The WORM That Eats SHIPS

Objectives: Students will learn how *Teredo* worms have adapted to various environments; why they are invasive; why they are an economic and cultural problem; how they represent a transfer of energy in the food chain; the symbiotic relationships within them; and the effect of environmental factors on a species. Students will use the example of the CSS *Georgia* to understand the topics above better.

Materials: "The WORM That Eats SHIPS" handouts (p. 4-5) and the map handout (p.6), one of each for each student.; Styrofoam cups (minimum 5 per student); markers, Internet access (if possible); dictionary; paper and pencil for each student.

Georgia Performance Standards:

CCGPS ELACC4L1
CCGPS ELACC7RL2
CCGPS ELACC7L6
CCGPS ELACC9-10W2, W7
Science S4L1, S7L4
HS Zoology SZ4
HS Biology SB4

Social Studies Skills Matrices
Map and Globe Skills 12
Information Processing Skills 2, 3, 5, 7, 11

Reading Standards for Literacy in History/Social Studies
L6-8RHSS2, RHSS4, RHSS7, RHSS10

Writing Standards for Literacy in History/Social Studies, Science
L6-8WHST2, WHST4, WHST6

Benchmarks for Science Literary Concepts
Energy Transformations

Aligns with Next Generation Science Standards (NGSS):

MS. Matter and Energy in Organisms and Ecosystems
MS. Interdependent Relationships in Ecosystems
HS. Interdependent Relationships in Ecosystems

Background

The CSS *Georgia* was an ironclad vessel constructed in Georgia by the Confederacy in 1862. Ironclads were sheathed in iron in an attempt to protect them from enemy vessels firing upon them. Ladies from across the state and the south raised money to fund its construction. The vessel was built of wood and iron railroad rails. This made it too heavy to be propelled by its engine , so the CSS *Georgia* sat in the Savannah River defending the city until December 1864 when Union Major General William T. Sherman took the town on his March to the Sea. Confederate troops sunk the vessel so Union troops would not get it. Several years after the Civil War, and several times during the 20th century, attempts were made to salvage parts of the wreck. During this time, the U.S. Army Corps of Engineers (USACE) dredged the river repeatedly to make the channel deeper. In 2015, the USACE hired underwater archaeologists to excavate the CSS *Georgia* wreck. This was done so that the Savannah River channel could be dredged five feet deeper to allow larger ships coming through the Panama Canal to enter Savannah's port.

The Teredo worm was given its name in 1758 by Linnaeus. It is recognized today as an invasive alien species. In 1733 Dutch zoologist Gottfried Snellius first recognized that it was actually a mollusc and not a worm. *Teredo navalis* grow from 8-24" long depending on their environment.

The WORM That Eats SHIPS

Procedure

1.Have students read the two handouts "The WORM That Eats SHIPS" (pages 1 & 2). Instruct students to list unfamiliar words from the handouts (some are underlined) and use a dictionary or internet source to find (and write down) their definitions. Have students write 1-3 paragraphs summarizing what they have learned about *Teredo* worms and their environment.

2.Have students put numbers on the map labelling cities, countries, or geographical areas where the Teredo worm was mentioned in the handouts. Number the areas chronologically, based on when the species was first observed.

3. F**ood Chain/Web** – Encourage students to make 3-D food web/chains by using Styrofoam cups to represent each components in the food chain. (They can brainstorm the list or pull from a list on the board that might include entities not related to the food chain.) *Items in the Teredo worm food chain might include sunlight, trees, wooden ship, Teredo worms, people.* (This is the order of consumption on the food chain, and the order the students will stack their finished cups, beginning with sunlight and ending with people. Don't put them in order when making the list.) If they are not brainstorming the list, consider adding a few bogus items in the list to make students think.

