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Anne received her B.S., M.S. and Ph.D. degrees from the Department of Zoology at the University of Florida in Gainesville. Dr. Archie Carr, her major professor, guided her doctoral efforts as she studied the feeding ecology of the hawksbill turtle. Today her research interests include studying the status, ecology, and migrations of marine turtles. She is especially interested in the hawksbill turtle.

Dr. Meylan began her career teaching in the New York City area. She has been employed at the Florida Marine Research Institute in St. Petersburg, Florida since 1987. As a research scientist, she conducts research on the life histories and migrations of sea turtles. She also coordinates the Statewide Nesting Beach Survey program which documents marine turtle nesting activity on the state's 800 miles of coastline. The data are collected by a network of volunteers, government employees, and researchers.

She views the best part of her job as observing turtles in the wild, particularly in their water habitats. She enjoys fieldwork that involves hands-on activities such as capture, tagging, and data collection.

She would like students to know that there is still much to be learned in the field of biology, including that pertaining to marine turtles. There are new discoveries all the time that alter the way we understand these animals. A career in this field can be very rewarding.

Unit III Migration Studies

On the cutting edge…
Researchers at the Florida Fish and Wildlife Conservation Commission's Florida Marine Research Institute are on the edge of scientific discovery. They are working diligently to unlock the mysteries of sea turtle migration including seasonal behaviors and patterns. They are also studying sea turtle life histories, population biology, and ecology in hopes of collecting data that will help the recovery of sea turtles globally.

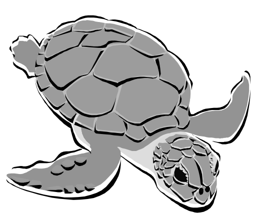
Sea Turtles

Lesson Objectives: Students will be able to do the following:
- Identify three of the seven species of sea turtles
- Explain one tagging system used to track sea turtles
- Discuss the implications of turtle migrations on a global level

Key concepts: endangered species, threatened species, life history patterns, instinct, migration, tracking devices

Introduction to Sea Turtles

See the Project Oceanography Fall 1999 Coastal Reptiles Packet for additional sea turtle information including basic physiology.



Sea turtles are large, air-breathing **reptiles** uniquely adapted to life in the ocean. Their streamlined bodies and strong flippers allow them to move swiftly through the water. Their excellent hearing at low frequencies and good underwater vision also help them to avoid predators.

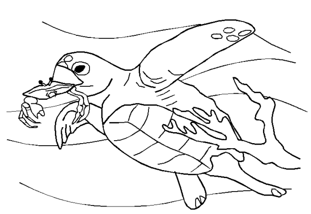
Five of the existing sea turtle **species** are regularly found in US waters. These include the green turtle, the hawksbill, the loggerhead, the Kemp's ridley, and the leatherback turtle. The first four species belong to the Family Cheloniidae. These turtles have hard shells made of skeletal bone. The leatherback turtle is the only living member of the Family Dermochelyidae. These turtles have leathery or rubbery skin overlying a mosaic of tiny dermal bones.

Four of these five species including the green turtle, hawksbill, Kemp's ridley, and leatherback are considered **endangered**. This means that the populations have become so small that they may not be able to recover. The most endangered of this group is the Kemp's ridley. The loggerhead turtle is **threatened** which means that the populations are diminished, and if they become smaller this turtle may become endangered.

Sea turtles are difficult to study due to their long, complex life histories that take place over large ocean expanses. Opportunities to study sea turtles are generally available to researchers only during the nesting process. This stage represents only a small percentage of the sea turtle's life span. Florida, with nesting beaches for the green turtle, loggerhead, and leatherback turtles, provides scientists with the opportunity to learn more about these three sea turtle species. The nesting beaches in Florida are of particular significance because they include the largest loggerhead aggregation in the world with tens of thousands of nesting females, the second largest nesting aggregation of green turtles in the Western Hemisphere, and the only leatherback nesting site in the continental US.

Sea Turtle Life History

Scientists using various research techniques have collected some interesting information about sea turtles. Sea turtles have extended life spans. Some species may live to be more than 75 years old. Scientists studying Florida's five species of sea turtles have learned that their life histories follow similar patterns with minor variations. From this information, scientists have been able to construct an overview of the sea turtle's life history.

