

Sea Turtle Science



A Research-Based Middle and High School Classroom Resource

www.marine-ed.org/bridge/survivor.pdf

Created by: Susanna Musick & Lisa Lawrence
Virginia Institute of Marine Science
Gloucester Point, VA 23062



Version 09.25.06

SEA TURTLE SCIENCE



Sea Turtle Quick Facts

BIOLOGY

- In the Atlantic, sea turtles are found from Massachusetts to Florida and throughout the Gulf of Mexico. Leatherbacks extend north to Iceland.
- Sea turtles are found in the tropics to subtropics year-round and higher latitudes in summer.
- Sea turtles feed in shallow waters (except leatherbacks).
- Sea turtles migrate from foraging grounds to mating grounds. Most nest in tropics (except loggerheads which nest in temperate areas)
- Females come onshore only to nest; aside from occasional basking, males spend entire life in water.
- Females will nest multiple times in a season, but generally nest only every other year.

LIFE CYCLE

- A clutch of 50-170 ping pong ball-like eggs incubate for 6-13 weeks.
- Hatchlings emerge from nest and head towards brightest horizon.
- A "swimming frenzy" occurs as they hit water and head towards open ocean.
- In the "Lost Years" loggerheads are believed to spend early juvenile years feeding in the Sargasso Sea.
- Older juveniles join adults in coastal feeding or mating grounds, except leatherbacks which remain pelagic.
- Females return to their natal regions to breed and nest.
- Reproductive maturity for some species occurs after 10-30 or more years, life span may be more than 50 years.

REFERENCES

Lutz, P.L. & J.A. Musick, (eds.). 1997. *The Biology of Sea Turtles*. CRC Press, Boca Raton, FL. 432 pp.

Atlantic Sea Turtle Species

Leatherback (*Dermochelys coriacea*)

Size: 1.8 m (6 ft), 727 kg (1 ton)

Diet: jellyfish

Status: endangered

Green (*Chelonia mydas*)

Size: 1 m (3.3 ft), 150 kg (68 lb)

Diet: Juveniles—molluscs, crustaceans, jellyfish

Adults—seagrasses, macroalgae

Status: endangered (FL)/ threatened

Loggerhead (*Caretta caretta*)

Size: 0.92 m (3 ft), 115 kg (52 lb)

Diet: benthic crustaceans & molluscs

Status: threatened

Hawksbill (*Eretmochelys imbricata*)

Size: 0.66-0.86 m (2.2-2.8 ft) 82 kg (37 lb)

Diet: sponges & benthic invertebrates

Status: endangered

Kemp's Ridley (*Lepidochelys kempii*)

Size: 0.58-0.80 m (1.9-2.6 ft) 40-50 kg (18-23 lb)

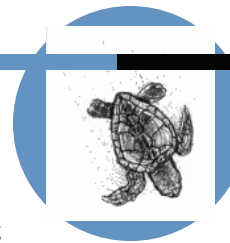
Diet: crabs, shrimp, molluscs

Status: endangered

REFERENCES

Wynne, K. & M. Schwartz. 1999. *Guide to Marine Mammals & Turtles of the U.S. Atlantic & Gulf of Mexico*. Rhode Island Sea Grant, Narragansett, RI. 114 pp.

SEA TURTLE SCIENCE



NATIONAL SCIENCE EDUCATION STANDARDS CORRELATIONS

Science as Inquiry

Ability to do scientific inquiry (K-12)
Understanding of scientific inquiry (K-12)

Life Science

Life cycles of organisms (K-4)
Organisms and environments (K-4)
Populations and ecosystems (5-8)
Reproduction and heredity (5-8)
Regulation and behavior (5-8)
The behavior of organisms (9-12)
The interdependence of organisms (9-12)

Science in Personal and Social Perspectives

Characteristics and changes in populations (K-4)
Populations, resources, and environments (5-8)
Natural resources (9-12)
Natural and human-induced hazards (9-12)

Sea Turtle Nesting Behavior by Kate Mansfield, VIMS

All sea turtles share a similar behavior pattern when nesting. Most turtles found nesting on the east coast of the United States have distinct "trademarks" or characteristics which can be used to identify what species of turtle nested. Typically this can be accomplished through the examination of the tracks or the nest site. Becoming familiar with the nesting process and the "trademarks" of each turtle enables beach monitors to more accurately identify what species of turtle was present, and whether the turtle laid eggs or not. The following is a step by step behavioral process that nesting sea turtles typically follow.