Instruct students to put the cups on their desk, rim side down. They will use markers to write the name of the entity they select on the outside rim of the cup and then draw an image of it on the cup above the rim. (One entity per cup). When finished have the students stack the cups in the correct order to represent the food chain. Discuss the order with them as a class, along with these discussion questions:

4a. Who/what are the producers, consumers, and decomposers in the *Teredo* worm's world?
4b. Ask students to brainstorm the flow of energy as you draw their answers on the board:

sunlight → *photosynthesis in tree* → *gives tree energy to grow trunk* → *person cuts trunk and makes a ship* → *Teredo worm eats wood* → *bacteria in worm digests cellulose in wood* → *digested cellulose turns into glucose/sugar giving worm energy* → *worm reproduces* → *person eats worm and gets energy from the food* → *the person uses that energy to cut down a tree to make a boat and the energy cycle starts all over again!*

5. Share with students that the CSS *Georgia* shipwreck mentioned in "The WORM That Eats SHIPS" (p.2) is located in Savannah, Georgia. It was sunk near the mouth of the Savannah River, which flows into the Atlantic Ocean (see inset on map). The final 45 miles downstream on the river is tidally influenced, so salt water from the ocean is pushed up the Savannah River when the tides come in. This makes the normally fresh water river brackish. The salinity changes due to the tides, and can range from a few parts per thousand (ppt) to 35 ppt, the latter of which approaches ocean salinity.

The WORM That Eats SHIPS

5a. Ask students to review their two page hand-out and make a list of factors that might be responsible for the sudden presence of *Teredo* worms on the CSS Georgia shipwreck. *Considerations include water temperature, changing salinity levels, dredging soils off of wreck (exposing wood to worms larvae), increased ship traffic from foreign countries, and release of foreign ballast water from ships coming from other ports.*

5b. Ask the following and brainstorm answers with K-8th grade students. For Middle and High School Students, write the questions on the board and have students write informative/explanatory text incorporating the answers, using the handouts as well as independent research. How can the *Teredo* worm population be reduced or eliminated in the Savannah River harbor? Some possibilities: require ships to empty their water ballast several miles offshore in the Atlantic Ocean rather than near the Savannah River; work with scientists to develop natural, environmentally safe mechanism for eliminating *Teredo* worms, try to maintain saline levels in the river that are too low for *Teredo* worms to survive.

5c. How has the *Teredo* worm adapted to dangers in its environment? *It digs and coats tunnels with calcium deposits, making a strong, secure place to hide from predators, low temperatures and unfavorable salinity levels. Unlike others, the Teredo has evolved to have bacteria that can digest wood.*

6. How does the bacteria, *Teredinibacter turnerae* depend on the Teredo for its own survival? Why does the *Teredo* need the bacteria to live? *The bacteria lives within the Teredo, where it thrives. The bacteria enables the Teredo to digest the wood cellulose as sugar/energy and to fix nitrogen so the Teredo can absorb amino acids. This is an endosymbiotic relationship, a mutually beneficial relationship between a host organism and an organism inside the host.*

Resources

Didatticarte
Blog, "The Vasa Museum, an example to follow " (August 2, 2014). http://www.didatticarte.itpublicvasa-legno.jpg accessed February 12, 2016.

Didžiulis, V. (2011): NOBANIS – Invasive Alien Species Fact Sheet – ***Teredo navalis***. – From: Online Database of the European Network on Invasive Alien Species - NOBANIS www.nobanis.org accessed March 6, 2016.

Matias, Jonathan R.
Science Blog. "Lunar eclipse, Christopher Columbus and the Teredo worm. A convergence of astronomy, history and biology. " (December 26, 2010). With photos by Coleen P. Sucgang.
http://scienceblog.com/41367/lunar-eclipse-christopher-columbus-and-the-teredo-worm-a-convergence-of-astronomy-history-and-biology/ accessed March 1, 2016.

Museum of Underwater Archaeology
CSS *Georgia*
http://www.themua.org/cssgeorgia launched April 5, 2016 with new additions to follow.

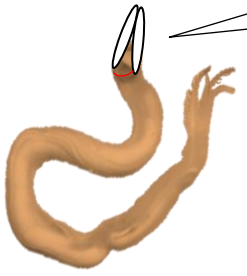
Smithsonian Marine Station at Fort Pierce
"Teredo navalis", http://www.sms.si.edu/irlspec/Teredo_navalis.htm accessed March 8, 2016.

Wiens, Mark
"Teredo Navalis – Look Like Worms, Taste Like Clams", http://migrationology.com/2014/11/eating-shipworms-teredo-navalis/ accessed March 1, 2016.

wreckProtect
"Shipworm", http://wreckprotect.eu/fileadmin/site_upload/wreck_protect/pdf/shipwormspdfnew.pdf accessed February 12, 2016.

