Sea Stats

Florida Fish and Wildlife Conservation Commission

Fish and Wildlife Research Institute

HORSESHOE CRABS

Living Fossils

The horseshoe crab is one of Florida's most mysterious and fascinating creatures. Although extensive research has been conducted, much is still unknown about this animal. Horseshoe crabs belong to a class of animals called Merostomata, a group more closely related to spiders and scorpions (Class Arachnida) than to true crabs (Class Malacostraca). Unlike true crabs, horseshoe crabs do not possess antennae or jaws, and they have seven pairs of legs, whereas true crabs have only five pairs. The fossil record suggests that the ancestors of horseshoe crabs were common about 350 million years ago, long before the age of the dinosaurs. Physically, horseshoe crabs have changed very little since then, making it no surprise that horseshoe crabs are often called "living fossils." Tolerant of extremes in temperature and salinity and resilient to environmental changes, horseshoe crabs can survive up to one year without eating.

Distribution and Habitat

Only four species of horseshoe crabs exist today, three of which are found in the western Pacific Ocean, from Japan to Vietnam. The fourth species, *Limulus polyphemus*, is found in North America along the Atlantic and gulf coasts from Maine to the Yucatan Peninsula in Mexico.

North American horseshoe crabs are most abundant in temperate waters, especially off the coast of the mid-Atlantic States, including Delaware, Maryland, and New Jersey. In Florida, horseshoe crabs are a conspicuous part of the marine ecosystem. Visitors to Florida's beaches have more than likely seen these creatures emerging from the water to mate and lay eggs. Horseshoe crabs are found in areas with low wave action and water bottoms of sand or mud, from shallow low-tide depths to water depths of about 75 feet.

Description and Anatomy

One of the most notable features of the horseshoe crab is its alien-like body, which, unfortunately, gives this animal an unfavorable reputation. In fact, the horseshoe crab was most likely given its scientific name, *Limulus polyphemus*, because of its odd appearance—*Limulus* means a little "askew" or "odd" in Latin, and *polyphemus* is the name of the giant cyclops of Greek mythology. Despite its fearsome look and name, the horseshoe crab is actually harmless.

The body of the horseshoe crab is divided into three regions: the cephalothorax, the abdomen, and the telson. The cephalothorax, also referred to as the carapace or shell, is the large anterior segment of the horseshoe crab. The carapace protects the legs and organs of the horseshoe crab and also keeps the animal upright in rough waters. Located on top of the carapace are two lateral compound eyes that

At a glance

Scientific name	*Limulus polyphemus*
Size	Up to two feet in width. Males are about one-third the size of females.
Range	Atlantic Ocean and Gulf of Mexico, from Maine to the Yucatan Peninsula
Habitat	Juveniles live on sandy intertidal flats and move further inshore when they become adults.
Status	Poorly understood, but there is growing concern that horseshoe crabs are overharvested, and their numbers are declining in some mid-Atlantic states.

are used to detect movement and locate mates. Each compound eye contains thousands of photoreceptor clusters called ommatidia. Horseshoe crabs also have eight other photoreceptor-containing structures located on various parts of their bodies, bringing their total number of eyes to 10. Signals from photoreceptor cells to the brain influence the horseshoe crab's circadian rhythm (inner clock) and various daily physiological processes.