THE CRAWL

Generally, female sea turtles swim in towards shore during the late afternoon or early evening just prior to sunset. At some point after nightfall, the nesting turtles emerge from the ocean and crawl up the beach to find a suitable nesting site. It is

possible to identify the species of the turtle that emerged by the tracks left in the sand. Key crawl characteristics include:

- Alternating or simultaneous right and left flipper marks
- Presence or absence of tail marks down the center of the tracks
- Relative width of tracks indicating the size of the turtle

Loggerhead sea turtle tracks are smaller on average than green and leatherback turtle tracks. They exhibit alternating right and left flipper tracks and no tail marks. Both green turtles and leatherbacks exhibit simultaneous right and left flipper marks and the presence of tail marks down the center of the tracks (LeBuff, 1990). Leatherback tracks are the widest of all species' tracks.

Tracks indicate the direction in which the turtle was traveling. Examining where the turtle pushed the sand back in an effort to move herself forward aids in determining the turtle's direction of travel. Determining direction helps identify where she may have nested. With old tracks, direction may be difficult to determine.

THE BODY PIT

Once the female has chosen a nesting site, she prepares the area by clearing the sand and brushing it away with all four flippers. In some cases, she excavates a large pit with her flippers. Loggerhead turtles make relatively shallow body pits, commonly in the form of two long, narrow hills of sand on either side of the turtle's tracks moving towards her nest site. Green turtles, however, have a characteristically large and deep body pit. Greens may leave a body pit that is one to two meters in diameter and up to .5 to 1.0 meters deep. Hawksbill sea turtles create little to no body pit and usually nest in the brush landward of the open beach. Both loggerhead and green turtles tend to nest on the open beach.

THE EGG CHAMBER

Upon completing the body pit, turtles excavate an egg cavity with their rear flippers. Using these flippers as shovels, the turtles scoop out sand from the egg chamber, alternating flippers as they dig. Sand

SEA TURTLE SCIENCE



that is scooped out of the cavity is spread to the side of the hole. The depth of the egg chamber is determined by the length of the rear flippers (van Meter, 1983). If a turtle is missing a large portion of one or both of her rear flippers, her egg chamber may be relatively shallow. The shape of most egg chambers beneath the sand resembles an inverted light bulb.

LAYING THE EGGS

When the egg chamber is completed, the turtle starts depositing her eggs. Once a turtle begins to lay her eggs, she becomes almost oblivious to any disturbance around her. Most loggerhead turtles spread their rear flippers beside their nest during deposition. The turtles position their cloaca over the hole and begin dropping eggs, two and three at a time, into the chamber. Once egg laying commences, the turtles often slightly curl their rear flippers as eggs are deposited. This action is an indicator that the turtle has begun to lay her eggs and can be approached by researchers without disturbing her. Unlike the loggerhead, leatherbacks and green turtles generally extend their rear flippers directly behind them during egg deposition (Ibid.). Some green turtles cover the exposed egg chamber with one of their rear flippers. With shallow egg chambers, some eggs may spill out on either side of the chamber. These eggs may be crushed by the turtle as she begins to fill in her egg chamber after she deposits the clutch.

COVERING THE EGGS

Once the turtle deposits all of her eggs, she covers the egg-filled chamber with sand, shoveling it in and packing it down with her rear flippers. Some species slap down or knead the sand, using the weight of their bodies to pack down the area.

NEST OBLITERATION

When the turtle finishes covering and packing the sand down on top of her eggs, she swipes sand with her front flippers, flinging it back over the nest site. A turtle ONLY does this if she lays her eggs (Florida Department of Natural Protection, 1994). The resulting nest site has a characteristic mound of sand over part of the turtle's tracks and nest site, as well as a small escarpment made from where the turtle used her front flippers to scrape away at the sand, flinging it back over her nest. Leather-

back and green turtles both leave characteristically large and widely flung mounds of sand. When covering is complete, the turtle crawls back to the ocean, leaving tracks as she exits the beach.

