Down Jersey LESSON PLAN

Horseshoe Crab Census

Theme: **Natural History**

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Subject Areas
Mathematics, Science

Duration
One 50-minute session or
two shorter sessions

Setting
Indoors or outdoors

Skills
Gathering information, interpreting, analyzing, inferring, formulating questions, identifying relationships

Charting the Course
The phenomenon of horseshoe crabs/ shorebird migration is well recognized and documented along the Delaware bayshore of Southern New Jersey. It is also included in the video as a significant point of interest for the region. The value of this resource and attraction is just beginning to be realized as a dollar figure is being placed on the eco-tourism that it provides the area. It is critical to the horseshoe crab and shorebird survival, as well as the economy of the region, to ensure that there is sufficient habitat available for the continuation of this major attraction and event of ecological significance.

Vocabulary
Spawning, migration, habitat, population trends

Correlation to NJ Core Curriculum Content Standards

Mathematics
4.1 (1, 2, 3, 5, 6, 7, 8)
4.2 (1, 2, 3, 5, 7, 8)
4.3 (3, 6, 7, 9, 10, 11)
4.4 (3, 4, 5, 6, 10)
4.5 (1, 2, 4)
4.6 (5, 12)
4.9 (5, 6, 7, 12, 14)
4.10 (5, 7, 11)
4.11 (5, 10)
4.12 (1, 2, 3, 5, 9, 13)

Science
5.1 (2, 4, 5)
5.2 (2, 5, 6, 8)
5.4 (1)
5.5 (3, 4)
5.6 (5, 6)
5.12 (1, 2, 3, 4, 6, 7, 9)

Horseshoe Crab Census

Objectives

Students will be able to: describe the life cycle of the horseshoe crab; make inferences about limiting factors affecting populations of horseshoe crabs; describe possible consequences, both positive and negative, to wildlife, humans, and the environment from man's actions; evaluate the importance of suitable habitat for wildlife (indirect); understand that there are many demands for the horseshoe crab resource and these demands can be difficult to balance.

Materials

One piece of rope 210 meters long, marked every 15 meters

14 sets of four pieces of rope, one meter long (one set for each 15 meters of the long rope)

Clipboards; rapid survey tally sheets

Paper plates of two sizes

Wooden stakes (or plastic cones if working indoors) — optional.

Making Connections

Biologists in New Jersey and Delaware are concerned that the horseshoe crab population in the Delaware Bay is declining. Many species of shorebirds depend on horseshoe crab eggs to provide them with sufficient food to complete their long flight to their Arctic breeding grounds. Without this important food source, much of the world's population of shorebirds might perish. Wildlife watchers who come to the area each spring to observe the phenomenon of horseshoe crabs and shorebirds pour millions of dollars into the local economy. If the horseshoe crab population collapses, so will the local economy suffer. Horseshoe crabs also provide additional income for commercial harvesters who are thought to have a negative impact on the population. Commercial harvesters only harvest females, with a 100% mortality. In addition, horseshoe crabs are important to the medical field. They are the only source of LAL, an important substance used in testing pharmaceuticals for toxins. The horseshoe crabs harvested for LAL experience less than a 5% mortality and have to be released by FDA law.

Background

Every year, on the new and full moon high tides in May, a natural phenomenon takes place on Delaware Bay beaches. Hundreds of thousands of horseshoe crabs come ashore to spawn. This spawning activity coincides with the arrival of hundreds of thousands of shorebirds who arrive from South America, starving and weary, on their way to their Arctic breeding grounds. During the two to three weeks the birds spend on the Delaware Bayshore, they will double their weight. They do this by consuming thousands of horseshoe crab eggs each day. The large number of crabs results in abundant egg resources for migrating shorebirds. Birds that don't eat enough to fulfill their energy needs will not meet the demands of their strenuous flight to the Arctic, or may not be able to complete breeding and nesting once they arrive. Having an abundant supply of horseshoe crab eggs is critical to the survival of the shorebirds.

