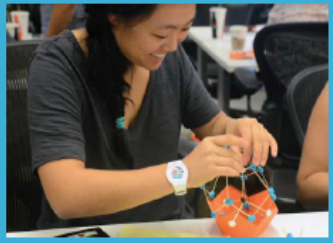


# Review of NOAA's Ocean Exploration Education Program

by the
Subcommittee of the Ocean Exploration Advisory Board

May 2018

At the Request
of
The Ocean Exploration Advisory Board

We thank the Ocean Exploration Advisory Board for commissioning the study, and the National Marine Sanctuaries for supporting the preparation of this report. We thank the OER education team for their support in providing the information needed to complete our review. We thank the parent organizations of several subcommittee members for giving them release time to participate in the review. We thank the Consortium of Ocean Leadership fro hosting the first meeting and the Aquarium of the Pacific for hosting the second meeting. We thank Linda Brown for all her help in preparing the final report.

**Ocean Exploration Advisory Board**
**Subcommittee on Ocean Exploration Education**
**Panelists and Participants**

***Panelists***
Jerry Schubel, Chair, Aquarium of the Pacific
Jacqueline Dixon, University of South Florida and Ocean Exploration Advisory Board
Allison Fundis, Ocean Exploration Trust
Catherine Halversen, Lawrence Hall of Science
Louisa Koch, NOAA Education
Tami Lunsford, Newark Charter School (DE)
Peter McLaren, Next Gen Education LLC
Debbi Stone, Florida Aquarium
April Tucker, Tamalpais High School (CA)
Carlie Wiener, Schmidt Ocean Institute

***NOAA Office of Ocean Exploration and Research***
David McKinnie, Engagement Division Lead
Susan Haynes, Education Program
Debi Blaney, Education Program

***National Marine Sanctuary Foundation***
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David Lang
Darlene Lim
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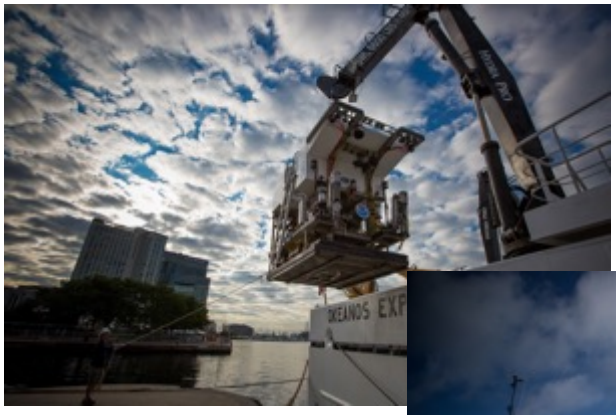
Richard J. Rikoski
Dominique Rissolo
Lance M. Towers

Subcommittee on Ocean Exploration Education Panelists

**OCEAN EXPLORATION ADVISORY BOARD'S**
**CHARGE TO THE**
**SUBCOMMITTEE ON OCEAN EXPLORATION EDUCATION**

Since the NOAA ocean exploration program was established in 2002, the office has operated an education program to promote ocean literacy and to provide educators with resources about ocean exploration for use in the classroom. The enabling legislation the NOAA Ocean Exploration Act, enacted in 2009, directs NOAA to establish a "coordinated national ocean exploration program" and "seek to facilitate coordination of . . . outreach and education programs to improve public understanding of ocean and coastal resources." The NOAA Office of Ocean Exploration and Research (OER) strategic plan includes a goal to "encourage the next generation of ocean explorers, scientists, and engineers" through education.

This subcommittee of the Ocean Exploration Advisory Board (OEAB) is charged with conducting a review of the OER education program and making recommendations to OER and the NOAA Administrator regarding the effectiveness of the program to date, whether OER should consider adopting new approaches to pursuing its education objectives under the OER Strategic Plan and the NOAA Education Strategic Plan, and what performance metrics would be most useful in measuring program effectiveness.




Okeanos Explorer and ROV Deep Discoverer

Diver capturing an image of a green sea turtle


NOAA workshop participants engaging in activities

Ship tours of the Okeanos led by crew

The subcommittee will prepare a report for OEAB consideration by 30 June 2018.

In particular, the subcommittee will:

1. Review briefly the history of the program; its evolution; its leverage of other marine education efforts; and how well it has cultivated its partnerships inside and outside of NOAA;

2. Evaluate the effectiveness of OER's approach of working through aquariums and informal science centers to deliver professional development workshops to educators;

3. Evaluate the quality and value of the ocean exploration education materials OER has produced;

4. Explore the potential for new partnerships to extend the reach and impact of OER's education programs;

5. Recommend strategies and approaches to increase the effectiveness of the OER education program and materials, with particular emphasis on reaching underserved and underrepresented communities in support of the relevant parts of the OER strategic plan; and,

6. Describe best practices and metrics that will help OER to monitor, assess, and adapt its education activities as conditions change and opportunities arise.

# Introduction

OER's education program has accomplished a great deal over its brief history, particularly considering its very limited budget and staff.[1] An effective program of education and outreach is a key element of raising awareness of the growing importance of the ocean, ocean exploration, and STEM (science, technology, engineering and math) education to the United States to create an ocean literate population. We recommend strongly that this program be given the resources needed for it to fulfill its mandate in the Ocean Exploration Act (PL111-11) to lead a national program of ocean exploration education and outreach that includes other federal agencies and the private sector as an integral part of a program of ocean exploration.

The ocean exploration sector is relatively small with only one dedicated government program vessel dedicated to exploration, and two private non-profit organizations that conduct expeditions—the Ocean Exploration Trust and the Schmidt Ocean Institute.[2] Both non-profits were represented on this subcommittee and both expressed enthusiasm to work with OER to strengthen the ocean exploration community and to expand and elevate its educational programs. We recognize that resources are limited and offer a number of relatively low cost suggestions on how to increase the scope and effectiveness of the program while additional resources are added incrementally. We also recommend that OER's education staff work to coordinate efforts with other educational initiatives throughout NOAA.

This brief report represents the unanimous conclusions and recommendations of the Subcommittee on Ocean Exploration Education (hereafter referred to as the Subcommittee). The findings and recommendations are organized into the following major categories:

1. Promoting and strengthening the community of ocean exploration education programs.
2. Enhancing the relevance and value of expeditions to the education community.
3. Revising and enhancing the workshops to make them more effective professional learning opportunities with more relevance and greater impact.
4. Improving and enhancing the organization of the educational materials and the website to make searches more user-friendly and effective.

[1] The current budget is $800,000. It has never exceeded $1 million and full-time staff has never been greater than three.

[2] Other governmental agencies and universities conduct research that includes exploration, but NOAA's OER is the only dedicated federal program of ocean exploration.

5. Updating and developing educational materials to reflect research on teaching and learning as described in a *Framework for K-12 Science Education (NRC, 2012).*[3]

6. Expanding the Alliance to reach more educators and students with an emphasis on the interior of the country.

7. Enhancing diversity in program participants.

Mark Heckman engaging in community outreach in front of NOAA ship Okeanos Explorer while in Honolulu, Hawaii

[3] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

## 1. Promoting and Strengthening the Community of Ocean Exploration Education Programs

**Finding**: There are numerous untapped opportunities for OER to spread the word about the excitement and importance of ocean exploration and to recruit more students and teachers, including people of color and from disadvantaged backgrounds.

**Recommendations**:

A. OER should lead and leverage partnerships such as those with Ocean Exploration Trust, Schmidt Ocean Institute, and NASA and other federal agencies in promoting the ocean exploration community as mandated by the Ocean Exploration Act. Education and outreach resources available through the OER and its education partners include: professional development of educators, telepresence-enabled expeditions and associated websites, the Ocean Today Kiosk network, Science on a Sphere, at-sea programs for educators and students, ocean exploration and STEM-focused curricular materials, Artist at Sea programs and exhibits, low-cost ocean exploration exhibits for informal science centers, and open houses of ocean exploration ships in port and opportunities to meet ocean explorers in person.

B. OER should collaborate with an experienced evaluator and education professionals to develop outcome-oriented metrics that more fully capture the program's contributions and recommendations of this report.

C. Acquiring the **OceanExploration.Gov** domain name would provide a good basis for building an ocean exploration community presence.

## 2. Enhancing the Relevance and Value of Expeditions to the Education Community

**Finding**: Expeditions are at the heart of an education program about ocean exploration. There are multiple ways to enhance their value.

**Recommendations:**

A. Organize workshop timing around expeditions when practical and include live feeds where possible. Arrange for tours of ships by the public during accessible port calls.

