Chapter 32
Green Eggs & Sand, Team Limulus, and More: Educating for Horseshoe Crab Conservation in the United States

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Abstract Efforts to educate people about the American horseshoe crab, *Limulus polyphemus*, have expanded greatly in the United States in recent years. This article provides highlights of five high profile programs, including: Ecological Research & Development Group's (ERDG) *Horseshoe Crab Conservation Network*™, the *Green Eggs & Sand* project, *Raising Horseshoe Crabs in the Classroom*, *Team Limulus* and *Crab App*. These programs represent a variety of approaches taken to increase public awareness, promote stewardship, and deepen understanding of the unique life history, ecological connections and human uses of this ancient species. The article includes profiles of programs targeting bayshore homeowners, teachers, school children and volunteer monitoring groups. Selected links and references to additional resources for horseshoe crab education are also provided.

Keywords ERDG • *Limulus polyphemus* • Raising horseshoe crabs • Molts • Education • Conservation • Sanctuary • Monitoring • Apps • Curriculum

32.1 Introduction

Over the last 15 years, interest in the American horseshoe crab has inspired increasingly widespread and varied efforts to promote awareness and conservation of this ancient animal. In just about every Atlantic coast state where horseshoe crabs come into shore and spawn, educational programs have sprung up to enlighten people about this species. This article cannot presume to cover them all. What it will do is highlight five examples of *Limulus* education programs representative of the varied

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approaches taken, with the hope that – in profiling these programs for those who work with horseshoe crabs in other parts of the world – pathways may emerge for adapting, applying and/or expanding those approaches to new audiences, thus broadening the impacts of education for conservation of this important group of animals.

32.2 Ecological Research & Development Group's (ERDG) *Horseshoe Crab Conservation Network*™

One could hardly present an overview of horseshoe crab conservation through education in the United States without highlighting the exceptional body of work done through the non-profit ERDG over the past two decades. As outlined by Gauvry (2009), the essence of ERDG's varied initiatives boils down to one common denominator – establishing a compassionate connection to an animal – the horseshoe crab – that for much of human history has gone unnoticed or been viewed as a trash species or commodity. In establishing that connection to this animal, seeds of awareness are planted in people, leading them to want to learn more, and with that knowledge, inspiring an interest in taking action for conservation. Building on that premise, ERDG's *Horseshoe Crab Conservation Network*™ offers a multifaceted, cross cultural suite of initiatives designed to inform and engage individuals, communities, organizations and scientists around the conservation of the world's four horseshoe crab species. Key components of that effort are summarized in the paragraphs to follow.

32.2.1 Just flip 'em*!* ®

One of the earliest directed forays into horseshoe crab education for conservation in the US occurred in the late 1990s when ERDG introduced its *Just flip* '*em*! ® campaign (ERDG 2006). At the time, public awareness of horseshoe crabs along the Atlantic coast, and even at its Delaware Bay spawning epicenter, was relatively low, with many people living along spawning beaches viewing the animals as a nuisance or, at best, with utter indifference. It was not uncommon at the time for communities to enlist contractors to come in with heavy equipment to bury or haul away horseshoe crabs stranded in spawning to keep their beaches looking (and smelling) cleaner. In the time since, *Just flip* '*em*! ® has worked wonders in mitigating that need and changing that mindset through a simple, but effective message: if one sees a live horseshoe crab flipped over on its back along the beach – rather than walk by and ignore it – take a moment to gently turn it over and give it the opportunity to continue its life.

The rationale for this derives from the scientifically established observation that when horseshoe crabs are flipped over on their backs along spawning shorelines, a

certain percentage of them (10–15 % or so) will not be able to right themselves, resulting in death by desiccation, predation by gulls, or other factors (Botton and Loveland 1989). But the intent behind *Just flip* '*em*! ® runs deeper than the number of crabs or percentage of the population that might be saved by this action. The larger goal lies in getting people to overcome their indifference to this animal (Fig. 32.1). In flipping over a stranded horseshoe crab on the beach, an individual makes a conscious compassionate connection to the animal. From that grows an interest in learning more, and ultimately, taking action in transferring that knowledge and passion to others.

Consider the person who is flipping horseshoe crabs during their morning walk along the beach (as has become the habit of many Delaware Bay shore residents in recent years). Along the way, that individual crosses path with a neighbor or visitor who sees her/him flipping horseshoe crabs and asks "why?". At that point that individual makes the transition from crab flipper to crab educator. In this way, a chain of awareness, linked to conservation action, grows person to person, expanding out to the community and beyond. Over the years, numerous wonderful examples of such impacts have emerged from the *Just flip* '*em*! ® program, including the woman, who during her morning walks along her Delaware Bayshore backyard, puts a stone in her pocket for every 100 crabs she flips, and in this way documented rescue of more than 20,000 crabs during a single spawning season! Then there's the story of Jasper the Golden Retriever – made famous in a recent poster sponsored by Charles

