

Pop-Up/Drill Down Science is submitted for Innovations in Development.



A. PROJECT RATIONALE

Much like missions to outer space, the NSF-sponsored ship *JOIDES Resolution's* (*JR's*) deep ocean expeditions have the potential to ignite the imaginations of a whole generation of Americans—to engage thousands of people in the excitement of exploration, the process of science, and the people and tools required to get there. The *JR* is on a mission of scientific discovery into the unknown. What lies beneath all that water? What secrets about our planet's development and ancient history can be revealed by sediments and rocks below? How can these explorations shed light on topics of great societal relevance, like climate change, the huge biosphere beneath the seafloor, and geo-hazards like earthquakes and tsunamis? As with space exploration, this program requires extensive scientific collaboration and teams of engineers trying to reach highly inaccessible places in search of discoveries.

Unlike many of NASA's missions, the *JR's* adventures and achievements have largely flown under the radar. The *JR* is one of the largest research vessels in the world and is the flagship vessel for the International Ocean Discovery Program ([IODP; www.iodp.org](http://www.iodp.org)), an international research program dedicated to advancing scientific understanding of the Earth through drilling, coring, and monitoring the sub-seafloor. Unbeknownst to most of the population, this country has invested more than \$668 million in scientific ocean drilling over the past ten years alone and generated key evidence for major scientific theories, such as plate tectonics, extinction of the dinosaurs, and existence of life below the seafloor. Just this past year, the *JR* was instrumental in identifying the largest single volcano on Earth.

This project proposes to use the *JR* and her science to intrigue, engage, and inspire informal science audiences across the nation. *The hypothesis of this project is that well-designed and facilitated Pop-Up exhibits and Drill Down opportunities at museums and libraries in carefully selected locations will provide an effective mechanism for increasing STEM learning access among underserved minorities, rural populations and girls – and create a broadly applicable model for doing so in other science fields.*

The ultimate educational experience would be to bring large numbers of people to this ship. Its technological marvels have provided powerful inspiration for a lucky few. However, this is impractical. Instead, we will bring the ship to the people. In formal education, the educational arm of IODP has implemented teacher workshops – called the School of Rock (SOR) – to immerse K-16 and informal educators in science on the ship and at the Gulf Coast Repository (home to more than 100 km of cores, in College Station, TX), utilizing key sets of 50 years of authentic data and samples. Among the many outcomes of this program has been development of effective classroom activities and resources.

In 2011, NSF awarded an Informal Science Education Pathways grant, Ship to Shore Science (STSS; NSF Award #1114678) to the Consortium for Ocean Leadership (which manages IODP education programs) to develop and pilot innovative ways to bring the science of the *JR* to informal science audiences *outside* the classroom. We implemented four pilot projects, enabling the development of new tools and networks. Pop-Up/Drill Down Science will integrate and ramp up these small-scale projects, making deep earth/ocean science available to informal audiences at a whole new level. *This project will be successful because it relies on a 10-year legacy of NSF-sponsored education materials and strategies, solid learning research, a fruitful and energizing 2-year Pathways grant, an innovative plan for new development and roll-out of programs and resources, and a fully integrated, experienced, energetic team.*

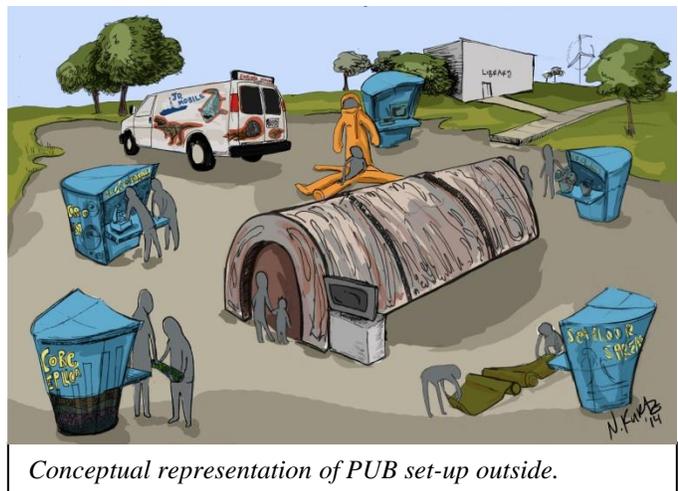
1.Goals The goal of Pop-Up/Drill Down Science is to learn more about how to increase access to and awareness of ocean/earth science and careers by exploring these key research questions:

- How do the Pop-Up Blitzes (PUBs) and Drill Down weeks create a sustainable model for STEM learning in informal environments (ranging from non-traditional venues like parks, parking lots, block parties, local festivals and malls to libraries and museums)?

- How does Pop-Up/Drill Down meet the needs of partner informal science education institutions and Girl Scouts to fulfill their own missions?
- What is the impact of short burst STEM programs for learning outcomes including a) increasing awareness and knowledge of ocean and earth science, technology, and the work of scientists/engineers and b) increasing interest in these activities among the general public (children, teens and adult participants) who attend the PUB and Drill Down events and activities?
- How does participation in the program’s workshops and volunteer opportunities for Girl Scouts contribute -- particularly among girls from underrepresented minority and rural groups -- to awareness, interest, and understanding of STEM topics and related career fields?
- Does participation in the PUB and Drill Down events foster partnerships between educators and scientists and lead to broader dissemination of scientists’ research and to the larger vision of NSF for broader impacts of its work?

