repair a lung tear in a sea turtle (Pers comm, Dover S, 2004). Intracoelomic administration of large volumes of sterile fluids has been used as an ancillary treatment for this condition in loggerhead sea turtles (Pers comm, Sheridan, T, 2005). Some turtles, especially those with spinal injuries, may remain abnormally buoyant for life.

**i) External parasites**

- **Leaches:** *Ozobranchus* species; can cause erosive skin lesions at attachment sites. Heavy infestations can be associated with anemia. Treatment consists of fresh water baths (24-48 hrs) and manual removal
- **Barnacles:** encrusting and burrowing barnacle species; can cause shell lesions, oropharyngeal obstruction, visceral and joint lesions in burrowing species. Treatment is similar to leach treatment.
- **Excessive epibiota (especially barnacles; leaches, etc**): is usually indicative of a debilitated turtle that has been spending excessive amounts of time on the bottom/moving around less. These turtles are usually anemic and hypoproteinemic. Heavy loads may increase the costs of locomotion. (refer to debilitated loggerhead turtle syndrome for further details)
- Placing marine turtles in freshwater for 24 hours will significantly reduce the external parasite load and aid in rehydration.

**j) Internal parasites**

Endoparasites may be a contributing factor in an already compromised chelonian and in some cases they may be the primary cause of debilitation. Stress, overcrowding, poor husbandry, infectious diseases, and immunocompromising conditions may lead to heavy endoparasite infestations.
Digenetic trematodes of the family Spirochiidae are commonly found in the cardiovascular system of freshwater aquatic and sea turtles and have been implicated as a cause of significant morbidity and may play a significant role in mortality in some cases. Numerous species of trematodes have been documented to infect sea turtles. The parasite has been found in several species of sea turtle with greater than a 30% infection rate of the wild-caught loggerhead sea turtle population. The eggs are released into the circulatory system, which eventually become trapped within the terminal arterioles in visceral organs and in peripheral structures such as the limbs and dermal bone of the shell. A granulomatous response is produced by the eggs in various tissues, including the gastrointestinal tract, liver, spleen, lungs and CNS. The life cycle of the organism (e.g. intermediate host-may be a snail or polychaete annelid) is not completely understood in sea turtles. Clinical signs are related to the pathology caused by the eggs and may include generalized debilitation, severe ulcerative colitis, pitted ulcerations (due to ischemic necrosis) of the carapace and plastron, edematous limbs due to vascular obstruction, and buoyancy problems secondary to pneumonia. A tentative diagnosis can be made by demonstrating eggs in feces or tissue sections. No lesions are typically produced by the adults. A granulomatous response is produced by the eggs. A granulomatous pneumonia with a secondary bacterial component due to trapped eggs within vessels in the lungs has been observed in some cases.. Bacterial infection in other organs affected by flukes is not uncommon. The spleen is a good organ for looking at trematode eggs.

A major loggerhead sea turtle stranding event occurred in south Florida in 2001. Most turtles presented with partial paralysis and many had secondary problems. Necropsy results revealed adult trematodes in the brain and spinal cord. No other primary agent has been identified in these turtles despite an exhaustive list of diagnostics that were performed. It is still suspected**,** however, that an unknown primary problem caused the immune system of the turtles to be suppressed and predisposed them to severe trematode infestations. These turtles may respond to intensive supportive care and treatment of the trematodes. High doses of praziquantel, a drug used to treat schistosmiasis in humans, may be effective in decreasing the severity of clinical signs but will not affect the eggs already in tissue. There is a high mortality rate in turtles parasitized by this trematode. A small percentage of turtles have been rehabilitated successfully with the treatment being very intense and prolonged. During the summer of 2005, we have seen our first cases of turtles afflicted with this parasite in Georgia.

**Summary of findings from this epizootic**

- Physical exam: varying degrees of paresis: lack ability to move voluntarily, no righting reflex, no corneal, palpebral, menace response, no swallowing or gag reflex, lock jaw-very difficult to open mouth, deep pain absent in the periphery but present more proximally; corneal lesions (ulcers and plaques), mucoid nasal discharge, rales upon auscultation. Asymmetric floating due to pneumonia (actually made turtles easier to find by fisherman and others, many may have drowned and never been seen), bradycardia (used doppler to assess; 20-32 bpm normal 4-8 in turtles that presented with this problem), heavy epibiota-especially leaches; sunken eyes indicated a poor prognosis and usually indicated decrease muscle tone and death was near

- Neurological exam: supported a diagnosis of neuromuscular junction transmission block and/or a severe demyelinating polyneuropathy that had spared axons
- EMG: no response to electrical stimulation in any muscle groups evaluated-suspected a NM junction blockade or conduction problem, diffuse NM disease with cerebral disease
- Clinical pathology: leukocytosis (primarily a heterophilia), hyperglycemia, and hypermagnesemia.
- Radiographic: unilateral and bilateral interstitial patterns consistent with pneumonia, possible secondary to aspiration in some cases
- Bronchoscopy: hyperemia, mucoid fluid accumulation, and plaques in the trachea and bronchi, severe cases had brownish caseous plugs occluding both the upper and lower airways
- Other diagnositics: cholinesterase levels were low when compared to mammalian values but were comparable to normal loggerhead sea turtles sampled from another part of the country
- Treatment: housed indoors in individual dry pools to prevent drowning due to turtles being too weak to hold heads up-maintained temperatures at 80 F (this created numerous problems-bed sores, so padded flippers, chin pads, diapers for feces and urine, developed prolapses and edema and corneal lesions), wide variety of treatments used most without success, most turtles died, 4 survived, successful treatments included atropine, 2-PAM, fenbendazole and droncit, supportive care (very time consuming to tube feed-45 min per turtle, used ropes on upper and lower jaws to open mouth-squid and gatorade milk shake, antibiotic therapy for pneumonia, fresh water baths for 24 hrs to remove excessive epibiota; physical therapy was useful in improving muscle strength, foam noodles were used in the recovery period and attached to the turtles with vet wrap which helped keep turtles floating
- Necropsy: Gross: squid plug in esophagus-possibly due to dehydration and paralysis, plaques in tracheal lumen, hemorrhage in meninges, patchy black material in mucosa of intestine-trematode eggs-can visualize eggs on squash preparation on slide; histopathology: most prominent lesions were tracheitis, proliferative pneumonia, and spirorchidiasis in a variety of tissues including brain and spinal cord. Tracheal and pulmonary lesions were probably secondary problems from immunosuppression and debilitation. Spirorchid eggs induced a granulomatous inflammatory response in a variety of tissues. Adult trematodes and eggs found in ventricles of heart, myocarditis found in many of the cases and was often associated with trematode eggs, the eggs of the trematode are elongated and some have spinous processes, trematode eggs found occluding meningeal vessels which caused meningeal edema, eggs can cross blood brain barrier into brain tissue causing an encephalitis; adult trematodes are long and thin and very difficult to dissect out of vessels; herpes virus workup was been negative, axons were spared myelin was normal.
- Suspect a toxin affecting NMJ and CNS at this point. Several toxins were being explored as possible underlying or contributing cause including jelly fish toxin, algal toxin, OP toxin, botulism (previously documented in sea turtles), cigua toxin (Ciguatera poisoning effects sodium channels in axons) toxin being produced by the fluke eggs; although the life cycle of the trematode affecting sea turtles is unknown-may be that the intermediate host had a population explosion; researchers are uncertain if this is a new species of trematode and thus leading to extensive aberrant migrations-possibly perform PCR down the road to elucidate if this is a different spp of trematode than previously observed.