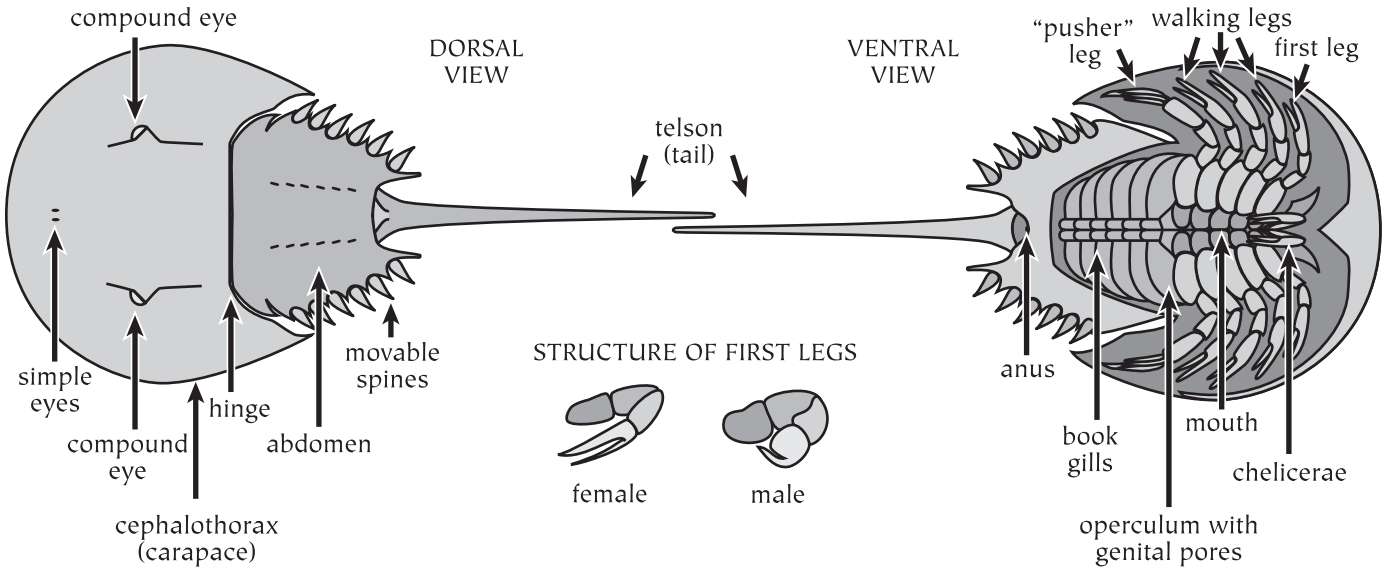
The underside of the horseshoe crab consists mostly of legs, also called appendages. In total, the horseshoe crab has seven pairs of appendages. The anterior-most appendages are called the chelicerae and are used for feeding. Food is picked up by the chelicerae and passed to the mouth, located between the bases of the legs. Food is then passed through the digestive system and expelled through the anus, located on the underside just in front of the tail. The middle five pairs of appendages have small claws at the ends and are used for walking. In males, the first pair of walking legs have modified hook-like structures, used to attach and hold on to females during mating. The last pair of appendages in both sexes is covered with numerous spines and is used for movement during normal activities.

The abdomen is the middle body region of the horseshoe crab and is attached to the carapace by a simple hinge joint. The underside of the abdomen consists mainly of respiratory and reproductive structures, the most visible of which are the book gills. The first pair of gills have been modified into the operculum, which bears the openings of the genital pores where eggs and sperm are released during mating. The operculum covers the five other pairs of gills, which are used for respiration. The horseshoe crab continuously moves the book gills to keep oxygenated water flowing around them. The book gills are also used as paddles during swimming.

The third body region of the horseshoe crab is the telson, or tail. The telson is connected to the abdomen by a ball and socket joint, which allows the tail to move in multiple planes. Contrary to popular belief, the spike-like tail is not used as a weapon. Horseshoe crabs often use their tails to right themselves when accidentally overturned. There is no evidence that the tail is ever used for defense against the horseshoe crabs' few natural predators, such as loggerhead sea turtles and tiger sharks.

Reproduction and Life History

In Florida, horseshoe crabs mate year-round, although spring and summer are peak season. Horseshoe crabs aggregate on low-energy beaches to mate and nest, with most nesting activity occurring at high tide during the three days before and after a new or full moon. Male horseshoe crabs, one-third the size of females, typically move parallel to the shoreline on sandy flats to seek out and intercept female horseshoe crabs as they pass by. A successful male will attach himself to a female using his hook-like front appendages. Together they will crawl onto the beach, where spawning takes place. The male fertilizes the eggs as the female lays them in a nest in the sand. In a single spawning, called a clutch, female horseshoe crabs lay an average of 4,000 eggs, but they have been known to produce up to 90,000 eggs in a season. During this time, unsuccessful single males outnumber mating pairs and swarm around a mating pair trying to fertilize the eggs of the female. Horseshoe crab sperm remains viable in salt water for up to 96 hours; sperm from



unattached males often fertilize some of the eggs. Thus, several different males may father eggs from a single egg clutch. To ensure reproductive success on additional visits to beaches, males will often remain attached to a female for several weeks at a time.