FALSE CRAWLS VS. NESTS

Occasionally, a nesting turtle may emerge from the ocean but not lay eggs on the beach. This event, characterized by an abandoned nesting attempt or simply a U-shaped crawl from the ocean up the beach, then back to the water, is called a False Crawl, Emerge No Lay, or Abandoned Nesting Attempt. A turtle may false crawl for a number of reasons, some of which include:

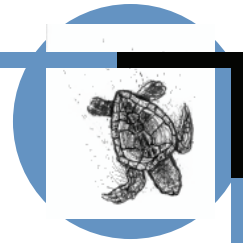
- She is disturbed by lights, noise or other unusual activities
- She encounters an obstacle while crawling up the beach
- She encounters roots, debris or rocks while digging her egg chamber
- The sand does not have the right consistency or moisture
- Her egg chamber collapses
- Other reasons not known

A turtle may false crawl at any point in her nesting sequence up to the point where her eggs are laid. A turtle may even complete her egg chamber and for some reason not deposit her eggs. The key factor that indicates whether a turtle has laid her eggs or not is the presence or absence of a mound of sand and the escarpment created when the turtle flung the sand back over her nest site. A turtle will not obliterate her nest site if she has not deposited eggs.

HATCHLING BEHAVIOR

Depending upon the species and the temperature of incubation, the time between egg deposition and hatchling emergence ranges anywhere from 45 to 75 days (LeBuff, 1990). Within the first 12 hours after deposition, the vitelline membrane (the cell wall of the egg that plays an important role in gas exchange through the egg wall) attaches to the interior of the egg shell (Ibid.). If the egg's orientation changes after the attachment forms, the membrane detaches from the egg wall and development ceases (Ibid.). Great care is usually taken by researchers if eggs must be moved for any rea-

SEA TURTLE SCIENCE



son more than six to twelve hours after a turtle has nested.

NEST EMERGENCE

After incubating beneath the surface of the sand for approximately two months, the young turtles begin to hatch out of their shells. Hatchlings may remain within the egg chamber several days after hatching. Hatchlings found in the process of crawling out of their shell are called pipped. The movement of fully hatched and pipped turtles while in the egg chamber serves to loosen the sand, allowing it to trickle down to the bottom of the nest. This process acts as a sort of elevator: the greater the movement caused by hatchlings, the greater the amount of sand filtering down to the bottom of the nest, thereby elevating the turtles closer to the surface.

Emergence occurs primarily at night. The temperature of the surface sand and sun/ambient temperature during incubation are key factors that determine when hatchlings emerge from their nest. Once the surface layers of the beach cool after sunset or after a rain storm, the turtles 'erupt' en masse and proceed to crawl down the beach to the water (Ibid.). Hatchlings orient themselves to light reflected off the water and beach, away from the darker vegetated areas typically found landward along the beach (Ehrenfield, 1968). Over a hundred hatchlings may emerge from a nest at one time.

FRENZY

From the time of nest emergence up to 24 to 72 hours after entering the ocean, hatchlings remain in a state often referred to as a "frenzy." During this period, hatchlings swim constantly. This may serve to get the hatchlings away from shore and coastal predators, out to deeper waters (van Meter, 1993). Very little is known about sea turtles from the point that hatchlings enter the ocean until at least 20 years later when the females become sexually mature and come ashore again to nest. This lack of information makes sea turtle management and conservation difficult.

LITERATURE CITED

Ehrenfield, D. W. 1968. The role of vision in the sea-finding orientation of the green turtle (*Chelonia mydas*) 2. Orientation range and spectral sensitivity. *Animal Behavior* 16:281-287.

Florida Department of Natural Protection 1994. Nesting Beach Monitoring Techniques. TOPIC: Crawl Identification. Monitoring protocol literature from FL DEP. Tequesta, FL.

Lebuff, C. R. 1990. The Loggerhead Sea Turtle in the Eastern Gulf of Mexico. Caretta Research Inc., Sanibel, FL. Pp 185, 190.

van Meter, V. B. 1983. Florida's Sea Turtles. Florida Power and Light Company. Miami, FL. P 25.

NOTES:

SEA TURTLE SCIENCE

Survivor!


Loggerhead Hatching Activity
Created by Susanna Musick, Jack Musick, and Lisa
Lawrence, Edited by Vicki Clark and Lee Larkin

BACKGROUND

A variety of factors can affect the hatching success of sea turtles. Temperature, amount of moisture, sand grain type, and gas exchange all play a part in hatching success within the egg chamber. Outside the nest, predators can also influence the success of the nest and hatchlings.