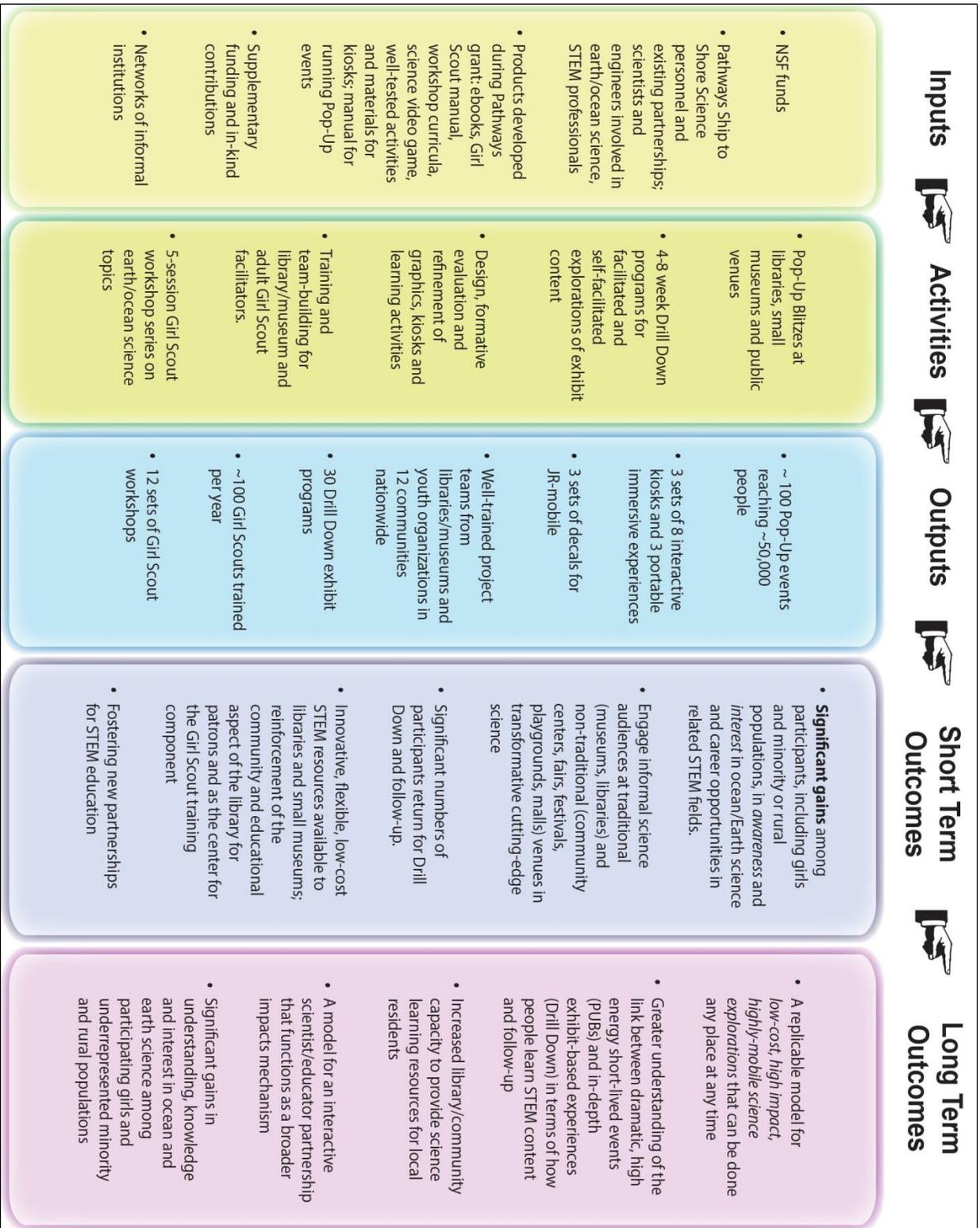
Key Activities Pop-Up/Drill Down Science will:

- Develop *Pop-Up Blitzes*, a series of interactive exhibit kiosks transported by a “JR-mobile” and centered on a Portable Immersive Experience. The Science Pop-Up Blitz is a replicable model for *low-cost, high impact, highly-mobile science explorations* that can be done any place at any time. They will:
 - **Be** transformative. The Pop-Ups enable gee-whiz science and engineering to serve as a magnet to engage informal science audiences at traditional (museums, libraries) and non-traditional (community centers, fairs, festivals, malls) venues. The experience includes an element of surprise.
 - Leverage existing networks, partnerships and tools to bring science and scientists to underserved audiences – particularly minorities, rural populations, and girls – in stimulating and innovative ways. Specifically, the project will tap existing relationships with *JR* researchers and educators and Girl Scout councils to provide science content and leadership opportunities to engage with the public.
 - Serve as a stimulating introduction that encourages participants to further explore earth and ocean science and career opportunities.
- Offer deeper experiences that will result in significant gains in knowledge and understanding through *Drill Down* weeks. After the high energy PUB events, visitors will be encouraged to participate in 3-week Drill Downs, during which the kiosks will be available at host sites (libraries and small museums) for both facilitated and self-serve explorations. *Live ship-to-shore events – bringing at-sea scientists into the venue in real time – will be featured.*
- Train and organize highly motivated program scientists/educators and local Girl Scouts to work together and facilitate both kinds of programing.
- Gather data on the link between dynamic, but short-lived PUB events and in-depth exhibit-based experiences, shedding light on how people learn science and follow-up on their exposures.



Conceptual representation of PUB set-up outside.

The project’s activities, outputs and outcomes are detailed in the logic model below:



2. Project Foci. This project focuses on STEM learning in informal venues, with particular attention to providing opportunities for informal STEM learning among minorities, rural populations, and girls. Women make up about 28% of the STEM workforce; Hispanics and African Americans make up a mere 10% (National Science Board, 2014). This project will bring the excitement of ocean research and exploration

to these audiences. Towards this goal, Girl Scout councils are ideal partners to address these disparities because of their record and interest in advancing gender equity in STEM, broadening participation of under-served and diverse populations, and their knowledge of local communities. Girl Scouts reach a large audience, including 3.9 million girls and women in the United States. Moreover, increasing STEM programming aligns well with their mission to “build girls of courage, confidence, and character, who make the world a better place.” (GSRI, 2012).

Beyond the management team, there are four primary audiences involved: 1) *JOIDES Resolution* Outreach Network (JRON) scientists and educator program alumni; 2) Girl Scouts—who have participated in the pilot project and training or who have been recruited; 3) Institutional Partners/Informal Educators—from libraries and museums who will host *PUB* and *Drill Down* events in partnership with JRON teams and Girl Scouts; and 4) the general public—groups of adults and families who will participate in *PUBs* and *Drill Down* events.

3. Building on prior knowledge This project builds directly on the lessons learned from the Pathways project as well the extensive body of research on the cognitive, socio-emotional, or psychological dimensions of student learning (Falk and Adelman, 2003, Falk and Balling, 1982; Falk and Dierking, 2000; Farmer and Wott, 1985; Knapp and Barrie, 2001; McLoughlin, 2004; and Pace and Tesi, 2004; Mintzes et al. 2005; Pugh et al. 2010). Moreover, this work is supported by results that indicate that short interactions can result in changes in student attitudes and understanding. For example, research by Falk and Balling (1982), found “strong support for the notion that single-visit field trips can promote cognitive learning and retention.” More recent research into the constructivist nature of interpretive programs at public zoos, for example, has supported this conclusion, finding evidence that brief experiences can enhance student cognitive understanding of science principles (Walters, 2006).