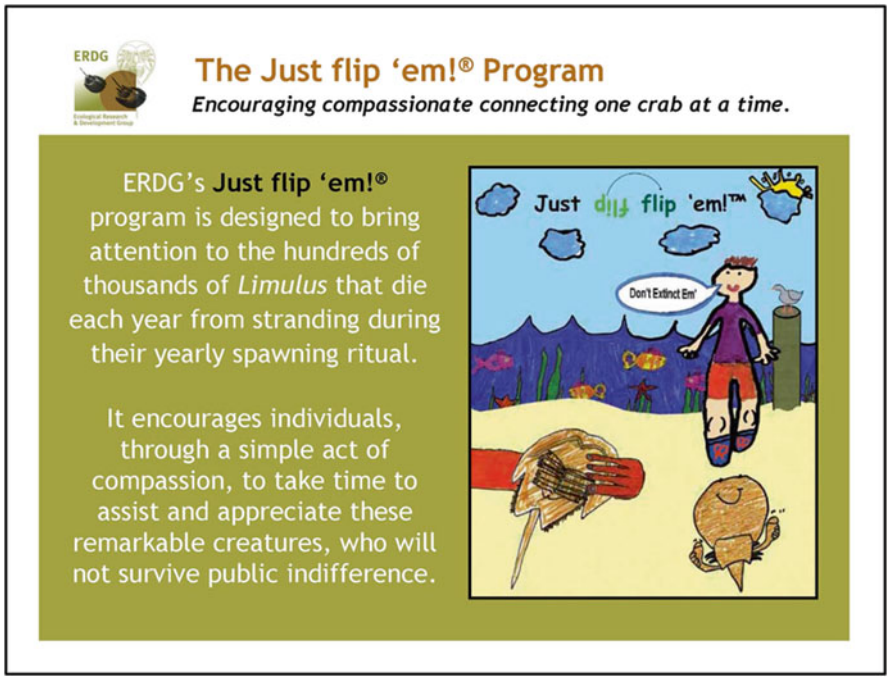

Fig. 32.1 ERDG's *Just flip* '*em*! ® program

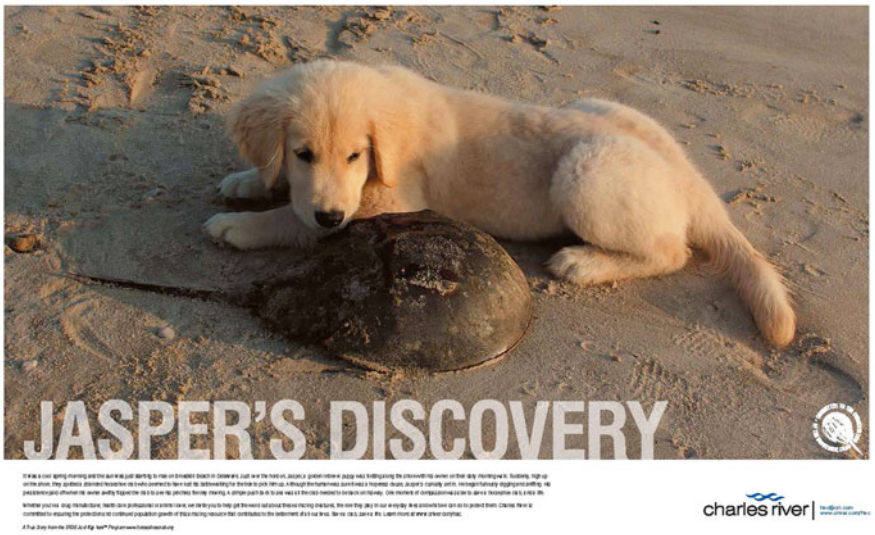

Fig. 32.2 Jasper's discovery poster (Produced by Charles River Laboratories in collaboration with ERDG)

River Laboratories (see Fig. 32.2) for the dog's ability to find dying crabs stranded high on the beach that his human crab-flipping companion had overlooked (Charles River is one of four companies in the United States that bleeds horseshoe crabs for human health biomedical benefits and is currently working with ERDG in promoting an *ICare* campaign for horseshoe crab awareness). In recent years, compassionate connecting to horseshoe crabs has expanded to include an annual blessing of the horseshoe crabs event that brings hundreds of Buddhists from across the Northeast to a Delaware Bay beach to pay homage to this ancient mariner (MacMillan 2012).

32.2.2 Back Yard Stewardship™

Residents in many of these same beaches where *Just flip* '*em*! ® has become a popular activity can further their conservation commitment by banding together – through ERDG's *Back Yard Stewardship*™ program – in declaring their shared habitats as horseshoe crab sanctuaries (ERDG 2009). This program was founded with the idea that the future survival of the world's four horseshoe crab species will ultimately depend upon preservation of spawning habitat – a challenging prospect in light of the ever-increasing human density along the same beaches horseshoe crabs rely on for spawning. Since the program was launched in 1999, ten beaches on Delaware Bay (seven on the Delaware side and three in New Jersey), encompassing over 15 miles of some of the most productive horseshoe crab spawning habitats in the world, have been protected through designation as horseshoe crab

sanctuaries. Efforts are also underway with citizen advocates in New York, Florida and the Yucatan to enlist community support for establishing sanctuaries in other parts of *Limulus*' range where horseshoe crab spawning occurs along human occupied beaches.