- **Coccidiosis:** Epizootic Mortality of Free-living Green Turtles, Chelonia mydas, due to coccidiosis, Gordon et al, JWD, 1993, 29: 490-494; at least 70 deaths (SE Queensland) over 6 weeks in spring; 24 necropsies-enteritis and encephalitis associated with Caryospora chelonae; coccidia in extra intestinal lesions; previously only documented in farmed ST hatchlings

### j) Viral Diseases

**Fibropapillomas**

Fibropapillomatosis (FP) is the most significant infectious disease affecting sea turtle populations worldwide. The disease was first reported in 1938 and only occasionally observed in green turtles found in South Florida until the early 1980s. Since that time, FP has been observed with increased frequency with a local prevalence in some green turtle populations of up to 92%. Although the disease occurs most commonly in green turtles, it has also been documented in several other sea turtle species, including the loggerhead. In Florida Bay, Florida, 11% of loggerheads captured from 1990 to 1996 and 13% in 2000 had the disease. Fibropapillomatosis had not been observed in sea turtles inhabiting Georgia waters until 2003 when two loggerheads were found to have very low numbers and mild FPs on their skin (A. Segars, pers. comm., 2003) and was first documented in stranded green turtles in Georgia in 2004 and again in 2005.

Fibropapillomas may present as very mild solitary wart like masses on the skin to numerous very large masses covering the skin, shell, eyelids, conjunctiva, and cornea. The disease may impair the turtle's mobility and vision and subsequently may lead to severe emaciation and eventual death due to the turtle's inability to find food. In severe cases, the internal organs (e.g. gastrointestinal tract, lungs, heart, liver, kidneys, and gonad) may be affected. All cases found in Georgia have been mild with no internal involvement.

A herpesvirus has been implicated as the causative agent of the disease syndrome; however, environmental pollutants or other unknown immunosuppressive factors are most likely a contributing factor in the disease process. Lung-eye-trachea disease (LETV) herpes virus is the only herpes virus of sea turtles that has been maintained in cell culture. Anti-LETV Abs in one wild population had a prevalence of 21.6%. One hundred percent of nesting females greens and 70% loggerheads had antibody titers. Researchers are currently working on developing an antibody based test for the herpes virus that has been implicated as part of the fibropapilloma syndrome.

Radiography and laparoscopy are used to identify internal FP (D. Mader, pers. comm., 2004). Humane euthanasia is recommended for turtles with internal lesions. Initial treatment consists of correcting dehydration, low blood glucose, and malnutrition. Antibiotic therapy is usually indicated prior to and after surgery. Laser surgery can be used to remove the FPs in stages with the skin left open to heal by second intention (D. Mader, pers. comm., 2004). If tumors do not regrow after 1 year post-removal, then the turtle is considered safe to release. FP lesions typically do not regrow once surgically removed.

Pathology: Gross-The smallest lesions are slightly raised, light-brown in color, oblong in shape and have a rough surface. As the lesions mature, they become more verrucous on the surface. The most mature lesions are rounded and a less verrucous, often ulcerated surface, moderate to severe emaciation especially if internal FP present, serous atrophy of fat, edema of SQ and muscle, anasarca, hydropericardium and pulmonary edema. FP lesions have been observed in GIT, lungs, liver, kidneys. Histologically, the FP lesions consist of a slightly to moderately hyperplastic epidermis overlying a thickened hypercellular dermis. In early lesions, ballooning degeneration is present predominantly in the stratum basale where rete ridges extend into the dermis, aggregates of mixed inflammatory cells are present around dermal vessels. More mature lesions have a less verrucous, often ulcerated at the surface, with the dermis composed primarily of large collagenous fascicles and relatively few fibroblasts. Similar lesions have been found in the kidneys and lungs of green turtles with cutaneous fibropapillomas.

**k) Bacterial and Fungal Infections**

Debilitated and injured chelonians often present with bacterial or fungal infections. These may include infected traumatic injuries, abscesses, stomatitis, shell infections, osteomyelitis, and respiratory disease. Poor husbandry, malnutrition, and lack of sanitary procedures are predisposing factors for infection in captive specimens. Bacterial abscesses are the most common inflammatory condition in reptiles. They can be subcutaneous or involve internal organs. Reptile abscesses are most often well encapsulated by fibrous connective tissue. Gram-negative bacteria cause the highest morbidity in chelonians, however, anaerobic bacteria (*Bacteroides*, *Fusobacterium*, *Clostridium*, *Peptostreptococcus*) can cause serious disease and should be considered in the therapeutic plan. *Bacteroides* and *Fusobacterium* produce potent tissue toxins, which cause tissue necrosis and increase severity of mixed aerobic and anaerobic bacterial infections. C*lostridial* spp. have systemically active toxins that cause hemolysis and renal tubular necrosis. *Salmonella* spp. can cause disease in chelonians and are a potential zoonosis. Atypical mycobacterial infections can cause abscesses, cutaneous and subcutaneous nodules, osteomyelitis, osteoarthritis, and other problems in chelonians. Predisposing factors include debilitation, injury, malnutrition, and other disease processes. This is also a potentially zoonotic disease. A multifocal bacterial encephalitis was reported in stranded juvenile loggerhead sea turtles from the Chesapeake Bay and coast of Florida. These turtles were found floating or stranded, lethargic when undisturbed, spastic movement of flippers when handled, hyperflexion of the neck; elevated WBCs and CPKs. Necropsy revealed multiple areas of hemorrhage and necrosis in brain and meninges. Caseous nodules between the cerebellum and brain stem were noted in some turtles. Histopathology revealed a granulomatous meningoencephalitis and fluke eggs were noted in tissue sections.. Corynebacteria was cultured from brain tissue.

Culture and sensitivity of various samples (discharges, biopsies, caseous material), cytology, histopathology, and molecular diagnostics are common methods used to diagnoses bacterial and fungal infections. Special stains, such as acid-fast stains for mycobacteria, may be needed to make a diagnosis.

Treatment for bacterial infections include antibiotic therapy based on culture and sensitivity. Anaerobic bacteria should be treated with metronidazole, penicillin, chloramphenicol, or clindamycin. Perform complete surgical excision of abscesses or removal of the accumulated caseous material and lavage the wound with antiseptic solution. Antibiotic-impregnated polymethylmethacrylate beads have been used to treat osteomyelitis in reptiles. A silver mesh previously described can be used to pack wounds and provides 72 hrs of antibacterial and antifungal activity. Pharmacokinetic studies involving fluconazole and itraconazole have been recently performed in sea turtles and have advanced the treatment capabilities for fungal infections.

**Septicemia**

Bacterial septicemia is a relatively common sequel to more localized infections discussed above in critically ill chelonians. Multiple gram-negative bacteria are most commonly cultured, however, anaerobic bacteria and fungal organisms may also be isolated. Clinical signs may include anorexia, lethargy, weakness, red-purple oral mucous membranes, and general malodor of the turtle. Sucessful treatment of sepsis is more likely if clinical signs are recognized early and treatment is begun prior to diagnosis on predisposed turtles. Administer room-temperature fluids and IV broad-spectrum antibiotics while the patient is still cool. Then gradually warm the pateint over a 48 hr span while continuing therapy.

**Pneumonia**

Pneumonia is a common problem of critically ill chelonians. Suboptimal temperatures, increased humidity, malnutrition, overcrowding, are predisposing factors for pneumonia. Because reptiles tolerate an anaerobic environment and they can conceal clinical signs of pneumonia until the condition is severe. Pneumonia can be caused by a wide array of infectious diseases. Gram-negative bacteria are recovered from a large percentage of the cases. These are often opportunistic infections with the same bacteria being considered normal flora in the healthy chelonian. Anaerobic bacteria are more difficult to culture but do represent an important cause of pneumonia. Although less commonly isolated, atypical bacteria such as chlamydia, and mycobacteria are also important pathogens to consider. Herpesviruses have been implicated in respiratory disease of several chelonian species including sea turtles and may lead to immunosuppression and predispose the patient to secondary bacterial and fungal infections.