B. OER should tie curricular materials to themes and phenomena, or engineering design challenges, rather than to specific expeditions. In this way, lesson plans will be more flexible and can be used for more than one expedition. Incorporate real data where appropriate and include activities that help teachers and students learn how to access and use them effectively.

C. Establish a master calendar of ship schedules on the OER website so educators can more easily align their classroom and field experiences with expeditions where feasible and appropriate.

D. Coordinate the schedules of *Okeanos/Nautilus/Falkor* and perhaps other ships of exploration such as JOIDES Resolution for World Ocean Day activities, and other opportunities with potential for high visibility.

E. Invite alumni of workshops and possibly students back to participate in live-streams of the expeditions to re-invigorate, motivate, and provide alumni with additional resources, and well as mentors and resources for less-experienced teachers.

F. OER should investigate the feasibility of using programs like the Chief Science Officers program and similar networks to better engage student voice.[4]

G. Create a "Track the Ships" program for ocean exploration ships similar to current programs for tracking commercial ships. Tracking activities are engaging and can set the context for more in-depth study of the ship's focus and expedition.

H. Generate online "buzz" and engagement for ocean exploration by creating social media competitions for cruises and awarding prizes for students.

[4] www.chiefscienceofficers.org/national

### 3. Revising and Enhancing the Workshops to Make Them More Effective Professional Learning Opportunities with More Relevance and Greater Impact

**Finding:** Teacher Workshops are a very important element in the success of the OER Education Program. They are one of the primary vehicles for engaging teachers and supporting them to bring ocean exploration into the classroom.

**Recommendations:**

A. The workshops need to be evaluated by an external evaluator to identify ways to make them more effective. These evaluations should include pre- and post-surveys to determine if teachers used the material and what impact it had on their students. A student impact assessment would be a valuable addition to the evaluations. Focus groups with alumni would also be useful perhaps at intervals of 1, 5, and 10 years after their involvement in a workshop. Evaluations should be rooted in current academic standards and reported in peer-reviewed education journals such as NMEA's *Current*: *The Journal of Marine Education, American Biology Teacher*, *Bioscience*, etc.

B. Increasing the diversity of facilitators is encouraged. In some areas giving a workshop in Spanish might attract a new audience of teachers, and providing the materials in Spanish might attract more Hispanic students.

C. Exploring other workshop formats outside of Saturdays all-day is encouraged. This could include surveying potential workshop sites for formats that work best for their audiences.

D. The design of future workshops should be informed by current professional learning standards. The Council of State Science Supervisors have developed the Science Professional Learning Standards (SPLS) to help professional development providers design and implement high quality, sustained professional learning opportunities for educators. These standards can be found at: http://cosss.org/Professional-Learning.

**Finding**: The experience level of workshop participants which often ranges from pre-K to community college is a challenge for facilitators to tailor the material to many grade-level specific needs, and hence can be frustrating for participants. OER materials are designed for grades 6-12 grades.

**Recommendation:**

A. Workshops should be held for the target audience (grades 6-12 educators) only. The focus of sessions should be project-based, aligned with *Framework*-influenced state science standards[5], and use real data. Workshop invitations

[5] At the time of the report, there are 39 states that have developed science standards using the *Framework For K-12 Science Education*.

should emphasize that the material is appropriate for educators from all disciplines, not just marine science educators.

**Finding**: While the current teacher workshops are not designed for Pre-K to 5, we want to encourage these younger students to develop interest in ocean science and ocean exploration building a foundation for the future.

**Recommendations**:

A. Host sites should strive to offer separate workshops for Pre-K to grade 5 teachers using their own educators. We recommend that these educators undergo certification to facilitate the grades 6-12 workshops before offering their own workshops for younger grades. Collaboration among affiliates in developing workshop content and associated classroom activities is strongly recommended since experience and expertise in creating curricular modules varies significantly among affiliated organizations.

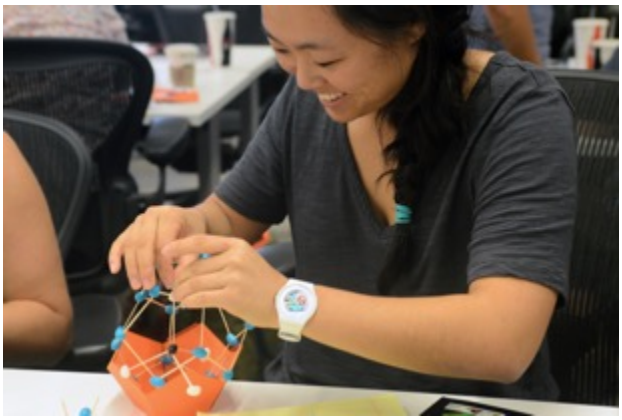
B. Include the Ocean Literacy Framework, the Ocean Literacy Principles and Fundamental Concepts, the Ocean Literacy Scope & Sequence for Grades K-12, and the Ocean Literacy-NGSS Alignment as an integral part of the Workshops.

Educators participating in one of NOAA OER's
Courtesy of Schmidt Ocean Institute

## 4. Improving and Enhancing the Organization of the Educational Materials and the Website to Make Searches More User-friendly and Effective

**Finding**: The scientific and educational material generated by the OER education program is impressive in its diversity and amount, but it is difficult to access. It is particularly challenging for classroom teachers in grades 6-12 who have demanding teaching schedules with a large number of different classes and coursework to prepare. The Multimedia Discovery Missions are the most popular products, possibly because they are complete modules, and therefore easy to access.

**Recommendations:**
The instructional materials need to be reorganized around themes, concepts, and phenomena in discrete packets that are searchable. Many of the existing lessons need to be repackaged around themes and phenomena using three-dimensional approaches to teaching and learning as described in the *Framework*. Expeditions are a less powerful way to organize material, but can provide valuable complements to thematic units.



Educator building a methane hydrate model during an OER workshop

**Suggestions for the OER Education Website**

- **General Comments**
  - Existing multiple websites (Okeanos and OER) should be merged into one
  - Website should be visually rich and utilize modern web design/functionality
  - Content should be prioritized in layout based on user behavior

- **OER Education Landing Page**
  - Should have a mechanism for users to self-sort (e.g., educator looking for resources, student, etc.)
  - Should have refreshed content that links to most current expedition, recent publications, etc.
  - Should highlight OceanAGE Careers

- **Content**
  - Should have advanced filters so content can be searched by multiple categories
  - Should be geo-referenced and accessible by interactive maps and search functions
  - Should be searchable by filters/tags including:
    - Ocean Literacy Principles
    - Science standards
    - Concepts/keywords
    - Content type (lesson plans, video, images, etc.)
    - Region
    - Expedition
    - Topic
    - Data types
  - Lessons should contain legend with icons/visual identifiers based on content (e.g., technology, ROV, etc.)
  - Lesson plans should be
    - Downloadable
    - Editable
    - Associated with prompting questions for videos
    - Contain assessments
    - Contain links to ongoing research, publications associated with lessons
    - Contain links to repositories and data sets
    - Linked to OceanAGE careers based on content and linked expeditions

- **Connections to Expeditions and Live Interactions**
  - Host information about Nautilus and Falkor with opportunities for ship-to-shore connections
  - Host synced calendars of *Nautilus*, JOIDES *Resolution*, *Falkor*, *Okeanos Explorer*, etc.

- **Website Examples to Review What Works:**
  - WHOI - Dive & Discover
  - Cal Academy
  - Ocean Networks Canada
  - NEON Observatory
  - National Geographic Education
  - Ocean Observatories Initiative
  - Link Engineering
  - Readwritethink.org
  - Various travel, shopping, etc. websites based on searches

- **Considerations**
  - Collaborate with web designer with experience in similar efforts
  - Hold focus groups with various audiences before full launch of website
  - Consider designing around science questions addressed during expeditions. Keep them general enough that they remain evergreen

## 5. Updating And Developing Educational Materials To Reflect Research On Teaching And Learning As Described In A *Framework For K-12 Science Education*

**Finding:** There are many useful lesson plans in the OER Education portfolio that could be updated and revised. Since their creation, the state standards to which they were originally aligned have been replaced by standards influenced by the *Framework for K-12 Science Education*. As a result, the existing materials do not reflect current educational theory or reform-based teaching and learning as described in the Framework.

**Recommendations:**

A. All new lessons should be thoughtfully and reflectively aligned to *Framework*-influenced state science standards through a rigorous vetting process to reflect aspects of three-dimensional teaching and learning. The Workshop should use these *Framework*-influenced lessons and explicitly model teaching and learning strategies aligned with the *Framework*. Three-dimensional learning refers to the integration of science and engineering practices, crosscutting concepts, and disciplinary core ideas within each standard, now called 'performance expectations. An example of the recommended approach is illustrated in Appendix E.

