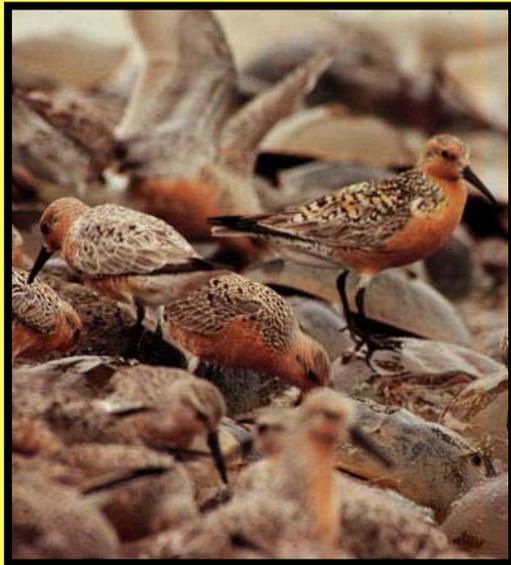


So, what's the big deal about
horseshoe crabs?



Kitts Hummock Beach, Delaware,
early 1990's (courtesy Jim White)

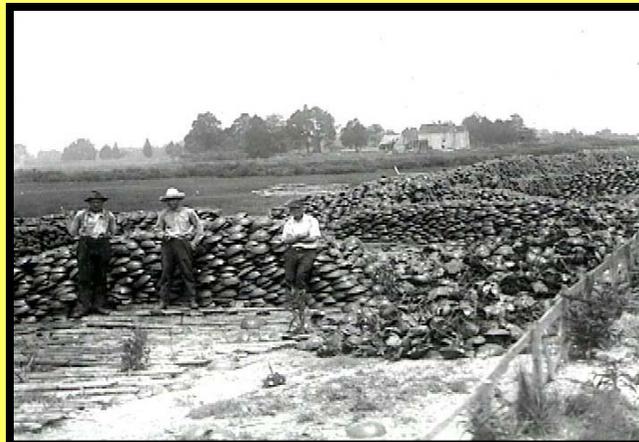
provides window on
globally-significant
in-our-own-backyard
natural phenomenon



example of an animal
once considered a
"trash species" that
now has all these
uses and values



Why
Horse-
shoe
Crabs?



fascinating animals,
unique life history,
longevity on planet,
"living fossils"



constitutes a highly
contentious natural
resource management
challenge and
controversy

2001: lessons for draft four-module curriculum developed
curriculum released for piloting to new group of educators at spring workshop

2002-3: video parts of curriculum finalized; workshops expanded to two each during spring lunar events on DelBay

2004: GE&S/HSC poster produced
curriculum/videos packaged to CD/DVD
workshops expanded up and down coast (MA, NJ, VA & GA)

Green Eggs & Sand Timeline

2000: Tri-state steering committee convened to chart project directions
teachers & experts recruited for inaugural workshop
module teams form & curriculum work begins

2008-14: workshops expand to Long Island, Maine & Connecticut
New team of educators complete major revision of curriculum modules 1-3; (new curriculum DVD released in 2012)

2005-7: GE&S earns recognition
Conservation Communicator of Year (NEAFWA)
Interpretive Media Best Curriculum (NAI)
invited to present at *1st International HSC Conference* (ISSCHC)

15 years of GE&S!

36 workshops in
8 states, involving:
>100 experts &
>1000 educators
from 25 states &
4 foreign nations



2015 Workshops

May 1-3: University of Georgia Marine Education Center & Aquarium, Savannah

May 29-31: Wetlands Institute, Stone Harbor, New Jersey

<http://tydb.mobiusnm.com/workshop>

GREEN EGGS & SAND IS ...

a unique, effective collaboration: working across state lines, scientists and educators, resource managers and stakeholders



a memorable workshop experience

an engaging mix of:
field experiences,
expert seminars and
hands-on activities.