Chelonians appear to be more susceptible to fungal pneumonia than other reptile orders. Over exposure to fungal spores, immunosuppression, or overuse of antibiotics are predisposing factors. *Aspergillosis, Candida, Mucur, Geotrichum, Penicllium, Cladosporium, Rhizopus, Beauveria, Sporotrichum*, *Basisiobolus ranarum* and *Paecilomyces* have been isolated from chelonians with pneumonia. Migrating nematode parasites and digentic spirorchid trematodes may predispose the chelonian to bacterial or fungal pneumonia. Aspiration pneumonia may occur in debilitated chelonians. Clinical signs may include anorexia, lethargy, increased or abnormal respiratory sounds, increased respiratory rate-especially at rest,and asymmetric floating in aquatic species. Abnormal posture can also be noted in cases of inspiratory and/or expiratory dypsnea, which may manifest itself as laboured breathing with the neck extended and mouth open.

Diagnosis of pneumonia is based on history, physical examination, and horizontal beam anterior-posterior and lateral radiographic views. A tracheal wash should be performed prior to starting therapy if the patient can tolerate the procedure. Sedation may be necessary. A sterile red rubber catheter or bronchoscope is placed through the glottis, down the trachea, through a bronchus and into the lung. If the pneumonia is unilateral based on radiographic findings then the appropriate side should be targeted. Sterile saline solution should be flushed through the catheter and then aspirated back. Bronchoscopy is limited to larger patients but will allow visualization of the respiratory tract and collection of appropriate samples. Cytology and culture should be performed on samples obtained. Fungal pneumonias often produce localized or diffuse granulomatous nodules, which makes recovery of the organism difficult without a biopsy. Nodules noted on radiographs are suggestive of fungal involvement. Therapy includes minimizing stress, providing a positive nutritional balance, and maintaining hydration. Patients in extreme respiratory distress from pneumonia should be positioned on a slight incline with head and forelimbs extended. Intubate and suction the trachea and clean the endotracheal tube and oral cavity frequently. Coupage may be helpful in bringing up debris to be suctioned. Supplemental oxygen may inhibit respiration and compromise the chelonian's limited ability to eliminate inflammatory debris. Oxygen supplementation should be humidified to avoid irritation of the respiratory system. Treat bacterial pneumonia with broad-spectrum antibiotics based on culture and sensitivity. Nebulization therapy increases the humidity of the respiratory epithelial microenvironment thus improving pulmonary hydration and the mucociliary transport mechanism. Furthermore, it assists in breaking up necrotic and inflammatory debris and delivers antimicrobials directly to the site.

Treatment of fungal pneumonia in chelonia is difficult and often unsuccessful. Medical management generally consists of oral subcutaneous administration of fluconazole or intraconazole based of pharmacokinetic data.

**Nutritional diseases**

Starvation or cachectic myopathy may occur in captive and free-ranging chelonians. In captive specimens primary malnutrition and poor husbandry (e.g. suboptimal environmental temperatures) are common primary causes. Emaciated free-ranging chelonians usually have an underlying problem. The underlying cause of the emaciation may be masked by numerous secondary medical problems such as bacterial or fungal pneumonia, septicemia, and severe endoparasitism. These turtles may be critically anemic, hypoproteinemic, and hypoglycemic. They often have severe ascites, serous atrophy of fat, lymphoid depletion, and bone marrow suppression.

Severely malnourished chelonians may present in a moribund state and require emergency care. Treatment of energy deficiency in chelonians should involve fluid and electrolyte replacement initially. Iron dextran injections, whole blood or artificial hemoglobin replacement products administered IV, broad-spectrum antimicrobial drugs, appropriate deworming, tube feeding electrolytes and glucose initially and eventually small but increasing levels of calories and nutrition.

**NECROPSY**

See the following website which has detailed information and recommendations for necropsy techniques in sea turtles. There are also images on anatomical structures and pathological conditions. There is also a necropsy report form that can be downloaded. http://www.vetmed.ufl.edu/sacs/wildlife/resear.html

**II. Captive sea turtles**

**Captive environment**

- **a) water quality:** temperature (25-28 degrees C recommended), salinity, pH, chlorine, ozone, ammonia, nitrite, nitrate, and total coliform bacterial counts
- **b) filtration:** larger aquaria typically use large filtration systems that either use chlorine or ozone injection to oxidize the organic material produced from the animals and to reduce bacterial loads-both can cause irritation to mucous membranes and eyes. Use less than 1 ppm total chlorine content. Smaller tanks (e.g. rehabilitation facilities) usually have less complicated filtration systems
- **c) lighting :** intensity, duration, wavelength (full-spectrum lighting (UV A and B and infrared light) may be of benefit to sea turtles that do not have access to natural sunlight), photoperiod (12-18 hrs); in the wild-bask and float at surface; outdoor enclosures with direct and indirect (shade cloth) sunlight are preferred for rehab when feasible
- **d) enclosure construction:** shape, materials, substrate, décor; as tank volume is reduced, the enclosure should become more cylindrical with few or no obstructions
- **e) water depth and current flow**
- **f) ambient sound levels**
- **g) destructive nature:** bite décor and divers, sturdy nonabrasive materials must be used in exhibits; will dig in substrate so may destroy portions of the biological filter
- **h) ingestion of foreign material:** can cause GI upset, ulceration, obstruction, or perforation
- **i) nutrition**
- challenge to provide captive sea turtles their natural diet in sufficient quantity
- greens: leafy dark green vegetables mixed with small amounts of fish and invertebrates, hatchlings are carnivorous and are often fed a diet consisting of fish, crabs, squid and shellfish. Commercial pelleted turtle feed, modified trout chow, and gelatin based diets have been used with varied success.

- Other species commonly fed fish and inverts such as smelt, herring, capelin, mackerel, squid, crabs and shrimp. Fish handling and storage are the same as recommended for other species. Multivitamin supplement twice weekly when feeding a diet such as this. Thiamine (25 mg/kg fish) and vitamin E (100 IU/kg of fish) are particularly important supplements. Vitamins that have been utilized in sea turtles include Mazuri avian vitamin supplement, SeaTabs, and multivitamins used in humans
- General rule of thumb: feed hatchlings 5% of their body weight, yearling turtles 1.2-3%, and 2 year olds 1.5%, 4 yr olds 0.8% of their body weight daily. Weigh hatchlings to l year old weekly and then monthly thereafter.
- Gelatin diet recommended for first year and then can switch to more natural food items
- Sea turtle gelatin diet

| Ingredient | Weight (g) | % of diet |
|---|---|---|
| Trout chow | 425 | 8.0 |
| Fish (various species) | 565 | 10.6 |
| Squid (viscera removed) | 282 | 5.3 |
| Peeled shrimp | 282 | 5.3 |
| Spinach (fresh or frozen) | 142 | 2.8 |
| Carrots (fresh) | 142 | 2.7 |
| Gelatin (unflavored) | 450 | 8.5 |
| Water 2800 ml | 2800 | 53.0 |
| **Supplements:** | | |
| -Sea Tabs (Pacific research labs, inc., El Cajon, CA), Mazuri avian vitamins May be more appropriate | #4 500 mg tabs | 0.04 |
| -Amino Acid Complex 1000 | #4 500 mg tabs | 0.04 |
| -Spirolina (lightforce, Santa Cruz, CA) | 50 ml powder (28 g) | 0.50 |
| -Rep-Cal (Rep-Cal Research Labs, Los Gatos, CA) | 200 ml powder (180 g) | 3.4 |

**j) nutritional diseases**

- any disease process causing cessation of feeding will eventually produce a malnourished sea turtle. See cachectic myopathy in free ranging turtles
- **generalized malnutrition:** hypoglycemia, hypoproteinemia, and anemia are commonly observed in malnourished turtles
- **metabolic bone disease:** caused by deficiencies in calcium, vitamin D, improper calcium/phosphorous ratio, lack of exposure to UV light, or a combination of these factors. Clinical signs may include a soft deformed shell, limb fractures, and malformed overgrown rhampthotheca. Radiographs can aid in diagnosis in advanced cases. Has been documented in sea turtles fed dried krill-cortical thinning, bowed femurs, and healed pathological fractures, decreased growth rates; has been documented on numerous occasions; rapidly growing captive animals continually fed diets below the generally accepted 1:1 to 2:1 ratio are prone to develop secondary nutritional hyperparathyroidism. Need proper UV radiation and dietary vit D3 (over supplementation and toxicity can also occur)
- **iron deficiency:** diets of squid and fish in juvenile turtles have lead to iron deficient anemias. Respond to dietary improvement and iron supplementation
- **gastrointestinal obtruction:** inappropriate sized food items fed to a sea turtle may cause obstruction, will eat anything in the tank

Example: Volvulus of the proximal colon in a hawksbill turtle JZWM 27(3): 381-391, 1996, Schumacher et al.