Horseshoe crab eggs are green and only about 1/16 inch in diameter when they are laid. Over a period of two to five weeks, the eggs expand and the embryos develop into larvae. The larvae remain in the sand for several weeks and eventually molt into juveniles, resembling adults with proportionally smaller tails. Young-of-the-year horseshoe crabs first appear around June. Young horseshoe crabs are good swimmers but spend most of their time on sandy intertidal flats within a few yards of the beach. For up to one week, they rely on nutrients from their yolk sacs while their digestive systems develop. Larger juveniles are found lower in the intertidal zone, and subadults are at the seaward limit of the intertidal zone.

Horseshoe crabs use their chelicerae to feel around the sandy bottom for prey such as mollusks, polycheate worms, and dead fish. Like other arthropods, horseshoe crabs grow by periodically molting their exoskeletons. Molting usually occurs once or twice a year, and young horseshoe crabs molt more often than adults. At each successive molt, horseshoe crabs grow 20–30% by pumping in water to expand their new shells, which harden within 24 hours. Male horseshoe crabs reach sexual maturity after about 16 molts, which can take between 9 and 12 years. Females need to molt at least one additional time to reach maturity. Captive horseshoe crabs have been documented to live 15 years, but some scientists speculate that they can survive up to 30 years.

In general, horseshoe crabs do not travel long distances. Tagging studies of horseshoe crabs indicate that males return to spawning beaches more frequently than females, and most horseshoe crabs do not move away from these beaches during the breeding season. In one study in Apalachee Bay, Florida, the average distance traveled for 40 tagged horseshoe crabs was 4.1 nautical miles. However, one individual traveled 22 miles in only 13 days.

Importance of Horseshoe Crabs

Horseshoe crabs are an important component of the ecology of coastal communities. Like most organisms that produce thousands of eggs in a relatively short season, few eggs and offspring survive to maturity. Horseshoe crab eggs are an important food source for many animals, including many species of fish. Migrating shorebirds rely heavily upon the eggs during the nesting season. Without an abundant supply of horseshoe crab eggs, these migrating birds would not acquire the energy reserves needed to fly their long migration routes. In the mid-Atlantic states, more than 50% of the diet of many shorebird species consists of horseshoe crab eggs. In Florida, ruddy turnstones, sanderlings, dunlins, shore-billed dowitcher, and many species of gulls have been seen foraging on horseshoe crab eggs.

Marine invertebrate species, such as barnacles, mussels, sponges, and flatworms, attach to the underside of horseshoe crabs and use the carapace as shelter. These organisms are left on the exoskeleton when the horseshoe crab molts, leaving the horseshoe crab clean of external organisms until more settle and attach themselves to the shell.

Humans harvest horseshoe crabs for many different uses. Horseshoe crabs were once widely used as fertilizer for crops, which caused a decline in population sizes. Fortunately, the horseshoe crab fertilizer industry came to a halt in the 1950s, partly because of the production of synthetic fertilizers. Horseshoe crabs have also been used as feed for chickens, hogs, and other livestock. However, this practice has stopped because the horseshoe crab feed negatively affected the flavor of the meat. Currently, horseshoe crabs are heavily exploited in the bait fishery. Horseshoe crabs are used as bait in the American eel and whelk fisheries along many parts of the Atlantic coast. Eel fishermen use mostly female horseshoe crabs, whereas whelk fishermen use both males and females.

Horseshoe crabs are also important to biomedical research. The horseshoe crab is the most well-studied invertebrate in the world, and several Nobel Prizes have been awarded to researchers based on their work on horseshoe crabs. During the past 50 years, research on the compound eyes of horseshoe crabs has led to a better understanding of how human eyes function. Researchers have also discovered that chitin, which makes up the horseshoe crab's shell, can shorten the healing time of wounds by 35–50% and reduces pain compared to other standard treatment. As a result, chitin is now used to make dressings and sutures for burns, surface wounds, and skin-graft donor sites.