Further, Powell and Wells (2002), Vaughan, et al (2003), and Knapp and Barrie (2002) have found that experiential activities organized around interesting science themes produce, perhaps through excitement alone, an interest in learning that transfers to long-term increases in content knowledge. These studies clearly support the findings about novel and exciting experiences that Falk and Dierking (2000) and Hein (2000) discuss with respect to learning in museums. These findings also suggest a path forward in the evolution of learning sciences in informal STEM education and student science learning. Exposure to transformative, experiential and meaningful science experiences has been demonstrated to lead to tangible gains for students in the cognitive depth of their understanding of STEM content. This theory-to-practice-to-learning pathway is this project’s conceptual underpinning.

In addition to museums, which were among our pilot partners, we focus on non-traditional STEM venues such as libraries, community centers, fairs, festivals, playgrounds and malls. Programs in non-traditional settings have been found to increase awareness on science topics, reach an extensive audience, establish new partnerships between groups within a community, and help to create or strengthen the stature of exhibit hosts within the community (Arcand n.d.; Arcand & Watzke, 2011). Furthermore, a report by the American Association of Museums estimates that only 9% of the core museum visitors in 2010 belong to minority groups (Farrell & Medvedeva, 2010). Therefore, there is a need to bring learning opportunities to these audiences.

Libraries are established community hubs with a focus on learning. They are also free to visit and frequently present in places where museums are not. The Pew Research Center (2012) reports that “People value public libraries and librarians and believe they are important to their communities. Of those aged 16 and older, 91% say that public libraries are important to them. Libraries are centers of learning and discovery, and librarians serve as guides and teachers.” The demographics of library usage also demonstrate that they are excellent places to reach underserved minorities (67% of Hispanics and African Americans have library cards [Pew, 2012]);

As the need for STEM learning in the U.S. has expanded, library associations are encouraging their members to become centers for STEM learning (IMLS, 2013). Data collected from 253 libraries as part of a related NSF-funded project, Star Library Education Network

(<http://community.starnetlibraries.org/>; NSF Award #1010844), indicate that the need for STEM resources at libraries is significant (ALA, 2012; Fitzhugh, 2013) and more than 97% of respondents agreed that a library's mission includes promoting lifelong learning. Libraries involved in STEM programming

through StarNet are eager for more, reporting that STEM programs helped them attract new visitors, and that patrons began to look at libraries as places for STEM learning (Fitzhugh, 2013). At the same time, exhibit space within most libraries is less than 500 square feet and budgets are less than \$1000. More than 50% of libraries reported that their exhibit space is dispersed throughout the building.

This project therefore seeks, in part, to bring together the challenges of increasing exposure to STEM learning with the current needs and opportunities of communities by:

- Bringing innovative, flexible, low-cost STEM resources to non-traditional venues and libraries;
- Reinforcing the community aspect of the library for patrons and Girl Scouts;
- Enhancing library staff capacity to provide science resources for the long term.

4. Innovation. The design of this project combines the excitement and novelty of dynamic live kick-off events, our **Pop-Up Blitz (PUB)**, with the continuity of longer term learning opportunities through the **Drill Down** program – during which visitors to the library or museum and electronically at home can figuratively drill down into the content for deeper learning. It addresses the limitations of informal, one-off events, while playing to their strengths and offering more. This combination offers a unique research opportunity to explore STEM learning in both contexts and the relationship between them.

Everything needed to create the PUB exhibit fits into a few crates and a standard rental van, which serves as a *JR-Mobile*, for transport around the local area. The vehicle is rented when needed but decked out with decals to attract attention and spark questions – thus avoiding issues of on-going costs and questions of storage, drivers, insurance and down times of other vehicle-centered mobile programs. This project brings world-class science and scientists directly **to people** at a variety of venues where underserved audiences can be found and works with each site team to determine what/when those places are.

5. STEM Content Areas. The science of the *JR* spans many content areas, including geology and geophysics, biology, chemistry, physics, and oceanography. By its very nature, engineering and math are central areas of focus for scientific data retrieved through seafloor exploration. The decadal science plan for IODP (<http://www.iodp.org/Science-Plan-for-2013-2023/>) includes four main research themes:

- Using records of past climate and ocean change to inform the future;
- Exploring deep life, biodiversity, and environmental forcing of ecosystems;
- Understanding deep Earth processes and how they impact Earth's surface;
- Investigating geological processes and hazards that occur on human time scales.

These themes will be addressed at appropriate levels for the project's target audiences.

6. Results from Prior NSF Support: The IODP U.S. education department (formerly called Deep Earth Academy) is the broader impacts arm of an NSF agreement that supports U.S. scientists' participation in



Conceptual drawing of PUB kiosks set up inside library.

IODP: NSF Cooperative Agreement OCE-0652315 (U.S. Science Support Program, Jeff Schuffert, PI, (2007-14, \$42,361,019). It has been supported in previous years also by NSF Contract OCE-0352500 (United States Implementing Organization) David Divins, PI, (2003-14, \$626,217,308).

Since 2005, more than 200 educators and scientists have participated in IODP's professional development program: either as School of Rock participants or onboard Education Officers. They have produced more than 200 learning activities, including videos, posters for K-12, undergraduate, and informal audiences, (thousands of which have been distributed through almost 200 workshops, presentations, and science and education conferences); and online through the *JR* website. In addition, the department offers resources through its joidesresolution.org website and social networking tools. It has produced more than 800 live, web-based ship-to-shore video broadcasts to 33,000 participants at more than 500 venues in 20 countries. School of Rock has also been featured as a highlight in NSF's Budget Request to Congress, in the American Geological Union's EOS and a special publication of the Geological Society of America.

Much of the immediate underlying work for this proposal comes from the Pathways grant. This grant funded four pilot projects aimed at identifying best practices and creating new resources to bring deep ocean science to informal audiences. Summary of evaluation reports for these pilots are in the supplementary documents. Pilot projects and their major products were:

- The Girl Scout Workshop Series: Materials and science from deep sea exploration were adapted and integrated into the programming of three Girl Scouts councils in NY, NJ, and VA. Results indicate that greater than 91% of the girls (Grades 6-12) reported an increase in interest in STEM after participating in the workshop series. New partnerships and a training manual were created.
- The *JOIDES Resolution* Outreach Network (JRON): Regional networks of School of Rock educators and *JR* scientists were established and utilized to engage audiences (over 675 people) through interactive stations at libraries and museums. This project demonstrated that libraries were ideal partners for these events. It also resulted in a set of tested and refined activities and materials for the stations, as well as a how-to manual.
- *Uncovering Earth's Secrets*: An e-book available through iTunes that brought *JR* exploration in rhyme and illustration to some of our youngest future scientists: children in grades 2-5.
- *Mystery of the Megafloods*: An interactive game that made core science appealing and engaging to informal test audiences from 6th grade to adult. By transforming complex science into a story that engaged users with the scientific process, the game inspired greater interest and vocabulary recognition in audiences who in pre-testing had expressed limited interest.