-lethargy and anorexia
-xray: obstruction of distal colon
-died, coelomitis, ascites

-distal colon contained multiple FB-rubberband, multiple pieces of wire incorporated into a firm fecal mass, 360 degree volvulus, heavy growth of clostridium--toxemia secondary to volvulus
-wild turtles often swallow rocks, stones, shells while foraging-may cause problems if immunosuppressed or altered GI motility, often do not cause problems
-plastic bags and fishing nets common causes of obstruction
-this was a turtle undergoing rehab at a facility for 9 mo for injured flipper

Example: Medical tx for multiple foreign objects in a hawksbill turtle, JZWM, 25(1): 158-160, 1994, Reidarson et al
-captive animal, presented with inappetence, wt loss, multiple objects on xray (pennies, plastic pipe pieces, and some rocks)
-reestablished motility with fluids, antibiotics, metaclopromide-all objects were then expelled
-Hatchlings spend much of their time floating at the surface-provide buoyant sargasm or artificial sea weed on which to rest and feed . May ingest large amounts of gravel or crushed coral, resulting in impaction.

**k) trauma:** other sea turtles, sharks, fish in same tank. Bite wounds on each other due to overcrowding. House sea turtles separately if possible to avoid intraspecific trauma.

l) **viral diseases:**

- **Grey Patch disease of green sea turtles**

**Etiological agent**: Herpesvirus, only found in captivity
**Clinical signs**: May infect up to 100% of hatchlings between 56 and 90 days (up to 1 year), skin lesions begin as small circular, papular lesions, eventually coalesce into patches
**Lifecycle**: Virus may be transmitted via the egg, direct transmission.
**Predisposing factors**: Overcrowding, increased water temperature, poor water quality.
**Pathology**: Basophilic intranuclear inclusions.

- **Herpesvirus in green sea turtles (Lung-eye-trachea disease LETD)**

**Etiological agent**: Herpesvirus, has been identified in tissue section and isolated.
**Clinical signs**: Twelve to 24 month old green sea turtles, 1 unpublished case occurred in a loggerhead sea turtle. Repiratory tract disease-gasping at surface of water, buoyancy abnormalities, and inability to dive properly. Eyes often covered with caseous exudate. Some turtles die after several weeks, some become chronically ill for several months. The disease spreads quickly through the tank and runs its course in 2 to 3 weeks.
**Pathology**: Gross-periglottal necrosis, tracheitis with intraluminal caseous and laminated necrotic debris, and severe pneumonia, caseous conjunctival exudate covering the eyes. Microscopically-fibrinonecrotic inflammation around the glottal opening, tracheitis, and severe bronchopneumonia and interstitial pneumonia. Hypertophic nuclei with amphophilic intranuclear inclusions in periglottal and tracheal epithelial cells. Secondary bacterial infections. Herpesvirus was isolated and visualized on EM.
**Comments**: This disease has occurred primarily at the Cayman Turtle Farm, but sporadic cases have occurred. Clinical signs only in captive turtles but finding serological evidence of exposure in free ranging populations

**m) Fungal agents**

- **Mycotic pneumonia in mariculture-reared green sea turtles**:

**Fungi isolated**: Sporotrichium sp, Cladosporium sp, and Paecilomyces sp.
**Clinical signs**: Abnormalities in buoyancy, chronic weight loss.
**Predisposing factors**: Outbreaks occurred during winter months (the lower the temperature, the higher the mortality).
**Pathology**: Exudative plug often found obstructing the trachea. Small white nodules in both lung lobes, however, right lung more severely affected and often collapsed and nodular whereas the left lung was often emphysematous and filled the left coelomic cavity, nodules found in liver. Histopatholgy revealed granulomatous lesions containing branching septate hyphae.
**Comments**: Normally juvenile green sea turtles have a right lung that is smaller than the left. The liver overlies the right lung but not the left and may have a mechanical effect.

**n) Bacterial agents:**

- Trauma from conspecifics
- Pneumonia secondary to poor environmental conditions
- Aeromonas hydrophila, Vibrio, E coli, Citrobacter, Enterobacter, Proteus, Pseudomonas, Salmonella, Mycobacterium, Edwardsiella, Arizona, Flavobacterium are the most common bacteria isolated from sea turtles
- Ulcerative stomatitis/obstructive rhinitis/pneumonia: can cause high mortality rates in hatchlings and juvenile green and loggerheads; initially plug of caseous material in one nares or in the pharygeal area of the oral cavity; become anorexic, lethargic and float; if pneumonia present often will float asymetrically; treatment consists of systemic antibiotic, supportive care, and isolation
- Dermal bacterial infections are not uncommon in captive sea turtles; may cause ulceration and discoloration or proliferative lesions of the skin; may lead to septicemia.
- Chlamydia spp documented in several hundred juvenile green turtle at the Cayman Turtle Farm; lethargic, weak, and floating. Necropsy: gray patchy lesions noted on hearts; liver enlarged and friable. Histo: necrosis of myocardium and hepatic tissues. Confirmed with EM and culture.

**p) Parasites**

- Caryospora cheloniae, a coccidian pathogen of mariculture-raised green sea turtle.
- Amebiasis: *Entamoeba invadens*; Enteritis and hepatitis. Mortality reported in captive sea turtles. Important to keep other aquatic turtles separated from sea turtles in a rehabilitation or captive setting. A parasite that may be asymptomatic in one species may be devastating to another.

**p) quarantine:** recommendations would be similar to other captive zoological species. It is also wise to quarantine new arrivals into a rehabilitation facility. Sixty to 90 days is the minimum period that a turtle should be kept completely separated. Each tank should have its own filtration systems if possible. Separate equipment should be designated for the quarantine turtle. Separate quarantine staff or staff should care for the quarantine turtle last, wash hands with disinfectant soap, and wear protective clothing. This especially important for turtle facilities receiving turtles with fibropapillomas or other infectious disease syndromes. Unfortunately, this is not always practical. When designing facilities for sea turtle rehabilitation, a small quarantine area would be very beneficial. A complete physical examination, CBC, plasma chemistry panel, radiographs, infectious disease serology, fecal examination should be performed during the quarantine period.

## SEA TURTLE MEDICINE AND SURGERY APPLICABLE TO THE CAPTIVE OR REHABILITATION OR FIELD RESEARCH SETTING

### STRANDED SEA TURTLES SHOULD BE TRANSPORTED IMMEDIATELY TO A REHABILITATION FACILITY OR OTHER DESIGNATED FACILTY FOR INITIAL EVALUATION

- Place on thick blanket or foam pad
- Prevent hyperthermia (wet towels, temperature controlled vehicle) or hypothermia (dry towels, temperature controlled vehicle) depending on the weather conditions

### PHYSICAL RESTRAINT

- can be utilized for most non-invasive/non-painful procedures
- small sea turtles: gently grasp the lateral margins of the turtle’s shell with one or both hands, avoid excessive pressure on the flexible shell
- larger sea turtles: firmly grasp the carapace just caudal to the head with one hand and grasp between the hind flippers with the other
- heavier animals: may need numerous personnel to lift the turtle, may need additional equipment such as a mechanical hoist and padded carrier
- healthy sea turtles will try to bite and slap their flippers; can inflict a serious bite
- turtles may calm down when placed on their back

## ANESTHESIA (refer to Table 2 for dosages)

While anesthesia or sedation is necessary in some emergency situations, it should be used with caution in dehydrated or debilitated patients. A thorough diagnostic workup should occur prior to anesthesia if blood work reveals a PCV less than 10% or a plasma TP less than 2.0 g/dl, or if there is evidence of sepsis or severe respiratory compromise.