B. Engage facilitators and alumni of workshops in aligning lessons to *Framework*-influenced state science standards. Doing this has many benefits. By engaging this group, OER would benefit from their experience and expertise and increase the probability that they will incorporate these lessons and this approach into their classrooms.

C. OER should engage a community of educators, both formal and informal, to guide priorities for exploration education programs just as the scientific community is engaged in setting priorities for exploration.

    a. OEAB should establish a standing subcommittee on ocean exploration education to ensure up-to-date and timely advice.

    b. In addition, the OEAB should increase the input, advice, and presence of K-12 educators and the informal education community at OEAB meetings and in planning future ocean exploration forums.

    c. Over the longer term, we recommend adding an educator either K-12 or informal to the OEAB.

D. Educational materials should be branded as aligned to *Framework – influenced* state science standards and shared widely in journals and with organizations

such as the NMEA, NSTA[6], the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), etc. The educational materials would provide students the opportunity to engage in the same practices and lines of inquiry used by scientists including asking questions, planning and carrying out investigations, developing and using models, and analyzing and interpreting data and transforming them into information and solutions to challenging problems.

E. The impact of the revised educational materials should be evaluated by a professional evaluator after they have been appropriately field-tested in the classroom.

F. All materials should be archived whether or not they have been revised and updated.

[6] Members of the subcommittee submitted an abstract to the upcoming NSTA for a session describing these efforts. It is included as Appendix E.

## 6. Expanding The Alliance To Reach More Educators And Students With An Emphasis On The Interior Of The Country

**Finding:** All but two of the 15 affiliated institutions are in coastal states. While this was an appropriate network to begin with, it's time to extend the reach into the interior of the country.

**Recommendations**:

A. The number of affiliated institutions should be increased by 1 per year for the next five years, and priority should be given to adding non-coastal institutions in states/cities with large underrepresented populations and that either have adopted or are in the process of adopting *Framework*-influenced state science standards.

B. OER should target existing networks focused on collaborations to expand the reach of the Alliance. Currently there are 56 National STEM Ecosystems in place (http://stemecosystems.org/ecosystems/). Many of them are non-coastal and already working to reach underrepresented audiences in STEM. Some candidate informal science institutions are listed in Appendix F.

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## 7. Enhancing Diversity in Program Participants

**Finding**: There is room for growth in all forms of diversity in the program to better reflect today's United States of America.

**Recommendations**:

A. As OER adds affiliates, they will need to expand their pool of facilitators. In doing this, OER should be intentional in their efforts to reach diverse and underrepresented audiences.

B. OER might engage the Institute for Broadening Participation at Davidson Institute[7] to help them increase diversity. Ocean Exploration Trust has experience working with them and may be able to provide some guidance on how best to pursue this avenue.

C. In addition to adding new organizations to the Alliance, the program should explore other opportunities to expand the ocean exploration community of teachers and learners.

D. Art and music can provide avenues to expand the audience for ocean exploration.

E. Currently there is no place in Washington, DC, that showcases ocean exploration. The Sant Ocean Hall could provide that place. Sant Ocean Hall in the Smithsonian Museum of Natural History has a number of important platforms for delivering the cean exploration story: Science on a Sphere (SOS™), the Ocean Today Kiosk, exhibits, interactives, and a large and diverse audience of six million visitors each year. The section of the Hall that includes SOS and several small exhibits is being updated at this time and NOAA has been asked to provide guidance, ideas, and expertise. OER should seize this opportunity and work with the Ocean Exploration Trust and the Schmidt Ocean Institute to tell the ocean exploration story. A Science on a Sphere story of ocean exploration featuring the tracks of *Okeanos Explorer*, *Nautilus*, and *Falkor* could be a valuable addition to the exhibit

F. OER already has a strong partnership with the Octonauts. This program reaches a large and diverse audience, but value can be added through their Podcasts by making them available to Kindergarten teachers and early education centers. Each podcast represents an exploration. Currently podcasts are audio only, but in the future perhaps actual footage from expeditions could be added to provide authenticity and increase their relevance.

[7] https://www.davidsongifted.org/

**Finding:** NOAA has a number of related education initiatives with potential to enhance ocean exploration. These could be better integrated into OER education efforts.

**Recommendations:**
OER should work with the Office of Education and other programs to better leverage initiatives including the following:

A. Hollings Scholarship
B. Nancy Foster Scholarship
C. Explorers in Training
D. Education Partnership Program
E. Liaison with Society for the Advancement of Chicanos/Hispanics and Native Americans in Science; American Indian Science and Engineering Society
F. Citizen science investigations/pilot programs

Public engaging in free-choice learning with science on a sphere and interactive exhibits at the SANT Ocean Hall

# Appendices

Appendix A. Ocean Exploration Education Vision Statement

Appendix B. Summary of Accomplishments of OER's Education Program

Appendix C. Inventory of Resources Available

Appendix D. Abstract for National Association of Science Teachers

Appendix E. An illustration of the recommended approach for a lesson plan on chemosynthesis.

Appendix F. List of non-coastal aquariums, science centers and museums.

Appendix G. Observations by the Aquarium of the Pacific's Educators on Enhancing the Effectiveness of OER's Education Program

# Appendix A
## OER Education Vision Statement

***Office of Ocean Exploration and Research Education Program:***
***Vision for a Flexible, Adaptive Future***
***April 2018***

NOAA's 2009 statutory mandate for ocean exploration education requires the agency to coordinate education and outreach activities under a national ocean exploration program. This coordination responsibility overlays the Office of Ocean Exploration and Research (OER) education programs, established as critical to a successful ocean exploration endeavor in 2002. Education products use results from expeditions to the deepest parts of the world ocean to illustrate key scientific concepts, support ocean science literacy, and share the excitement and wonder of the deep ocean with the next generation of ocean explorers, engineers, and scientists.

*Support for Educators*
Our network of educators, developed through aquariums and other informal learning institutions like natural history museums, reaches many thousands of students each day. Our vision is that educators have easy access to a virtual collection of relevant ocean exploration education modules and resources including video, exercises, short summaries, and other media that are short, flexible, and lightweight. The collection is refreshed continually with new expedition results from NOAA and its national program partners. These resources:

- promote understanding of global ocean physical features, processes, and resources;

- inspire young minds and excite them about the ocean to make them care about it (relevance), inspire stewardship (ownership), and help create possibilities for careers in STEM careers;

- are easy for teachers to find, select, and use. An educator should be able to locate and download material and content that amplifies the topic to be addressed with minimal time and effort;

- align with current educational field needs (e.g. standards, phenomena); and

- leverage current events, trends, and developments.

*Operating in Partnership*
Since 2009, more ships of exploration have joined NOAA's *Okeanos Explorer* and new not-for-profit entities operate these ships, offer education resources, and engage the

public. Our vision is dynamic collaboration with these organizations to leverage both investments and comparative advantages to greatly expand and strengthen the education programs and resources available to teachers and students.

*Leveraging Opportunity*

There is growing awareness of the critical role oceans play in sustaining life, as a major component of national and global economies, for recreation, and as places of unique wonder and beauty. Whether "Blue Economy," Sustainable Seas," "Big Ocean Network," "Coral Triangle" or myriad other initiatives or programs, education plays a vital role. Our vision is for an education program that responds quickly and flexibly to capitalize on political and policy initiatives.

*Linking Oceans and Space*

As long as humans have gazed at the stars there has been a love affair with space. Whether Sputnik or Mercury, Apollo or Soyuz, Shenzhou or Falcon X, the wonder, science, and technology of spaceflight captivates humans around the world. NASA, NOAA, and other partners are collaborating under nascent initiatives to apply ocean exploration methodologies to space and vice versa. Our vision is for an education program that leverages these partnerships to generate excitement about and interest in the deep ocean that parallels the interest in interplanetary exploration.

