CURRENT LOG We’re excited to bring you another general issue of Current featuring articles by NMEA members from all over the country and overseas to provide new ways to discover the “world of water.” In this issue, you’ll find a variety of engaging articles and activities, including lessons on how research data in a classroom is supporting student’s learning of complex ecological concepts and improving STEM literacy, a look at a professional development program in Hawaii that explores misconceptions teachers have about ocean literacy, as well as many other exciting topics.

From June 25-29th in Charleston, South Carolina, marine educators from near and far will gather for our 2017 annual conference, Seas of Change: Lowcountry Lessons in Resiliency, hosted by the South Carolina Marine Educators Association (SCMEA). The conference brings together formal and informal educators, scientists, students, and government and industry members to network and inspire. The conference hosts general and concurrent sessions, workshops, field trips, and evening events. Visit NMEA2017.org for more details and register today, or contact the FMSEA conference coordinators at info@nmea2017.org with any questions. We hope to see you there!

NMEA publishes two digital issues of Current each year, so please continue to send in your original manuscripts on research, lessons, resources, or strategies focused on marine and aquatic science, education, art, literature, and maritime history. Look for contributor guidelines on our website under Current: The Journal of Marine Education. The deadline for submitting articles for consideration in the Fall/Winter 2017 general issue of Current is October 30, 2017.

Remember to stay connected to the NMEA by liking us on Facebook and following us on Twitter for the latest news and updates.

Cheers,

Lisa M. Tooker
Editor

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ACTIVITY: One Fish, Two Fish—Assessing the Habitat Value of Restored Oyster Reefs: Using Scientific Research in the Classroom

BY JENNY PATERNO, LISA CALVO, REBECCA JORDAN, PH.D., AND DAVID BUSHEK, PH.D.

ABSTRACT
Reef habitats play critical roles in marine ecosystems across the globe. Here, we investigated fish use of a small mid-Atlantic oyster reef built via a community-based restoration project. The reef supported a diverse faunal community consistent with natural oyster habitats. Data from this research were incorporated into a lesson plan that was piloted in a middle school classroom. Summative assessments (n=21) indicated that the lesson improved student’s analytical skills and knowledge. Use of authentic, locally relevant research data in the classroom via a problem-based model supported learning of complex ecological concepts and improved STEM literacy in students.

Key words: oyster restoration, estuary, research data, species diversity, Simpson’s Index, biodiversity, K-12, lesson plan, ecological concepts

INTRODUCTION
Reef habitats play critical roles in marine ecosystems across the globe. Here, we investigated fish utilization of a small mid-Atlantic oyster reef built via a community-based restoration project. The reef supported a diverse faunal community consistent with natural oyster habitats. Data from this research were incorporated into a lesson plan that was piloted in a middle school classroom. Using experimental data from a research investigation as a tool to teach students about key concepts in science and mathematics provides real-world scientific practices in the classroom. This methodology supports the inclusion of relevant material to meet science standards (e.g. NGSS 2013). This study employed a newly developed, research-based activity and a local theme, within the framework of an existing outreach program, to promote data interpretation skills and science literacy.

This activity looks at the four pieces of this multidimensional project:
1. Overview of a student community-based restoration program
2. Scientific study: Oyster reef monitoring
3. Adaptation of research data for classroom lesson
4. Classroom pilot study and lesson evaluation

BACKGROUND
The eastern oyster (*Crassostrea virginica*) is an estuarine, filter-feeding bivalve that ranges in distribution along the east coast of North America from the Gulf of St. Lawrence to the Gulf of Mexico (Kennedy et al. 1996). They currently are, and historically were, harvested as an important food item throughout much of their range. Oysters are “ecosystem engineers” (sensu Jones et al. 1994). In other words, oysters build habitat. Sessile for most of their lives, oysters form gregarious communities that create hard structure in

FIGURE 1. First grade friends from the Boys and Girls Club of Vineland, NJ show off the shell bag they just built with Project PORTS. Courtesy of Jenny Paterno
estuaries. Eastern oysters will settle subtidally or intertidally depending on habitat conditions, but their overall ecosystem functions remain the same (Coen et al. 2007). Some of these functions include water filtration, concentration of bio-deposits, and creation of habitat for associated resident and transient species which, enhances estuarine biodiversity (Wells 1961; Tolley et al. 2005). With widespread declines in oyster populations due to over-fishing, habitat loss, pollution, and disease (e.g. Kennedy et al. 1996), many estuarine restoration programs exist to improve oyster stocks and enhance the ecosystem services they provide. Oyster reefs have been successfully constructed by community-based programs which engage stakeholders and local citizens in ecological restoration efforts (e.g. Brumbaugh et al. 2000 and Hadley et al. 2010). Community-based programs offer a unique opportunity and an ideal platform to communicate relevant scientific information to the public, especially youth.

Overview of a Student Community-based Restoration Program

Our model for introducing "real-world" science in the classroom is Project PORTS (Promoting Oyster Restoration Though Schools); an outreach initiative of the Haskin Shellfish Research Laboratory, Rutgers University (Calvo 2008). The goals of Project PORTS are: (1.) to increase awareness and understanding of the oyster as a cornerstone species and a significant natural resource of the Delaware Bay; (2.) to promote an understanding of important scientific concepts and stewardship values; (3.) to enhance Delaware Bay oyster habitat; and (4.) to evaluate success and natural value of enhanced oyster reef habitat (Calvo 2008). These goals are continuously pursued through a series of interwoven activities, including community-based oyster habitat enhancement efforts, habitat assessments, and school enrichment programs. The oyster population in the Delaware Bay has shown dramatic declines over the past century. Located in the mid-Atlantic, the Delaware Bay is bordered by New Jersey and Delaware and fed primarily by the Delaware River. Project PORTS’ education program provides and facilitates learning activities that utilize the oyster as a vehicle to improve science literacy, acquaint school children with the Delaware Estuary, and promote stewardship. This study was conducted under the existing framework of Project PORTS.

Project PORTS places scientists in the classroom to deliver program activities. Hands-on lessons vary in delivery and scope, but usually include at least one in-class program and a stewardship activity in which students create shell bags that will become the foundation of the restored oyster reefs (see Figure 1 on page 2). Teachers are encouraged to present students with additional activities provided in the Project PORTS Curriculum and Activity Guide (Calvo 2008) to build on the initial introduction delivered by the program scientists and staff. All lessons are designed to address and supplement current national and state curriculum standards, e.g., the Next Generation Science Standards (NGSS 2013) and the former, but still widely used, New Jersey Core Curriculum Content Standards in Social Studies (NJ Dept. of Education 2014).