The author's preference for injectable anesthetics include use of combination of medetomidine and ketamine (M-K) or propofol IV for short relatively non-invasive procedures or for induction of general anesthesia. The advantages of the M-K combination are that it may be given IM or IV, the M is reversible with atipamezole given IM so recovery is relatively fast, and very low doses of ketamine may be used because of synergism with medetomidine. The low ketamine dose does make a significant difference in the level of sedation and muscle relaxation. Butorphanol may be added to the M-K cocktail for additional analgesia and sedation.[67] Disadvantages of the M-K anesthetic regimen include induction of significant bradycardia, hypotension, hypercapnia, and hypoxemia. Furthermore, these drugs may be contraindicated in debilitated or dehydrated chelonians especially those with hepatic or renal dysfunction. Use the lower end of the dose range in debilitated sea turtles after stabilization. Propofol is a hypnotic sedative that provides rapid induction. While intravenous injection is preferred the drug does not cause irritation if it is extravasated. Dilute the drug with two parts saline to one part propofol and administer over one to two minutes. The faster the drug is given, the more marked the respiratory depression. Propofol dosages range from 2-15 mg/kg with recovery rates being dosage dependent. Use the lower end of the dose range in debilitated chelonians to allow intubation. Local anesthesics, such as lidocaine, may be used alone or in combination with injectable or inhalation anesthesia.

Inhalant anesthetics are used for invasive or prolonged procedures. In critical chelonian patients, it may be advisable to use inhalation anesthetics without an injectable induction agent. Ventilation and thermoregulatory support should be maintained during the procedure and throughout the recovery period. Monitor heart rate via a Doppler, pulse oximeter, or ECG. Intraoperative fluid therapy and vascular access for emergency support should be maintained. Although isoflurane is useful in reptiles, sevoflurane provides significant reduction in recovery times and may be more appropriate for critically ill patients. Sea turtles are notorious for prolonged recoveries with a variety of anesthetic regimens and have much faster recoveries when using the reversible combination of medetomidine and ketamine for induction and sevoflurane for maintainance anesthesia.

## ANALGESIA (refer to Table 2 for dosages)

Many critically ill chelonians are painful and benefit from analgesics. Chelonians are relatively stoic and challenging to assess for pain. Pain may be exhibited in chelonians by a decreased appetite, depression, or alteration in normal behavior. The non-steroidal anti-inflammatory drugs (NSAID) are long acting and decrease endotoxin production in septic patients. Meloxicam, carpofen, ketoprofen, and flunixin megalimine have been used in chelonians. Although the NSAID efficacy has not been evaluated extensively by controlled studies, anorexic and depressed chelonians often develop normal feeding behavior and activity after NSAID administration. Adequate hydration and renal function should be assured prior to NSAID administration and duration of administration should not exceed 3 to 5 days.

The opioids butorphanol and buprenorphine are commonly used in chelonians for pain control. Disadvantages of opioid administration include that they are relatively short acting and may cause sedation in debilitated patients. Butorphanol is contraindicated in patients with head trauma.

## DIAGNOSTIC TESTS/SAMPLE COLLECTION/THERAPEUTIC PROCEDURES

### Triage Principles In Chelonians Presented For Emergency

Ideally, the emergency chelonian patient should be medically evaluated and then stabilized. However, initial emergency treatment may need to take precedence over a diagnostic work up in a critically ill turtle. When possible a minimum database should be established prior to starting emergency therapy. The keys to success in medically managing chelonians are patience, minimize stress throughout the course of treatment, minimize handling time by being prepared, treat dehydration and monitor maintain adequate hydration status, provide appropriate nutritional support, and lastly maintain the turtle at its POTZ.

A physical exam form that includes a turtle diagram is recommended for recording morphometrics and external abnormalities such as shell fractures, missing flippers or limbs, and lacerations. Digital images can document specific lesions or injuries for long-term case monitoring. Gender and a rough age estimate via counting scute growth rings, morphometrics and body weight should be determined. Determine a body weight prior to therapy and then serially during patient treatment. Weight trends can be a good indicator of hydration status. Body weight, morphometric measurements can aid in evaluating and quantifying nutritional problems such as obesity (captivity), cachexia, and metabolic bone disease. Sunken eyes, depressed pectoral muscles, and a convex plastron are signs of weight loss and dehydration. Observe turtles respirations prior to handling, auscultation is not very helpful.

Deep cloacal temperature may be representative of the recent environmental temperature and is an important parameter to obtain and monitor in hypo- and hyperthermic patients. A digital, distant laser, thermal monitor device (Rayngеr ST, Raytek Corporation, 1201 Shaffer Road, P.O. Box 1820, Santa Cruz, CA 95061-1820) detects surface body temperature and when directed at the pre-femoral or pre-scapular areas correlate well with core body temperature. Heart rate and rhythm can be assessed with an esophageal stethoscope, a pulse oximeter cloacal probe, or a doppler probe placed in the region of the thoracic inlet between the distal cervical region and the proximal front leg.

Evaluate the limbs for swollen joints and fractures. The plastron and carapace should be evaluated for scute quality, abnormal keratinization, hardness and pliability, fractures, ulceration, malodor, and external parasites or epibionts. Hemorrhages of the scute keratin may be indicative of trauma if localized or septicemia if more generalized. Examine the skin for sloughing, abnormal shedding, swellings, edema, abscesses, ulceration, exudate, malodor, and epibiota and external parasites. Assess epibiota load (barnacles, leeches, etc); look for fibropapillomas; biopsy/histopathology of skin lesions and growths..

Digital palpation of the caudal coelomic cavity in the inguinal fossa while rocking the turtle gently can determine the presence of eggs, cystic calculi, organ enlargement, masses, or fluid. The cloacal region should be examined for swelling, trauma, abnormal discharge, and infection. Digital palpation of the cloaca may aid in assessing gravidity, colonic and cloacal tone, cystic calculi or space occupying lesions.

Evaluate oral cavity: nylabone can be used as a mouth gag or rope can be used on lower and upper beak to open (mouth can be opened with constant pressure on the lower jaw (easy to fracture or chip beak if hard materials are used to hold mouth open. Inspect the oral cavity including the tongue, glottis, choana, and outlets of the eustachian tubes. Pay attention to mucous membrane color, excessive mucus, petechiation, plaques, ulceration and caseous material. Perform a complete ophthalmic exam of the cornea, anterior and posterior chambers and assessment of menace and papillary visual reflexes. A periocular exam and evaluation of the beak, mandible, tympanic membranes and nares should also be performed while the head is restrained.

An emergency chelonian minimum database should consist of a hematocrit, total solids, glucose and subsequently a complete blood count and plasma biochemical panel. Perform bacterial blood cultures prior to antimicrobial therapy if enough blood can be obtained. While, the size and condition of the patient dictate the amount of blood that is possible to obtain, the author generally recommends 0.5-0.8 ml /100 g body weight with volume decreased in ill patients. Lithium or sodium heparin are the anticoagulants of choice, because EDTA causes red blood cell lysis in sea turtles. Blood drawing sites: dorsal cervical sinus: most commonly used, 20-22 gauge, 1 to 1.5 inch vacutainers work well in larger turtles (not leatherbacks); smaller needles for small sea turtles; important to extend neck; needle is placed paramidline and angled slightly toward the shell. Leatherbacks: spinal needle for cervical sinus, other potential sites includemetatarsal vessels, tail vein, or digital vessels.