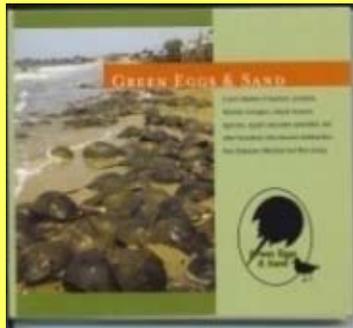
an award-winning curriculum: "Conservation Communicator of the Year" (NEAFWA, 2004), "Best Curriculum (NAI, 2005)

GREEN EGGS & SAND IS NOT ...

your typical
teacher
workshop



heavy focus on hearing from the experts
opportunity to 'hang' with the scientists
curriculum/activities take a back-seat



an over-
the-counter
product



the only way to get
the curriculum is by
full attendance at a
GE&S workshop

about
advocacy
for any view



presents multiple points of view
strives for accuracy and balance
encourages critical thought & analysis

What Educators **LIKE** about GE&S workshops



'real science' field experiences

access to the experts

chance to learn so much

wealth of take-home materials

Typical GREEN EGGS & SAND Workshop Structure

TIMEFRAME	PRESENTATION COMPONENT	ACTIVITY COMPONENT
FRIDAY EVENING	Workshop welcome, Ice breaker & Intro to HSC presentation	Molt study lab and/or Field trip to survey/observe HSC spawning
SATURDAY MORNING	HSC Ecology/Research expert(s) Shorebird Research expert(s)	HSC module overview/activity Shorebird module overview/activity
SATURDAY AFTERNOON	Biomedical use of HSC's expert Human use module overview	LAL (biomedical use) demo Visit with HSC bait user Shorebird viewing in the field
SATURDAY EVENING	GE&S curriculum share fair or other special speaker/program	Optional return trip to beach to observe HSC spawning
SUNDAY MORNING	HSC management module overview and presentations by experts on HSC management & conservation	Management videos viewing, Workshop wrap-up, and distribution of materials

GREEN EGGS & SAND Workshop Presenters



Biomedical scientists



Commercial Fishers



Fisheries Managers



Environmental Educators



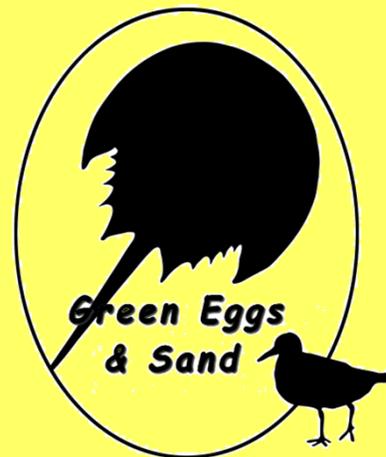
Horseshoe Crab & Shorebird Researchers

Module 1: The Horseshoe Crab

Module 2: Shorebird Connections



The four

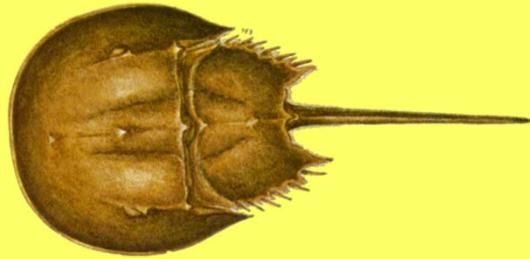


modules



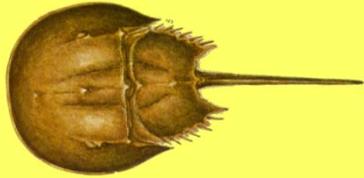
Module 3: Human Connections

Module 4: Managing the Resource



Horseshoe Crab (HSC) Module Activities

- 1) ***“A Shotgun Approach”*** (intro to life of HSCs video clip)
- 2) ***Horseshoes Alive*** (read article & do graphic organizer)
- 3) ***HSC anatomy*** (article, paper model, molt lab & videos)
- 4) ***Time-Tracking*** (create timeline of HSC history on Earth)
- 5) ***Life Stages*** (teaches about the life stages of *Limulus*)
- 6) ***Food/Energy Web*** (create an HSC food web & pyramid)
- 7) ***Tidal Urges*** (explores tides & impacts on spawning)
- 8) ***Reach the Beach*** (game on factors influencing spawning)
- 9) ***Horseshoe Crab Jeopardy*** (great module review game)
- 10) ***Field Projects*** (projects for observing HSCs on beach)