The community-based restoration project, the core of Project PORTS, extends lessons from the classroom to an authentic application. Students construct shell bags that are deployed in the Bay to serve as cultch for oyster spat (Figure 2). Typically, a truckload of surfclam shell is delivered to participating schools and, after learning about the ecology of oysters and their decline, students fill mesh bags with shell in their schoolyard. Community volunteers of all ages then help transport the bags and deploy them to an area in the Delaware Bay where oyster larvae will attach and become spat. A few weeks later, community volunteers return to transport the ‘spatted shell’ to the restoration site. Since the program’s start in 2007, student-stewards have constructed approximately 28,000 shell bags supporting the placement of more than 20 million oysters on a five-acre oyster reef restoration site in the Delaware Bay. The planted shell and attached young oysters have formed a low-relief oyster reef that is now home to several generations of adult oysters. This work begs the question; did these small scale-shell planting efforts from Project PORTS alter community species abundances relative to unenhanced bottom? In other words, has the work of this program impacted the local habitat and the creatures that use it?
Scientific Study: Oyster Reef Monitoring

To answer that question, we conducted a study in 2013 in which we: (1.) delineated seven sites in the Delaware Bay based on bottom habitat characteristics; (2.) sampled fishes and invertebrates on the Project PORTS enhancement site, unaltered oyster reef with many oysters, and unaltered oyster reef with few oysters; and then (3.) compared species diversity among these three different area types. Sampling methods to characterize the community structure on these low-relief reefs included otter trawling and the use of benthic habitat trays. We deployed habitat trays monthly to collect resident fishes and invertebrates using the reef substrate. To sample larger transient and resident species, we used a small otter trawl. The trawl net was towed behind a boat across the bay floor. Each animal captured was identified, measured, and weighed before release. Results revealed that the enhancement area supported a diverse faunal community consistent with nearby natural oyster habitats (Figure 3; Paterno 2015).

Adaptation of Data and Classroom Pilot Study

Using Project PORTS’ school enrichment programs and the oyster habitat enhancement efforts, we designed a classroom activity that included scientific data to extend a practical connection to the estuary into the classroom. The data utilized were collected in the oyster reef monitoring study described above. Titled One Fish, Two Fish—Assessing Habitat Value of Restored Oyster Reefs, this educational activity incorporates science and math to examine habitat value of an enhanced oyster reef. The goals of the activity are to: introduce students to ecological restoration, acquaint them with common mid-Atlantic oyster reef inhabitants, develop graphing and data interpretation skills, and examine the concept of species diversity in conjunction with a mathematical method to quantify it. Students use some of the same techniques that scientists and restoration practitioners use to analyze catch data and describe the biodiversity of a habitat. Using a set of provided equations, they calculate Simpson’s Index of Diversity for each habitat type to develop conclusions about the restored oyster reef.

OBJECTIVES

Students will be able to:
1. Understand the concept and basic goals of ecological restoration
2. Develop a hypothesis and use mathematical equations to test the validity of the claim based on existing data
3. Use graphical and mathematical techniques to represent and interpret data
4. Describe how modifications of environmental conditions may result in changes of species’ abundances

FIGURE 3. Bar graph depicting Simpson’s Index of Diversity values calculated from cumulative trawl survey catch data* across sites ranging from greatest number of oysters present to least. The closer the index values to 1, the greater the diversity. The Project PORTS restoration area exhibited the highest diversity of species collected in the trawl net during the study compared with natural oyster reefs of varying densities. *Excluding Anchoa mitchilli (bay anchovy), the 10 most abundant species collected in the trawl were included in the calculations.
TEACHING TIME: One to two 40-minute sessions

GRADE LEVEL: Geared towards grades 6-9 (can be modified for upper grade levels)

STANDARDS: Next Generation Science Standards (NGSS 2013)

<table>
<thead>
<tr>
<th>Performance Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.</td>
</tr>
<tr>
<td>MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td>
</tr>
<tr>
<td>MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.</td>
</tr>
<tr>
<td>MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</td>
</tr>
<tr>
<td>HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.</td>
</tr>
<tr>
<td>HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems at different scales.</td>
</tr>
<tr>
<td>HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.</td>
</tr>
<tr>
<td>HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.</td>
</tr>
<tr>
<td>HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.</td>
</tr>
<tr>
<td>HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.</td>
</tr>
</tbody>
</table>

MATERIALS
- Student Worksheet (see pages 9-10)
- Pencils
- Data set (Table 1 on Student Worksheet, see page 9)
- Calculator
- Colored pencils (optional)
- Computer graphing program (optional)

ACTIVITY: LEARNING PROCEDURE

1. Warm Up: Introduce habitat or ecological restoration to the students. Ask: What does it mean to restore something? Why might humans care about returning natural areas to a former condition? Can you think of any examples? Are there any restoration areas in your county or community? Re-planted forests, wetlands, meadowlands, coral reefs, etc.? In conjunction with a possible local site, use the Project PORTS oyster restoration area as an example during an in-class discussion. Show the students a map of New Jersey and orient them to the Delaware Bay where this study takes place. If your school is in a coastal state, do you have oyster reefs in your local estuaries?

2. Set the Stage: Briefly describe some of the background information provided above. Query: What benefits do oysters provide to the environment, animals, and humans? Why might we want to restore their populations? Ask: What types of animals might use oyster reefs? How do we know? Since oysters live on the bay bottom and create complex structures, what would be an effective way to collect animals to determine which species are utilizing that habitat? Explain that the data in this activity were collected by Rutgers University scientists using an otter trawl that drags along the bottom as it is towed by a boat. It has two otter doors that keep the net open, and a long mesh bag at the end to hold the critters it encounters. Three tows were made over each of the seven study sites twice a month for five months. The animals collected in the net were identified, weighed, measured, and released. The study sites consisted of (two) natural reefs with many oysters, (four) natural oyster reefs with few oysters, and (one) oyster restoration area that has received plantings of young oysters and shells.

3. Divide the class into teams of restoration scientists assigned the project of studying the effects of oyster restoration on native fish species. Give each student a copy of the Student Worksheet (see pages 9-10).
4. Remind students how the data were collected (trawl net) and orient them with the table layout.