Radiography is an important diagnostic tool often used in sea turtles. Sedation is not required. Radiopaque materials such as barnacles should be removed from the shell prior to radiographic study. Three radiographic views should be routinely performed in chelonians: anterior-posterior and lateral projections using a horizontal x-ray beam and a dorsoventral view. Additional views such as lateral, dorsoventral and oblique, may be needed for specific problems such as fractures of the limbs or skull. An anterior-posterior horizontal beam radiograph should be taken in chelonians with fractures of the carapace to assess lung involvement. Digestive tract radiographic contrast procedures are often necessary to document intestinal obstruction, ileus, and foreign bodies. Radiology may be useful in evaluating the extent of external trauma, bone density, fractures, foreign body detection, respiratory tract, internal fibropapillomas.

Other diagnostics that are useful in evaluating ill and injured sea turtles include:

**a) endoscopy (flexible and rigid)**

- flexible endoscopy allows removal of esophageal and gastric foreign bodies (difficult due to esophageal papillae which tend to impale or catch items as they are withdwawn; can be hard to pass the endoscope down the distal esophagus because it turns sharply to the left under the heart before passing through the muscular esophageal sphincter and into the stomach); laparoscopy (rigid endoscopy) allows for an internal examination and biopsy collection without major surgery. The turtle is placed on its back with its cranial carapace tipped slightly downward so that the intestines fall away from the site of entry just anterior to the right or left rear flipper. Insufflation with CO2 or air is often needed to carry out a complete exam.

**b) ultrasound:** sedation not required, small turtles 7.5 MHz transducer, 3-5 MHz probe in larger turtles; 3 acoustic windows for visceral examination: mediastinal (cardiac), axillary (liver, pectoral muscles, and heart, inguinal (kidneys, urinary bladder, stomach, intestines, right liver lobe, reproductive tract, and gallbladder); adult males can visualize heart through the plastron (wear down plastron when breeding females); can use to evaluate internal fibropapillomas; reproductive tract evaluation

c) **Coelomocentesis:** withdrawal of fluid or air in coelom; needle size depends on size of turtle; ultrasound can be utilized to find fluid or air pockets more efficiently; place turtle in VD recumbancy, extend rear flippers caudally, and insert needle anterior to the femur in a craniomedial direction.

**SURGERY**

**a) inguinal incision**

- provides access to caudal half of coelom
- intestines can be exteriorized through incision (intestines are not supported by strong attachments unlike other chelonians)

**b) rigid fiberoptic laparoscopy**

**c) plastronotomy**

- avoid if possible

**d) laser surgery for fibropapillomas removal (see FP section)**

**Determining hydration status and fluid therapy**

Upon completion of the initial evaluation, the patient should be stabilized. Most chelonians presented for emergency care are dehydrated, thus rehydration is often the first step in treatment. Physical examination findings indicative of dehydration in chelonians include sunken eyes, changes in skin turgor, skin tenting, loss of skin suppleness, dry mouth with ropey, thick oral secretions, depression, a slow and difficult to find heart beat, and minimal to no urination. Venipuncture is more challenging in the dehydrated patient. Weight loss found over 1 to 14 days is likely caused by dehydration, thus serial body weights should be performed during hospitalization. Elevation of the packed cell volume (PCV) and total solids or total protein (TP) can be helpful in determining the extent of dehydration. However, ill chelonians are often anemic and hypoproteinemic, which may mask the extent of dehydration. Serial PCV and plasma TP determinations help assess the status of the patient and target the most appropriate therapeutic regimen. Hypoglycemia or hyperglycemia is often present in sick chelonians. Blood glucose determination is easy, quick, inexpensive and essential in choosing the appropriate fluid therapy in chelonians.

**Fluid types**

Fluid choice is dictated by clinician preference, and the patient's presenting problem, clinical pathology and acid-base abnormalities. Most debilitated chelonians benefit from rehydration therapy and glucose supplementation. Mammalian crystalloid fluid preparations are suitable for chelonians. Fluids commonly used in chelonians include "reptile ringers solution" (one part Lactated Ringers Solution + 2 parts 2.5% dextrose and 0.45% sodium chloride), Normasol-R, and lactated ringers solution. Use of lactated ringers solution is controversial in chelonians based on the common finding of lactic acidosis. It is critical to correct hydration status of the ill chelonian prior to starting oral nutritional support.

Whole blood transfusions are indicated in cases of acute hemorrhage and life threatening anemia. Sea turtles with a PCV of 5% or less may benefit from whole blood transfusion from a healthy captive sea turtle donor (Manire, C, pers comm., 2005). Those chelonia with a higher PCV can often be successfully managed with fluid therapy, iron supplementation, and other supportive measures. The donor and recipient should be the same species, because cross matching has not been perfected in reptiles. Use Acid-citrate-dextrose (ACD) solutions to collect blood for transfusion.

Other colloid options include hetastarch, diluted 1:2 or 1:3 with 0.9% saline and given at a rate of 0.1ml/kg every 10-15 minutes, may be used in chelonians with severe shock from massive blood loss. A purified bovine hemoglobin (Oxyglobin) has had limited clinical use in sea turtles[29] and desert tortoises with out adverse affects. In healthy desert tortoises (*Gopherus agassizi*) this product was used at doses of 20 ml/kg intravascularly at a rate of approximately 100 ml/hr without adverse effect.[30] Discolored mucous membranes are normally observed after using this product.

**Route of fluid therapy**

**Intravascular**

In severely compromised chelonians, intravenous (IV) or intraosseous (IO) routes of fluid administration allow for rapid rehydration and emergency therapy. However, placement and maintenance of catheters in these sites can be technically challenging and should be reserved for patients that are unconscious or minimally responsive. Intravenous or IO routes are necessary for administration of whole and artificial blood, colloidal fluids, and fluids containing greater than 5% dextrose. Intraosseous catheters may be placed in the distal humerus. An appropriately sized spinal needle is inserted in the distal one fourth of the medial aspect of the humerus at an angle of approximately 30 to 45 degrees from parallel. The needle should be inserted as distally as possible without entering the joint capsule. Confirm the spinal needle position radiographically. The catheterized limb is then be folded and secured with tape to the carapace. Disadvantages of IO catheterization are that the fluid flow is rate limited due to the small bone marrow space in chelonians, fluid and drug administration may be painful, and the metal of the spinal needle may fatique and break.

Bolus IV fluid therapy can stabilize some patients prior to pursuing other routes of administration. The cervical sinus is used for this purpose in sea turtles. Advantages to the bolus IV method include easy vessel accessibility, minimal stress to the patient, and repeated vascular access.

The intracoelomic (IC) route is commonly used for maintenance fluid therapy in sea turtles. Fluids may be injected into the coelomic cavity through the inguinal fossa. An IC catheter has been described for use in sea turtles for up to 5 days. This route is technically easy and allows administration of crystalloid fluids with up to 5% dextrose, however, fluids may not be absorbed rapidly when given by this route. Disadvantages of ceolomic administration include the potential of compromising the lung space or perforating the lungs, the urinary bladder, or an ovarian follicle in mature females. Hypoproteinemic patients may have fluid in the coelomic cavity (ascites/anasarca), which will further complicate absorption.

Subcutaneous fluid administration is technically easy. Fluids can be given into any accessible fold of skin, but typically are placed in the inguinal fossa, medially in the front limb fossa and the ventral neck fold. Administering the fluids in multiple sites may improve absorption and rehydrate the chelonian faster. Disadvantages to this route include poor absorption in severely debilitated chelonians and that only 2.5% dextrose or less can be administered.