As described by ERDG, creating a horseshoe crab sanctuary is, at its simplest, a community's expression of how they view their beach and the natural resources it encompasses. Communities vary widely in how this designation is manifested (Gauvry 2009). Many communities erect signs to alert visitors to the significance of their beach to horseshoe crab spawning. Some have incorporated the horseshoe crab into their town logo, symbol or slogan and a few even hold festivals to celebrate the annual spawning ritual. Others engage more quietly, enjoying the resource and educating their friends, neighbors and visitors about it as opportunities arise.

32.2.3 ERDG's Horseshoe Crab Website

Not everyone lives on or visits beaches where horseshoe crabs spawn, and even for those that do, there needs to be a place where people can satisfy their interest in learning more about this animal. The information-rich, user-friendly and ever-evolving ERDG website fulfills that need and then some. In addition to being the most frequented horseshoe crab website on the internet, www.horseshoecrab.org (ERDG 2008) serves as the umbrella for ERDG's global horseshoe crab conservation network. As such, it provides community interaction, cultural exchange, education resources and peer-reviewed information on the world's four horseshoe crab species to over 300,000 visitors annually and 1,500 linked sites worldwide. The success of this site can be measured by the tens of thousands of students, educators and researchers from around the world who use it annually. Major topics addressed on the web site include natural history, anatomy, global distribution, evolution, medical uses, conservation, and news (the latter featuring postings of the latest articles and news releases about horseshoe crabs from around the world). The depth and breadth, user-friendliness, and accuracy of information about horseshoe crabs available on this site are unparalleled.

Efforts to improve the website and update the information it provides are ongoing. A key recent addition is development of a comprehensive data base for horseshoe crab research (ERDG 2012), providing citations, listings (and a growing number of pdf downloads) for over a thousand publications on various aspects of horseshoe crab research. The ultimate goal of providing the world with the most comprehensive source of peer-reviewed information on the four horseshoe crab species drives these efforts. The user-friendly data base interface offers visitors the ability to search by topic, resource type and key words, along with access to easy download and upload of resources. This same approach will be applied to a recently conceived (in development) "Teacher Toolbox" section of the website, that will be dedicated to exchange of lesson plans, posters, PowerPoints, booklets, student research submissions, and various other outreach and education resources from

around the world. One of the latest website enhancements provides important new information relating to the biomedical use of horseshoe crabs, and conservation practices critical to that use. For social media enthusiasts, ERDG's popular Facebook page (https://www.facebook.com/horseshoecrab.erdg) provides an engaging venue for more casual and immediate global sharing of horseshoe crab information, stories, photos, and videos (ERDG 2014a).

32.2.4 Young Voices™ Horseshoe Crab & The Arts™

The final component of ERDG's educational repertoire cultivates horseshoe crab awareness and education via a whole other arena – engagement of young people in sharing their heartfelt expression for horseshoe crabs through poems, stories, images and even musical compositions. Since the inception of the *Young Voices*™ *Horseshoe Crab & The Arts*™ program in 1999 (ERDG 2014b), thousands of students from various locations around the world have contributed to this collective voice, exploring, expressing and nurturing the compassionate heart – not only in themselves through the power of expression and creativity they bring to, and take from, their work, but also in adults who view these works and are moved in their own hearts by the messages they conveyed and emotions they evoke. Figure 32.3 offers a montage of a few examples of the many wonderful works contributed by these young artists.

32.3 *Green Eggs & Sand*

In 1999, at a time when schools in Delaware, Maryland and New Jersey were teaching middle and high school students ecology via lessons on Australian kangaroo rats, mid-western prairie dogs, and South American tropical rain forests, an important ecological and economical drama was occurring right in their own backyards. A major conflict was being played out in the media, courts and politics between the rights of fishermen to harvest horseshoe crabs for bait and the need to conserve horseshoe crabs for providing a superabundance of eggs as a vital food resource for migratory shorebirds.

Consequently, a group of environmental education specialists from those three states, along with a prominent horseshoe crab video documentarian, Michael Oates (2014) put their collective heads and resources together and decided to do something to change that. After considerable thought, planning, and a great deal of effort, a program emerged from all this that came to be called *Green Eggs & Sand*.