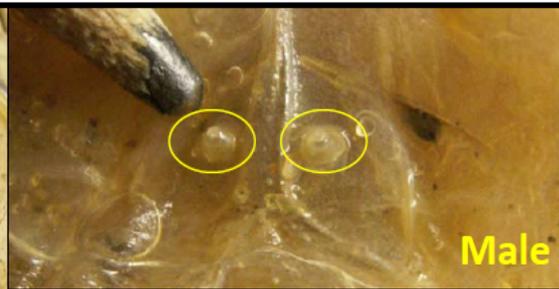
HSC Molt Study Lab

Horseshoe Crab Molt Lab: Station #7 (sexing your HSC)

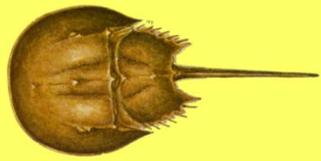
7. The underside of the HSC operculum holds the gonopores through which eggs (in adult females) and sperm (in adult males) are released during spawning. The shape and feel of these gonopores can be used to sex HSCs. This can be done by lifting the operculum (as in photo at left below) and gently running your fingers along the underside. In males, the pores will protrude, feel hard, and appear raised and conical. In females, the pores feel softer, appear flatter and more rounded, and feature a horizontal slit (see photos at right). The two specimens at this station have been soaked in solution to make them more flexible for observing. *Gently pull back the operculum and view the gonopores with the hand lens. Label the sex of each specimen on your answer sheet.*



Photo above: underside of HSC molt operculum showing gonopore location (circled in yellow).
Right photos: view of male & female gonopores



Uses a rotation lab (8 stations) approach to engaging students in learning the finer points of horseshoe crab anatomy through the study of shed molt specimens.



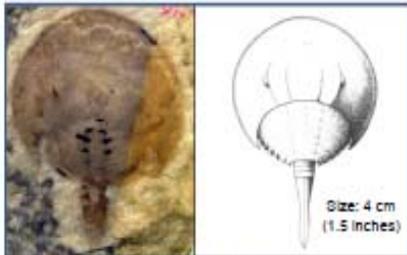
Time-Tracking (HSC Timeline)



Heinrich Harder www.copyrightexpired.com

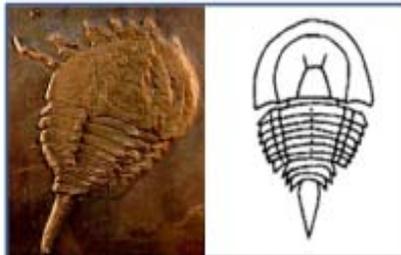


fossil (left) and illustration (right) of a horseshoe crab-like Trilobite from the Cambrian Period (300 mya)



Size: 4 cm (1.5 inches)

Photo (left), courtesy G. Young, The Manitoba Museum. reconstruction (right), D. Rudkin, Royal Ontario Museum



fossil (left), and reconstruction (right) of ancient horseshoe crab Weinbergina, courtesy Dr. Carl N. Shuster Jr.



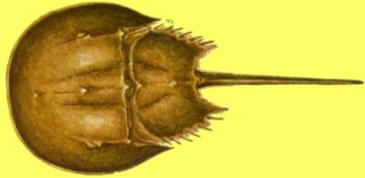
body is the size of a penny

Fossil horseshoe crab (left); and reconstruction (right) of *Euproops danae* (Illinois Natural History Museum)



fossil (left), and reconstruction (right) of *Mesolimulus*

Offers a lesson plan & detailed instructions for constructing a spatial timeline of HSC's amazing (nearly 500 million years!) march through time, including a series of 80 reproducible event cards (such as those at left) for students to place along the line.