The WORM That Eats SHIPS

Greetings and Salutations! My name is *Teredo navalis*, but you can just call me Terry. Some call me a naval shipworm. I am NO lowly worm! I am a mollusc because I have a shell that opens and closes, kind of like a clam, but a lot smaller. In fact, my shell is at one end and it is so small that most of me hangs out of it! I sure LOVE wooden ships and lots of other wooden things, too. Love to eat them, that is! I don't know why they call me the termite of the sea. Hey are you hungry or is it just me?



- My shell is for drilling and digging through wood, not for hiding inside! I hide in the long holes I drill in the wood. I coat the holes with a calcium deposit that hardens and protects me from fresh water, ice , air and things that want to eat me!
- I can't stand fresh, cold or hot water! The salt, or salinity must be over 8%. Water temperature must be between 52-59 degrees Fahrenheit.

Photo: Coleen P. Sucgang

- Wood sure is tasty with all those sugar molecules in its cellulose. All that wood could give other shipworms heartburn. Not me, buddy! I've got bacteria that uses enzymes to break down the cellulose so I can digest it and to allow the nitrogen to build amino acids. Makes a yummy meal for a shipworm!

REPORT CARD for Terry the Shipworm

Clears the oceans and mangrove swamps of rotting wood	**A+**
Provides cool-looking wood that people can make things out of	**A+**
Provides food for some people in the Philippines, Vietnam and other parts of Asia	**A+**
Eating ships, wharves, and docks since 3,000 B.C. through today	**F-**
Spreading around the world, even in places not lived in before	**F-**

Guitar made from Teredo - infested wood sold for $52,000 (Matias 2010).

Worms harvested in mango swamps are cooked in soup or eaten raw in vinegar and seasonings (Matias 2010; Wiens 2014).

Bonus The scientific name for the bacteria inside Terry is *Teredinibacter turnerae.* Research the bacteria. Why it is called endosymbiotic? What is one of its enzymes, cellulase, derived from? Why is it used on stonewashed denim jeans, in laundry detergents, and maybe in biofuels?

The WORM That Eats SHIPS

3,000 B.C.

Greeks, Phoenicians, and later Romans spread wax, tar, and lead on the hulls of their wooden ships, trying to keep *Teredo* worms from eating them.

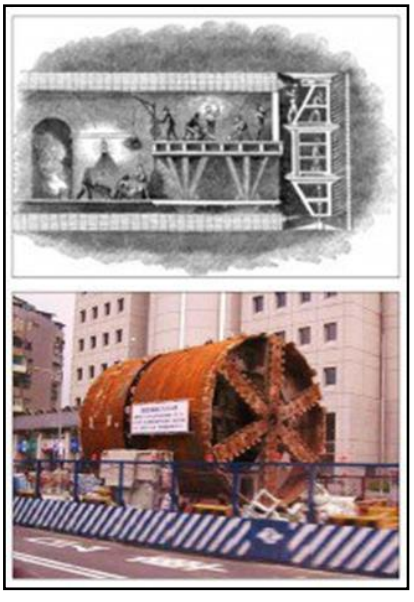
Photo: Didatticarte.

1731

A "plague" of *Teredo* worms destroyed enough wooden dikes in the Netherlands to cause flooding and threaten the country, which replaced them with stone dikes.

1818

French engineer Marc Brunel patented a mechanical method of tunneling under the Thames River in England. His method was based on the *Teredo* worm using its fine-ridged shell to drill while not being crushed. The design is still in use.



Courtesy Matias 2010.

1839

Teredos documented in foreign wooden ships entering Massachusetts Bay.

1913

Teredo worms in San Francisco Bay destroyed a major wharf or pier every week for two years. Damage in 1919-1921 cost between $2-$20 billion in today's dollars.

1979

Underwater archaeologists dive on the Civil War CSS *Georgia* wreck in the Savannah River in Savannah, Georgia.