The average clutch count or number of eggs laid by loggerhead sea turtles is 112.4 eggs (Miller, 1997). Female turtles usually lay three to seven nests per season and nest every one to three years. Eggs that incubate for extended periods at temperatures lower than 23°C (73.4°F) or greater than 33°C (91.4°F) seldom hatch (Miller, 1997). The temperature profile will vary widely from beach to beach, depending on tides, weather, and nest location. Temperature also determines the sex of the hatchling. The pivotal temperature for loggerhead sea turtles is 28.74°C (83.7°F). Generally if the nest's temperature has been below 28.74°C, most of the hatchlings will be males. If the temperature has been above 28.74°C, the majority will be females (Ackerman, 1997). Eggs at the top of the nest have the highest risk of predation and overheating. Eggs at the center of the nest have less of a risk of predation or inundation, but less gas exchange. Eggs at the bottom of the nest are cooler, and at a higher risk for inundation, but at a lower risk for predation. Eggs will usually hatch after 6-13 weeks of incubation, depending on the temperature (Miller, 1997). Usually, incubation period decreases as incubation temperatures increase (Ackerman, 1997).

On average, there is an 80% hatching success rate for loggerheads. However, from the time they leave the nest, hatchlings are exposed to many threats. They may get lost, or die from disease, exhaustion, and predators. It is estimated that only 1 or 2 out of 1000 turtles will survive to maturity (Frazer, 1986). This estimate does not include the negative impact of humans on the life cycle of turtles. Humans threaten sea turtles in various ways



on land, and in the water. On land, human threats include egg harvesting, beach lighting and development, pollution, vehicles, sea walls, beach compaction, and sand quarrying. In the water, anthropogenic effects include turtle harvesting, bycatch, boat collisions, and habitat degradation (including pollution). These human threats lower survivorship estimates even further. Conservation of these threatened animals is important so that we may continue to study and appreciate them in the future.

This activity is a modeling exercise that involves population estimates and natural (non-human) mortality factors. Actual survivorship numbers are highly variable and differ from one population to the next. The activity scenario takes place on one nesting beach. Ten nests with 100 eggs each are laid (1000 eggs total). In this activity, we will follow the outcome of one of these nests. Each egg in the nest will actually represent 10 eggs from the entire nesting beach.

OBJECTIVES

- Identify threats to sea turtle nests, hatchlings, and adults
- Define factors limiting the development and survival of eggs, hatchlings, and adults
- Discover characteristics of the nest environment
- Investigate the life history stages and habitats of threatened and endangered species
- Learn about conservation and protection of threatened and endangered marine species
- Discuss percent mortality, survival of the fittest, and management concepts

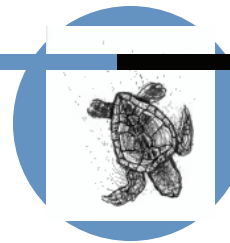
MATERIALS

- 100 ping pong balls (www.ballsonline.com)
- 10 gallon glass aquarium or clear plastic bin
- sand (enough to fill the aquarium 3/4 full)
- small trowel or hand shovel
- printout of Kate Mansfield's excerpt on Sea Turtle Nesting Behavior

PROCEDURE

Total time, 65 minutes

SEA TURTLE SCIENCE



PREPARATION

20 minutes

1. Number eggs 1-100.
2. Cover the bottom of the tank with sand.
3. Place ping-pong balls (eggs) in a plastic bag and set in the aquarium against one of the long sides. Begin putting sand in the tank around the bag of eggs forming a flask-shaped chamber. Once most of the sand is in, remove the bag of eggs. Take the eggs out of the bag and place them in the hole or nest chamber.
4. After all the eggs are inserted in the nest chamber cover the opening with the remaining sand.
5. The nest chamber will be used to illustrate sex ratios in sea turtles. In general, northern areas with cooler beaches will produce more male turtles, and southern, warmer beaches will produce more female turtles. Virginia is the northern most nesting area for loggerheads. Sex ratios vary highly from beach to beach. For most nesting beaches in Florida, about 90% of



the hatchlings will be females (Mrosovsky, 1984). In Georgia and South Carolina, most nests will have an approximate 50/50 ratio of males to females (Mrosovsky, 1984). In Virginia, about 90 % of the hatchlings will be males (Jones, 1998).