Horseshoe Crab Jeopardy

Horseshoe Crab Jeopardy!

Anatomy	Biology	Life Cycle	Ecosystem	Misc.
<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
<u>200</u>	<u>200</u>	<u>200</u>	<u>200</u>	<u>200</u>
<u>300</u>	<u>300</u>	<u>300</u>	<u>300</u>	<u>300</u>
<u>400</u>	<u>400</u>	<u>400</u>	<u>400</u>	<u>400</u>
<u>500</u>	<u>500</u>	<u>500</u>	<u>500</u>	<u>500</u>

provides a Powerpoint-based template and series of answers & questions on different things learned about HSCs in the module



GE&S Shorebird Module Activities

- 1) ***“A Feeding Bonanza”*** (Delaware Bay shorebird video)
- 2) ***Build a Shorebird*** (exploring shorebird adaptations)
- 3) ***Be ‘Shore’ about your Birds*** (dichotomous key activity)
- 4) ***Eat and Go*** (simulates HSC-egg eating challenge for birds)
- 5) ***Red Knot Olympics*** (explores shorebird Olympian feats)
- 6) ***Be ‘Shore’ about your Data*** (interpreting data challenges)
- 7) ***Every Bird Counts*** (assessing shorebird populations)
- 8) ***Where Have You Been?*** (reading the shorebird leg bands)



Build a Shorebird



Introduces students to the various adaptations of shorebirds for long-distance migration.

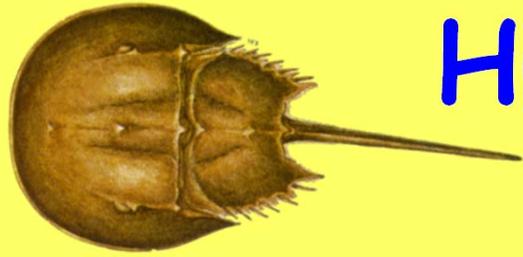
A volunteer from the class is recruited to be "dressed" as a shorebird, using selected objects that are keyed to clue cards describing different shorebird adaptations.



Eat and Go

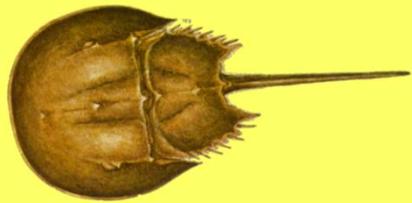


Engages students in a simulation of the challenges shorebirds face in consuming sufficient horseshoe crab eggs to meet their energy needs for their May migration from Delaware Bay to their Arctic nesting areas, including various natural and human disturbance factors that can keep them from putting on the fuel they need.



Humans & HSCs Module Activities/Sequence

- 1) *Humans and Horseshoes***
- 2) *Share the Beach***
- 3) *Wanted Dead and Alive: Economics of the HSC***
- 4) *Horseshoe Crabs Around the World***
- 5) *Paging Dr. Limulus***
- 6) *HSC Vision - Eyes on the Prize***
- 7) *LAL-Lab: Modern Medical Marvels from an Ancient Mariner***
- 8) *Experiments with Chitosan***



Eyes on the Prize

Engages students in exercises designed for in-depth exploration of the HSC's unique visual system.

This includes gathering info on structure and function of each of the HSC's 10 "eyes", and using this to locate and describe each type of eye on dorsal and ventral diagrams provided.