From the outset, the goal of *Green Eggs & Sand* (GE&S) was to provide an intensive teacher workshop experience and comprehensive classroom curriculum for immersing Mid-Atlantic educators and their students in the horseshoe crab/migratory shorebird phenomenon and the contentious management controversy sur-

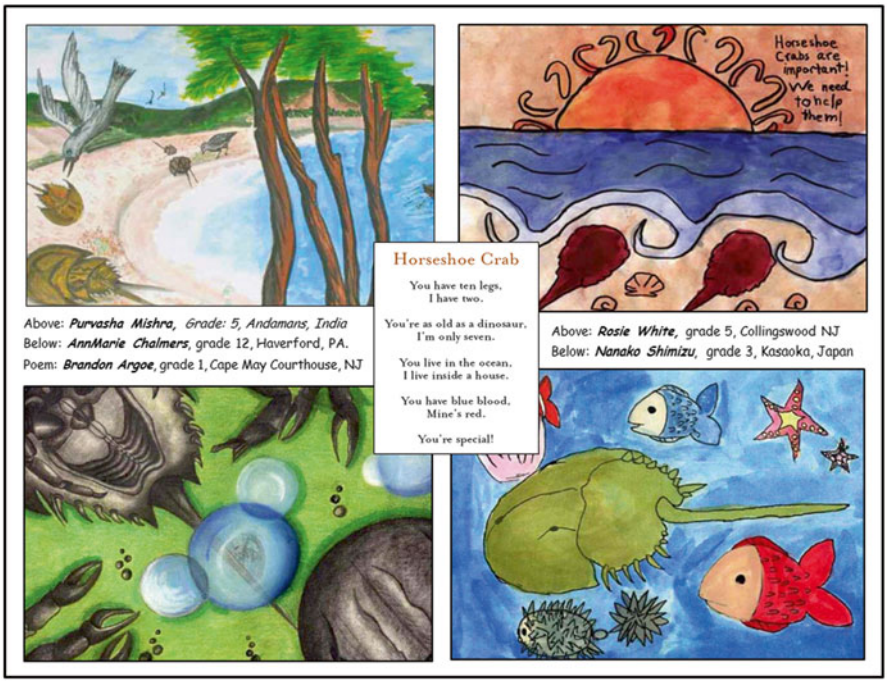

Fig. 32.3 Montage of selected young voices horseshoe crab in the arts competition winners

rounding it. At the first International Symposium on the Science and Conservation of Horseshoe Crabs on Long Island in 2007, members of the GE&S team delivered a detailed overview of the history, philosophy and underpinnings of that approach (O'Connell et al. 2009). A key focus of that presentation, and a big reason for the success of GE&S, can be described in one word – collaboration. By working together across state and agency lines, costs in staff time and funding are spread and shared (so no one program or state's budget is too burdened), at the same time that diverse talents and access to resources are synergized. Equally vital has been the collaboration fostered in bringing scientists and educators together through this project. Over the 15 years of presenting GE&S workshops in various Atlantic Coast venues, more than 100 expert presenters – including horseshoe crab and shorebird researchers, biomedical scientists, fisheries managers, commercial fishermen, and representatives of the conservation community – have shared their time, talents and perspectives on these issues with participants. The contributions of these experts in providing real data, video lessons and scientific ground-truthing to the curriculum have likewise been significant.

Building on that foundation of collaboration, GE&S continues to expand its audience, focus and resources in enhancing education about *Limulus* in numerous arenas. Educator workshops remain at the heart of that approach, with interest in the program leading to expansion of these opportunities well beyond the original Mid-Atlantic region focus. As such, three intensive weekend-long workshops are now

offered each spring in tune with the full and new moon peak spawning times for horseshoe crab spawning in various locations, including: a late April/early May session (hosted by the University of Georgia's Marine Education Center and Aquarium on Skidaway Island), a mid-to-late May session on Delaware Bay (alternating between venues in Delaware and New Jersey), and a "northern" workshop in June (including sessions in recent years hosted by partners in New York, Massachusetts, Maine and Connecticut). These workshops (TYDB 2014) feature a mix of field activities (including at least one horseshoe crab spawning observation trip), numerous expert and stakeholder seminars, and demonstration activities from each of the four GE&S curriculum modules. Since the inaugural Delaware Bay workshop in 2000, 36 GE&S workshops have been presented, reaching over 1,000 educator/scientist participants, encompassing 25 states and 5 foreign nationalities. Educator surveys over the years document use of the GE&S experience and resources in reaching more than 100,000 students coast wide with teachings on various aspects of horseshoe crab biology, ecology, and connections to humans and the environment.

In 2010, as a consequence of the expanding geographic interest in horseshoe crabs, and to address the ever-changing and growing body of knowledge around horseshoe crabs, shorebirds and human use of the resource, the GE&S coordination team initiated a major update and revision to the then decade-old curriculum. A cadre of past participant educators were recruited from up and down the Atlantic coast and assigned to teams for review, update and enhancements to lessons in the first three modules of the curriculum. Over the course of several writing workshops held during 2010 and 2011, each of these teams collaborated in completing substantive rewrites/revisions of all lessons from the Horseshoe Crab, Shorebird and Human Connections modules (Fig. 32.4). Gaps in the curriculum were also identified, resulting in development of several new lessons for each of those modules, including many featuring strong interdisciplinary connections and/or offering an engaging STEM (Science, Technology, Engineering and Math) focus. This included new lessons providing in-depth exploration of horseshoe crab anatomy and vision, the tidal cycle (as it relates to horseshoe crab spawning), shorebird sampling methodologies, webquest information gathering and reporting challenges, and (thanks to the generous support of Lonza USA Inc.) simulation of the gel-clot test for biomedical use of horseshoe crab blood product. In the horseshoe crab module, new video segments were also produced to further improve its content, including four clips highlighting the functional anatomy of *Limulus* (inspired and directed by Dr. Carl N. Shuster Jr., one of world's foremost authorities on horseshoe crabs), and a six-segment companion piece featuring Dr. Jane Brockmann (an expert on the spawning behavior of *Limulus*) demonstrating field research projects to engage student observation of *Limulus* spawning activities (Brockmann 2012). As a standing policy of the GE&S team, the new curriculum-on-DVD is only distributed to educators participating in a full-weekend workshop.