Draw a line or tape an arrow onto one side of the tank indicating the pivotal temperature of 27.4°C. Designate the placement of the line based on your geographic location. If you are in a northern area near Virginia, place the line 1/4 down from the top of the nest. If you are near Georgia or South Carolina place the line halfway through the nest (see photo above). If you are near Florida or farther south, place the line 1/4 up the side from the bottom of the nest. During the activity, students will remove the eggs from the nest. Eggs removed above the line will be females and eggs removed below the line will be males.

CLASS ACTIVITY

45 minutes

Students should read Kate Mansfield's article on Sea Turtle Nesting Behavior (p.3). Discuss the nest environment and factors such as temperature, moisture, position of the egg, predators, etc. that determine the outcome of the eggs and hatchlings.

Uncover the nest chamber by removing sand and ask students to take turns removing eggs from the chamber. If possible, each student should extract the same number of eggs from the nest. For example, if you have 25 students and you use 100 eggs, each student will have 4 eggs.

Based on the position of the egg in the nest, each student records the sex of his or her eggs on the board. Was each hatchling a male or female?

Discuss why there were more males or females in the nest based on its location (in a warm or cold beach).

STAGE ONE: Hatching success

(eggs hatch after 6-13 weeks of incubation)

Using the tables for the life history stages (p.8), call out the numbers for the eggs that failed to survive and ask students to look up (p.8) the factors that contributed to their mortality. Discuss the factors that contributed to mortality. Record the percent survivorship and mortality on the board.

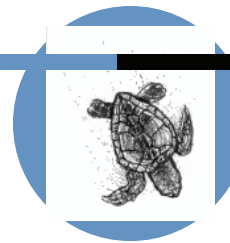
STAGE TWO: Year one survivorship

(journey from beach to the pelagic gyres)

This stage includes the journey from the beach to the surf, and the surf zone to the pelagic gyres. The hatchlings spend little time traveling from the beach to the gyre, so much of the first year is spent in the pelagic zone where juveniles are often found in large mats of *Sargassum*.

Announce the numbers for the eggs/turtles that survived the second stage. Ask the students to look up the factors (p.8,9) that contributed to their mortality. Discuss these factors and record the percent survivorship and mortality on the board. Why is mortality so high in this stage? Hint: What size are the turtles?

SEA TURTLE SCIENCE



STAGE THREE: Pelagic juveniles

(duration ~ 8 years)

Call out the numbers that survive this stage. Students continue to look up the factors that contribute to mortality and discuss them. Record the survivorship and mortality percentages on the board.

STAGE FOUR: Benthic juveniles

(duration ~ 10 years)

Announce the surviving eggs/turtles. Only two students or eggs/turtles will remain.

STAGE FIVE: Adults

Since the remaining two ping-pong balls actually represent twenty eggs or turtles, the game will continue by having the final two students each pick a number from 1-10. If they choose 3 or 7 then they survive to maturity. These final eggs/turtles will actually be the turtles that survived from the 10 nests that were laid on the nesting beach (2 out of 1000 survivorship).

How many times will one female turtle need to nest in order to have a stable population (i.e. replace herself and one male)?

Wrap up the activity with a review of all the contributing factors that determine whether or not a sea turtle will survive to maturity. Ask students to think of human factors that could influence the survivorship of the turtles. How might these factors effect the outcome of the game? (Example: If one of the surviving turtles had been run over by a car in stage one, and the other drowned in a fishing net in stage four, no turtles would survive). Discuss why it is important to protect and conserve threatened and endangered marine species and how poaching, bycatch, pollution, and other human sources contribute to the decline of sea turtles.

LIFE HISTORY TABLES

STAGE ONE

80% overall survivorship, 20% overall mortality
Hatchling mortality (incubation = ~60 days)

Egg #	Factor Contributing to Death
4	Inundation with water
8	Inundation with water
13	Inundation with water
16	Not enough gas exchange
23	Eaten by ants
33	Eaten by ants
35	Eaten by ants
42	Trapped by plant roots
50	Trapped by plant roots
51	Erosion
55	Erosion
56	Erosion
57	Eaten by a fox
58	Eaten by a vulture
61	Nest temperature too cold
64	Bacteria
68	Eaten by a raccoon
75	Eaten by a raccoon
86	Desiccation (too hot, egg dried out)
96	Desiccation (too hot, egg dried out)

STAGE TWO

Journey from nest to the shoreline, surf zone, and gyres/pelagic zone (duration = 1 year)

20% overall survivorship, 80% overall mortality

Beach/shoreline

Egg #	Factor Contributing to Death
5	Eaten by a ghost crab
6	Eaten by a raccoon
28	Eaten by a vulture
34	Eaten by a seagull
36	Eaten by a ghost crab

(Stage Two continued on next page...)