The horseshoe crab *(Limulus polyphemus)* has existed for millions of years. While horseshoe crabs are found from Maine to Mexico, Delaware Bay has the single largest population of horseshoe crabs on the Atlantic Coast. But the numbers used to be larger. In the past populations have fluctuated due to over harvest and/or disease. The baseline for abundance records in the Delaware Bay comes from harvesting reports in the mid 19th century and these contain high numbers. During one year, 4.3 million horseshoe crabs were harvested. The crabs were used mainly for fertilizer and poultry and hog feed. The population began to decline drastically during the late 1800's and early 1900's due to overharvest. With the advent of chemical fertilizers, commercial harvesting stopped and horseshoe crabs slowly recovered. Concerns have been revived, however, with the crab's increased use as bait for conch and eels. The declining trend biologists are seeing today seems to parallel a significant increase in the number of crabs harvested. Harvesters exacerbate the problem of overharvest by selecting for female crabs which are as much as twice as large as the males. The females are preferred since their eggs attract the eels. In addition, many females are often harvested before they have a chance to spawn. Strict regulations are in effect which limit the overall harvest. In New Jersey,

harvesters are allowed to collect crabs from May 1 to June 30 and only by hand. In addition, harvesters can only take crabs from the beaches on Tuesdays and Thursdays. On all other days, they can only collect crabs that are more than 1,000 feet beyond the high tide line. Harvesters are unhappy with these regulations because they feel they unfairly restrict their livelihood.

The horseshoe crab is not actually a true crab but a member of an ancient group of arthropods, closely related to scorpions and spiders. They are well adapted to their environment and have changed little during the evolutionary history of life on Earth.

Horseshoe crabs have nine eyes, two of which are compound. The large compound eyes are sensitive to polarized light and can magnify sunlight ten times. A pair of simple eyes on the forward side of the carapace can sense ultraviolet light from the moon. Their eyes are not used to “see,” but rather for orientation. In addition, five eye spots are located under the carapace, with more on the underside of the tail. Horseshoe crabs occasionally swim upside down, and may use these eyes then. The crabs have a centrally located mouth with no teeth or jaws. They use gnathobases — heavy, spiny projections that surround the mouth (located at the bases of five pairs of legs) — to maneuver small clams, mussels, and sea worms into their mouths. They crush their food by simulating walking.

Horseshoe crabs spend the winter burrowed into the mud, fifty miles offshore, on the continental shelf. In early spring, they begin their migration toward Delaware Bay beaches. By mid-to-late-May (and perhaps as early as April), they will be massed in the shallow waters just off the beaches, waiting for the spring tides of the full moon and new moon to come ashore and lay nearly 100 tons of eggs. Horseshoe crabs reach maturity at nine years of age and are believed to live 15 to 20 years. A mature female measuring 11 inches, can carry up to 90,000 eggs and may spawn several times during each spawning period. Female crabs are larger than male crabs and their claws are all alike. Males have specially adapted front claws, shaped like hooks, so that they can hook onto the female during the breeding season.

Horseshoe crabs need flat, sandy beaches on which to lay their eggs. During the full moon high tides in May and June, the crabs will come ashore to lay their eggs. The female drags the male, who is hooked onto her, to the nest site. She digs a shallow nest, up to eight inches deep, near the high tide mark, and deposits 200-4,000 tiny green eggs. The eggs are externally fertilized by the male. Newly laid eggs are soft and sticky. When they come in contact with seawater, they will swell and harden. Within a few days, a transparent, spherical capsule forms, swells and bursts the old green egg coat. Inside this new transparent sphere, all embryonic development can be seen. On the next full moon high tide, the survivors will

hatch and make their way to the Bay. The tailless larvae will undergo at least six molts during the first year. They will continue to molt, though less frequently, until they reach full size at about 12 years of age.

Because the crabs do not breed until they reach nine or more years of age, impacts on populations may not be apparent immediately. For example, if an entire generation were wiped out by an oil spill, populations might not show dramatic declines until that generation would have reached maturity, in nine years. Loss of habitat is also of concern. In our struggle with sea level rise, more and more Bayshore beaches are being lost to erosion, and in many cases, to bulkheading. People often bulkhead their property in an effort to stop erosion and save their property. Bulkheading eliminates breeding habitat for the crabs.