5. **Calculate and Analyze:** Now that the data have been collected, we will use a few methods to interpret the information and draw conclusions. **Query:** What are some ways to visually express number data? (e.g. pie charts, bar graphs, line plots). Review how to make a bar graph.

6. Instruct students to choose three fish species from the table and graph their abundances across the three habitat types using pencils or colored pencils (either by hand or using Microsoft Excel). Using their bar graphs, students should:
   a. Visually compare their selected species abundance across bottom types
   b. Determine which species were most abundant and least abundant on each habitat type

7. To dig a little deeper and learn something about the animal community structure, as a whole, we need to use a second method. **Query:** What is diversity? Why is diversity considered a positive attribute in ecosystems? Using a set of mathematical equations, Simpson’s Index of Diversity calculates richness (the number of species) and evenness (the relative abundances of those species) of species to provide a measurement for community diversity. The resulting diversity index value can then be compared across sites or treatments and act as one useful tool to assess the success of restoration efforts.

8. Part B: Students will calculate Simpson’s Index of Diversity for each of the three bottom types using the following two step equations:
   a. Simpson’s Index (D): \[ D = \sum \left( \frac{n}{N} \right) \]
   b. Simpson’s Index of Diversity: \[ 1 - D \]

9. Introduce or review the meaning of sigma and order of operations. Students can write calculated numbers as they generate parts of the equation in the margin of Table 1 (see page 9).

10. Using the calculated ranges from 0 to 1, determine which bottom type hosts the highest diversity of fishes (Remember: the greater the value, the greater the sample diversity). Review the meaning of species diversity. **Ask:** What conclusions can you draw about the restoration project? Is it providing a similar habitat to mature oyster reefs?

**MODIFICATIONS**

1. Have students enter the data from Table 1 into Microsoft Excel and create bar graphs using the graphing features in the program. Students can customize colors, axes labels, and units.

2. Students can work in groups/pairs as they select an animal from Table 1 (or choose additional fish) and conduct research on their species; gathering key life history characteristics. A few additional fish of the Delaware Estuary, in addition to those listed in the table, are: striped bass, Atlantic sturgeon, summer flounder, black drum, and Atlantic menhaden. Students can orally present their research and ultimately construct a class "Field Guide of Fish in the Delaware Estuary" by compiling their reports (Calvo 2008).

**Classroom Pilot Study and Lesson Evaluation**
Project PORTS activity: One Fish, Two Fish—Assessing Habitat Value of Restored Oyster Reefs was conducted with three groups of sixth to eighth grade students from a public middle school in Cumberland County, New Jersey in 2014. In an effort to quantify potential impacts of the activity, students were asked to complete assessments before and after their participation. The timeframe to complete a pre-activity assessment and activity was one 40-minute session. The post-assessment was administered one week later. The criterion-referenced assessments distributed were summative surveys that consisted of four multiple choice questions, one true/false question, and two performance tasks. The assessment was designed to measure student performance and learning progress against a fixed set of activity objectives (outlined in the lesson plan). Each assessment was scored from 0 (lowest) to 13 (highest) points using a rubric. The rubric score included the number of correct multiple choice and true false questions, and completeness in understanding the performance tasks.

**DATA ANALYSIS AND RESULTS**
Similar to that of Nicosia et al. (2014), ANOVA tests were performed on each category of the pre- and post-activity assessments. Twenty-one students participated in the lesson. Project PORTS activity One Fish, Two Fish positively affected student assessment scores, \( t=5.342, \ a < 0.05 \). Pre-activity assessment scores across all grades (sixth to eighth) ranged from 1 to 13 and had an average of 7.17 (SD=3.28). Post-activity assessment scores across all grades ranged from 5 to 13 and had an average of 10.02 (SD=2.4) (see Figure 4 on page 7). Post-participation mean scores were greater for the ecology multiple choice questions (\( p = 0.011 \)) and creating the bar graph task (\( p = 0.009 \)) (Paterno 2015). Students
were able to apply the graphing and data interpretation skills they learned during the activity to unfamiliar data of a different subject matter, indicating student understanding of the concept.

**DISCUSSION**

Student assessment scores measured after completion of the *One Fish, Two Fish—Assessing Habitat Value of Restored Oyster Reefs* activity were significantly improved relative to pre-activity assessment scores. Students learned targeted information in the areas of oyster biology, restoration ecology, and graphing. These results have implications for designing science lessons to include real-life applications for enhanced science literacy and data interpretation skills. It is likely that multiple sessions would have been even more effective than a single-session program in teaching students’ complex concepts. Multiple classroom sessions to help reinforce the newly introduced information might have aided in information retention, which was not studied in this experiment.

In addition, few teachers at Project PORTS partner schools have had firsthand experiences with scientific research or contact with professional scientists until collaborating with the program. The *One Fish, Two Fish* activity and Project PORTS as a whole may help to bridge such gaps by identifying science happening in the local community, and giving students a more familiar frame of reference. Lemke (1990) recommends that educators emphasize that science consists of real activities being conducted by real human beings, perhaps most sincerely conveyed when the educators are scientists themselves. Contrary to the stereotypical lab coat clad male scientist with crazy hair and bubbling test tubes in hand, the personal characteristics of local scientists, with which students can identify, may create a stronger learning experience. This activity also offers full-circle learning to students that have participated in the stewardship component in constructing the shell bags. They can discover the improved ecological outcomes of their work.

By teaming with educators, Project PORTS brings together content knowledge and classroom experience to deliver an applied science curriculum. This study demonstrated how a novel education program with a local, real-world connection can be used as a platform to expand participating students’ STEM knowledge consistent with national science priorities. Recognizing these benefits, this activity was also featured in the New Jersey Science Teachers Association’s Maitland P. Simmons Summer Institute and an educators workshop hosted by the Mid-Atlantic Chapter of the American Fisheries Society.

**ACKNOWLEDGEMENTS**

Funding for this research was provided in part by The Geraldine Dodge Foundation, NJ Sea Grant Consortium, DuPont Clear into the Future as well as USDA NIFA Hatch projects 32109 and 32114. We would also like to thank the Haskin Shellfish Research Laboratory, Rutgers University staff for their continued support of Project PORTS, and Port Norris Middle School for participating in this activity. In addition, Jenny Paterno would like to acknowledge her thesis committee members, Drs. Thomas Grothues and Olaf Jensen, for their valuable input to this work.