# Appendix B
## Summary of Accomplishments of OER's Education Program

### NOAA Office of Ocean Exploration and Research Education Accomplishments

| 2001-2002 | 2003-2007 | 2008-2012 | 2013-2015 | 2016-2018 |
|---|---|---|---|---|
| OE is established in the National Ocean Service. About 5% of the program funds are dedicated to education | ***Learning Ocean Science through Ocean Exploration:*** Curriculum and Onsite Professional Development (Offered through 2011) | ***Okeanos Explorer* Education Forum:** Recommendations guided the formation of the education programming for the *Okeanos Explorer*. | **Science Standards:** Began indicating lesson support for the Framework for K-12 Science Education and NGSS | **Exploring the Deep Ocean with NOAA:** Combined the Why Do We Explore? and the How Do We Explore? professional development offering into one workshop |
| Hired **Education Coordinator** | Hired **part-time Education Specialist**<br><br>Established corps of contracted facilitators to assist in executing professional development workshops | Hired **full-time Education Program Manager** and ¾ **time Education Specialist**<br><br>Expanding and refined corps of facilitators | | Education Coordinator/**Director position paused**; hired new **full-time Education Specialist** |
| Began developing e**xpedition-based lesson plans** explicitly tied to the exploration | Built extensive **grant funded partnerships** with informal aquariums and science centers | **NOAA Ship *Okeanos Explorer* Education Materials Collection, Volume 1 and Volume 2:** | **Expedition Education Support Expanded:** Began offering 1 hour Expedition Webinars for | **Spanish translations:** Translated all current professional development lessons to Spanish. |

| | | | | |
|---|---|---|---|---|
| mission science | (Education Alliance Partners) providing opportunity for maximum impact via a "train the trainer" educator professional development model<br><br>Established **funding mechanism and partnership with the National Marine Sanctuary Foundation** | Why Do We Explore lesson pkg ((2010)<br>How Do We Explore lesson pkg (2012)<br>Two one-day PD workshops with evaluation plan, logic model, performance measures | Educators (~4/yr to date) | |
| **National education workshop:** 50 scientists and educators met to shape the future of a national Ocean Exploration Education initiative. | Began creating **Expedition Education Modules** and other specific education products (some grant funded) | **INDEX 2010: Indonesia-USA Deep-Sea Exploration of the Sangihe Talaud Region (EX maiden voyage)** Expedition education content specific to Indonesia with content and **activities translated into Bahasa Indonesia**; professional development and | Professional development activities in **Puerto Rico, Saipan and Guam**; some **material translation into Spanish** | **Updated Exploring the Deep Ocean with NOAA professional development** offering to incorporate most recent findings, science and technology; **new lesson binder** for PD |

| | | | | |
|---|---|---|---|---|
| | | engagement activities in Indonesia | | |
| | Began offering **online ocean exploration courses** in cooperation with the College of Exploration (10 courses offered 2004-2015) | Created **package of historic Gulf of Mexico lessons and an online course** in response to the Deep Horizon explosion | | **Independent Education Review:** This is the first independent review of the OER education program since its inception |

# Appendix C
## Inventory of Resources Available to Subcommittee

**Strategic Plans**
2016 OER Strategic Plan
2015 NOAA Education Strategic Plan
2015 OER Education Strategic Plan

**Logic Model**
2012 OER Education Logic Model

**Review Reports**
2002 Planning Workshop Summary (will have soon)
2008 Okeanos Explorer Education Forum Report
2012 Decadal Review

**Evaluation Reports**
2011-2016 Survey Data Analyses and Reports (based on pre-and post-surveys of professional development workshop participants)

**Budget**
Budget summaries by year

**Products**
Product list
Product examples

# Appendix D
## Abstract for National Association of Science Teachers Conference

TITLE: Using the NGSS to Explore The Oceans: Engaging Students in the Phenomena of Inner Space

BRIEF DESCRIPTION: This session is designed to support educators engage students with the rich phenomena that Ocean Exploration provides through lessons aligned to the NGSS.

SUMMARY OF PROPOSAL: Exploration of the world's oceans provide rich opportunities for students to be exposed to the excitement and the many and varied phenomena of ocean discovery. This session is designed to connect educators with the resources of Office of Ocean Exploration and Research (OER) program and a host of lessons developed to support the NGSS classroom. Providing students with the opportunity to use the science and engineering practices to explain the phenomena of the marine environment as well as design solutions using the technology of underwater exploration is the focus of this session. Participants in this session will learn how classroom educators use ocean exploration phenomena to design lessons where student collaboratively engage in performances aligned to the NGSS and other three-dimensional state science standards. It is within these performances where students reveal their understanding and provide educators and students formative assessment opportunities. Session attendees will be engaged in and experience the lesson as students would use the many resources of NOAA's OER.

# Appendix E
## An Illustration of the Recommended Approach For A Lesson Plan On Chemosynthesis

<table>
<tr><td>Topic: Chemosynthesis</td><td>Lesson Title: Life Without Light<br>Developed by:<br>April Tucker - Science Teacher, Tamalpais High School, Mill Valley, CA<br>Tami Lunsford - Teacher and High School Team Lead, Newark Charter School, Newark, DE<br>Catherine Halversen - Senior Project Director, Lawrence Hall of Science, University of California Berkeley<br>Peter McLaren - Executive Director, Next Gen Education LLC</td></tr>
<tr><td colspan="2">Performance Expectation(s) (Standard) from State Standards or NGSS:<br>HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]<br><br>Ocean Literacy Principal 5g: “There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, methane cold seeps, and whale falls rely only on chemical energy and chemosynthetic organisms to support life.”</td></tr>
<tr><td colspan="2">Lesson Performance Objectives(s):<br>● Students will construct an explanation for how life in hydrothermal vent environments and other environments transforms energy into stored energy.<br>● Students will use models to illustrate how carbon is cycled for autotrophic nutrition.</td></tr>
<tr><td colspan="2">Teacher Notes:<br>● Internet access<br>● LCD Projector<br>● Video Clip: https://ed.ted.com/on/yT7Fomq8<br>MATERIALS (per group of 4)<br>● Molecular Model Set (NOTE: If molecular model sets are not available Ts can use styrofoam balls or candy of different colors to represent C, H, O, and S and toothpicks)<br>● 3 Whiteboards (60cm x 60cm) (NOTE: Chart paper can be used to substitute for student whiteboards)<br>● Whiteboard markers and eraser<br>● Chemical Formula Cards (NOTE: Pre-made cards with the formulas - $H_2S$, $H_2O$, $C_6H_{12}O_6$, $O_2$, $CO_2$ written separately on each card)<br>● Coefficient cards and plus sign (+) and arrow (→) cards<br>● Periodic Table<br>● Chemosynthesis and Photosynthesis laminated graphics go to https://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/chemovsphoto.html</td></tr>
</table>

***Phenomenon:*** *Life can exist without sunlight.*

***ENGAGE***

- Ss, as a class, view the Hydrothermal Vents engagement video (see Video Clip in Teacher Notes.)
- After viewing the video Ss will **develop questions** about how life can exist without sunlight.

*(Teacher suggestion: Present the phenomenon to Ss by showing the Ted video listed in Teacher materials. Have students work in groups of 4 and obtain information from the suggested OER websites found in the appendix.)*

***EXPLORE***

- Ss, in groups of four, use whiteboards to **develop models and use them** to compare the **patterns** of how organisms undergo photosynthesis and chemosynthesis. Ss will detail the reactants and products of both processes and show how the processes **change** types of energy into stored chemical energy and how carbon is cycled.
- Ss are provided with chemical formula cards to **add to and refine their whiteboard models**.
- Ss groups are distributed molecular model kits. Ss are provided with the exact quantity of materials to create the reactants for each process. Ss groups then **use the model kits to represent** the reactants in their original models.
- Ss then use the **reactant models** to develop **models of the products** involved in both chemosynthesis and photosynthesis. This can be completed in the original groups or moved to use the reactants of the alternate process (those who created the reactants of photosynthesis move to a chemosynthesis table group and create those products).
- Ss are then provided with coefficient cards and plus sign (+) and arrow (→) cards. Ss use all the chemical formula cards and coefficient and sign cards to develop the full chemical equations for each process.
- Ss view the NOAA OER chemosynthesis video at https://oceanexplorer.noaa.gov/edu/learning/player/lesson05.html and use the information to further refine their **whiteboard models**

***Suggested Prompts Using Crosscutting Concepts for Ts to Stimulate Class Discussion During the Explore Phase:***

- Describe how **energy** flows into and out of the photosynthetic and chemosynthetic **systems.**
- Develop a **model** that describes how **matter** cycles into and out of the chemosynthetic and photosynthetic **systems**.
- Develop a **model** that describes how **energy** flows into and out of the **system**.
- Describe the conditions necessary for life to exist without **light energy.** (**cause and effect**)
- Describe the organisms and other components of the environment found in the **system** of hydrothermal vents.
- Describe how matter was conserved in the photosynthetic and chemosynthetic process.
- How do the organisms found in the **system** of hydrothermal vents change matter (carbon) into new substances used by the organisms?

***EXPLAIN***

- Ss groups will then use molecular models to **revise their initial whiteboard models** to more accurately illustrate how **carbon cycled and matter is conserved**.
- Ss groups will **use the model to gather evidence to explain** how life can exist without light.