Figure 32.5 illustrates a piece of one of the new GE&S lessons developed for the horseshoe crab biology and ecology module – involving use of molt specimens as a tool for studying finer points of horseshoe crab anatomy. Inspired by a short paper

Fig. 32.4 Screenshot of *Humans and Horseshoe Crabs* module menu from *Green Eggs & Sand* curriculum

contributed by Dr. Shuster some 50 years ago (Shuster and Horrell 1966), this hands-on lab-based activity engages students in rotating through a series of eight stations, each challenging the student to observe particular aspects of the horseshoe crab dorsal, ventral and even internal shell anatomy. A favorite station for students is one where they sex specimens by observation of gonopore structure on the molt operculum. As they move through the respective stations, students answer questions about what they observe via a two-page worksheet. Copies of the station cards, worksheet and answer key are provided with the lesson plan, along with an interactive PowerPoint for assessing student learning. Once the molt study kits are assembled for conducting this lab, they can be brought out year after year for repeated use with new groups of teachers or students. Thanks to the savvy of Delaware Aquatic Resources Education (ARE) program assistant Anthony Jackson, a process for presoaking molts in a 50/50 solution of glycerin and water imparts long-term flexibility to the molt specimens for enhancing ease of manipulation of various structures during the labs. In late summer and early fall, horseshoe crab molts of various sizes can pile up in large numbers along many Delaware Bay and coastal Atlantic beaches, enabling GE&S coordinators to collect sufficient quantities to distribute to teachers as part of the wealth of take-home materials provided through a GE&S workshop.

As GE&S looks to the future, the goal of providing quality workshops at venues up and down the Atlantic coast to equip and empower legions of new classroom

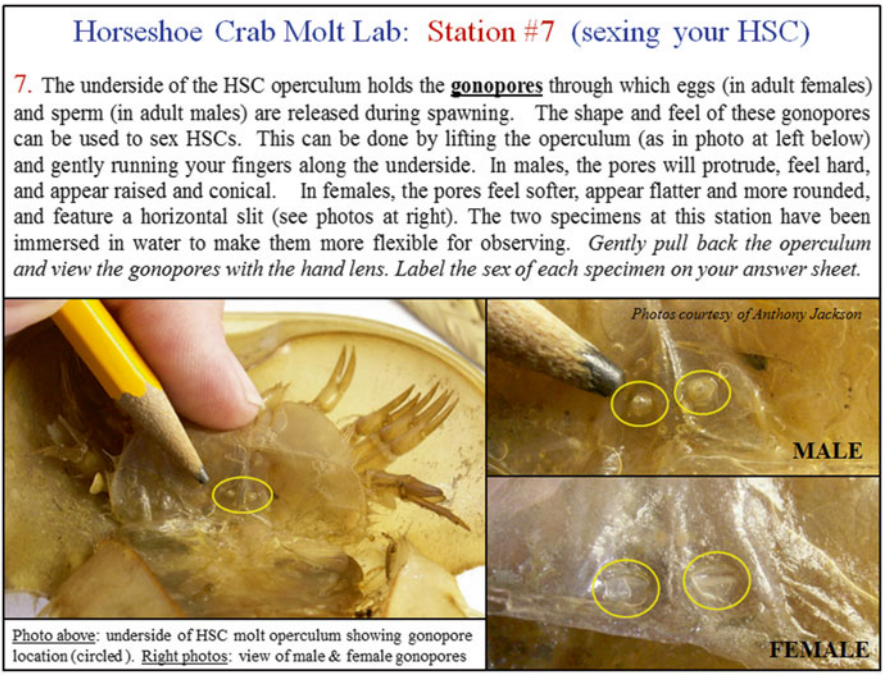

Fig. 32.5 Horseshoe crab molt anatomy lesson components (From *Green Eggs & Sand* curriculum)

teachers, curriculum coordinators and non-formal educators with knowledge and resources for educating about the wonders of horseshoe crabs will continue to be given high priority. Efforts to obtain the funding required to appropriately update the fourth and final video-driven management module of the curriculum – which serves as a wonderful case study of the chronology, complexities and challenges inherent in managing the multiple-use horseshoe crab resource – is also a key area for future focus. The GE&S team is also open to opportunities and inquiries on adapting the GE&S approach and materials to educating about horseshoe crabs in other parts of the world.