Continuing Work: Since the Pathways grant expired and this proposal was first submitted last January, work on the pilots has continued with limited Ocean Leadership funds:

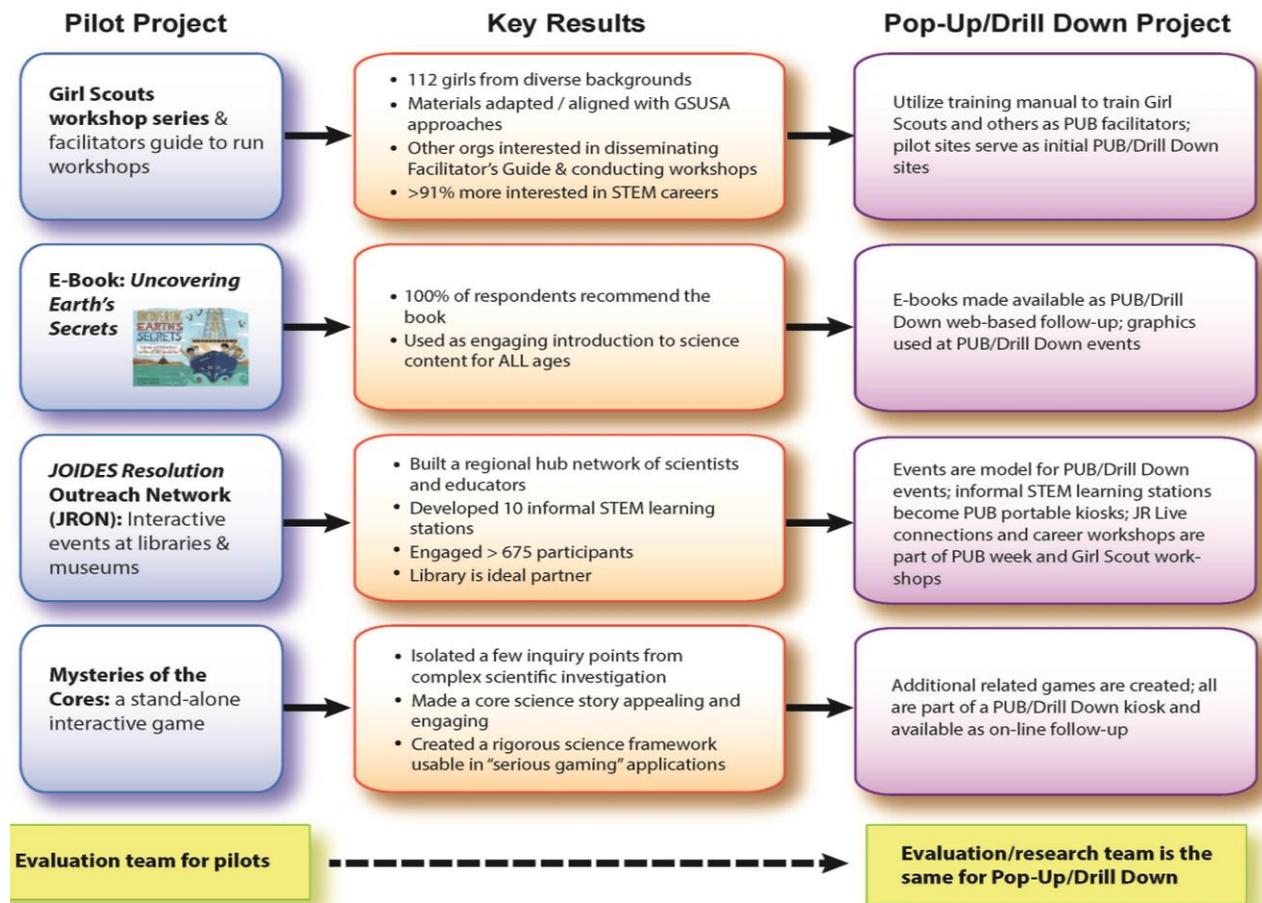
- Interactive elements have been added to *Uncovering Earth's Secrets* for a new, improved second version scheduled for release this month on iTunes and at joidesresolution.org.
- Another ebook, *Where the Wild Microbes Are*, was funded by a separate grant from the Center for Dark Energy Biosphere Investigations (C-DEBI, an NSF-funded STC).
- Presentations on STSS were given at the AGU Ocean Sciences meeting in February, 2014 and *Uncovering Earth's Secrets* readings were given at a number of venues and conferences.
- Three more JRON events have been held at 1) Nat'l Museum of Natural History; 2) Carnegie Science Center in Pittsburgh, and; 3) Aquarium of the Pacific in Long Beach, CA.
- *Mystery of the Megafloods* won Best Demonstration at the 2014 INTETAIN conference (www.intetain.com). Game development processes/outcomes were presented at the conference.

B. PROJECT DESIGN

The Pathways pilot projects will evolve directly into Pop-Up/Drill Down Science as detailed in the graphic below. This project intertwines pilot resources with new and existing networks for delivery. It

seeks both to broaden and deepen the limited impact the Pathways projects could achieve. By taking the component parts and combining them with novel methods of delivery and expansion, this project will stand on the shoulders of Ship to Shore Science and reach a much larger and more diverse audience.

How Pilot Projects Flow Into Pop-Up/Drill Down



1. Project Deliverables

- Portable immersive experience (PIE): similar in concept to an inflatable planetarium but modified as a large walk-through core with the media show theme of time-traveling back in Earth's history. Learning research shows that immersive experiences have the potential for more dramatic impact than a kiosk-style interactive alone (Savin-Baden, 2010; Barab and Dede, 2007; Parrish, 2007).
- Three sets of 8 exhibit elements; interactive, engaging pop-up kiosks adaptable for a variety of venues. All or sub-sets of these 8 can be used at a given venue, depending on size and number of facilitators available. Each includes 2 levels of engagement: quick experiences for the PUBs and a deeper exploration option for use during Drill Down. Two examples of the activities/stations planned/piloted are in the chart below. Others are detailed in supplementary documents.