Biologists are concerned about increasing evidence that points to a continued decline in the horseshoe crab population. Studies have included: counting stranded crabs on the beaches, an annual spawning census on beaches, monthly bay trawl surveys, a study of egg densities on the beaches, and surveys on the continental shelf. Experts fear that overharvesting of the crabs for bait is the main reason for the decline; however, loss of suitable spawning habitat due to bulkheading, jetties and erosion; incidental loss due to dredging; and oil spills play a role as well.

Many people are aware of the connection between shorebirds and horseshoe crabs, but fewer people are aware of the important role the crabs play in medicine. Much of what we know about human vision stems from a Nobel prize-winning scientist's work with cells from the horseshoe crab's eye. Studies on the long single cell of the crab's optic nerve helped to establish the field of neurobiology. Important progress has been made toward understanding diseases such as arthritis, cancer, AIDS, Alzheimer's and arteriosclerosis because of research on horseshoe crab cells. Possibly one of the most important roles the horseshoe crab plays in medicine is the use of its blood in the formulation of Limulus Amebocyte Lysate (LAL). Derived from the horseshoe crab's white blood cells, LAL can detect small quantities of pyrogens, bacterial endotoxins that can contaminate drugs. Bacterial endotoxins can cause fever, shock, hemorrhage and even death. Today, all drugs manufactured by pharmaceutical companies must be tested with LAL for bacterial contamination before they are marketed. LAL is also used to detect spinal meningitis and some B_{12} deficiencies as well. Horseshoe crabs that are collected and bled are returned to the Bay unharmed.

The decline of horseshoe crabs can have a direct impact on human health and well-being. The horseshoe crab is the sole source for LAL. The Delaware Bay population of horseshoe crabs is a primary source of LAL. (There are also labs located in South Carolina and Virginia.) The loss of horseshoe crabs and shorebirds on Delaware Bay will also have a significant impact on the economy of many bayshore communities. Dollars generated from wildlife enthusiasts flocking to the bayshore to view the horseshoe crab/shorebird phenomenon are estimated to be over $4,000,000. Commercial harvest of the crabs contributes between $400,000-$800,000. Clearly, the collapse of the horseshoe crab population will have a significant impact on the whole ecology of the area.

Preserving these resources is of the utmost importance. Since 1990, an annual census has gathered information about horseshoe crab population trends. This information is being used to ascertain these trends and learn more about the health of the crabs. Preservation efforts will require innovative strategies, varied protection techniques, and cooperation between many government agencies, non-profit organizations, and private citizens.

Procedure

Warm Up

Teacher can ask students to discuss what they know about horseshoe crabs. Use the Horseshoe Crab Model from Marine Communications ($1, 302-831-8083) or find pictures to show students. If students are familiar with the crabs, have them draw pictures of them in their habitat. Discuss the background, life history of the crabs, and some of the issues surrounding their decline. Discuss scientific methods of estimating populations. Tell students they will be conducting one method of estimating spawning populations of horseshoe crabs — the rapid survey. Explain how to use the rapid survey tally sheets.

The Activity

Tell the students they are on a Delaware Bay Beach (if you have one close by pretend it is that one; better yet, do this activity on the beach). They should pick an easily accessible section of beach near the high tide line. Explain to them that spawning surveys are conducted in May on the full moon at peak high tide, both AM and PM. If you are conducting this activity on the beach, students should lay out their marking rope near the water but far enough away so that they have enough room to work without getting wet (two-three meters above high water). Explain that biologists would census the entire beach, not just 210 meters.

1. Lay out the 210 meter rope (or string) in a straight line. Have students place a stake every 15 meters along the rope (or have the rope pre-marked with colored tape). Designate one end of the rope as the starting point and begin marking out one-square-meter plots every 15 meters using the pre-cut rope sets.
2. The teacher should place paper plates in each plot to simulate spawning horseshoe crabs. Use the diagram on the rapid tally survey sheet as a guide for crab placement. You will be simulating several years worth of surveys so think about how you should start and end the activity (the number of crabs present each year). Some years, the beach will be very populated, some years not.