*(Teacher suggestion: Models can be diagrams, chemical equations, or other ways for students to show the processes of photosynthesis and chemosynthesis.)*

- Ss groups **construct an explanation** supported by evidence from **patterns** in their models to show how **carbon is cycled and energy flows** through both processes of photosynthesis and chemosynthesis.
- Ss groups **share and explain their models with classmates as they use** the **models to construct explanations**. Other Ss groups will **argue from evidence** when reacting to the group share-outs in order to help the class come to **consensus of an explanation for the causes** for how life can exist without light.

*(Teacher suggestion: Focus students on conservation of matter and conservation of energy)*

***Suggested Prompts Using Crosscutting Concepts for Ts to Structure Student Thinking During the Explain Phase:***

- **Compare and contrast observable patterns in each of the two processes.**
- **Use your model to describe how energy flows and matter cycles within the hydrothermal vent system.**
- **Describe how the specific components of your model interact within the system.**
- **Does your model describe a** stable **system or a** dynamic **system?**

***ELABORATE***

- Ss individually **construct an explanation (e.g., create a model, write explanation)** of the phenomenon of life existing without light **using evidence from their revised models** and **classroom discourse**.

***Suggested Prompts Using Crosscutting Concepts for Ts to Structure Student Thinking During the Elaborate Phase:***

- Describe the conditions necessary for life to exist without **light energy**.
- Describe the key components of the photosynthetic and chemosynthetic **systems** shown in your model.
- Draw a model that shows how the components of the **system** interact.
- Describe how the photosynthetic and chemosynthetic **systems** compare to each other.
- Describe how energy is transferred within the **system** without sunlight.

***EVALUATE***

***Assessment of Student Learning***

*Provide students with the simplified equation for cellular respiration:*

$C_6H_{12}O_6$ *(s)* + 6 $O_2$ *(g)* → 6 $CO_2$ *(g)* + 6 $H_2O$ *(l)*

*Challenge Ss to compare the equation for chemosynthesis to the equation for cellular respiration and* **construct an explanation** supported by evidence from patterns in the equations to show how **carbon is cycled and energy flows** through both processes of cellular respiration and chemosynthesis.

***EXTENSION OF LEARNING:***
Below are some logical extensions of this learning designed to serve as next steps in the instructional sequence:

- Ss **obtain, evaluate, and communicate information** (using Internet) from oceanexplorer.noaa.gov and other reliable sources on the organisms and other components of the environment found in the system of hydrothermal vents.
- Ss **develop a model** of a chemosynthetic food web using the **Chemosynthetic Food Web Site** available at https://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/hydrothermal.html#activity
- Students **obtain, evaluate, and communicate information** about how vent organisms change energy from chemicals into stored chemical energy.
- Ss **obtain, evaluate, and communicate information** (using Internet) from oceanexplorer.noaa.gov and other reliable sources on how the organisms found in the system of hydrothermal vents change matter (carbon) into new substances used by the organisms.

## Appendix:

**Web Resources**
https://oceanexplorer.noaa.gov/edu/learning/player/lesson05.html
https://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/hydrothermal.html#activity
https://oceanexplorer.noaa.gov/edu/learning/player/lesson05/l5ex1.htm
https://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/chemovsphoto.html
https://divediscover.whoi.edu/hydrothermal-vents/chemosynthesis-2/
https://www.biogeosciences-discuss.net/9/17037/2012/bgd-9-17037-2012-print.pdf

**Expedition Connections:**
**NautilusLive**
https://nautiluslive.org/expedition/2018

**Schmidt Ocean Institute**
https://schmidtocean.org/cruises/#filter=.deep-sea-vents

**NOAA Okeanos Explorer**
https://oceanexplorer.noaa.gov/okeanos/explorations/ex1605/welcome.html

# Appendix F
## List of non-coastal aquariums, science centers and museums.

| Location | Type | Name | Link |
|---|---|---|---|
| Albuqerque, NM | Museum | Explora | www.explora.us |
| Albuqerque, NM | Museum | New Mexico Museum of Natual History and Science | www.naturalhistoryfoundation.org |
| Allentown, PA | Science Center | Da Vinci Science Center | www.davincisciencecenter.org |
| Anchorage, AK | Museum | Alaska Science Center | https://alaska.usgs.gov/ |
| Anchorage, AK | Museum | Alaska Museum of Science and Nature | https://www.alaskamuseum.org/ |
| Asheville, NC | Museum | Ashville Museum of Science | www.ashevillescience.org |
| Ashland, KY | Science Center | Highlands Museum and Discovery Center | www.highlandsmuseum.com |
| Augusta, ME | Children's museum | Children's Discovery Museum, Maine | www.childrensdiscoverymuseum.org |
| Aurora, NE | Museum | Edgerton Explorit Center | edgerton.org |
| Bangor, ME | Museum | Maine Discovery Museum | www.mainediscoverymuseum.org |
| Baton Rouge, LA | Museum | Louisiana Art and Science Museum | www.lasm.org |
| Belle Chasse, LA | Museum | Tulane Museum of Natural History | www.museum.tulane.edu |
| Bismark, ND | Museum | Gateway to Science | www.gatewaytoscience.org |
| Bloomfield Hills, MI | Museum | Cranbrook Institute of Science | https://science.cranbrook.edu |
| Bloomington, IN | Museum | WonderLab Museum of Science, Health, and Technology | www.wonderlab.org |
| Bloomington, MN | Museum | The Works Museum | www.theworks.org |
| Boise, ID | Museum | Discovery Center of Idaho | www.dcidaho.org |
| Buffalo, NY | Museum | Buffalo Museum of Science | www.sciencebuff.org |
| Charlotte, NC | Science Center | Discovery Place, Inc | www.discoveryplace.org |
| Charlottesville, VA | Museum | Virginia Discovery Museum | www.vadm.org |
| Chattanooga, TN | Aquarium | Tennessee Aquarium | http://www.tennesseeaquarium.org |
| Cherry Hill, NJ | Museum | Garden State Discovery Museum | www.discoverymuseum.com |
| Cincinnati, OH | Museum | Cincinnati Museum Center | www.cincymuseum.org |
| Cleveland, OH | Museum | Cleveland Museum of Natural History | www.cmnh.org |
| Cleveland, OH | Science Center | Great Lakes Science Center | http://greatscience.com |
| Concord, NH | Science Center | McAuliffe-Shepard Discovery Center | www.starhop.com |
| Crawfordsville, IN | Museum | Carnegie museum of Montgomery County | www.cdpl.lib.in.us |
| Davenport, IA | Science Center | Putnam Museum and Science Center | www.putnam.org |
| Dayton, OH | Museum | Boonshoft Museum of Discovery | www.boonshoftmuseum.org |
| Des Moines, IA | Science Center | Science Center of Iowa | www.sciowa.org |

| | | | |
|---|---|---|---|
| Detroit, MI | Museum | Michigan Science Center | www.mi-sci.org |
| Detroit, MI | Zoo | Detroit Zoo | https://detroitzoo.org |
| Detroit, MI | Aquarium | Belle Isle Aquarium | https://www.belleisleconservancy.org/belle-isle-aquarium |
| Dover, NH | Children's museum | The Children's museum of New Hampshire | www.childrens-museum.org |
| Dubuque, Iowa | Museum | Mississippi River Museum and Aquarium | https://www.rivermuseum.com |
| Duluth, MN | Children's museum | Duluth Children's Museum | www.duluthchildrensmuseum.org |
| Elizabeth City, NC | Science Center | Port Discover: Northeastern North Carolina's Center for Hands-on Science | www.portdiscover.org |
| Evansville, IN | Museum | Evansville Museum of Arts, History, and Science | evansvillemuseum.org |
| Fairfax, VA | Children's museum | Children's science Center | www.childsci.org |
| Fort Wayne, IN | Science Center | Science Central | www.sciencecentral.org |
| Grand Rapids, MI | Museum | Grand Rapids Public Museum | www.grpm.org |
| Great Lakes Bay Region, MI | Learning Center | Great Lakes Regional STEM initiative | http://stemecosystems.org/ecosystem/great-lakes-bay-regional-stem-initiative |
| Greensboro, NC | Science Center | Greensbro Science Center | www.greensboroscience.org |
| Hays, KS | Museum | Sternberg Museum of Natural History | sternberg.fhsu.edu |
| Helena, MT | Museum | ExplorationWorks | www.explorationworks.org |
| Hickory, NC | Science Center | Catawba Science Center | www.catawbascience.org |
| Hot Springs, AR | Museum | Mid-America Science Museum | www.midamericamuseum.org |
| Jackson, MS | Museum | Mississippi Museum of Natural Science | www.mdwfp.com |
| Jersey City, NJ | Science Center | Liberty Science Center | www.lsc.org |
| Kansas City, MO | Science Center | Kansas City Science Center, Science City | www.sciencecity.com |
| Lafayette, IN | Science Center | Imagination Station | www.imagination-station.org |
| Lancaster, PA | Museum | North Museum of Nature and Science | www.northmuseum.org |
| Lansing, MI | Children's museum | Impression 5 | https://impression5.org |
| Las Cruces, NM | Museum | Las Cruces Museum of Nature and Science | www.las-cruces.org |
| Las Vegas, NV | Museum | Las Vegas Natual History Museum | www.lvnhm.org |
| Lawrence, KS | Museum | University of Kansas Natural History Museum | naturalhistory.ku.edu |
| Lexington, KY | Science Center | The Living Arts and Science Center | www.lasclex.org |
| Lincoln, NE | Museum | University of Nebraska State Museum | museum.unl.edu |
| Little Rock, AR | Museum | Museum of Discovery | www.museumofdiscovery.org |
| Los Alamos, NM | Museum | Bradbury Science Museum, Los Alamos National Laboratory | www.lanl.gov |