Part C. Looking More Closely at the Compound Eye

1. When a HSC molts, it is shedding its exoskeleton. This includes the lenses of the ommatidia that make up the crab's compound eyes. Working with your partner, take the HSC molt provided by your teacher and carefully cut around one of the compound eyes with a pair of scissors to remove the compound lens. Make your cuts about a half a centimeter from the eye, so that a little bit of additional exoskeleton is still attached.
2. Place the compound eye on the stage of a dissecting microscope and light the microscope from below. Focus in on the individual lenses of the ommatidia. As HSCs grow, each successive molt produces more ommatidia than the one before it.
3. Turn the compound eye over and focus the image. Compare what you see to the photos below. Does the inside surface of the individual ommatidia look different than the external surface? If so, describe the difference and hypothesize as to why that difference might exist.

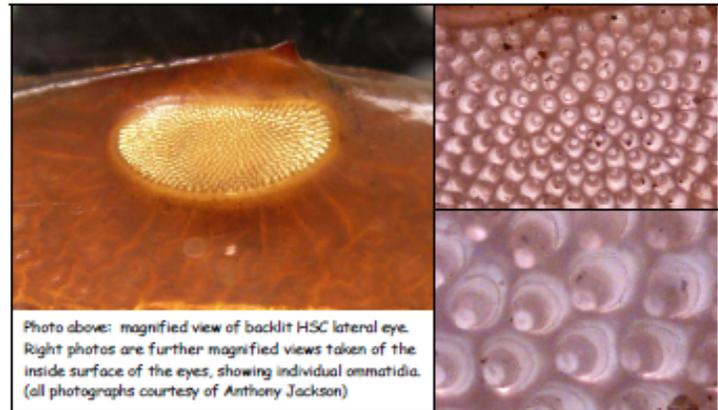


Photo above: magnified view of backlit HSC lateral eye. Right photos are further magnified views taken of the inside surface of the eyes, showing individual ommatidia. (all photographs courtesy of Anthony Jackson)

4. If your classmates are looking at compound eyes from molts of different sizes and ages than yours take a look under their dissecting scopes. Compare the number of ommatidia in your molt's eye to that of your classmates. Are there fewer or more? Does the internal surface of the ommatidia look the same for eyes of different sizes?
5. Optional: look through the pair of plastic mesh sunglasses provided by your teacher. This simulates the view that a HSC has through its compound eyes. Describe how this view differs from what you see when you look at an object.

Paging Dr. Limulus



***web-research
based activity***



***assign teams of
students diff. Q's***



***links & scoring
rubric provided***



***Can be combined
with 'HSCs around
world' to engage
8 student teams***

Team Two: Chitin and Chitosan

RESEARCH QUESTIONS

1. What is chitin? What is chitin's "job" in the HSC?
2. How is chitin extracted for use by humans?
3. What is chitosan? How is it produced?
4. What are some current medical uses of chitosan? Describe at least four uses.
5. How can chitosan be used to prevent medical implant infections?
6. What is PluroGel and how is current medical research on it connected to chitosan?

INTERNET RESOURCES

- Chitin is Excitin:
<http://www.ceoe.udel.edu/horseshoecrab/Research/chitin.html>
- Chitin: <http://www.greatvistachemicals.com/biochemicals/chitin.html>
- Chitosan bandages:
<http://www.allbusiness.com/manufacturing/chemical-manufacturing/1114577-1.html>
- Chitin, chitosan, surgical materials and seed germination:
<http://www.sciencedaily.com/releases/2007/07/070713131300.htm>
- Chitosan and medical implant infections:
<http://www.sciencedaily.com/releases/2006/09/060910142640.htm>
- Chitosan and PluroGel: <http://oscar.virginia.edu/explorations/x15670.xml>

LAL-Lab: Modern Medical Marvels from an Ancient Mariner



video, PowerPoint & lab-based lesson



Lab simulation of actual LAL gel-clot test process used by biomedical industry



ppt offers extensive background notes, references & web-links for review



The image shows horseshoe crabs (HSCs) being bled in a biomedical laboratory. Notice that the needle has been inserted through the middle (hinge) area of the HSC and into its heart.¹

Note: The HSC heart doesn't pump like a human heart, so inserting the needle into it does not kill or cause serious harm to the crab.²

Reports vary widely on both the volume and percentage of blood (properly call hemolymph) that is drawn from a HSC in biomedical bleeding.³ Typically, the larger the HSC, the more blood it holds. Most accounts put the volume of blood taken to be about 100 ml on average (equivalent to a small coffee cup's worth), corresponding to about 25-30% of a HSC's total blood volume.