**RESOURCES**


East Coast MARE: Oysters and Oyster Reefs in Your Classroom: http://coseenow.net/mare/oysters-in-your-classroom/

COSEE NOW Marine Lesson Plans: Fish Biology and Ecology, Shellfish Recruitment and Reproduction: http://coseenow.net/education-resources/lesson-plans/

New Jersey Sea Grant Lesson Plans: http://njseagrant.org/education/resources-for-educators/lesson-plans/
**ENDNOTE**

1 ‘Cultch’ is a technical term for loose material, usually oyster or clam shells, to which metamorphosing oyster larvae will attach. Once attached, the oysters are called ‘spat’.

**REFERENCES**


JENNY PATERNO recently obtained her master of science degree in ecology and evolution from Rutgers University and received her bachelor of science degree from The Richard Stockton College. She is a program coordinator at the Haskin Shellfish Research Laboratory, Rutgers University. Her work includes coordinating K-12 school programs as well as monitoring faunal utilization of oyster reefs and living shoreline projects along the Delaware Bay.

LISA CALVO jointly serves as aquaculture program coordinator at the New Jersey Sea Grant Consortium and Rutgers University where she supports aquaculture development in New Jersey. During her 25-year career in shellfish research and extension, Lisa has been engaged in many outreach efforts. Most notably, she has developed a successful community-based oyster restoration program known as Project PORTS: Promoting Oyster Restoration Through Schools, which engages students and adults in science and habitat restoration.

REBECCA JORDAN, PH.D., is currently professor of environmental education and citizen science in the Departments of Human Ecology and Ecology, Evolution, and Natural Resources at Rutgers University. Here she works with students in the study of behavior in Lake Malawi cichlids. As director of the program in science learning; however, she devotes most of her research effort to investigating public learning of science through environmental education and citizen science.

DAVID BUSHEK, PH.D., is the director of the Haskin Shellfish Research Laboratory and associate professor at Rutgers University. The predominant focus of his research concerns host-parasite interactions in bivalve molluscs. A second focus aims to enhance understanding of the ecological impact of bivalves, particularly the eastern oyster, at the population, community, and ecosystem levels.
Student Worksheet  Activity 3.7—Assessing Habitat Value of Restored Oyster Reefs

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Restoration Area</th>
<th>Non-oyster</th>
<th>Mature oyster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic croaker</td>
<td><em>Micropogonias undulatus</em></td>
<td>44</td>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>Weakfish</td>
<td><em>Cynoscion regalis</em></td>
<td>22</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Hogchoker</td>
<td><em>Trinectes maculatus</em></td>
<td>27</td>
<td>28</td>
<td>8</td>
</tr>
<tr>
<td>Oyster toadfish</td>
<td><em>Opsanus tau</em></td>
<td>24</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Blue crab</td>
<td><em>Callinectes sapidus</em></td>
<td>14</td>
<td>19</td>
<td>14</td>
</tr>
<tr>
<td>Northern kingfish</td>
<td><em>Menticirrhus saxatilis</em></td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Silver perch</td>
<td><em>Bairdiella chrysoura</em></td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Spot</td>
<td><em>Leiostomus xanthurus</em></td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>White perch</td>
<td><em>Morone americana</em></td>
<td>17</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>163</strong></td>
<td><strong>148</strong></td>
<td><strong>109</strong></td>
</tr>
</tbody>
</table>

A. Using the chart below and the data in Table 1, choose three fish species and create a bar chart showing their abundance at each habitat. Color or pattern the bars for each species and create a legend to denote each species. Note: each site should have three bars (one for each species)
**Student Worksheet**  Activity 3.7—Assessing Habitat Value of Restored Oyster Reefs

B. Using the formula below calculate Simpson’s Index of Diversity including all the species for each of the three different habitats shown in Table 1.

**Formula for Simpson’s Index of Diversity:**

\[ 1 - D, \text{ where } D = \sum (n / N)^2 \]

- \( n \) = the total number of organisms of a particular species
- \( N \) = the total number of organisms of all species

1. Using the data in Table 1 find \( n \) and \( N \) for each site.
2. Calculate \( D \) using the equation (hint: \( \sum \) means sum, calculate \( (n/N)^2 \) for each species and then add all the values together). Calculate \( D \) for the data from each site.
3. Subtract \( D \) from 1 to calculate Simpson’s index of Diversity. \( D \) ranges between 0 and 1, the greater the value, the greater the diversity.

C. After completing your graphs and calculating Simpson’s Index of Diversity answer the following questions.

1. Compare fish abundances at each habitat.
2. For each of the three fish that you chose, which bottom type had the greatest number? The least number?
3. Compare species diversity for each habitat. Which habitat has the greatest diversity? Which habitat has the lowest diversity?
4. What conclusions can you draw about the restoration area based on your results? Is it providing useful habitat to the fish?
5. Why might some fish species benefit from the restoration project and others not? (Hint: think about life cycle, feeding, hiding from predators etc.)
“Sure, I can read an ocean book:” Teacher’s Misconceptions About Ocean Literacy

BY CATHERINE LINDSAY LINSKY, PH.D.

ABSTRACT
After a 14-day professional development program in Hawaii, teachers revealed three misconceptions about the definition and purpose of ocean literacy, including ocean literacy as synonymous with ocean reading, ocean literacy as synonymous with oceanography, and ocean literacy as unattainable. To counteract these misconceptions, I recommend that workshop developers and professional development instructors differentiate their programs based on an ocean literacy “Continuum of Development.”

The Problem
Without a doubt, the United States needs an ocean literate public. According to studies like Brady and Koch (1990) many Americans lack even a basic understanding about the ocean. Without such knowledge, much of the public is unaware of the choices they make each day (i.e. what food to buy, what to do on vacation, how much water to use, how much fertilizer to apply, etc.) could have negative effects on the oceans. Since we depend on the oceans for climate regulation, transportation, food, and countless other ways, we need an ocean literate public now more than ever.

For the public at large to become ocean literate, we need science teachers to understand ocean literacy first and include ocean literacy-based lessons in their classrooms. Sadly, many science teachers fail to do so and may even be confused about what ocean literacy entails, exactly. This disconnect is what sparked the Ocean Literacy Network to develop the seven Essential Principles of ocean literacy, or “An understanding of the ocean’s influence on you and your influence on the ocean.” However, if we are going to advance toward a more ocean sustaining society, we must understand teachers’ thoughts, beliefs, and misconceptions about ocean literacy. This article discusses teacher misconceptions about ocean literacy discovered in a 2012 dissertation study.