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|---|---|---|---|
| Louisville, KY | Science Center | Kentucky Science Center | www.KYScienceCenter.org |
| Malden, MO | Museum | Bootheel Youth Museum | www.bootheelyouthmuseum.org |
| Manchester, NH | Science Center | SEE Science Center | www.see-sciencecenter.org |
| Manhattan, KS | Science Center | Flint Hills Discovery Center | www.flinthillsdiscovery.org |
| Martinsville, VA | Museum | Virginia Museum of Natural History | www.vmnh.net |
| Milwaukee, WI | Museum | Milwaukee Public Museum | www.mpm.edu |
| Green Bay, WI | Learning Center | Greater Green Bay STEM Network | http://stemecosystems.org/ecosysstem/greater-green-bay-stem network/ |
| Milwaukee, WI | Museum | Discovery World | www.discoveryworld.org |
| Minneapolis, MN | Museum | Bell Museum of Natural History | www.bellmuseum.umn.edu |
| Missoula, MT | Museum | Montana Natural History Center | www.montananaturalist.org |
| Nashville, TN | Museum | Adventure Science Center | http://www.adventuresci.org/ |
| New Orleans, LA | Aquarium | Audubon Aquarium of the Americas | https://audubonnatureinstitute.org/aquarium |
| New Orleans, LA | Children's museum | Louisiana Children's Museum | www.lcm.org |
| New York, NY | Aquarium | New York Aquarium | https://nyaquarium.com |
| Newark, OH | Science Center | The Works: Ohio center for history, art, and technology | www.attheworks.org |
| Oakland, CA | Science Center | Chabot Space and Science Center | http://www.chabotspace.org/index.htm |
| Oklahoma City, OK | Museum | Science Museum Oklahoma | www.sciencemuseumok.org |
| Omaha, NB | Zoo | Henry Doorly Zoo and Aquarium | http://www.omahazoo.com |
| Omaha, NB | Learning Center | Omaha STEM Ecosystem | http://stemecosystems.org/ecosystem/omaha-stem-ecosystem/ |
| Oneonta, NY | Science Center | A.J. Read Science Discovery Center | www.oneonta.edu |
| Phoenix, AZ | Science Center | Arizona Science Center | www.azscience.org |
| Pierre, SD | Science Center | South Dakota Discovery Center | www.sd-discovery.org |
| Pittsburgh, PA | Science Center | Carnegie Science Center | www.carnegiesciencecenter.org |
| Pittsburgh, PA | Children's museum | Children's museum of Pittsburgh | www.pittsburghkids.org |
| Prestonsburg, KY | Science Center | East Kentucky Science Center and Planetarium | www.bigsandy.kctcs.edu |
| Queens, NY | Museum | New York Hall of Science | www.nysci.org |
| Raleigh, NC | Museum | North Carolina Museum of Natural Sciences | www.natualsciences.org |
| Reno, NV | Science Center | Fleishmann Planetarium and Science Center | www.planetarium.unr.edu |
| Reno, NV | Museum | Terry Lee Wells Nevado Discovery Museum | www.nvdm.org |
| Richmond, VA | Museum | Science Museum of Virginia | www.smv.org |
| Roanoke, VA | Museum | Science Museum of Western Virginia | www.smwv.org |
| Rocky Mount, NC | Children's museum | Imperial Center for the Arts and Sciences | www.imperialcentre.org |

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|---|---|---|---|
| Santa Fe, NM | Learning Center | Los Alamos National Lab | http://www.lanl.gov |
| Schenectady, NY | Museum | Museum of Innovation and Science | www.misci.org |
| Seward, AK | Aquarium | Alaska SeaLife Center | http://www.alaskasealife.org/ |
| Sioux Falls, SD | Science Center | Kirby Science Discovery Center | www.washingtonpavillion.org |
| Springfield, MO | Science Center | Discovery Center of Sprinfield | www.discoverycenter.org |
| St. Johnsbury, VT | Museum | Fairbanks Museum and Planetarium | www.fairbanksmuseum.org |
| St. Louis, MO | Zoo | St. Louis Zoo | https://www.stlzoo.org |
| St. Louis, MO | Learning Center | St Louis Regional STEM Learning Ecosystem | http://stmecosystems.org/ecosysstem/st-louis-regional-stem-learning ecosystem/ |
| St. Louis, MO | Museum | Saint Louis Science Center | https://www.slsc.org/ |
| St. Louis, MO | Children's aquarium | World Aquarium | https://www.childrensaquarium.org/ |
| St. Paul, MN | Museum | Science Museum of Minnesota | www.smm.org |
| Syracuse, NY | Museum | Milton J. Rubenstein Museum of Science and Technology | www.most.org |
| Troy, NY | Children's museum | SUNY Poly Children's Museum of Science and Technology | www.cmost.com |
| Union City, TN | Museum | Discovery Park of America | http://discoveryparkofamerica.com/ |
| Watertown, NY | Science Center | Sci-Tech Center of Northern New York | www.scitechcenter.org |
| Wichita, KS | Science Center | Exploration Place, The Sedgwick County Science and Discovery Center | www.exploration.org |
| Wilson, NC | Museum | Imagination Station Science and HIstory Museum | www.scienceandhistory.org |
| Nation Wide | Learning Center | MATE Programs | https://www.marinetech.org |

# Appendix G
## Observations by the Aquarium of the Pacific's Educators on Enhancing the Effectiveness of OER's Education Program

## Observations on Enhancing OER's Education Program

**David Bader, Alie LeBeau, Emily Yam**
**Aquarium of the Pacific**

### EXECUTIVE SUMMARY

Because ocean exploration is a new topic for many K-12 educators, they appreciate any opportunity to learn more and connect to available resources for their classroom. In this report, we offer ways to enhance educational materials presented by NOAA's Office of Exploration and Research that can strengthen the program at various levels including institutions that host workshops, teachers who participate in workshops, facilitators who implement the workshops, and the curriculum and materials available.

1) ***All stakeholders need to participate in goal setting for the program.*** Defined goals for the curriculum, workshop, implementation, and the education alliance will clarify how program materials can be implemented, improved, and evaluated.
2) ***OER Workshops expose teachers to new content, so teachers need opportunities to collaborate on how best to use activities and resources.*** Reducing the number of workshop activities will allow for depth, not breadth, of understanding. More time for reflecting on individualized modification and cross-disciplinary integration may help teacher utilize more content.
3) ***Feedback from workshop participants can reshape and restructure the workshop content.*** OER programs will benefit from more direct feedback and follow up with teachers. Teachers may be able to provide more insight in how the OER website can be reorganized to limit barriers to classroom implementation. Simplifying the website and reorganizing it into relevant and important themes may be a starting point. Additionally, webinars, social media-based teacher groups, "meet an explorer" programs, or live connections with ships of exploration could be incentives for teachers to continue their experience beyond the workshop.
4) ***Building a community of practice among facilitators will strengthen the program.*** There are limited opportunities for facilitators to share and reflect on how they implement workshops. Providing either in-person or asynchronous opportunities to interact with one another will give facilitators more opportunities to reflect upon and improve their practice in implementation. More

facilitators working in different regions will also allow the OER materials to reach new audiences.

5) ***Redefining the Ocean Exploration Education Alliance will elevate the individual alliance member strengths and elevate the work of the network.*** Workshops should allow for hosts to leverage their own exhibits, collections, and staff that align well to OER themes. Additionally, identifying new alliance partners who are also well connected to teacher audiences will expand the reach of OER materials.

Successful teacher engagements with ocean exploration advance OER's mission to build ocean literacy and explore our little-known ocean world. Strategic changes in the current approach will build more momentum, not only with teachers, but with the entire network of scientists and educators whose work intersects with the OER network and workshops.