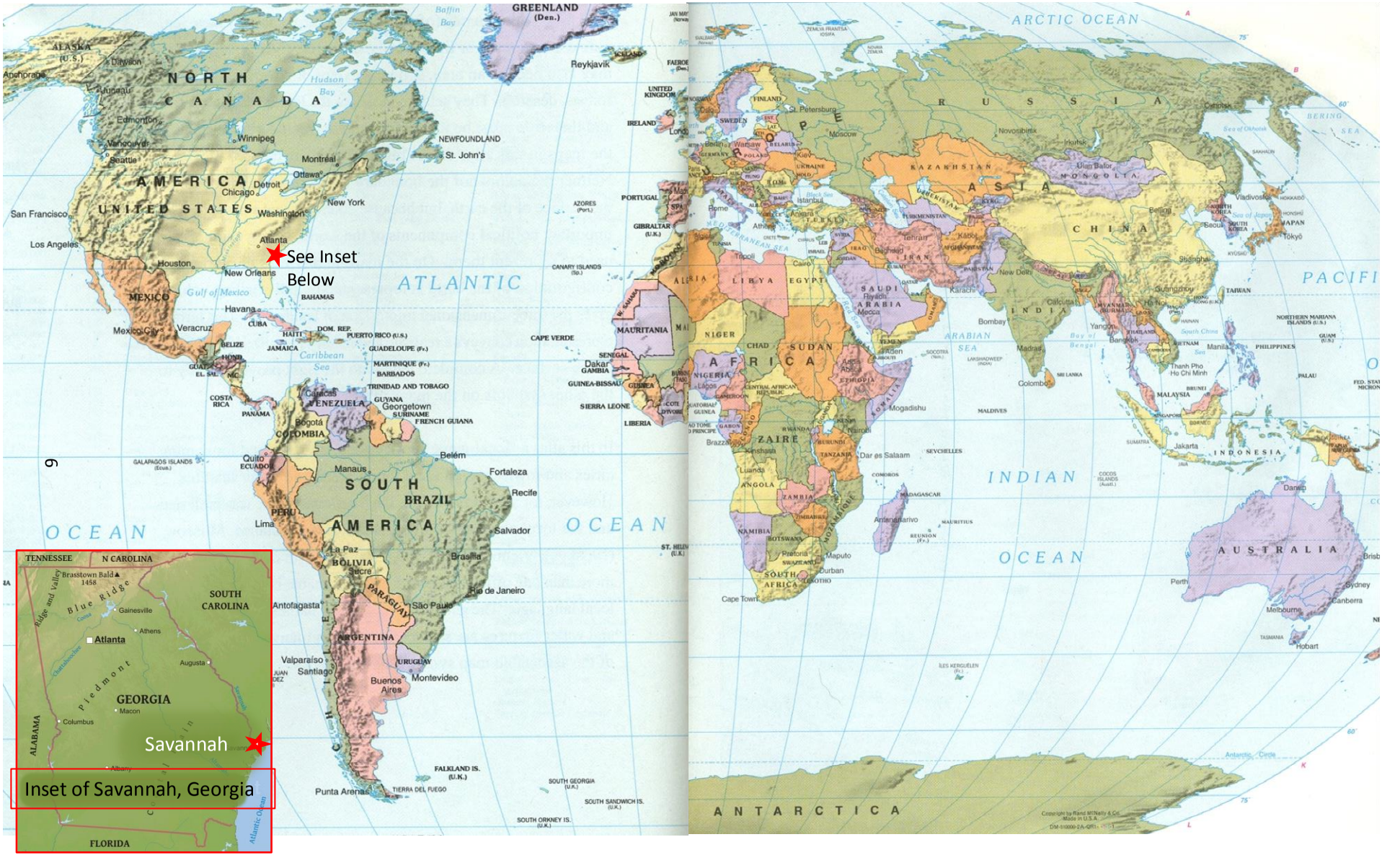
1983

U.S. Army Corps of Engineers dredged river channel around CSS *Georgia* wreck.

2003, 2015

For the first time, underwater archaeologists document *Teredo* worm-eaten wood on the CSS *Georgia* shipwreck.

Photo: Jeremy S. Buddemeier.


See Inset Below
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
ARCTIC OCEAN
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
ANTARCTICA
GREENLAND (Den.)
Reykjavik
ICELAND
NEWFOUNDLAND
St. John's
Baffin Bay
Hudson Bay
Gulf of Mexico
Caribbean Sea
Mediterranean Sea
Black Sea
Red Sea
Arabian Sea
Bay of Bengal
South China Sea
Sea of Okhotsk
Sea of Japan
BERING SEA
ALASKA (U.S.)
Anchorage
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