About 30 years ago, scientists discovered that horseshoe crab blood clots in the presence of small amounts of bacterial toxins. The chemical in their blood responsible for this clotting is called Limulus Amoebocyte Lysate (LAL). Currently, LAL is in high demand worldwide as the most effective substance used to test for bacterial contamination in commercial drugs and medical equipment. The Food and Drug Administration requires all injectable and intravenous

drugs to be tested with LAL, and LAL is also used to diagnose certain diseases such as spinal meningitis.

Fast FACT

Horseshoe crab blood is blue; the copper-containing molecule hemocyanin turns their blood blue when it is exposed to air, whereas the iron-containing hemoglobin in humans turns our blood red.

Threats to Horseshoe Crabs

After the use of horseshoe crabs by the fertilizer and livestock feed industries stopped, population numbers on the Atlantic coast rebounded and seemed fairly healthy. Unfortunately, more recent studies suggest that horseshoe crab abundance is once again declining in some areas, especially around Delaware Bay. Although scientists are unsure of the exact causes of this decline, it is most likely due to a variety of factors, including the degradation of habitat and overfishing. Reproductive activities of horseshoe crabs can be disrupted when seawalls or other types of development alter the configuration of the shoreline. The harvest of horseshoe crabs for the bait fishery climbed from an estimated 6,115 horseshoe crabs in 1970 to almost 2,364,000 horseshoe crabs in 1997, the majority of which were harvested in just three states: New Jersey, Delaware, and Maryland. In Florida, annual horseshoe crab landings for the bait fishery have been reported only since 1999 and tend to vary between 0 and 4,600 individuals. For the marine life fishery, however, horseshoe crab landings vary between 17,000 and 64,000 individuals in Florida.

Fortunately, pharmaceutical companies that extract blood from thousands of horseshoe crabs to obtain LAL do not have to kill the animal. About one-third of the animal's blood is removed, and the horseshoe crabs are released back to the water. One study estimated that mortality caused by bleeding horseshoe crabs is about 10%.

Management and Research Efforts

Because many shorebirds rely on horseshoe crabs for survival, the decline in the abundance of horseshoe crabs may have contributed to notable declines in the abundance of some shorebird species. In response to these declines, many mid-Atlantic states have restricted horseshoe crab harvesting. Consequently, some of the fishing pressure has been diverted to other states, such as Florida. Florida implemented rules for managing the harvest of horseshoe crabs in 2000. Individuals with a valid saltwater products license can harvest up to 25 horseshoe crabs per day. Individuals with both a valid saltwater products license and a marine-life endorsement or a permit to harvest eels commercially are allowed to harvest up to 100 horseshoe crabs per day.*

In 1998, the Atlantic States Marine Fisheries Commission developed a Horseshoe Crab Fishery Management Plan. One requirement of the fishery management plan is that all Atlantic coastal states identify horseshoe crab spawning habitat. The overall goal of this plan is to conserve and protect the horseshoe crab while maintaining its use in the various industries described above. Many Atlantic states are now providing volunteer programs where the public can become involved in collecting valuable data to help monitor the status of various populations during the nesting season.

Biologists at the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute initiated a horseshoe crab survey in 2002. The goal of this survey is to locate nesting beaches around the state with the help of the public. Anyone who observes mating and nesting activities of horseshoe crabs can help in this effort to document the critical locations where nesting occurs. If you observe any reproductive activities of horseshoe crabs, please report the information on (1) the location of your observation, (2) date and time of your observation, (3) an estimate of the number of horseshoe crabs seen, and (4) whether the horseshoe crabs were mating (i.e., two or more horseshoe crabs attached). Information can be reported by toll-free phone (1-866-252-9326), by e-mail (horseshoe@myfwc.com), or through an on-line survey (research.myfwc.com/horseshoe_crab/).

*Fishing regulations may change annually. Contact the FWC Division of Law Enforcement for information about current regulations. You can also view the current saltwater fishing regulations at the Web site for the FWC, Division of Marine Fisheries Management, located at http://myfwc.com/marine.

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