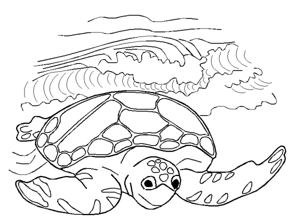


The cycle begins as a mature, female turtle travels from the feeding grounds to its birthplace or **natal beach** to reproduce. It is thought that sea turtles on reproductive migrations locate their natal beaches using a natal homing **instinct**.

Scientists have several theories about how sea turtles find their natal beaches, including the use of coastal landmarks and their keen sense of smell. One of the strongest theories involves magnetic navigation. It is thought that the turtle can detect the angle and intensity of the earth's magnetic field and use this information to determine latitude and longitude. Combined with a "map sense", the turtle would then be able to accurately navigate worldwide using this information.

The reproductive migration includes adult females accompanied by adult males and possibly some subadults. The immature females, though not yet ready to lay eggs, appear to be training for their own reproductive migrations. Even though the turtles may travel in groups they have limited interaction during the migration except for courtship and mating. As the turtles travel, they may have to swim against the current or they may take advantage of its flow. In some places, humans have reported sea turtles following favorable currents both close to and far away from shore. Sea turtles using their natal homing instincts may swim 25 miles or more per day to reach the nesting beaches where they were born. This journey may take them hundreds or thousands of miles from their feeding grounds.

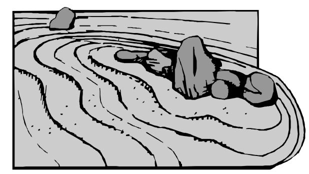
Turtles also mate in the near shore waters of the nesting beach. The males remain in the water while the females come ashore to nest. The adult males make this journey to breed yearly while the mature females only make this journey when they nest. Nesting intervals vary among species but are usually two to five years. The adult females also may nest more than one time per season using sperm stored from mating



to fertilize the eggs. It is thought that the green turtle may stay in the nesting area up to three months and lay eggs one to eight times before returning to the feeding grounds. Eventually, the males leave while the females remain to lay their last clutch of eggs.

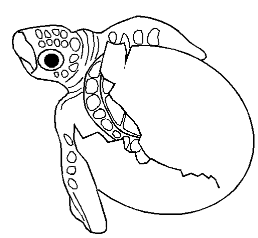
The females move slowly onto land usually during the nighttime hours. It is a difficult process to traverse the beach in order to nest. They must locate a good nesting area high enough on the beach, so it will not be flooded by the tide. The sand must also be the right consistency, allowing the turtle to easily scrape it away with her flippers to form a pit for her body and a chamber where the eggs will be deposited.

Two to three eggs are laid at a time until approximately 100 have



been laid. These eggs are typical reptile eggs with the soft, leathery shells affording protection from breakage and desiccation. After the eggs are laid, the turtle covers the nest with sand and then makes vigorous sweeping motions to disguise the site from predators. The female turtle then returns to the ocean to rest before nesting again later that season or to begin the migration back to the feeding grounds. The female sea turtle does not return to check her nest nor does she ever see her hatchlings.

The eggs begin to hatch in 50-70 days. The temperature of the incubating sand during the middle third of incubation determines the gender of the turtle. Females are produced from eggs incubated in warmer sand while males are produced from eggs incubated in cooler sand. Next, the turtle must break out of the shell and find its way to the water. The turtles use an egg tooth or **caruncle** to free themselves

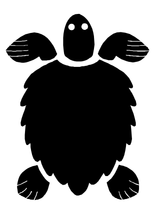


from the egg. The baby turtles then move in mass to break through the top of the nest. They must move quickly to be safe from shoreline predators.

The turtles orient themselves toward the brightest horizon to locate the water. In a natural world, this is usually the ocean. Once they reach the water, it is thought that they swim far offshore and then associate themselves with drifting mats of **sargasso** weed where they may feed for several years. Little is known about the first few years of development and growth of sea turtles. Scientists refer to this period as the "**lost year**" although we now know that it may entail as much as a decade.