Dissertation Study: Project ISLE
I set out to understand what teachers’ conceptualizations (thoughts, beliefs, impressions, concepts, etc.) were about ocean literacy, and how they included the professional development materials in their classrooms afterwards. To do so, I studied participants in a program called Project ISLE (Integrated Science Learning Experiences). Project ISLE...
was a grant-funded program that took 12 Georgia public school teachers (six elementary, three middle, and three high school) to Hawaii for 14 days to study island ecology, fish identification, coral reef health, environmental advocacy, and other topics. Project ISLE made a good setting for this particular study, since the program’s science activities and educational initiatives addressed 31 of the Ocean Literacy Network’s Essential Principal elements. The activities included visits to marine sanctuaries, talks with island ecologists, snorkeling, fish identification, aquarium visits, and many other ocean literacy-based learning experiences. Additionally, at the end of the program, I delivered a presentation about the meaning and purpose of ocean literacy and the seven Essential Elements. All 12 teachers received copies of the official ocean literacy brochure at that time. I purposefully limited my ocean literacy instruction because I did not want to impose my own personal biases. I wanted each teacher’s own conceptualizations (or misconceptions) about the topic to come through in the research.

**Teacher Misconceptions of Ocean Literacy**

In total, I reviewed 17 different data sources collected before, during, and after Project ISLE. These included pre/post-surveys, interviews, classroom observations, lesson plans, blog posts, pre/post-content tests, and a focus group. All data were collected and analyzed using qualitative methodologies. More specifically, I utilized grounded theory data collection methods (Glaser and Strauss 1967) with constant comparative analyses (Strauss and Corbin 1998) to formulate eight main data assertions. The majority of this article comes from Assertion Five: “Teachers’ Experiences and Assigned Grade Level Influence their Ocean Literacy Conceptualizations” (Linsky 2012).

The teachers revealed some major misconceptions about ocean literacy. These misconceptions fell into three main categories:

1. Ocean literacy as reading about the ocean (3)
2. Ocean literacy as oceanography (5)
3. Ocean literacy as unattainable (at least 4)

Also, in this particular group of teachers, the three misconceptions aligned with teachers’ grade levels. All teachers received basic ocean literacy training and many of them could quote the correct definition of ocean literacy in the individual interviews. However, when I asked for further clarification in probing questions, their underlying beliefs were shared.

For example, half of the elementary teachers (three of the six elementary) focused on the word “literacy” and interpreted ocean literacy as ocean reading. In other words, they believed if they were confident to read about ocean science concepts, then they could consider themselves “ocean literate.” When I asked one elementary teacher, Sarah, to describe her own level of ocean literacy, she said:

* I would say…It’s from a one to a ten… I just want to read!...When we were at the ocean, I Googled it and I wanted to know, what fish were there? What were we going to see? … So, I would say a 10 because I love reading and I love learning (Linsky 2012).
Because she felt comfortable reading about the ocean she believed that meant she was fully ocean literate. Again, it should be noted that this teacher quoted the official definition of ocean literacy at the beginning of the interview as “Understanding the ocean's influence on you and your influence on the ocean,” but her discussions of the topic indicated misconceptions.

On the other hand, the three high school teachers and two of the middle school teachers tended to use “ocean literacy” and “oceanography” synonymously. They focused solely on the science and tended to overlook the human impact implied in the official definition. For example, when asked to rate her own level of ocean literacy, one high school teacher, Alissa, said:

＞On a scale of one to ten—one: having no knowledge of the oceans, and ten being: put me on a boat. I know everything about the ocean. I know what organisms live here, what everything is about, the salinity, everything. I think I’m about a three to a four. I feel like I know ocean levels. I definitely know the different oceans, but I don’t feel like I have really dived into understanding oceans and all there is to know about them (Linsky 2012).

Even though Alissa has extensive ocean knowledge and teaches high school chemistry, biology, physics, and forensics, her focus on ocean literacy as “oceanography” and her belief that she was ill-equipped to conduct ocean science research made her feel that she was not ocean literate.

Lastly, at least four of the teachers viewed ocean literacy as unattainable despite their extensive ocean knowledge. I discovered this misconception through data analysis of their answers to this interview question: “How would you describe your own level of Ocean Literacy?” Since this trend was discovered after the fact, it is possible that more of the teachers felt the same way.

For example, two of the Earth science teachers grasped the true definition of ocean literacy accurately and exhibited a real passion for the ocean. One of these teachers said in her pre-program survey that she “always seemed to find her way back to the ocean” no matter what topic they addressed (astronomy, plate tectonics, etc.). However, despite their teaching experience on the topic, they did not consider themselves ocean literate, and did not believe it would be possible to attain full ocean literacy due to the time constraints of their current professional situations. Two of the three high school teachers echoed this concern. Both middle and high school teachers included minor amounts of Project ISLE materials in their classrooms after the program. They explained that administrative pressures and high stakes testing requirements prevented them from including more than a few lessons except for anecdotal stories and pictures.

The Problem with Each Misconception
There are significant problems with each of these three misconceptions. First, the teachers that view ocean literacy as ocean reading may brush off the topic as unimportant. When approached with an ocean literacy professional development opportunity; for example, they may think, “I already know how to read an ocean book, so I don’t need that”; thus, preventing them from correcting their misconceptions.

Next, having a science exclusive view of ocean literacy could impact teachers’ inclusion of ocean literacy professional development materials in their classrooms. As stated earlier, I saw this among most of the middle and high school teachers. Although the high school teachers included one or two lessons in their classrooms from Project ISLE, they saw the information as incongruent to their classrooms since they taught chemistry, forensics, and biology (instead of oceanography). Therefore, the bulk of their classroom material inclusion came in the form of anecdotal stories and pictures when topics were presented.

Next, if teachers do not believe that they can attain ocean literacy, they too may brush off future professional development programs and opt for ones they view as more helpful. What’s more, they probably don’t believe their students could attain ocean literacy either. This mindset could lead to nihilism and the absence of ocean literacy materials in their classroom.

The most worrisome aspect of all, however, is that of misconception dissemination. If these misconceptions are common among large numbers of teachers and if they are left uncorrected, teachers could pass them on to their students, preventing the development of an ocean literate public.