32.4 *Raising Horseshoe Crabs in the Classroom*

One of the tried-and-true ways of getting people connected to caring about a little-known or unappreciated animal is to put them in touch with the living creature in its early life stages, and that has certainly proven true with horseshoe crabs. Back in the mid-1990s and early on in the emerging horseshoe crab controversy (and in the principal author's work with horseshoe crab education), this approach was put to the test via construction of a simple three-window rectangular viewing box, each

window containing a small aquarium featuring horseshoe crabs eggs, larvae and hatchlings at various stages of development. The box was taken to workshops, conferences and special event venues around Delaware, and everywhere it went, it attracted interest and engagement of people far surpassing the large number of fancy, high-quality information displays surrounding it. In addition to the attraction of viewing these tiny, elegant, seldom-seen life forms in a whole different light – relative to the somewhat coarse and beat-up versions of adults most people were accustomed to seeing spawning on bay beaches – people were amazed to hear that it took as long as it did (8–10 years) for those little creatures to become those large adults on the beach. At the time such awareness carried a valuable message in getting the public to appreciate the challenge inherent in sustaining populations of a slow-to-mature species like *Limulus* in the face of the heavy harvest pressure it was experiencing.

The success of that venture prompted Delaware ARE educators to initiate workshops for teachers demonstrating how to hatch and grow horseshoe crab eggs in the classroom. Although other staff and program priorities made this project short-lived in Delaware, the idea and approach were passed along to education colleagues in Maryland's Department of Natural Resources ARE Program, who have since adapted, enhanced and expanded it (MDNR 2014). The ambitious product of their efforts – *Raising Horseshoe Crabs in the Classroom* – engages teachers and students in raising newly-hatched horseshoe crabs in the classroom and monitoring conditions for their growth and development. Since its launching in 1999, this program has engaged more than 20,000 Maryland students in exploring the wonders of the horseshoe crab life cycle (Fig. 32.6).

As with *Green Eggs & Sand*, teacher attendance at a *Raising Horseshoe Crabs in the Classroom* workshop is a prerequisite for receiving the materials and accompanying lesson plans. At these workshops, in addition to a supply of pre-collected eggs or larvae, teachers receive a 10-gal aquarium, filter, dipnet, sand, salt, hydrometer, thermometer and water quality test kits. A Teachers' Guide, including instructions, lesson plans, data collection procedures and forms, rearing protocols, and other resources is also provided. The protocols enable schools participating in the project to learn the most up-to-date techniques for raising horseshoe crabs in the classroom, as well as procedures for monitoring salinity, nutrient levels and other water quality indicators that might impact rearing success. As part of their obligations, participating teachers are required to record and submit a monthly data sheet containing water quality and horseshoe crab maintenance information.

At the end of each academic year, schools may participate in one of four horseshoe crab release events on Chesapeake Bay. These events offer an opportunity for students to celebrate what they have learned, release horseshoe crabs they have raised, and participate in a host of hands-on field activities. These events mark the culmination of months of study for students involved in the program. Ada Stambaugh, a high school teacher participant in the program since 2001, described the benefits of her students work in the program as follows: "Several years ago I challenged my students to think of what horseshoe crabs might run into as food in the Bay possibly working toward the continental shelf. So they felt we should feed

Fig. 32.6 Scenes from Maryland's raising horseshoe crabs in the classroom program

them a variety of things that could be found pretty easily in the grocery store. We tried many things to see what they might enjoy the most and scallops were one of those things. We also feed them in smaller amounts and not as often: chicken liver/hearts, frozen clams (large stone clams), flounder, cod, rock fish, squid, and raw whole shrimp cut into pieces … I have really found this project helpful in making my students think and solve real life problems."

A key aspect of this program is that the number of young horseshoe crabs reared and released is a very small percentage relative to the wild populations, and are thus not intended to provide population restoration outcomes. This contrasts with horseshoe crab culture programs going on in Asia – including excellent initiatives in Hong Kong (Cheung et al. 2011), Taiwan (Chen et al. 2009) and Japan (Tsuchiya 2009) – where horseshoe crab populations are in serious decline, and captive breeding and release programs are a vital component to species survival. But comparable rewards and benefits in terms of enhanced student appreciation of the need for conservation of this remarkable animal are certainly seen through Maryland's program and reinforce that key idea articulated earlier in this article – planting seeds of connectivity in young people for horseshoe crabs that they will carry with them for the rest of their lives.

32.5 *Team Limulus*

Another unique example of student involvement in the research and conservation of horseshoe crabs is seen in *Team Limulus* at the Wheeler School, located in Providence, Rhode Island. Founded in 2008, *Team Limulus* is a group of high school and middle school students (ages 12–18) who are committed to monitoring a local population of horseshoe crabs and to educating other students and local communities about the importance of these animals (The Wheeler School 2011). Membership in the team is not limited to a particular grade, but rather based on the interest of students. As an indication of the impact such participation has on students, more than a dozen *Team Limulus*/Wheeler School graduates have returned at the end of the spring semester of college to continue participation in the program.