SEA TURTLE SCIENCE



Egg #	Factor Contributing to Death
46	Eaten by a tern
54	Eaten by a raccoon
59	Eaten by a ghost crab
88	Eaten by a night heron
92	Eaten by a fox
93	Eaten by a wild hog
100	Eaten by a fox

Surf Zone

Egg #	Factor Contributing to Death
1	Eaten by a seagull
9	Eaten by a spinner shark
14	Eaten by a snapper
15	Eaten by a jack
20	Eaten by a blacktip shark
22	Eaten by a sharpnose shark
24	Eaten by a young sandbar shark
26	Eaten by a pelican
32	Exhaustion
37	Eaten by a cormorant
40	Eaten by a frigatebird
43	Eaten by a speckled trout
52	Eaten by a snook
53	Eaten by a tarpon
66	Eaten by a bullshark
71	Eaten by a red drum
72	Eaten by a bullshark
77	Eaten by a Spanish mackerel
81	Eaten by a tarpon
83	Eaten by a snook
84	Eaten by a snapper
85	Eaten by a jack
87	Eaten by a pelican
90	Eaten by a seagull
95	Eaten by a cormorant

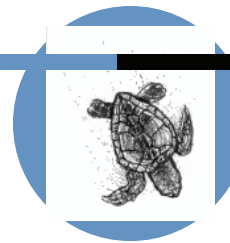
Pelagic gyre (juveniles <1 year old)

Egg #	Factor Contributing to Death
7	Eaten by a yellowfin tuna
11	Eaten by a bluefin tuna
17	Eaten by a dolphin fish
18	Eaten by a dolphin fish
19	Eaten by a mako shark
21	Eaten by a sailfish
25	Eaten by a silky shark
29	Eaten by a shearwater
38	Exhaustion
41	Eaten by a shearwater
44	Eaten by a white marlin
47	Eaten by a dolphin fish
65	Eaten by a dolphin fish
67	Eaten by a skipjack tuna
73	Eaten by a frigatebird
74	Eaten by a yellowfin tuna
76	Eaten by a frigatebird
78	Eaten by a mako
79	Eaten by a whitetip shark
82	Eaten by a frigatebird
94	Eaten by a frigatebird
97	Eaten by a seagull
98	Eaten by a barracuda

Eggs that survived Stage Two:
2,3,10,12,27,30,31,39,45,48,49,60,62,
63,69,70,80,89,91,99

(Stage Three continued on next page)

SEA TURTLE SCIENCE



STAGE THREE

5% overall survival, 15% mortality
Pelagic zone (juveniles 1-8 years old)

Egg #	Factor Contributing to Death
2	Eaten by a bluefin tuna
3	Eaten by a dolphin fish
10	Eaten by a whitetip shark
12	Eaten by a blue marlin
31	Eaten by a blue shark
39	Eaten by a dolphin fish
45	Eaten by a blue shark
49	Eaten by a blue shark
60	Eaten by a dolphin fish
62	Starved
63	Eaten by a whitetip shark
69	Eaten by a yellowfin tuna
70	Eaten by a barracuda
80	Eaten by a amberjack
89	Eaten by a wahoo

Eggs that survived Stage Three:
27,30,48,91,99

STAGE FOUR

Demersal juvenile to adult stage (10+ years)

Egg #	Factor Contributing to Death
30	Eaten by a tiger shark
48	Disease
91	Hypothermic stunning

Eggs that survive stage Four:
27, 99

STAGE FIVE

0.02% overall survivorship (2 out of 1000)
Adult stage
3,7 survive (refer to *Stage Five* directions on page 8 for explanation)

References

Ackerman, R.A., 1997. The Nest Environment and the Embryonic Development of Sea Turtles, in *The Biology of Sea Turtles*, Lutz, P. and Musick, J., Eds., CRC Press, 88.