Topic	Activity	Ocean Literacy Principles	Earth Science Literacy
How We Know What We Know: Microfossils and Climate Change	Pop-Up: Visitors interact with a replica of a core with microfossils in it. They use a sieve and microfossil models to simulate how JR	2d, 5a, 5f, 7b	1.3, 1.5, 3.7, 3.8, 4.1, 6.1, 6.7

	<p>scientists collect microfossils from a core.</p> <p>Drill Down: Visitors look at photos of microfossils from an idealized core, then use field guides to identify them and chart the climate history represented by the core.</p>		
<p>Seafloor geology</p> <ul style="list-style-type: none"> • Earthquakes and Volcanoes • Seafloor Spreading • Plate Tectonics 	<p>Pop-Up: Visitors interact with simple models of seafloor topography, subduction zones, spreading centers and plate boundaries as an introduction to the geology of the seafloor.</p> <p>Drill Down: A complex, interactive 3-D model of the seafloor helps visitors explore and understand spreading centers, subduction zones and the causes of earthquakes and volcanoes.</p>	1b, 2e	2.4, 2.7, 3.6, 4.1, 4.4, 4.5, 4.7, 5.4, 8.1

Other kiosk topics: Engineering and Coring Technology, What is a Core?, Dinosaurs: Mass Extinctions, Paleomagnetism, Stories from the Cores, and Life Below the Seafloor.

- Activities that do not require a kiosk: Live interactions with the ship (using pop-up screens), and Try On a Survival Suit.
- Multi-media components that are a part of the above: two additional Stories from the Cores interactive video games focused on deep biosphere and geohazards, and on-line resources for follow-up.
- JR-Mobile decals: a set of large, colorful magnetic decals designed to make a standard panel van look like the ship and its science, including the derrick, ship outline and colorful graphics.
- Trained Girl Scout and library/museum teams/facilitators at 12 sites
- One week of facilitated Pop-Up Blitz events and 3-4 Drill Down weeks per year at up to 12 sites
- 5-session Girl Scout workshop series on earth/ocean science topics for 100 scouts per year.

Phase 1: Years 1 and 2:

The first year of Pop-Up/Drill Down will be devoted to the development of the Portable Immersive Experience and refinement of the existing *JOIDES Resolution* Outreach Network activities into durable interactive kiosks. The team will work with a professional exhibit designer to develop sturdy, mobile kiosks that are colorful, “hip,” and easy to pop up. A graphic designer will create graphics for all components, including magnetic decals for a rental van for our temporary “JR-Mobiles.”

The Stories from the Cores project team, which developed an interactive video game, will develop two additional games to play on multiple electronic platforms; these will be subtitled in Spanish. A multi-media producer will develop the Portable Immersive Experience show: narration in English and Spanish. The Digital Media team will review and modify web-based resources, many of which already exist.

The leadership team and Girl Scout partners will refine the workshop series based on results from the Pathways grant. During Year 1, we will also solidify our partnerships with the three initial site teams and solicit their input to develop the Pop-Up/Drill Down kiosks.

Implementation will begin in Year 2. Training (5 days) will take place at the Gulf Coast Repository in College Station, TX. Workshop facilitators will include IODP scientists, educators and project staff. The trainees will be a 3-member site team from each site: a Girl Scout adult leader or intern, host site staff, and 1 more person from either of those groups. These teams will be trained in IODP science and the pedagogy of using the PUB kiosks. This team-based approach has shown to be quite effective in building capacity with new material (Loucks-Horsley, et al, 1998). Additionally, as part of the workshop, each team will develop a draft PUB plan, thinking about the best schedule, times, audiences and sites to target, including attention to logistical and permitting needs.

- At the selected time, kiosks will be shipped from Ocean Leadership to the host site and a workshop/PUBs module will begin. PUB/Drill Down modules can be scheduled to meet the needs at

each host site, but will remain at the host site for 8 weeks and travel locally during the Pop-up Blitz. An 8-week module might look like this:

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Girl Scout Workshop Session 1	Girl Scout Workshop Session 2	Girl Scout Workshop Session 3	Girl Scout Workshop Session 4	PUB Week!	Drill Down! @ host site	Drill Down! @ host site	Drill Down! @ host site
Drill Down! @ host site	GS Workshop Session 5	GS facilitate @ host site	GS facilitate @ host site	GS facilitate @ host site			

Weeks 1-4: While flexibility is key to our success, the module may begin with four sessions (~ 90 minutes each) of a five-part Girl Scout workshop series on earth/ocean science topics conducted at the host site, using the kiosks as resources. JR scientists, educators and site team leaders will facilitate. Girls will become familiar with the kiosks, not only for their own learning, but in preparation for facilitating during the PUB. There is a great deal of evidence (Koke and Dierking, 2007, Harvard, 2011) that shows the benefit to individuals’ learning when they take an active role and work alongside mentors. Note: Since the kiosks will now be at the host site, *Drill Down* can also be available for visitors.

Topics for the Girl Scout workshop sessions can be found in the table below:

Session 1	Session 2	Session 3	Session 4	Session 5
Introduction to the nature of science, shipboard science: gathering and evaluating evidence about past climate and environmental change	Dramatic events: mega-floods and dinosaur extinction!	What lies beneath?! Life below the seafloor OR plate tectonics.	What do scientists and crew on the JR do? Focus on science careers.	JR Live! Talk to scientists and crew aboard the JR using Skype or Zoom. Participate in workshop with local scientists.

Week 5: PUB week! At the start of PUB week, Girl Scouts will participate in the last of their workshop series, which includes a career workshop, discussion with scientists, and a *JR Live* connection. Site leaders will have previously selected the community sites (parks, malls, community centers, etc.), obtained any necessary permits and identified logistics. Sites can be indoors or outdoors, day time or evening, week days or weekends. The selection of appropriate sites is determined by the community partners. The JR-mobile van will be rented, decked out with decals and packed with the crated kiosks. It will travel around the region to conduct the PUBs. We initially envision one location per day for 7 days, but this could be modified. Girl Scouts, JRON members, and trained staffers facilitate PUBs with 6-10 volunteers at each event. Participants receive a takeaway magnet with the host site and website addresses.

At the end of the PUB week, the kiosks will return to the host site for **Drill Down**, where they will be set up for an additional 3 weeks. Girl Scouts, site leaders and JRON members will staff kiosks for set times each week. Otherwise, the kiosks will be self-facilitated. At the end of Drill Down, Girl Scout participants will receive participation patches.

Phase 2: Years 3-5

The project will add 3 sites each year. These will be determined based on research results and criteria developed during Years 1-2, including attention to resource needs, staff availability and demographic and geographic diversity. Existing relationships with IODP alumni nationwide provide numerous opportunities to identify these partners. Transitioning to post-grant sustainability mode is built into our plan: Each set of 3 sites (Years 3-5) will participate in a full 8-week module with workshops in their first year, and a 4-week PUB/Drill Down-only module in their second year. Based on feedback from the pilot projects, girls trained in the workshop year will be able to refine their skills in the second year. After that, we expect that the local site would take on a greater role in continuing the project without central project staff. A small amount of funding will be available for them to continue in their 3rd or 4th year, with the

goal of enabling the community to support more of the program with local resources. The kiosks will be available indefinitely and can be put into action with relatively few additional resources.