   Note: Large plates represent female crabs, small plates represent male crabs
3. Have the students conduct the rapid survey using their tally sheets and diagrams, checking off the appropriate box for each 15 meters. After each run-through, the teacher should alter the number of crabs present. Discuss limiting factors with students. One year, there may be inclement weather. Another year, a portion of the beach may have eroded prior to spawning, etc. Discuss the impacts of limiting factors for each year. Students will need a separate tally sheet for each year.
4. When the tallying of several years has taken place have students total up their estimates for each year. To do this, add the number of crabs for each density noted on the tally sheet: a moderate density is equal to three females, six males; heavy density is six females, 15 males. If you had two zero density plots, three moderate density plots, and two heavy density plots you would have 21 females and 48 males or a total of 69 crabs.
5. After you have tallied the totals for each year, graph the results. Look at the ratio of males to females as well as the population trends from year to year. Note that your male to female ratio will be skewed due to the survey method used.

Wrap Up

Discuss possible methods that could be used to determine a more accurate male to female ratio. Why would it be important to know what that ratio is? Keep in mind also that the method used here is an estimate. Biologists use many methods to help ensure a more accurate determination of population trends. Discuss additional ways the crabs could be counted. Let the students brainstorm this idea.

Action

Ask the students if they know anyone in their community who benefits directly from horseshoe crabs, does anyone in their family? Have students gather opinions about the horseshoe crab issue from family members. Discuss the opinions in class. Is there a right or wrong opinion? What are some possible solutions which might help balance the use of this important resource?

Assessment

Participation in activity and presentation/interpretation of data/results.

Extensions

1. Have students research the life history of horseshoe crabs.
2. Make a list of the things horseshoe crabs are used for, list the positive and negative consequences of each use.
3. Explore the issues surrounding the commercial harvest of horseshoe crabs.
4. Learn about the regulations that protect horseshoe crabs and their habitat.
5. Give students the opportunity to examine a live horseshoe crab and identify the parts.
6. See additional activity located in this packet — making a horseshoe crab model.
7. Explore the web for horseshoe crab websites. Try University of Delaware-Sea Grant at www.ocean.udel.edu

Resources

New Jersey at the Crossroads of Migration, *NJ Audubon Society*

Horseshoe Crabs and Shorebirds, *The Wetlands Institute — An Activity Packet*

Map of Viewing Sites/ Brochure on Delaware Shorebirds — *NJ Division of Fish, Game & Wildlife, Endangered and Nongame Species Program*

NJ Nature Conservancy

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1993 Tally Sheet

Census of Horseshoe Crabs Spawning on the Shores of Delaware Bay

Location (name of beach) _____

_____ (NJ) (DE)

Time: Arrival at Site _____ AM PM Leave _____ AM PM

Weather Conditions _____

_____

Other Observations _____

_____

Date _____ Recorder _____

Census Team _____

_____

Tally of Spawners During Routine Sampling of the 200-Meter Station

Time of Census: Start _____ AM PM Finish _____ AM PM

Males _____

_____ Total _____

Females _____

_____ Total _____

Tally of Shorebirds During Routine Sampling of the 5-Meter Segments

Time of Census: Start _____ AM PM Finish _____ AM PM

#1 Males _____ Total _____

Females _____ Total _____

#2 Males _____ Total _____

Females _____ Total _____

N53a

#3 Males _____ Total _____

Females _____ Total _____

#4 Males _____ Total _____

Females _____ Total _____

#5 Males _____ Total _____

Females _____ Total _____

#6 Males _____ Total _____

Females _____ Total _____

Additional Sampling (if any): 200 Meters _____ 5 Meters _____

Time of Census: Start _____ AM PM Finish _____ AM PM

Where? _____

Males _____

_____ Total _____

Females _____

_____ Total _____

Males _____

_____ Total _____

Females _____

_____ Total _____

Comments _____

_____

_____