## OVERVIEW

The upcoming 2018 National Ocean Exploration Forum will have a special focus on effective messaging and engaging the public in the importance and relevance of ocean exploration. As aquarium educators committed to promoting ocean exploration, we offer our reflections on ways to enhance teacher professional development workshops offered by NOAA's Office of Exploration and Research (OER) and its education alliance partners.

Surveys and interviews with various stakeholders were used to gather input for this report. Feedback from alliance partners and facilitators underscored two things: (1) ocean exploration is a new topic for many teachers, so any exposure to any resources is appreciated; and (2) there may be ways to reorganize, reframe, and redefine existing OER materials to make them more usable, relevant, and informed by best practices. Enhancements to educational materials presented by OER address the following areas:

1. institutions that host the workshops,
2. teachers who participate in the workshops,
3. facilitators that implement the workshops, and
4. workshop materials and resources.

### Defining and measuring success

While we make recommendations at several scales of OER workshop implementation, there is one clear need throughout all levels: alliance partners should work with NOAA to establish shared goals for the workshop. In its current form, the "Exploring the Deep Ocean" curriculum does not clearly define goals or measures to determine the success of the OER workshops and education alliance. Quantitative measures, such as number of teachers attending workshops, may not give alliance members the tools to effectively support teachers. By establishing shared goals across the partners, both hosts and facilitators can confirm that activities are successful.

## WORKSHOP AND CURRICULUM

Effective teacher professional development extends beyond an introduction to new activities. Teachers participating in professional development offerings have expressed interest in novel experiences and an appreciation for free materials provided. However, the *way* that teachers are exposed to new content matters as well; teachers do not seek out detailed lesson plans, but instead crave *inspiration and conversation.* Teachers appreciate opportunities to discuss how to make use of new material and resources in practical ways. Highlighting STEM careers, telling stories from the field, focusing on skills, and sharing media pieces can introduce new topics like ocean exploration. Each educator is the expert on his or her classroom, and will know how to adapt and implement materials for the audiences they serve.

The structure of the current OER workshop introduces many resources, ideas, information, and materials. In a recent OER workshop, the agenda included six different activities or demonstrations in a six-and-a-half-hour period. Teachers, like the students they serve, need context to make sense of the robust content. While there is time in the agenda for planning and reflection at the end of the day, there is not enough opportunity to check-in with teachers throughout the program. Teachers need time to consider how they would translate and modify this content into their classroom. If teachers were encouraged to attend in teams, they could be asked to establish fairly detailed implementation plans and then present them to the other "teams." These implementation plans should include key people to include in the conversation, materials that would need to be provided, and a timeline for accountability.

Workshop activities should be limited to only the strongest and most immediately applicable activities. Through a depth-not-breadth approach, teacher participants would be more likely to take the materials home to use with their students. For example, "To Boldly Go" is one of the first activities shared in the workshop, but may be better served as a pre-workshop assignment to prime teachers. On the other hard, "Invent a Robot" and "Wet Maps" are stronger activities that encourage hands-on exploration and use of models. These lessons align well with Next Generation Science Standards (NGSS) and allow teachers to work through new content. Refocusing time on introducing these lesson plans, and then debriefing the experience, may strengthen the teachers' comfort immediately implementing the activity with their students.

We should also consider that many of the activities require extensive preparation or new materials that may inhibit a teacher's ability to implement. Classroom teaching has unique limitations which must be considered when suggesting activities. Providing teachers with as much detail, even the size of the dowel used in a model, will help eliminate barriers for teachers. Activities that require a lot of time-intensive set up will not work for teachers who have four preparations of the same class.

The current OER workshop is targeted towards $6^{th}$-$12^{th}$ grade educators; however, there are often elementary educators present in the workshops. They typically have a high level of interest, but a lower level of confidence in their ocean literacy. Even middle and high school teachers, who may feel very comfortable with their life or earth science

background, may not have the marine science background that allows them to connect workshop content to their curriculum. It should be noted that ocean literacy is often limited throughout K-12 classrooms. Elementary educators can be a new targeted audience that is served with a new workshop specifically designed and promoted to them. With the new audience, a new implementation of the materials would be required. One way to make the curriculum more flexible for K-5th grade educators is to present the activities as a way to align with science and engineering practices found in NGSS. Elementary teachers need new ways to encourage students to ask questions, make observations, work with models, and debate with evidence. Ocean exploration is the perfect theme to provide them that opportunity.

At the workshop, each participant receives the "Exploring the Deep Ocean with NOAA" binder. This is not meant to replace the previously published "How do we explore?" and "Why do we explore?" books. The binder supports the implementation of the workshop itself. The organization of the binder, missing materials, and an absence of Table of Contents, caused confusion from participants in a recent Aquarium of the Pacific workshop. Similar confusion about the website was also noted. While the facilitators are comfortable with finding materials, teachers sometimes struggle to make use of the vast amount of materials available.

The workshop should be seen as a "starter kit" that allows any teacher with limited prior knowledge about the ocean to leave with more content, specific applications, and a confidence to be successful. The starter kit requires an introduction of content which can be paired with activities that are immediately applicable to their school curriculum. Time to explore the website, and a simplification of where to find the "starter kit" materials would be useful.

The workshop can also highlight media that can be used for multiple purposes; this encourages teachers to make connections to other disciplines. Footage that shows the diversity of organisms, unusual landscapes, or even sounds of the deep sea could be inspiration for writing or connections to other disciplines. These connections are currently listed at the end of each lesson in the workshop, but using this as a theme throughout the workshop may make it easier for teachers to strengthen connections with language arts and math.

## WEBSITE ENHANCEMENTS

Like the ocean itself, the OER website is vast. And just as teaching about the ocean can be intimidating, so can navigating the website. As teachers' comfort grows, they may want to move past the "starter kit" and take on new information and lesson ideas. Visitation to the website could be a quantitative measure of success. To gauge that success, it would be helpful to have more information about what is used on the website in order to restructure and make it more user-friendly. The following website analytics could be a helpful place to start:

- What are the most popular entry sites?
- What page has the longest view time?
- What are the most popular exit sites?
- Are older materials accessed with any frequency?

A primary purpose for the website is access to lesson plans. However, lessons organized by expeditions are less likely to be immediately applicable for educators. While materials can be searched by subject area, the website is still difficult to navigate; searches for a particular subject (for example, "hydrothermal vents") may yield too many results for teachers to identify the most relevant link. A simplified website may encourage educators to access materials more quickly. Just as the workshop can be seen as a "starter kit," so too can the website be reconstructed with a similar goal.

As the website is restructured, organization strategies and search engines should be carefully considered. Teachers often will not investigate materials that are not clearly labeled for the grade levels they teach, and some teachers are not confident about how to make connections to NGSS. Asking past workshop participants how best to organize materials could indicate appropriate tags or keywords.

Another way to simplify the website is to prioritize accessibility to OER assets that are most valuable. Teachers value videos, images, and live webcams, but there are so many resources, that the strongest materials may be lost or hard to identify. Highlight reels can be created with simple prompts that encourage students to make observations. Audio of scientists and short (less than two-minute) videos of scientists sharing their work or experiences in STEM fields is also a media resource to highlight.

OceanAGE is a valuable resource available online. Facilitators, teachers, and hosts see the benefit of the career highlights. Teachers are hungry to introduce their students to STEM career opportunities, especially when those careers represent the diversity of their students. Engineers, cooks, interns, undergraduates, and PhDs all play a role in ocean exploration. Students need to see themselves through those career stories. Making the skills, job duties, and daily responsibilities of those careers as simple to find as possible will help teachers translate those to their students.

## NEW MECHANISMS FOR FOLLOW-UP

Both hosts and facilitators identify a need for feedback from workshop participants. While a previous OER workshop design had individual teachers attend two different sessions and included time to "report back" about what was implemented, there is currently not a mechanism for teachers to provide detail about what materials ended up in their classroom. An asynchronous online option may serve the need for workshop follow-up.

Many online platforms exists for teachers, however since Facebook is a comfortable platform for many people, it eliminates the need to remember another website and

password. It may offer an easy opportunity to maintain connection to teacher participants. Creating a Facebook group would require an administrator, but the time needed to oversee an online group could be minimal, as long as norms for participation are made clear. The online groups could be a closed group, with only past participants able to join as members, or it could be a public group available to all teachers interested in the information. The forum could provide a marketing opportunity to advertise upcoming events, ask questions directly of the teachers, and encourage communication between facilitators and teachers. It could also provide a mechanism for sharing when materials are out-of-date. Other online platforms may also exist as a mechanism to gather feedback from facilitators and teachers. Further investigation into the College of Exploration webinars may lead to a better understanding of what online offerings are achieving, and opportunities to use those forums as a mechanism to provide feedback from teachers. Other synchronous, online workshops and webinars may also provide new avenues for workshop follow-up that are interactive and support professional learning communities. Webinars hosted on Zoom (or other conferencing platforms) have been successful for remote-participation in webinars for other projects. Webinars that are structured, interactive, and allow for collaboration have been most effective.