The oral route of fluid administration should be reserved for use in patients that are mildly to moderately dehydrated and for maintenance fluid therapy. Severely dehydrated and weak turtles tend to regurgitate orally administered fluids. Initial tube feeding should be performed using oral fluids consisting of electrolytes and dextrose, rule out an impaction or obstruction and make sure the turtle is well hydrated prior to starting solid food. Fluids can be administered into the stomach tube using an appropriately sized, well-lubricated red rubber or metal feeding tube. An equine stomach tube may be used for large sea turtles. A nylabone works well as an oral speculum or padded wood or plastic rod place turtle into a vertical position with caudal edge of the carapace resting on a soft surface, such as a foam pad, extend head and neck (straightens the esophagus during passage of the tube into the stomach), before returning to a normal position, the tube is removed but the head remains in an extended position and the turtle is allowed to swallow For long-term oral medication, fluid therapy and nutritional support, an esophagostomy tube may be consideration. The stomach volume in most chelonian patients is about 2% of the body weight or 20 ml/kg. Anatomically, the stomach is located in the anterior one third to mid-carapace. The distance to the anterior portion of the stomach should be marked on the tube selected for feeding. The patient is placed at a slight incline on a padded board avoid regurgitation and to assist in passing the feeding tube into the stomach. The head and neck should be extended to straighten the esophagus for tube passage. The head should be secured by grasping the turtle on either side behind the mandible. Steady downward pressure will cause the lower jaw to fatigue and open. A padded speculum or Nylabone in larger specimens will then assist in keeping the mouth open. The turtle is held in a vertical position after tube removal with head and neck extended until it swallows to prevent leakage of the fluid from the stomach and mouth when the turtle is returned to its normal position.

Mildly dehydrated sea turtles will benefit from placement in fresh water for 24 hours via rehydration and reduction of epibiota load. Fluids, various drugs, elemental diets, and dewormers may be administered by the intra-cloacal route. Absorption is slightly better if the turtle is tipped with the cloaca higher than the head in the 10 to 20 min after fluid administration.

**Volume of fluids to administer**

The volume of fluids to administer depends on the degree of dehydration and if hypoproteinemia and anemia are present. Fluid volume should not exceed 2 to 3% total body weight (TBW) in chelonians. Generally recommended maintenance fluid rates range from 15 ml/kg/day in species greater than 1 kg to 25 ml/kg/day in species less than one kilogram. Over hydration is a concern because of the slow metabolism in chelonians. Infusion or syringe pumps can be used to accurately control the flow rate.

**CPR principles in chelonians**

The following protocol is recommended for sea turtles presented in respiratory or cardiovascular arrest. Check the heartbeat with a Doppler probe, electrocardiogram, and/or ultrasound. Proceed only if cardiac electrical activity is present. Extend the head and neck, swab the mouth to remove any materials blocking the glottis, and intubate the patient with an uncuffed endotracheal (ET) tube. Use suction and or gravity by tilting the anterior aspect of the turtle downward to remove any material in the tube. Ventilate the patient with oxygen supplementation. An ambubag can be used for field emergencies. Lubricate the eyes if they are open. Place an IV or IO catheter, obtain blood for a minimum database, and then bolus fluids and emergency medications. If heart rate stays below 20 bpm with ventilation and bolus fluids, give glycopyrrolate or atropine IV. Epinephrine can be given IV, IO, IP, intratracheally or intracardiac. Administer broad-spectrum antimicrobial therapy.

Although several pharmacokinetic studies have recently been conducted on chelonians, limited information is available for accurate dosing. Drugs with available pharmacokinetic data should be choosen when possible. Although there are limitations to metabolic scaling, it can be a useful tool where no pharmacokinetic data is available. Sick chelonians do not necessarily absorb drugs well, so correct hypothermia, dehydration, hypoglycemia, acid-base and electrolyte imbalances prior to or in conjunction with starting other therapeutic agents. This is especially important when using nephrotoxic or hepatotoxic drugs and anesthetics. Drug pharmacokinetics are temperature dependent in reptiles and it is best to keep the chelonian patient at its POTZ while on therapy.

**Antimicrobial therapy (Refer to table 1 for dosages)**

Sick and injured turtles are usually given broad-spectrum antibiotics as a treatment for established bacterial infections or as a preventive measure. Diagnositic samples should be obtained for culture and sensitivity testing prior to starting antibiotic therapy whenever possible. Although controversial, the front half of body including the soft tissues of the forelimbs and neck should be used for injections and is especially important when using nephrotoxic drugs. Enrofloxacin is a commonly used antibiotic in chelonians and has good efficacy against several aerobic bacteria especially gram negatives. Unfortunately, it causes tissue necrosis when injected IM or SQ and is painful upon administration. The irritating effect of the drug can be reduced significantly by diluting it in fluids or sterile water and using the subcutaneous route for injection. Once the patient is stabilized, it can be administered orally. Anaerobic bacteria can also cause significant morbidity in chelonians and should be considered when deciding upon a therapeutic plan.

**Nutrition needs of this species in the emergency setting**

Nutritional support is an important component of chelonian critical care. Patients respond more quickly to therapy if their nutritional status is positive. The critically ill chelonian is often immunosuppressed secondary to starvation. Regurgitation and aspiration may occur in dehydrated and debilitated chelonians. These turtles may not be able to digest solid food and the material may remain in the stomach as a result of decreased gastrointestinal motility. Thus gastrointestinal (GI) nutritional support should not be instituted until the patient has been rehydrated and attains normal blood glucose and GI motility. The volume of formula fed by stomach tube is approximately 7% of the turtle’s body weight in grams daily. Begin with smaller volumes and more dilute solutions and steadily increase the volume and concentration to meet the turtle’s nutritional requirements. Weigh the ill turtle frequently during the convalescent period and use weight gain and loss as a guide for dietary management.

Debilitated turtles are often dry docked on a padded surface for initial emergency care. These turtles are kept moist by regular misting and placing Vaseline or water-soluble (K-Y) jelly on the skin and shell. Upon stabilization, specialized facilities are needed for critical care. Sea turtles require specially designed circular fiberglass tanks with a filtration system and continuous flow temperature controlled salt water. You must adjust water levels to accommodate turtles with varying degrees of debilitation. Electrical outlets, cords and filtration systems should be separated from direct turtle contact.

**Convalescence**

- Turtles that are still weak and debilitated can be placed in a pool with drain holes that allow continual spraying to keep them wet but prevent from drowning
- Seriously ill turtles that are unable to swim will drown if placed in more than a few inches of water. A sling may be fashioned that allows the turtle to float with its head above water while reducing pressure on the plastron, which otherwise may result in repiratory compromise. Foam noodles kept in place with vet wrap
- Weak turtles that can lift their heads to breathe and can swim should be kept in approximately 2 feet of water
- Active turtles place in deep pools that allow room for swimming (4 to 5 foot diameter plexiglass pools in rehab setting)
- Dehydrated turtles and those covered with barnacles should initially be placed in fresh water
- Normally hydrated turtles should be kept in salt water with salinity equal to that of sea water (35 parts per million (ppm)
- Chlorinated water can be used (1 ppm or less, greater than this will cause ocular irritation)
- Water temperature (25-30 degrees C, 77-86 degrees F)
- Once rehydrated and normal glucose established, then can start feeding a gruel (increase thickness as condition improves) or feeding natural food items (high protein, low fat fish such as smelt or mackerel are first good choices), may need to cut fish into smaller pieces for smaller turtles, avoid squid and clams initially because they take longer to digest, romaine and other dark green leafy lettuces can be offered to green turtles, trout chow and specially formulated pellets to green turtles
- Goal for amount of formula to feed is 7% of turtles body weight per day, start out with small volume and increase gradually
- Weigh frequently
- Hatchlings can be tube fed an electolyte/glucose solution (may regurgitate) or given SQ fluids initially and then converted to a gruel and then start offering solid food such as feeder fish and small shrimp
- May need to hold food in front of nostrils in all ages of sea turtles initially to get them to eat
- Frequent CBC/chemistry panels, body weights
- Medical records to monitor behavior and appetite and defecation
- Wound care: clean environment and water quality are essential for proper wound care; deep wounds should be debrided, cleaned, antibiotic ointment, tegaderm or biodress can be used.