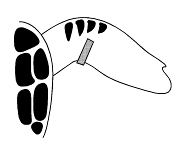
As sea turtles mature, they travel through a series of developmental habitats. For green turtles, hawksbills, and ridleys, these developmental habitats are typically in coastal waters. Some of these habitats do not have any adults present. They may contain immature turtles from different natal beaches. Seagrass beds, coral reefs and coastal bays and estuaries are preferred habitat for dinner-plate-sized green turtles, hawksbills, and ridleys, respectively. The various habitats occupied by turtles as they mature meet their needs at different life stages. For instance, young **carnivorous** green sea turtles have different habitat requirements than their older **herbivorous** counterparts. The turtles grow until they reach sexual maturity and it is time to make their reproductive journey to the nesting grounds.

Sea Turtle Tracking

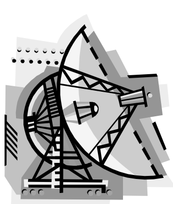


Field studies and tracking devices are used to gather information about sea turtles. Field studies supply basic biological facts about turtle populations such as size and growth rates. Tracking devices supply information about migratory patterns and the whereabouts of turtles of different life history stages. Today scientists use three types of tracking devices in their research: metal flipper tags, satellite telemetry, and genetic tags. These techniques help researchers identify individual turtles, collect population data, and accumulate behavioral information necessary to understand the sea turtle's complex life history.

Metal tags, first used in the 1950's, are still used by scientists today. These tags, attached to the sea turtle's flipper, contain unique numbers for identification purposes, a reward message, and contact information. The information requested from whoever encounters the tagged turtle is the date, location, and circumstances of the

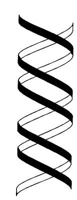


observation. This type of tag has been very useful for gathering basic reproductive information, but it has its limitations for studying migratory behavior. Even though people are given a small reward for returning tags, the tag return rate is less than 10% (usually much less). Some of the low return rate is due to tag loss. Also, some fishermen do not return tags because they have taken the turtles illegally and are afraid they will be fined. Additionally, tags are generally not returned from areas that do not have turtle fisheries, so turtles traveling in open ocean waters may never be included in data counts. Since the number of tag returns is low, data can be difficult to interpret. For instance, turtle catch locations may be listed as the ship's homeport rather than the exact coordinates where the turtle is caught. This gives incorrect data for migratory pathway locations. Scientists have begun to use other tracking devices to help solve some of these problems.



Today **satellite telemetry** is used to provide information about sea turtles during migration and during many stages of their life history. Walkman-sized **transmitters** are attached to the turtle's **carapace** with a special adhesive and fiberglass that can withstand the rigors of turtle life without injuring the turtle. The antenna attached to the transmitter sends messages when the turtle surfaces to breathe. A satellite then picks up this information. The information is then returned to earth. The transmitter stops working and falls off the turtle after several months. This type of tag provides information about turtle migration such as where they travel, what routes they take to get there, and how long it takes for them to arrive at a particular destination. By mapping this information, researchers can profile the types of habitats used by turtles in various parts of their journeys. This helps researchers determine some of the major feeding grounds for various species of sea turtles. This information is useful in conservation efforts as researchers try to design global programs to help save the sea turtle. It is essential to show people that sea turtles are international travelers and that their conservation requires regional cooperation and management.

Molecular genetics including **DNA** sequencing has also helped researchers answer questions about sea turtle behaviors and life histories. DNA sequencing can be used to determine nesting beach origin of turtles caught at sea by comparing the DNA with the genetic profile of known nesting beaches.



Knowledge gained from these studies has helped researchers develop comprehensive conservation management plans for sea turtle recovery.

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Activity: The Lungs Have It

This activity has been adapted from several sources including Addison-Wesley Biology 1994.

Sea turtles spend most of their lives in ocean waters, periodically surfacing to breathe. They have developed efficient reptilian lungs with large internal surface areas created by alveoli. They also breathe by changing the volume of their body cavity. Two large flank muscles contract to cause the body cavity to enlarge creating a negative pressure and air rushes into the lungs. Alternate relaxation in conjunction with two other muscles forces the internal organs upward against the lungs causing exhalation. The rate of respiration is also dependent in part on the temperature and emotional state of the animal.