Student members of *Team Limulus* (Fig. 32.7) along with a faculty advisor, conduct spawning surveys (James-Pirri 2011, 2012a) at Gaspee Point Beach in Warwick, RI during the months of April, May, and June. The team also tags horseshoe crabs as part of the US Fish and Wildlife Service's Cooperative Horseshoe Crab Tagging Program (DCIB 2014a, b). Tagging data provide information about abundance, distribution, and migration patterns of populations along the Atlantic Coast. State agencies use this data to manage populations, so the students are collecting and contributing meaningful and significant data. The spawning survey data collected by *Team Limulus* are uploaded to two larger research data bases: one maintained by researcher Mary Jane James-Pirri of the Graduate School of Oceanography at the University of Rhode Island (James-Pirri 2012a, b) and the other by researchers Jennifer Mattei and Mark Beekey in the Department of Biology at Sacred Heart University in Fairfield, Connecticut (SHU 2014), the latter of whom also manage *Project Limulus*, a community-based research program within Long Island Sound (see Mattei et al. 2015 for more information on that effort). A Rhode Island Environmental advocacy group, *Save the Bay*, has also used *Team Limulus*' spawn-

Fig. 32.7 *Team Limulus* students at work: collecting morphometric data while tagging horseshoe crabs at Gaspee Point Beach, Warwick, RI (*Photo left*) and presenting their research at Massachusetts Audubon Wellfleet Bay Wildlife Sanctuary in Wellfleet, MA (*Photo right*)

ing survey data to support lobbying for greater harvesting restriction of horseshoe crabs during the spawning season in Narragansett Bay, RI.

32.5.1 Student Presentations

Beyond the field work, student members of *Team Limulus* also organize, analyze, and present their findings from the spawning and tagging data at local conferences. Students presented their research from 2009 to 2010 at a Massachusetts Audubon Society conference on horseshoe crabs (Fig. 32.6) and as a keynote speaker group for an evening talk as part of a summer series at the Wellfleet Bay Audubon Sanctuary in Massachusetts. Additionally, *Team Limulus* students share their passion for horseshoe crabs with younger students by guest teaching in science classes in both the Wheeler School elementary and middle school divisions. As part of those efforts, the high school students design and present hands-on activities with *Limulus* molts to engage the younger students in discovering the unique features of horseshoe crabs and helping them develop a love and respect for the organism.

32.5.2 High School Biology Level Activities

At Wheeler, interest and involvement in *Team Limulus* is also stimulated through use of elements of the *Green Eggs & Sand* in various classes. This includes engaging students in the Advanced Placement (AP) Biology class in running the LAL (*Limulus* Amoebocyte Lysate) lab during their microbiology and immunology unit, as a practical, hands-on application of the concepts they are learning in class. In this lab, student use LAL to test for the presence of bacterial endotoxin in their saliva and various water sources. This lab activity allows students to gain an awareness of the vital role that horseshoe crabs play in human health. As a culmination to the ecology unit, AP students participate in another *Green Eggs & Sand* activity: *Webquest*: *the horseshoe crab controversy* (Fig. 32.8). Here students learn about the challenges and difficulties involved in resource management of a fishery species. Teams of students are assigned different roles and must research their stakeholder's position online in preparation for a town hall style meeting. Stakeholder roles include: watermen, biomedical researchers, birders/ecotourists, environmentalists, beachfront home owners, and natural resource managers. The end goal is for each stakeholder group to knowledgably and confidently present their viewpoint, back it up with data, answer questions successfully, and ultimately work together to create a management solution. Students truly enjoy this activity and the opportunity to role play an actual real-world scenario. It is an excellent learning experience because students come away from it with the realization that there is no easy solution that will satisfy all the stakeholders' needs in this complex conservation and management issue.

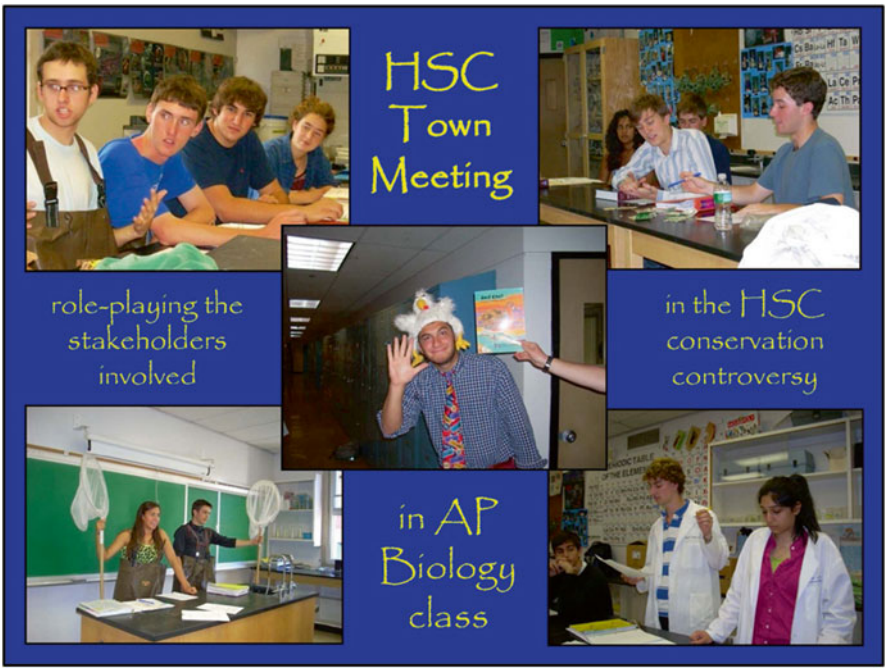

Fig. 32.8 AP Biology students participate in a mock town meeting from the *Green Eggs & Sand* curriculum