2. Measures of Learning Outcomes

Using Stufflebeam’s (2007) CIPP model (Context-Inputs-Processes-Products) for project knowledge management, as was done in this group’s Pathways project, the project leadership and external evaluators view the learning outcomes, evidence and knowledge generation, research design and evaluation framework as a single, continuous effort. The context for the project, the inputs and the processes that make up the PUBS and Drill Down elements and learning outcomes all contribute to overarching success. The project evaluators will also be guided by the logic model above, which will be modified as needed.

The evaluators will use a mix of quantitative and qualitative data collection methods in the front-end, formative and summative assessments. They will gather various types of data from multiple sources (as shown in Table 1) at all stages of the project and will be geared towards answering the hypothesis and key research questions.

Learning Outcomes by Group

A *Systems* approach to project management suggests that there are important, but distinctly different, outcomes for the various audiences. *Table 1* below delineates each audience, key learning outcomes, data to be measured to monitor progress towards these outcomes, methods to capture that data, and analyses to be incorporated to generate evidence-based knowledge.

Table 1. Evaluation Plan with Outcomes

Audience	Learning Outcome	Method or Instrument	Data Type	Analysis/es
JRON Community	<ul style="list-style-type: none"> • Use of STEM content and skills in public outreach • Strong education/science/engineering partnership (JRON) • Meet broader impacts needs of scientists 	<ul style="list-style-type: none"> • Field observations of program • Surveys • Interviews of JRON members 	<ul style="list-style-type: none"> • Narrative, qualitative • Select demographic (categorical, statistical) 	<ul style="list-style-type: none"> • Self report of comfort level with public audiences • Social network analyses • Constant comparative analyses of narrative responses • Correlational summaries
Girl Scouts	<ul style="list-style-type: none"> • Use of STEM content and skills in public outreach • Identity formation (perspectives on women in STEM careers and content disciplines) • Applicable elements of GSUSA’s “Discover” and “Take Action” Leadership Outcomes 	<ul style="list-style-type: none"> • Field observations of program • Surveys • Semi-structured interviews of randomly sampled Girl Scout Leaders and Senior Scouts 	<ul style="list-style-type: none"> • Narrative, qualitative • Select demographic (categorical, statistical) 	<ul style="list-style-type: none"> • Constant comparative analyses of narrative responses • Grounded theory analyses of interview transcripts • Self-report of attitudes about science and careers
Institutional Partners	<ul style="list-style-type: none"> • Support of the institution’s mission and goals • Understanding and familiarity with ocean and Earth science findings • Familiarity with the PUB model and Drill Down model for public engagement and outreach 	<ul style="list-style-type: none"> • Field observations of program • Surveys • Semi-structured interviews of educators and institutional leadership of partnering organizations 	<ul style="list-style-type: none"> • Narrative, qualitative • Select demographic (categorical, statistical) 	<ul style="list-style-type: none"> • Detailed compilation and analyses of institutional programming history (content and instructional frameworks) • Constant comparative analyses of survey and interview data
Public	<ul style="list-style-type: none"> • Enhanced interest, awareness, and understanding of select ocean science, ocean literacy, and Earth science content, principles, and career paths • Increased engagement and comfort level with STEM topics and activities 	<ul style="list-style-type: none"> • Field observations • Interviews of randomly selected adult and youth program participants from PUBs and Drill Down events • Demographic checklists and attendance records from both programs 	<ul style="list-style-type: none"> • Narrative, qualitative • Select demographic (categorical, statistical) • Quantitative /Statistical (correlational and continuous measures of time on task and number of program visits) 	<ul style="list-style-type: none"> • Quantitative analyses of time and persistence in programming elements • Content analyses of narrative data and field observations, interview transcripts • Self reflections of participants

3. Target Audiences

This project can be adapted for different kinds of sub-audiences. It will be open to anyone in the public. However, by the *choice of locations* and the kinds of venues chosen, we aim in particular to engage:

- Minorities, especially African Americans and Latinos, who are largely under-represented in the sciences (through location and Spanish translation),
- Rural populations (through choice of location) with reduced access to permanent STEM resources;
- Girls (through participation in the Girl Scout workshop series and facilitators at events.)

4. Broadening Participation of Underserved Groups

Group 1 sites are those from the Pathways grant and represent a cross-section of our target groups:

- *Martinsville, VA*: The partners in this small, rural area are the Blue Ridge Regional Library, the Virginia Museum of Natural History and the Girl Scouts of Virginia Skyline Council. Since 2002, the percentages of children living in poverty here increased from 25% to 37% in Martinsville and from 19% to 34% in Henry County. The city's population is 45% African American and 4% Latino.
- *New Brunswick, New Jersey*: The partners are Rutgers University, Girl Scouts of Central and Southern New Jersey, the New Brunswick Free Public Library, and the Rutgers Geology Museum. Both the Library and the Museum, which will share responsibilities as host sites, serve the larger New Brunswick community, which consists of a population that is Hispanic (52%) followed by White (25%), Black (14%), and Asian (7.8%). Economic data for the city from 2008-2012 indicates 19% of the reporting residents had an income in the past 12 months that was below the poverty level (U.S. Census Bureau) and 71% of the students attending New Brunswick High School in 2010-2011 were eligible for free or reduced-price lunch (National Center for Education Statistics).
- *Brooklyn, NY*: The partners will be the Girl Scouts of Greater New York and Brooklyn Public Library (BPL). BPL's experience with bookmobiles will inform strategies for the Pop-Ups. The team will select a host branch near a subway station from which Girl Scouts can arrive, open on weekends, with space and technology for the workshops and live links with the ship, and in a neighborhood with a high proportion of minority residents. In 2011, 81% of Brooklyn's public school students in grades K-6 qualified for free or reduced-price lunch, and 34% of all children lived below the poverty level (CCF); 32% of children were Black, 23% Latino, 10% Asian, and 32% White (CCNY).

Broader Impacts

This project is at its essence a broader impact project for cutting-edge earth/ocean science research:

5. Evidence-based knowledge generation process

The evaluation/research team will use the questions mentioned in section 1A and the methods and analyses in the Evaluation Plan with Learning Outcomes chart above to test the hypothesis. The project team will disseminate this new knowledge through journal articles, presentations and the posting of formative and summative assessments of accomplishments on a public project website.