**Table 1. Antimicrobials used in critical chelonian patients**

| Drug | Dosage and frequency | Comments |
|---|---|---|
| Amikacin | *5 mg/kg IM q 48 hr (gopher torts)[42], 2.5-3.0 mg/kg IM q 72 hr (sea turtles), 50 mg/10 ml saline x 30 min nebulization q 12 hr | Targets primarily gram negative bacteria, potentially nephrotoxic |
| Ceftazidime | *20 mg/kg SC, IM, IV q 72 hr[44,45] | Targets primarily gram negative bacteria, less nephrotoxic than amikacin |
| Chloramphenicol | 30-50 mg/kg IM q24hr, 50 mg/kg PO q24hr[79] | Bacteriostatic, Aerobic and anaerobic antibacterial spectrum |
| Clarithromycin | *15 mg/kg PO q 48-72 hr[47] | Used to treat mycoplasma URTD |
| Clindamycin | 5 mg/kg PO/IM q 24 hr | Good anaerobic spectrum, use in combination with amikacin, ceftazidime, or enrofloxacin |
| Enrofloxacin | *5 mg/kg SC/IM q 24-48 h,[49,50] *10 mg/kg PO q 24 hrs[53] | irritating to tissue, recommend diluting and giving SQ, |

| | | |
|---|---|---|
| Metronidazole | *20 mg/kg PO q 48 hrs (anaerobes) (yellow rat snakes and iguanas)[48] | Excellent efficacy against anaerobic bacteria, very bitter, potential for toxicity |
| Fluconazole | *21 mg/kg loading dose, then 10 mg/kg q 5 days SQ, IV[51] | |
| Intraconazole | *5 mg/kg PO SID or 15 mg/kg PO q 72 hrs (sea turtles)[46] | |
| Acyclovir | 80 mg/kg PO SID (1) to TID[30]; Topical (5% ointment) q 12 hr[30] | |

* indicates the dose is based on pharmacokinetics, duration of therapy will depend on the clinical problem and response, but most antimicrobial regimens in critically ill chelonians are administered for a minimum of 2-3 weeks

**Table 2. Analgesics and Anesthetics used in the critically ill chelonian**

| Drug | Dosage | Comments |
|---|---|---|
| Butorphanol | 0.2 –2 mg/kg IM, 0.2-0.5 mg/kg IV, IO[67] | Premedication, analgesia, lower dose if debilitated, 4 hrs duration |
| Buprenorphine | 0.1-1 mg/kg IM[67] | Same, longer acting than above |
| Meloxicam | *0.2 mg/kg SC, IM, IV; 0.4 mg/kg PO q 24-48 hrs[56] | Rehydrate patient prior to administration |
| Carpofen (Rimadyl) | 1-4 mg/kg PO, SC, IM, IV q 24 hrs[175] | Same |
| Medetomidine/ketamine M/K | Tortoises M:0.075 to 0.15 mg/kg K:5 mg/kg[58,59,60,65,66] Aldabra tortoises: M:0.025 to 0.08 mg/kg K:5 mg/kg[59] Freshwater aquatic turtles M:0.3 mg/kg K:5 mg/kg [67], can add 0.4 mg/kg butorphanol to this regimen[67]; | Reverse M with atipamazole at 5 times the medetomidine dose in mg |
| Propofol | 10-15 mg/kg IV[67]; desert tortoises: low dose 2-4 mg/kg IV, moderate dose 5-8 mg/kg IV, high dose 12 mg/kg IV[67] | Administer slow to effect over 1-2 minutes, dilute 1:2 with saline[67] |

| **Table 3. Emergency drugs used in chelonians** | | |
|---|---|---|
| Drug | Dosage | Comments |
| Doxapram (Dopram) | 5 mg/kg IM, IV | Respiratory stimulant |
| Prednisolone sodium succinate (Solu-Delta Cortef) | 5 to 10 mg/kg IV | Short acting steroid, used in shock therapy |
| Dexamethosone Na Ph | 0.1-0.25 mg/kg IV/IM | Same |
| Methylprednisolone (SoluMedrol) | 20 mg/kg IV | Short acting steroid, CNS trauma |
| Glycopyrrolate (Rubinol) | 0.01 mg/kg or 0.05 ml/kg IV, IM, SC | Treat bradycardia |
| Atropine | 0.01-0.02mg/kg IV, IM, SC | Treat bradycardia |
| Epinephrine (1:1000, 1 mg/ml) | 0.1 mg/kg IV, intracardiac | Cardiac stimulant |
| Midazolam | 1.0 to 2 mg/kg IM or IV | Control seizures |
| Diazepam | 0.5 mg/kg IV | Control seizures |
| Activated charcoal, kaolin (Toxiban, Vet-A-Mix) | 2-8 gm/kg oral via stomach tube | Absorbs and neutralizes some poisons |
| Ca EDTA | 10-40 mg/kg IM q12 hr | Heavy metal chelator, zinc and lead toxicity |
| Vitamin $K_1$ | 0.2-2.5 mg/kg PO or IM, as needed | Coagulopathies, hepatic disease |
| Iron dextran | 12 mg/kg IM 1-2x/wk | Iron deficiency anemia |
| Calcium gluconate | 100 mg/kg IM or IC q 8 hr | Hypocalcemia |
| Calcium lactate/ Calcium glycerophosphate (Calphosan) | 10 mg/kg SC, IM | Hypocalcemia |
| potassium chloride | 15-30 mEq/L of fluid | Hypokalemia |
| 50% dextrose | 1 ml/kg IV | Recommend administering at 5-10% in fluids slow bolus for hypoglycemia |
| Mineral oil | 6-10 mg/kg PO | |
| Cisapride | 0.5-2.0 mg/kg PO q 24 hrs | Gastrointestinal stasis |

**Table 4. Enteral feeding formulas and diets for anorexic and critically ill chelonians**

| | **Enteral diet information** | **Comments** |
|---|---|---|
| **Herbivores** | Critical Care diet (Oxbow Pet Products, 29012 Mill Road, Murdock, NE68407, 800-249-0366), | Alfalfa based product, may clog smaller tubes, www.oxbowhay.com |
| | Ensure alone or mixed with fish blenderized (sea turtles), add mixed green vegetables for green sea turtles | Add vitamin/mineral supplementation |
| Elemental diets easily absorbable | 1) Peptamen (elemental diet for children, made by Nestle, Deerfield, IL<br>2) Vivonex | |

**The Georgia Sea Turtle Center www.georgiaseaturtles.org and www.jekyllislandfoundation.org**

Stranded sea turtles are often found on the coastal areas of Georgia, most of which are dead and a small percentage still alive. From 1995 to 2004, the average annual number of stranded sea turtles in Georgia was 238. Over the past decade, there has been a steady increase of stranded live turtles along the southeastern Atlantic coastline (Pers. comm., W. Teas, 2004). Currently, Georgia's stranded live sea turtles are evaluated and provided emergency care by the author and Georgia Department of Natural Resources (GADNR) wildlife biologists. Since there are no facilities in Georgia in which to rehabilitate the turtles after the initial evaluation, they must be transported long distances to reach a suitable facility, with the closest being located in Charleston, SC and near Daytona, FL. On occasion, these facilities are filled to capacity and the turtles have to be prematurely released or housed in sub-optimal conditions.
The Georgia Sea Turtle Center (GSTC) will eliminate long distance travel to and from these facilities. Rehabilitation should be part of the overall sea turtle conservation program because the most common age class of turtles to present for rehabilitation consists of older sub-adult and mature adult turtles. These are the most valuable members of the population, because they are either close to or are currently capable of reproducing. Several components of the natural history of the sea turtle emphasize the importance of the older age classes to the population: (a) sea turtles are long-lived animals, potentially surpassing human life spans; the loggerhead sea turtle does not reach reproductive maturity until approximately 30 years of age; and (c) it has been estimated that for every one thousand eggs laid, only one will survive to become a mature adult. An additional reason for the importance of rehabilitation in sea turtles is that most of the illnesses and injuries they encounter are either directly or indirectly caused by humans; therefore, we have an obligation to assist in their recovery. To fill the need for rehabilitation, efforts have been underway for several years to create a facility in Georgia to care for injured and ill sea turtles so that more of them reach reproductive age.

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