32.6 *Crab App* Smart Phone Technology

One of the newer tools available to groups such as *Team Limulus* for use in their horseshoe crab monitoring efforts is the aptly titled "*Crab App*." Over the last decade in the United States, increasing focus has been given to citizen science, often referred to as "public participation in scientific research" (Mattei and Beekey 2008; Hand 2010). At the same time, increasing use of smartphone technology has opened a new door equipping the ordinary citizen to collect data that can then be used in scientific research. *Crab App* combines these two trends in offering a free I-Phone app that not only educates the user about horseshoe crabs, but allows a person who sees/finds a horseshoe crab on a beach to upload meaningful data to an online data base. Dr. Matthew Sclafani, of Cornell Cooperative Extension, Suffolk County, Marine Program in New York, and Jared Lamenzo, of The Wildlab (2014) are the creators of this application. The goal of this app is to enable citizen scientists to count horseshoe crabs, monitor populations and report data in a meaningful way that can then be easily accessed and utilized by researchers. The App identifies location using GPS and has an information button that teaches the user how to distinguish between male and female crabs and provides other useful information (Fig. 32.9). Crab App version 1.1.0 is available at no cost and can be downloaded from Itunes (Apple, Inc. 2014). Another more recent example of this approach is the

Fig. 32.9 Screen shots of homepage and data collection pages of *Crab App*

My HSC App Android mobile application. Designed by a team of scientists from Malaysia, and downloadable from Google Play (2014), this app provides a valuable, user-friendly tool for inputting information on the global distribution of all four horseshoe crab species.

32.7 Conclusions

A wealth and variety of efforts are being directed towards educating about horseshoe crabs in the United States (Fig. 32.10). It is interesting to contemplate how substantially and quickly this point of focus has emerged and magnified. Two decades ago, one would be hard-pressed to name a single program dedicated to horseshoe crab education in this part of the world. Today, interest in *Limulus* and the conservation of their estuarine habitats appears to be growing exponentially, with new video programs, books, website components, social media networks, celebratory festivals, and educational resource materials exploding on the scene each and every year. It is essential to find ways to tap into and translate this vein of human interest and fascination to address serious challenges in the conservation of horseshoe crabs in parts of the world where resources are lacking, and priorities conflicting. A recently-convened Education Working Group of the International Union for the Conservation of Nature's (IUCN) Horseshoe Crab Science Specialist Group (2013) is poised to tackle that challenge. It is hoped that, through that network – in sharing the above and other initiatives from the United States, along with the advanced education programs underway in Japan, Taiwan, Hong Kong and Singapore – further development of approaches and pathways to help address that goal will be realized.

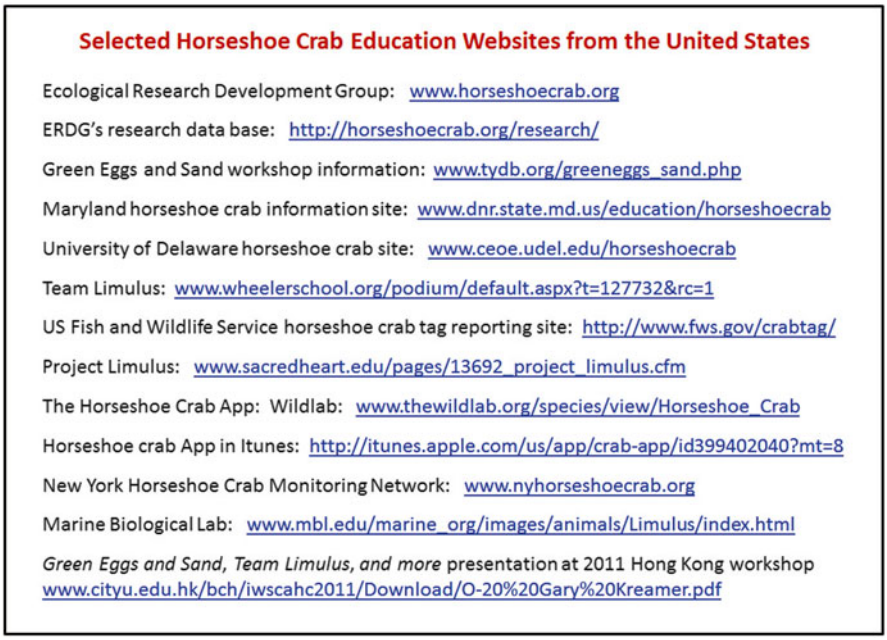

Fig. 32.10 Selected websites featuring horseshoe crab education information and resources from the US

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