Strategic Professional Development
Due to misconceptions such as these, the ocean literacy community must be strategic in their approaches to ocean literacy professional development. In this study, elementary and secondary teachers had very different views about ocean literacy and how it should be used in the classroom. These conceptualizations affected their inclusion of the materials from Project ISLE the following school year. I believe it would be beneficial to tailor future ocean literacy professional development opportunities to address these needs and
misconceptions. However, additional research is necessary to see if the findings are indicative of the majority of elementary, middle, and high school teachers, or if any other misconception exists.

To help ocean literacy professional development programs challenge these assumptions, I tailored Bybee’s (1997) scientific literacy continuum of development and adapted it to ocean literacy as part of my dissertation work. Instead of viewing scientific literacy as a dichotomy between literacy and illiteracy, Bybee argues that a continuum of development exists containing a series of “thresholds” from scientific illiteracy, to full “conceptual and procedural scientific and technologic literacy.” This allows science literacy to be viewed as a process instead of an unattainable goal.

I believe ocean literacy can be viewed on a similar continuum, with the following thresholds: (1.) Ocean Illiteracy, where individuals are unable to provide basic facts about ocean science; (2.) Basic Literacy, where individuals can describe basic facts about the ocean and its organisms; (3.) One-sided Literacy, where individuals understand ocean science concepts but cannot explain how their lives are connected to the ocean; (4.) Functional Literacy, where individuals have a sizeable knowledge of the ocean and interconnection, but act on this knowledge infrequently; and (5.) Fully Applied Literacy, when individuals have highly developed ocean-interconnection knowledge put into action in the form of ocean stewardship, advocacy, or research (Linsky 2012). Figure 1 provides a graphic representation of this proposition.

Ocean literacy professional development programs could survey teachers ahead of time to find out where they stand on the continuum and differentiate their curriculum to better meet participants’ needs. For the elementary teachers in the study, even the process of placing themselves on the continuum could have helped break down the misconception of ocean literacy as reading. Depending on where they fall in their development, the workshop could be tailored toward bringing them up to the next level. Next, based on my research, all of the middle and high school teachers would have fallen under Functional Literacy. Therefore, future professional development programs could focus on more practical solutions for their classrooms. Lastly, many of the Project ISLE teachers believed that full ocean literacy was unattainable—at least for them—because there was too much to know about the oceans to ever be fully literate. However, viewing ocean literacy as a process in which all people are developing may be slightly less threatening and more attainable.

We still have a long way to go…

Although the Ocean Literacy Network has progressed the public at large toward marine stewardship, we still have a long way to go before we will have an ocean literate populace. As
this study demonstrated, many teachers have misconceptions about ocean literacy’s definition and purpose. Some important implications of this research are the multiple ways in which ocean literacy professional development can be altered and strengthened to bolster teachers’ ocean literacy and support classroom inclusion. Additional research is necessary to see if the trends discovered in this study are indicative of larger groups of elementary, middle, and high school students. Also, the effectiveness and impact of viewing ocean literacy as a continuum will need to be studied. Ultimately, I hope that such knowledge would lead to a public who truly understands the ocean’s influence on us and our influence on the ocean.

REFERENCES

C. LINDSAY LINSKY, PH.D., is an assistant professor of Middle Grades Education and coordinator of the Master of Arts in Teaching Program at the University of North Georgia. Lindsay has a strong interest in developing ocean literacy and environmental advocacy through religious groups and is the author of Keep It Good: Understanding Creation Care through Parables.

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How Big is a Whale? A Kinesthetic Integrated Science and Mathematics Lesson

BY AMANDA M. GUNNING, PH.D., MEGHAN E. MARRERO, ED.D., AND NERMEEN DASHOUSH, PH.D.

ABSTRACT
How many kindergarteners equal the length of a blue whale? In this engaging integrated science and mathematics lesson, students analyze and interpret whale data to develop an understanding of their immense sizes. Students also are introduced to how whales survive in their ocean environment. Students make personal connections to marine animals by using their own body length as a nonstandard unit of measurement.

INTRODUCTION
The blue whale is the largest animal to have ever lived on Earth. Students tell us that they are interested in learning about marine animals (Marrero 2010), but how can we cultivate meaningful connections? While kindergarteners are fascinated with whales, how can they truly grasp the immense size of these amazing creatures? One focus of mathematics in kindergarten is for students to be engaged in “representing and comparing whole numbers, initially with sets of objects,” (National Governors Association and Council of Chief State School Officers 2016). Cognitive research has shown that children take on new ideas by assimilating them into schemas with which they are already familiar (Piaget 1929). So, why not have students meet mathematics and science standards by using their own bodies to better understand the size of diverse whale species? In this lesson, students are engaged as they watch videos of whales in the ocean. Then they measure out the length of some common whale species in comparison to the heights of kindergarteners. Students interpret the data they collect to make comparisons; use appropriate mathematical/scientific vocabulary such as “more than” and “less than,” create a bar graph from their findings, and sort whales into size categories. This fun activity is a great way for kindergarteners to become kinesthetically involved while developing mathematical skills and connecting to the world’s ocean.

FIGURE 1. Students forming a chain to measure out the length of a whale. Courtesy of Amanda M. Gunning
The objectives for this lesson were:

**Students will be able to:**
- Measure the lengths of different types of whales in “kindergarteners”
- Compare the lengths of different species of whales using terms such as “longer than” and “shorter than”
- Describe how whales meet their needs (i.e., food, oxygen)
- Categorize whales as small, medium, or large based on their length.

**Activity Progression**

This lesson was conducted with a diverse group of nine kindergarten students, the majority with special needs, although in the past we have done a similar activity with diverse general education students in grades K-2. The learning activities are made up of manageable segments that scaffold learning and keep students engaged. These learning segments can be stretched over days, if necessary. It is part of a larger integrated unit on animals and the power of qualifying observations.

The required materials are as follows:
- A 90-feet-long piece of rope or string (must be thick to avoid knots)
- A meter stick or long tape measure
- Chart paper and markers
- Whale cutouts
- Access to a computer with a projector or interactive whiteboard

To activate students’ prior knowledge and draw on students’ preconceptions and misconceptions (Gomez-Zwiep 2008), students were asked, “What is the biggest animal to ever live on Earth?” The answer is, of course, the blue whale, but students were surprised—our class guessed dinosaurs or elephants. On the whiteboard presentation, we showed a scale drawing that illustrated a blue whale corresponding to the length of three school buses! We recommend that future lessons include a comparison of the blue whale to elephants or dolphins in order to continue tackling and dismantling misconceptions. Starting this lesson with students considering the size of the blue whale set the stage for observing whale behavior via videos and observations and measurements of size.