Objectives: Students will be able to do the following:
1. Measure and calculate tidal volume.
2. Measure and calculate vital capacity.
3. Compare and contrast human and sea turtle respiration.

Materials:
- Spherical balloon-one for each student
- Flexible Metric tape measure (type used by a seamstress)-one for each group of students
- Paper
- Pencil
- Calculators-optional

Procedure:
1. Discuss human lungs and briefly describe how they work.
2. Explain the following terms:
   - Tidal volume - the normal amount of air that a person can exhale
   - Vital capacity - the greatest amount of air that a person can exhale
   - Residual volume - the amount of air in the lungs that cannot be expelled
3. Tell students that they will be calculating their tidal volume and vital capacity.
4. Tell students that each measurement will be taken three times. Discuss why scientific experiments are replicated and review the procedure for finding an average.
5. Have students create data sheets for their measurements.
6. Give each student a balloon and each group of students a metric tape measure.
7. Have students stretch their balloons by blowing them up several times.
8. Remind students to be sure to empty the air from the balloon before each trial.

9. Have students work in groups or pairs so they can take turns blowing into the balloons and taking measurements.
10. Have one student in each pair or group inhale normally and then exhale normally into his/her balloon to find his/her tidal volume.
11. Have the student hold the balloon shut at the neck.
12. Have a partner measure the circumference of the balloon in centimeters at the widest part.
13. Record the results on the data sheet.
14. Repeat this test three times.
15. Calculate and record the average circumference in centimeters.
16. Have each student complete the experiment.
17. For the second experiment, have each student inhale as deeply as possible and then exhale completely into the balloon to find his/her vital capacity.
18. Repeat steps 11 through 16.
19. Students can convert their circumference measurements to volume using the following formula: Volume = $1/6\pi^2 \times C^3$ where C = circumference in cm
20. Next have a student from each group or pair run in place for two minutes.
21. Have the student exhale into his/her balloon and record the circumference measurement. Have all students complete this experiment once and record their results (converting measurements to volume if desired).
22. After students have rested, have them repeat this final experiment, measure circumference, record results, and convert if desired.
23. Have students compare and contrast the results from each experiment and hypothesize about efficiency of respiration in various situations.
24. Review the information about reptilian respiration found at the beginning of the activity.
25. Discuss theories about why turtles may drown and how being cold-blooded may effect respiration rate and efficiency. Compare and contrast turtle lungs and breathing with those of humans. Have students find resources to support their conclusions.

Possible Extensions:
1. Measure lung capacity under a variety of conditions.
2. Have students research other ways to measure tidal volume and vital capacity. Try some of these experiments and compare the results with the results of this activity.
3. Have students design an experiment to simulate the breathing response of a turtle in various situations such as sleeping or being trapped in a trawl net.

Check out Turtle Hurdles, a turtle migration simulation, from the Project WILD curriculum at http://florida.conservation.org/educator/turtle%20hurdles.PDF

Activity: Migration Fascination

Scientists interested in studying sea turtle populations use several techniques to collect information. Researchers using tracking devices can collect information about the different stages in the sea turtle's life history. This information is then used to help researchers understand the affects of natural and human impacts on sea turtle populations. Ultimately this information can be used to develop management tools important in sea turtle conservation programs.

Objectives: Students will be able to do the following:
1. Locate facts in written materials.
2. Use information to solve problems.
3. Calculate solutions using basic math principles.

Materials:
- Writing instrument
- Copies of the calculation sheets (one for each student)
- Copies of the turtle packet background information (one for each student)

Procedure:
1. Brainstorm with students ways that scientists gather information, what kind of information they need, and why.
2. Explain that one type of information is statistical data. Discuss how this information differs from other types of information.
3. Tell students that they will be looking for information in their packets and that this information will be used to solve some mathematical problems. (Remind students that this is applied math and that they will be solving real world problems.)
4. Hand out packet materials and calculation sheets.
5. Have students read the information and complete the calculations.
6. Discuss the answers with students. Discuss how this task is like what real scientists do when gathering information and how it is different.

Possible Extensions:
1. Have students log on to the sea turtle website at www.cccturtle.org Have students find one of the turtle migration tracking maps. Have students calculate the distance traveled by one sea turtle on all or part of its migratory journey using the information provided.
2. Have students find their own information in the packet and create mathematical problems for other students to solve.