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation, *Ecology*, 68, 1412-1423.

Frazer, N.B., 1986. Survival from egg to adulthood in a declining population of loggerhead turtles. *Caretta caretta*. *Herpetologica*, 42 (1), 47-55.

Jones, W.M., 1998. Physical parameters affecting incubating temperatures in loggerhead sea turtles, *Caretta caretta*, in Virginia, M.sc. thesis, College of William and Mary, Williamsburg, VA, 91 pp.

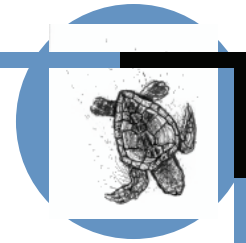
Miller, J.D. 1997. Reproduction in sea turtles, in *The Biology of Sea Turtles*, Lutz, P. and Musick, J., Eds., CRC Press, 65-68.

Mrosovsky, N. 1994. Sex ratios of sea turtles, *Journal of Experimental Zoology*, 270, 17-27.

National Marine Fisheries Service Southeast Fisheries Science Center. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the Western North Atlantic. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SEFSC-455, 343 pp.

Wynne, K. & M. Schwartz. 1999. *Guide to Marine Mammals & Turtles of the U.S. Atlantic & Gulf of Mexico*. Rhode Island Sea Grant, Narragansett, RI. 114 pp.

SEA TURTLE SCIENCE



SEA TURTLE WEB RESOURCES

SEA TURTLE SCIENCE

<http://www.marine-ed.org/bridge/survivor.pdf>
Contacts: ayers@vims.edu & petrone@vims.edu

GENERAL BIOLOGY

EuroTurtle
<http://www.euroturtle.org/>

All About Turtles
<http://octopus.gma.org/turtles/index.html>

Sea Turtles
<http://www.seaworld.org/animal-info/info-books/sea-turtle/index.htm>

Caribbean Conservation/Sea Turtle Survival League
<http://www.cccturtle.org>

Ocean Planet: Stranded Along the Coast
http://www.smithsonianeducation.org/educators/lesson_plans/ocean/stranded/essay.html

Sea Turtles Coloring Book
<http://www.yoto98.noaa.gov/books/seaturtles/seatur1.htm>

NESTING

Spotlight on a Scientist: Kate Mansfield, Sea Turtle Biologist
http://www.marine-ed.org/bridge/index_mansfield.html

See Turtles Nest! See Turtles Hatch!
http://www.marine-ed.org/bridge/index_archive0700.html

Watamu Turtle Watch
<http://www.watamuturtles.com>

Folly Beach Turtle Watch Program
<http://www.follyturtles.com/tracks.html>

TRACKING

Tracking Sea Turtles
<http://octopus.gma.org/space1/turtles.html>

Sea Turtle Survival League Educator's Guide
<http://www.cccturtle.org/eduform.htm>

Track a Turtle
<http://139.70.40.46/loggrhd.htm>

Satellite Turtle Tracking
<http://www.seaturtle.org/tracking>

CONSERVATION

Sea Turtle Protection and Conservation
<http://www.nmfs.noaa.gov/pr/species/turtles/>

Biology and Conservation of Sea Turtles
http://marinediscovery.arizona.edu/lessonsF00/brittle_stars/2.html

SPECIES SPECIFIC

Teaching Guide-Saving the Sea Turtles
http://teacher.scholastic.com/activities/explorer/oceanlife/main.asp?template=field_sites&article=turtles_field1

Leatherback Turtle Hurdle Game
<http://teacher.scholastic.com/activities/explorer/oceanlife/main.asp?template=show&article=turtle>

Green Sea Turtles
<http://earthtrust.org/wlcurric/turtles.html>

Leatherback Sea Turtle
<http://www.tpwd.state.tx.us/huntwild/wild/species/lethback/>

Kemp's Ridley Sea Turtle
<http://www.tpwd.state.tx.us/huntwild/wild/species/ridley/>

GLOSSARY

Desiccation - the process of drying up

Escarpment - a long cliff or steep slope separating two comparatively level or more gently sloping surfaces and resulting from erosion or faulting

Gyre - a giant circular oceanic surface current

Hypothermic - having a subnormal body temperature

Pelagic - of, relating to, or living or occurring in the open sea