The next phase of the lesson focused on students using observations to determine what whales need to survive (relating to NGSS K-LS1-1). We began by calling upon students’ prior knowledge and relating these majestic marine animals to animals that they might be more familiar with, such as household pets. One slide was dedicated to explaining the characteristics of mammals, and students were able to identify dogs and cats as fellow mammals. Students were asked to consider what whales do in the ocean and how they meet their needs (see standards on page 20). This led to the observation of whales in the wild via online videos. These free videos illustrated how there are many different types of whales and dolphins, including blue whales, spinner dolphins, bottlenose dolphins, orcas, fin whales, and more. We used resources from the NOAA, National Geographic, and Arkive websites. The images and videos were not only engaging, but also allowed students to gain information through observation. Student observation was guided through the following questions, which also served to assess whether the students met the lesson objectives:
- What do you notice about whales?
- Where do whales and dolphins live?
- What do whales eat?
- How are they similar and different?

Students were able to observe whales swimming, breathing out (“blowing”) through their blowholes, eating, and interacting with other whales. These observations led to students thinking about whales’ needs and how they live. Students were able to see that whales breathe through their blowhole, catch fish, krill, or other prey to eat, and that some whales remain in a group or pod for protection. In order to promote connections to self, we asked students to remember what they need to survive. Student’s responses included: food, air/oxygen, water, and shelter. As the students compared their needs to whales, they realized that they need the same things as the whales. The discussion also related back to other organisms that students had studied earlier in the year, including plants and earthworms.

The video observations provided an exciting context to continue the whale lesson as we then integrated the math investigation. After discussing what whales and organisms needed to live, we explained to students that we were going to find out more about the size of whales and dolphins. The students were excited to measure a whale from their virtual observations. The measurement part of the lesson helped make a stronger connection with these large animals and the students. While there are more than 80 species of these animals, we focused on investigating the size of just a few. Holding up a pencil, we prompted students to brainstorm different ways that they would measure it. Then we asked how we could measure the height of a student in the class. On a PowerPoint slide, we showed pictures of a few of the whale species, and asked students how they thought we could measure the whales. We demonstrated to students how their height was fairly equal to their “wingspan,” or the
measurement from fingertip to fingertip when a person stands with his/her arms outstretched. We used a tape measure to show that the measurements were nearly equal, and that we could therefore have students stand with arms outstretched, touching finger to finger, rather than lying on the floor head-to-toe (see Figure 1 on page 16). We discussed how we would measure out the lengths of some whales by using students standing with arms outstretched.

We showed students a table (on the interactive whiteboard and photocopied for students) with the typical maximum length of different whale species (see Table 1 on page 21), and asked them to estimate how many kindergarteners it would take to equal the length of a short whale—a spinner dolphin—writing their estimates in the table. We measured out that length with measuring tape for students to observe. After recording the whale’s length in students on the chart, we discussed how we would measure more whales in the schoolyard using the same method. We showed a scaled image depicting many species of whales, and students were eager to come up to the SmartBoard to compare the different sizes and species. This connected nicely back to the science of how the whales live, and how scientists learn about whales through observation—just as the students had by watching the videos. Furthermore, the students were exposed to the idea that scientists document and communicate their observations through measurement.

The students were divided into small groups to measure out some of the smaller whales, such as the beluga and minke whales. They soon realized that they needed many more students to complete the larger species, like the fin or humpback whales, and worked as a larger team to determine the number of kindergarteners needed to equal the lengths of these large mammals. This group of students needed a fair bit of guidance to create the human chains (lines of students with outstretched arms) at first, but then they understood as the whales got larger, they needed to go from the beginning of the line to the end to make up the whole length of some of the large whales, such as the humpback. This helped the educators determine whether students were understanding how to categorize size (small, medium, large) and the need to adjust measurements in accordance to increasing whale size. It is important to note to students that you are modeling the length of the whale, but not the width or any other measurements. As students were working, we asked questions such as:

- What are you noticing about the size of the whale?
- Has your thinking about the size of the whale changed? If so, how?
- How would these measurements change, if we used only adults?

Finally, we used the rope to measure out the length of a blue whale with students positioned several feet apart holding the rope. Students were amazed to see that a blue whale was nearly as long as their school building! Several of the students’ parents commented afterwards that the lesson was memorable and the children loved “seeing” the size of the blue whale.

After the measurements were recorded (Figure 2), we brought the class together to discuss our findings. Due to class size and time constraints, we were unable to measure all of the whales, however, the experience was still meaningful. Students were familiar with bar charts from prior experience creating pictographs. This science-math lesson provided an exciting, experiential context for bar graphs. The class results were compiled and we created a bar graph with our data. Using the graph and data table, students were able to analyze the class data and respond to our discussion questions, which included:

- Which whale required the most kindergarteners? The fewest?
- Which was the longest? The shortest?
- What are two whale species that are similar in length?
• How do you know?
• What are two that are very different?
• What would be another way to measure out the length of these whales?

Using the frequency bar graph, the students recognized that the whales fell into categories—small, medium, and large whales. Using labeled whale cutouts, children came up and categorized each according to their size by referring to the bar graph. It was an engaging way to compare and contrast whale lengths and have students analyze information from the bar graph we had just created (Figure 3).

As another assessment, we provided students with additional whale species’ lengths/measurements. We asked the learners to give examples of species that were longer/shorter than the new examples, and to determine into which category the whale would be classified (large, medium, or small). Students placed the whale cutouts in the appropriate category, referencing the bar graph (Figure 4). They also estimated how many kindergarteners it would take to equal these new species, based on the data they had already recorded.

We finished the lesson with a discussion as an informal assessment of how whales meet their needs, using questions such as:
• How do the whales meet their needs in the ocean?
• What do whales have in common with other animals when it comes to meeting their needs? What is different?
• What do different whale species eat?
• How do whales compare to fish?

Students were able to answer the questions, some of them referring back to the videos they watched, or making connections to fish they had previously observed in tanks as they considered how whales breathe air versus fish breathing through the water.