6. Impacts on Informal STEM field

- Borrowing from other successful non-science models, such as roving art carts and pop-up restaurants (e.g., food trucks), we will apply these models to bring STEM education to audiences with less access to high quality stationery resources – whether because of distance, cost, or lack of exposure. While this project focuses on earth/ocean science, this model can be easily replicated for other science topics. Envisioning future needs of diverse learners, this model will be a useful one through which the country can reach out to its rural and underserved audiences.
- Permanent exhibits are expensive and time consuming to mount, and are not easily changed in response to new and changing scientific discoveries. Traveling exhibits are less so but also somewhat daunting for the average small venue. Pop-Up/Drill Down features a flexible, relatively inexpensive model that can be easily adapted for rapidly changing science topics.

- This project challenges existing assumptions about learning and learning environments by presenting science in new, non-traditional and unexpected locations: How do people respond to science in a mall parking lot or next to a playground? We will find out.

C. DISSEMINATION PLAN

Dissemination of project *research results and hypothesis testing* to STEM professionals will take place through scientific and educational conferences attended by project staff at all levels (regional and national), through publication of project data and through stories on well-established websites and the *JR*'s robust social media sites. Project staff will work with the individual sites to assist them in sending their own leadership teams to regional and national events. In addition, project staff will aim to publish project findings in established science education journals (such as NSTA publications).

Dissemination of project *activities* will be focused on the audiences in target communities. The project will make concerted efforts to attract local media attention through the prominence/appearance of the *JR*-mobile driving around town and PUB events. Each site has its own existing networks that can be utilized. The project will also leverage the *JR*'s website and social media to its fullest extent, announcing events through Facebook, Twitter, and YouTube videos. We will also work with existing national networks, such as the StarNet Libraries, to send out notices of events and opportunities.

D. EVALUATION AND EXTERNAL REVIEW

This project relies on an integrated data collection, management, and analysis system under the direction of an internal evaluator (Dr. Karen Thomson) and an external evaluation team (Drs. Tina Bishop and Howard Walters) who possess deep experiences with these types of complex projects. The same evaluation team managed evaluation for the Pathways grant. In addition, they have been involved from the outset in planning for this new project. The evaluation team will monitor the degree and quality of attainment of key outcomes, and test and answer the hypothesis and stated research questions over the project's life. See detailed table in Evaluation Plan with Learning Outcomes (Table 1) above.

The evaluation plan addresses the learning outcomes and evidence-generated knowledge creation as described above using a mix of methods, both qualitative and quantitative for the purpose of formative and summative evaluation. All methodologies will be continuously reviewed to ensure their relevance to ongoing project goals. The evaluation plan includes utilizing front-end data already collected from the pilot projects, formative evaluation after the first project year of full implementation (Year 2), and iterative evaluation and feedbacks during each subsequent year. All project data will be evaluated by the external evaluation team and incorporated into a final summative report.

An External Advisory Board (EAB) will meet quarterly by webinar and in person every other year to advise the project management team on content, pedagogy and adjustments to program design and to review interim and final evaluation reports.

E. PROJECT MANAGEMENT Ocean Leadership manages education programs in the U.S. for IODP. Of note: this team and the advisory board capture a cross-section of early and mid-career female (and male) scientists and educators as well as minorities of the target demographics.

1. Leadership Team (Note: complete bio sketches are in supplementary documents.)

Sharon Cooper (Ocean Leadership, PI) will provide overall project direction, including advisory board meetings, budget, external evaluation, oversight of the training workshops, host site communications and management of exhibit kiosk development. She has been with the program nearly 8 years, during which she had led educational initiatives in both formal and informal science education. She was the P.I for Ship to Shore Science, the Pathways grant out of which this new project grows.

Dr. Katerina Petronotis (Co-PI: IODP-TAMU) will provide close coordination with the ship's schedule and science operations, science review and organization of annual training workshops. Dr. Petronotis is a Staff Scientist/Expedition Project Manager with IODP at Texas A&M. She earned her PhD in geophysics in 1991 from Northwestern University.

Dr. Kevin Johnson (Co-PI: University of Hawaii) will provide overall scientific review during all stages of resource development. Dr. Johnson is on the marine geology faculty at University of Hawaii and has sailed on two JR expeditions. He earned his Ph.D. in 1990 from Woods Hole and M.I.T. and has worked as an NSF Program Director for Ocean Drilling and for 11 years as the staff geologist at the Bishop Museum (natural history museum) in Honolulu.

Dr. Carrie Ferraro (Co-PI: Rutgers University) will act as the project coordinator for the New Jersey region for the duration of the project. She will assist in the refinement of exhibit materials, recruit and coordinate new and existing volunteers and venues for the Pop-Up Blitzes and Drill Down events throughout the state, and participate in the trainings. Dr. Ferraro earned her Ph.D. in Oceanography from Rutgers in 2010. She currently works at the Department of Marine and Coastal Sciences as a coordinator for the Education and Outreach group.

Key Personnel contracted through Ocean Leadership

Dr. Tina Bishop (Evaluation/Research) will serve as part of the evaluation/research team for this project. She is the Academic Director for the College of Exploration in Potomac Falls, Virginia. She has extensive experience in research and evaluation of informal and formal science education programs, including the Ship to Shore Science Pathways project, NSF COSEE-Coastal Trends program, online and face to face teacher professional development, and instructional materials for National Geographic, NOAA, and PBS.

Dr. Howard Walters (Evaluation/Research) will serve as part of the evaluation/research team for this project, as he did for the STSS project. He is Associate Professor of Educational Foundations at Ashland University. He has been involved in numerous evaluation and learning research studies, including those for COSEE Great Lakes, National Ocean Sciences Bowl, and QuikScience Challenge Competition.

Kevin Kurtz (Project Manager: JRON and Digital Media teams) will lead the development of JRON activities into the PUB kiosks and the training of its facilitators, as well as leading the development of website content that supplements the PUB/Drill Down events. Mr. Kurtz is an independent consultant who has been involved with IODP since 2009 as a School of Rock participant, Education Officer, and co-coordinator of the *JOIDES Resolution* Outreach Network and eBook pilot projects.

Dr. Karen B. Thomson (Project Manager, Internal Evaluator: Liaison to Girl Scouts and Site-Based Teams) will conduct internal evaluation and guide the development of partnerships with Girl Scout councils and host libraries or museums, particularly from populations underrepresented in STEM fields, and will work with the Girl Scouts to link the project with their program models and ensure the best possible learning and growth experiences. Dr. Thomson is an independent consultant specializing in education and other issues affecting children.