Calculation Answers:
1. 25 miles; 10 days
2. 100; 24,900 turtles
3. 8; 800 eggs
4. 3; 141 tracking devices

Challenge: 7200 eggs

Migration Calculations

Use information from the packet to complete the following statements. Then calculate the answers to the problems.

1. How far can a sea turtle swim in one day? _______________
Use this information to calculate the number of days that it would take a sea turtle to swim 250 miles.

2. How many eggs does a sea turtle usually lay in one nest? _______________
Use this information to calculate the number of eggs that 249 turtles could lay at one time on one beach.

3. How many times can a green sea turtle lay eggs in one nesting season? ____
Use the answers to questions two and three to calculate the number of eggs one green turtle could lay in one season if she nested the maximum number of times.

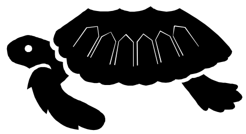
4.How many types of sea turtle tracking devices do scientists use? ______
Use this information to calculate the total number of tracking devices used, if each type of device was used 47 times.

Challenge Math: Use the following information to solve the problem.

This turtle lays its first eggs at age 20.
This turtle lives to be 76.
This turtle returns to its nesting beach every 5 years to lay eggs.
This turtle makes 6 nests every journey.
This turtle lays the maximum number of eggs in each nest.
All the turtle eggs hatch.

How many hatchlings will this turtle have in its lifetime?

Student Information: Sea Turtles Beware



Sea turtles have existed for over 110 million years, but today their numbers are dwindling. In the past, they overcame harsh environmental conditions and natural **predators**. Today they must survive the threat of humans.

In some countries, sea turtles are still hunted for their meat and eggs. In the United States, there are strict regulations forbidding the hunting of sea turtles, but other things have caused sea turtles to become **endangered**. Some turtles are accidentally caught and drowned in trawl nets. Beach development may displace turtles. Bright lights lead turtle hatchlings toward buildings instead of to the water. Sea walls may block paths to suitable nesting sites. New beach sand may be packed too tightly for proper nest building to take place. Replacing beach sand with sand from another source can change sand temperatures resulting in different proportions of male and female hatchlings. Pollution kills many sea turtles. Turtles may mistake plastic bags for jellyfish. Once eaten, the bag can stay lodged in the turtle's digestive system causing it to slowly starve to death. Chemical pollutants may be the cause of large tumors called fibropapillomas found on sea turtles.

What can be done to save the sea turtle? Scientists now know that sea turtles travel long distances throughout the world's oceans during their life cycles. Turtles that feed in one area may travel nearly halfway around the world to lay their eggs. To save the sea turtle, we need to protect the habitats they use during all of their life stages.

Conservation measures must focus on global agreements to protect nesting beaches and feeding habitats. Laws preventing the importation of turtle products must continue to be enforced. Education programs can help the public become aware of turtle conservation measures. More turtle research can help us learn about sea turtles and perhaps save them from becoming **extinct**.

Sea Turtle Vocabulary

Alveoli-tiny, thin-walled, capillary-rich sac in the lungs where oxygen and carbon dioxide exchange takes place; air sac

Carapace-upper shell of a turtle

Carnivorous-meat eater

Caruncle-egg-tooth, temporary jaw extension of turtle hatchlings used to break through their eggshell

DNA-deoxyribonucleic acid; substance carrying the genetic information that determines hereditary characteristics

Endangered-threatened with extinction

Extinct-no longer existing

Herbivorous-plant eater

Instinct-an unlearned pattern of behavior that causes complex responses in animals

Lost year-first few years of turtle development

Migration-long-distance, seasonal travel by animal populations

Natal beach-nesting beach where an individual was born

Predator-an animal that hunts for food

Reptile-cold-blooded vertebrate having scales or horny plates

Sargasso weed-a brownish, tropical Atlantic seaweed often forming dense mats

Species-a group of closely related organisms that can interbreed

Satellite telemetry-technology that uses a radio transmitter to send signals to satellites orbiting the earth

Threatened-likely to become endangered

Transmitter-an electronic device that gives out signals that can be followed

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