Since teachers are eager for opportunities to introduce their students to STEM professionals, an incentive for continued participation on the part of the teacher may exist in experiences that connect students directly to people working in ocean exploration. This ensures that teachers use workshop materials to prepare their classes, and also helps cultivate the next generation of ocean explorers. OER should consider live "meet a scientist" or "meet an explorer" videoconferencing programs. As much as possible, we also recommend having a diversity of people represented in these classroom connections. Teachers can provide their students with "pre-meet" opportunities to learn more about deep sea exploration, and then have students prepare questions for the scientists during the live connection. Similarly, live connections between workshop participants and the Okeanos can encourage more investigation into ocean exploration topics and current events.

## WORKSHOP PARTICIPANTS

Informal science institutions, including almost all alliance partners, have networks of teachers who are interested in professional development opportunities offered by each institution. This model has been the foundation of OER education alliance. Partners have varied success in filling workshops to capacity. To increase the reach, and potential impact of the curriculum, there are opportunities to expand the audience. These new audiences may require an adjusted curriculum, or a different implementation strategy. New audiences may include:

- Elementary educators
- After-school programs
- Pre-service teachers
- School district administrators
- Professional organizations and teacher associations
- Libraries

- Elderhostel leaders
- Informal educators teaching at aquariums and science centers
- Science education departments at colleges and universities

Workshop participants are appreciative of the content and materials, especially since stipends, free materials, free parking, lunch, and access to the host institution is included in the experience. It is also important to be respectful of their time. Having a well-organized agenda will increase the likelihood of it being used. As previously mentioned, knowing more about what specific tools are being used by teachers would provide feedback to facilitators. As one host site identified "…Perhaps pursing feedback channels with educators will assist in producing educational materials with greater accessibility and easier assimilation from the end-user's perspective."

Since participants are given a stipend for their participation, asking more of them prior to the workshop is tenable and can prime them for a more successful in-workshop experience. If new content is a challenge, teachers can be given a homework assignment prior to the workshop. Exploration of the OER website, a prompt about their understanding of ocean literacy, or even a copy of the "To boldly go" lesson plan will provide the foundation for a shared experience to kick off the workshop.

Similarly, teachers may be interested in longer engagements with workshop facilitators. Workshop facilitators can provide support for classroom teachers in order to encourage continued engagement with content, get feedback about workshop implementation, articulate barriers for curriculum integration, and provide more personalized support as needed. Creating a longer-term engagement with workshop participants may require reducing the number of teachers; however, this approach may also lead to more ocean exploration lessons and themes in the classroom.

## FACILITATORS

There are currently six facilitators that travel to alliance partners in order to lead "Exploring the Deep with NOAA" workshops. These six individuals include both informal educators and formal classroom teachers. Facilitators check in regularly with OER program staff to make sure programs are somewhat consistent in content, but they have more flexibility in terms of how the workshops are implemented. The greatest area of opportunity at this level is developing a robust community of practice among facilitators in order to make implementation more dynamic, relevant, responsive, and current.

OER facilitators were consistent in their responses; facilitators identified a lack of understanding what happens with the materials after the workshop. They expressed interest in more follow-up from the workshop participants such as adaptations to lessons plans, what they used, what worked best, and what needed improvement. Facilitators hear immediate positive feedback about the sessions, but they crave more specific information about the lasting impact. A delayed post survey could indicate what is being used, what adaptations can be suggested for future workshops, and what is most important to keep for future versions.

Facilitators also work in relative isolation for much of the year and go for long stretches between workshops. Connecting facilitators and OER program staff with one another more often (through face-to-face meetings or asynchronously, online) can build a stronger community of practice across facilitators. During these sessions, they could discuss how workshops went, strategies on integrating current events, and ways to improve activities and discussions. Checking in with one another can also keep things more top-of-mind, and will allow facilitators to support each other throughout the year. Increasing the number of facilitators could allow each individual facilitator to specialize in a smaller area of coverage, and spend more time following up with teachers who are interested in a longer-term investment (e.g., figuring out practical ways to implement the programming, connecting to scientists working in the field, and providing feedback to the OER program about how things work.)

## ALLIANCE PARTNERS –HOST SITES

According to the OER website, the following institutions are education alliance partners: Audubon Aquarium, Aquarium of the Pacific, Birch Aquarium, Loveland Living Planet Aquarium, Georgia Aquarium, New England Aquarium, Shedd Aquarium, Oregon Museum of Science and Industry, Texas State Aquarium, National Aquarium, South Carolina Aquarium, US Naval Academy, Waikiki Aquarium and University of South Florida's College of Marine Science. Dauphin Island Sea Lab has upcoming workshops listed, but is not on the alliance website. Great Lakes Aquarium was identified as a host in an interview with one of the six facilitators, but wasn't found on the website.
Our surveys, interviews, and conversations with participants indicate that the model for teacher workshop implementation, which involves aquariums and institutions hosting and recruiting OER workshops, is a successful model, however adjustments could support and extend the network of alliance partners.

Densely populated areas like Southern California may offer a large concentration of potential teachers, but in other areas of the country, those educators may need to travel greater distances in order to attend in-person professional development. In more populated areas, there may also be competition for educators' time and participation, with lots of options vying for their attention.

Perhaps identifying new strategies for disseminating information and offering a diversifying approach will allow access to more educators. Some alternative approaches may include: workshops for elementary educators, online options, pre-recorded content pieces, interviews with STEM professionals, and quick connections to curriculum based on current events (for example: when an image of the googly-eyed, stubby squid went viral, a simple post on OER social media could remind teachers where they could find information on deep sea creatures in the curriculum).

### Recruitment and Participation

While participation in workshops has fluctuated, typical audience size ranges from 12-25 teachers. Some host institutions have had success collecting a deposit from teacher participants, while others have overbooked the workshop in order to have a good size

group. According to facilitators and alliance partners, recruitment is often aided by existing relationships with teacher communities. Expanding audiences will help host sites recruit and fill workshop space.

NOAA OER may also be able to leverage the proliferation of deep sea images on social media. Viral images and news stories that feature Okeanos footage can be leveraged to advertise OER workshops. Many teachers do not currently teach about the ocean or are not aware of professional development opportunities. Building awareness of these resources around images and news stories that already have their interest could be a good way of recruiting more participants who otherwise may not have been engaged.

**Identifying new alliance partners**

As previously mentioned, there is interest and opportunity to expand the target audience beyond the 6th-12th formal educators. In order to expand the targeted workshop audience, we must also expand the types of alliance partners. If access to a strong and engaged teacher network is an asset to recruitment, there may be opportunities to identify new partners to serve as host sites. Libraries, county office of education, parks, and even after-school programs may provide more access to educators that can make use of the resources and curriculum.

**Highlighting strengths of alliance partners**

For partners with relevant connections, such as exhibits, library connection, scientists on staff, the workshop is an opportunity to connect with the assets of the alliance host. For example, if a host site has an exhibit on Ocean Exploration, or staff with additional expertise, those assets can be utilized during the workshop. As much as possible, using the resources unique to the host site will strengthen the experience for the teachers. It will require collaboration between the facilitator and host site, but can increases buy-in from alliance partners and the teachers who look to the institution as a source of information.

## CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the work of NOAA's Office of Exploration and Research have provided teachers with access to professional development opportunities, an introduction to ocean exploration content, activities, resources, and other materials. The teachers express appreciation for these workshops that are fairly well attended. However, there are opportunities to enhance the curriculum, the audience, and the implementation strategies in order to increase the impact. Major areas of recommendation include:
**Shared goals:** Identify shared goals for the curriculum, the workshops, the facilitators, and the participants. Increase buy-in across at each level by seeking input from all stakeholders in establishing goals.

**Expand audiences and alliance partners:** Consider new alliance partners, aside from aquariums, which have strong existing teacher networks. With new audiences, new workshop formats may be needed. Initially, the elementary educators should be considered.

**Mechanisms for feedback**: A stronger community of practice among facilitators is needed to inform implementation strategies. Feedback between facilitators is fueled by feedback from teachers. Alliance hosts and facilitators need feedback from workshop participants about the workshop implementation and materials. Additionally, time for collaboration during the workshop will allow for teachers to consider modifications and adjustments.

**Website restructure**: Major restructuring of the website should be considered to simplify access and ease teachers' ability to search for appropriate materials. Teachers may provide the best insight into organization.