So it's important to point out that the amount of blood shown in each bottle in the picture above is not all from one HSC, but the product of bleeding several. Students will also notice the blue blood. That and other aspects of the discovery, processing, applications, and benefits of using HSC blood in biomedical testing will be covered in detail in the slides that follow.

LAL Testing

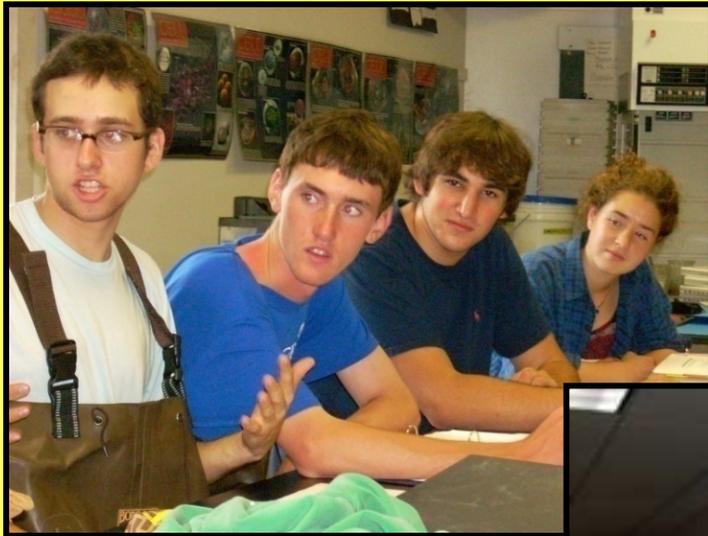
AP Biology students performing the LAL lab as part of a unit on microbes & the immune system.



Module 4: Managing a Resource Activities

STORY: Video Segments	LEARNING: Exercises/Activities
<i>Dollars on the Beach</i> : opening 'teaser' clip, establishes the HSC controversy, circa 1997	<i>Tragedy of the Commons</i> : game that shows how shared resources can become depleted
<i>Identifying the Stakeholders</i> : clips of 10 stakeholders, their views on controversy	<i>How behaviors impact nat. res. Challenges Beliefs & Values, Art of Argument</i> lessons
<i>Managing for Everyone</i> : perspectives from F&W directors on managing multi-use resource	<i>WebQuest: the HSC Controversy</i> : engages students in role play of various stakeholders
<i>Managing with Scientific Data</i> : HSC Tech. Comm. Biologists speak to gaps & flaws in data	<i>The Rest of the Story</i> : examines graphs from real data sets used in stock assessment
<i>Other Views of Research</i> : 4 stakeholders offer insights on difficulties inherent in how data is interpreted and used in issues like this	<i>Issues Analysis: Using Secondary Data</i> : challenges students to do critical review of selected news articles' spin on HSC situation
<i>What Happened Next?</i> picks up chronology of development/implementation of HSC-FMP	No accompanying lessons, other than discussion of how fisheries management process works
<i>Designing a HSC Survey</i> : Bio-Statistician on how/why of new scientific spawning survey	<i>Let's Count the Crabs/Spawning Survey</i> : classroom-simulated spawning survey activities
<i>Working for Solutions</i> : clips of players and approaches aimed at resolving HSC controversy	<i>Getting More Involved</i> : ideas for student action projects related to natural res. issues

HSC Management



role-playing the
stakeholders
involved



in the HSC
conservation
controversy



Town Meeting simulation



Coming soon to a bay beach near you ...



QUESTIONS?

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