Dr. Denny Casey (Project Manager, Martinsville site team) is the Director of Education and Public Programs at the Virginia Museum of Natural History. He participated in the STSS School of Rock program in 2012 that led to the implementation and evaluation of the Girl Scout component of the Pathways grant, and is a member of JRON. Dr. Casey will be involved in Pop-up/Drill Down kiosk development, working with Girl Scouts and community libraries, offering professional development to staff and volunteers, and engaging in design based research to best implement this project.

2. Larger Project Team

- Library/museum host partners at each site – providing space, personnel and community participation.
- Girl Scout council leaders/interns: will attend the training and lead the GS workshops, assist in running the PUBs/Drill Down and drive the JR-Mobile.
- Exhibit developer/fabricator: will be selected through a bidding process
- Stories from the Cores video game team: Barbara Becker and Patrice Ceisel
- Digital Media and graphic design team: Kevin Kurtz, Carl Brenner, Alice Feagan, Nicole Kurtz

Our External Advisory Board brings a wide range of valuable background and expertise to this project. Their support letters are in supplementary documents.

- Dr. Jon Lewis: geologist at Indiana University of Pennsylvania
- Leslie Peart: former IODP education director and informal science educator
- Dr. Amanda Haddad: scientist, deep biosphere
- Dr. Phyllis Katz: informal science educator
- Barbara Davis: librarian at New Rochelle Public Library
- Suraida Nanez-James: minority educator with Hispanic focus
- Cheryl Rodgers: education consultant on STEM projects for at-risk students
- Patty McNamara: exhibit/program evaluator
- Hannah Jennings: exhibit and graphic designer
- Anne Holland: project manager, StarNet Libraries
- Glen Schuster: U.S. Satellite Laboratory

3. Management plan for collaboration An unanticipated result of Ship to Shore Science was the interconnectedness that developed between the pilot projects – leading to an integrated team that is passionate about its work and already functions well. Despite the obvious complexity of Pop-Up/Drill Down, this team already possesses a demonstrated ability to hit the ground running and existing relationships that will assure *getting the job done*. The leadership team will meet for bi-monthly conference calls and include other team members as appropriate. The EAB will meet every other year in person and more often through virtual meetings as needed. Several members of the leadership team (including major subcontractors) will also attend each training week, both to facilitate and to touch base on all aspects of project progress. Project documents will be posted to the project website in a password-protected area for regular comments and review.

4. Collaboration with specific groups This project features collaborations with these groups:

- Learning researchers/evaluators: Howard Walters (Ashland University) and Tina Bishop (College of Exploration). Both of these individuals have extensive evaluation and learning research experience as well as direct experience with this project.
- Research scientists: Kevin Johnson, University of Hawaii and Katerina Petronotis, Texas A&M University. On our advisory board, we have additional research scientists (Amanda Haddad and Jon Lewis). As content specialists, these and other IODP scientists will be involved in the training weeks, review of all materials, and as facilitators during the PUBs.
- Community and youth-focused groups: this project is collaborating with individual Girl Scout councils at each of 12 sites.
- The project will work with public libraries at nearly every site. We are collaborating closely with previously established networks of libraries interested in STEM resources, the STAR Library Education Network in particular. One of their staff members is on our External Advisory Board.
- The project will collaborate with small museums at some of the target sites. We have several museum practitioners on our team and advisory board, including Denny Casey (VMNH), Leslie Peart (Texas State Aquarium) and Barbara Becker (exhibit planning and research).
- Once funding is secured, close collaboration with the chosen exhibit design firm will begin.

5. Work plan

Phase 1: Development and refinement	<u>Year</u> <u>1</u>	<u>Year</u> <u>2</u>	<u>Year</u> <u>3</u>	<u>Year</u> <u>4</u>	<u>Year</u> <u>5</u>
Launch (July 2015)	x				
Solicitation for and contract Exhibit Designer (Aug 2015)	x				
External Advisory Board meeting (Oct. 2015)	x				
Create 2 new Mysteries from the Cores games (Oct 2015 – July 2016)	x				
Solicit and contract PIE multi-media developer (Aug 2015)	x				
Refine GS workshop series (Jan - April 2016)	x				
Add to and modify web-based follow-up resources (April - June 2016)	x				
Focus groups with Group 1 sites (Feb - May 2016)	x				
Aggressive recruitment of JRON volunteers (on-going)	x	x	x	x	x
Select training week attendees from Group 1 sites (Aug 2015)	x				
First set of 8 exhibit kiosks/PIE available (Aug 2016)	x				
New exhibit components ready (PIE media, games: Sept.2016)	x				
Phase 2: Implementation					
School of Rock training - TAMU, Oct. 2016, 2017, 2018, 2019		x	x	x	x
EAB annual meeting (in person 2015, 2017, 2019, virtual in 2016/18)	x	x	x	x	x
GS workshop series at Group 1 sites (Nov 2016 - July 2017)		x			
PUB/Drill Down at Group 1 sites (Nov 2016 - July 2017)		x			
Evaluation of PUBs/workshops (on-going)		x	x	x	x
Update/tweak on-line content (on-going)	x	x	x	x	x
Refinement of exhibit kiosks (July - October 2017)		x			
Recruitment of Group 2 sites (Summer 2017)		x			
GS workshop series at Group 2 sites (Nov 2017 - August 2018)			x		
PUB/Drill Down at Group 2 sites (Nov. 2017 - Sept. 2018)			x		
PUB/Drill Down at Group 1 sites (Sept. 2017 - August 2018)			x		
Production of 2 new sets of kiosks (Nov 2017 - April 2018)			x		
Recruitment of Group 3 sites (Summer 2018)			x		
GS workshop series at Group 3 sites (Nov 2018 - Aug. 2019)				x	
PUB/Drill Down at Group 3 sites (Nov. 2018 - Sept. 2019)				x	
PUB/Drill Down at Group 2 sites (March - Sept. 2019)				x	
Options for involvement: Group 1 sites (April - Sept. 2019)				x	
Recruitment of Group 4 sites (Summer 2019)				x	
Exhibit repair/maintenance (on-going in between scheduled weeks)		x	x	x	x
GS workshop series at Group 4 sites (Nov. 2019 - June 2020)					x
PUB/Drill Down at Group 4 sites (Nov. 2019 - June 2020)					x
PUB/Drill Down at Group 3 sites (Oct. 2019 - June 2020)					x
Options for involvement: Group 1 and 2 sites (Oct. 2019 - July 2020)					x
Summative Evaluation (completed Oct. 2020)					x