Throughout this integrated math and science lesson, children were encouraged to move around and participate, both in the classroom and outside. They were interacting with media, measuring, writing, discussing, and graphing. The subject matter was of high interest to students, who became excited to learn more about whales outside of the classroom.

FIGURE 3. Students create a bar graph to examine their data. Courtesy of Amanda M. Gunning

FIGURE 4. Classification of whale species based on the students’ findings. Courtesy of Amanda M. Gunning
The Relevant Standards Addressed By This Activity Are As Follows:

COMMON CORE STATE STANDARDS – MATHEMATICS

**CCSS.MATH.CONTENT.K.MD.A.2**

Directly compare two objects with a measurable attribute in common, to see which object has “more of”/“less of” the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter.

Classify objects and count the number of objects in each category.

**CCSS.MATH.CONTENT.K.MD.B.3**

Classify objects into given categories; count the numbers of objects in each category and sort the categories by count.

Standards for Mathematical Practice:

**CCSS.MATH.PRACTICE.MP2**

Reason abstractly and quantitatively.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectation:

**K-LS1-1.** Use observations to describe patterns of what plants and animals (including humans) need to survive.

[Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

Science and Engineering Practices:

4. Analyzing and interpreting data
5. Using mathematics and computational thinking

Crosscutting Concepts:

3. Scale, Proportion, and Quantity

Disciplinary Core Ideas:

**LS1.C: Organization for Matter and Energy Flow in Organisms**

All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)

For more available resources on this activity, including PowerPoints, please feel free to contact the author Meghan Marrero at megmarrero@gmail.com.

REFERENCES


AMANDA M. GUNNING, PH.D., is an assistant professor of science education at Mercy College. She teaches K-12 science methods courses and interdisciplinary science content courses for teachers. Her research interests lie in science teacher education using a self-efficacy framework; family learning of STEM; and the history of physics education. Gunning co-founded (with co-author Marrero) Mercy College’s Center for STEM Education, which she co-directs, providing outreach programs for K-12 students and teachers.

MEGHAN E. MARRERO, ED.D., is an associate professor of science education at Mercy College, where she teaches courses in assessment, oceanography, and P-12 science methods, and serves as a clinical supervisor for preservice teachers in science and mathematics. Her research interests include marine education and STEM teacher education, and she serves on the NMEA Board of Directors.

NERMEEN DASHOUSH, PH.D., is a clinical assistant professor at Boston University. She works with preservice educators in order to increase quality science instruction in early childhood classrooms. Nermeeen’s research interests include developing methods for educators to reconstruct their perceptions of what science is.

The authors would like to add special thanks to Maureen Coddington and Sapphire Elementary, Monroe, NY, for her support of this article.
TABLE 1. Measurements: How Big is a Whale?

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (in feet)</th>
<th>Length (in kindergarteners)</th>
</tr>
</thead>
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<td>Harbor Porpoise</td>
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<td></td>
</tr>
<tr>
<td>Beluga Whale</td>
<td>15 feet</td>
<td></td>
</tr>
<tr>
<td>False Killer Whale</td>
<td>18 feet</td>
<td></td>
</tr>
<tr>
<td>Orca</td>
<td>27 feet</td>
<td></td>
</tr>
<tr>
<td>Humpback Whale</td>
<td>55 feet</td>
<td></td>
</tr>
<tr>
<td>Finback Whale</td>
<td>80 feet</td>
<td></td>
</tr>
<tr>
<td>Blue Whale</td>
<td>90 feet</td>
<td></td>
</tr>
</tbody>
</table>

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Go to the NMEA website at [www.marine-ed.org](http://www.marine-ed.org) and click on the “Join Us” link to choose your membership category and start the sign-up process.
Incorporating Deep Sea Science and Underwater Robotics in Low-Income Schools

BY DIEUWERTJE KAST

“We have to add the foam noodles or else it won’t float!”
“What if we make the frame of our underwater robot a square, will it still work?... Let’s try it!” Splashes, laughter, scientific thought, “ooh,” and “aahs” were many of the reactions around the pool at a workshop about deep sea science at a Los Angeles elementary school.

JOINT EDUCATIONAL PROJECT’S YOUNG SCIENTISTS PROGRAM (YSP)
The Joint Educational Project’s Young Scientists Program (YSP) works in partnership with six University of Southern California (USC) community schools to engage more than 1,400 low-income elementary school students, 50 Los Angeles United School District (LAUSD) teachers, and six principals through a broad repertoire of science curricula. YSP’s undergraduate teacher’s assistants (TAs) are placed at each school presenting hands-on science labs to fourth and fifth grade classrooms. YSP brings scientific laboratory experiences directly to students and their teachers with the goal of supplementing current science instruction, complimenting LAUSD and state grade level science learning standards, strengthening science literacy, and promoting interest in scientific careers. One of YSP’s primary objectives is to increase science activities for a larger number of neighborhood children as a means to encourage them to consider careers in Science, Technology, Engineering, and Mathematics (STEM), and to apply what they are learning in the classroom to the real world. Additional outcomes include: USC undergraduate students learn how to become successful mentors; gain valuable teaching experience; and learn how to directly respond to the needs of the schools, communities, and families.

YSP & C-DEBI PARTNERED WORKSHOP
The USC Young Scientists Program (YSP) Director, and the National Marine Educators Association (NMEA) Expanded Audience Committee Chair Dieuwertje Kast, hosted a deep
a robotic arm—and used straws to make each of the various advanced underwater robots used for scientific research—like also recreated and used tools that are found on more videoed all of the students' robotic creations. Students Fung) provided a high-tech underwater robot for the event propellers, and PVC pipe. OpenROV (constructed by Roee exploration by the robots made with waterproof motors,rary 150-gallon pool was set up at the school for underwater underwater robots using a small obstacle course. A tempo -

In the first station, students constructed and piloted their own underwater robots using a small obstacle course. A temporary 150-gallon pool was set up at the school for underwater exploration by the robots made with waterproof motors, propellers, and PVC pipe. OpenROV (constructed by Roee Fung) provided a high-tech underwater robot for the event and videoed all of the students’ robotic creations. Students also recreeted and used tools that are found on more advanced underwater robots used for scientific research—like a robotic arm—and used straws to make each of the various joints. Afterward, they conducted an experiment to illustrate how the deep sea floor is measured by sonar, and how data collection occurs on the bottom of the ocean. This was done with an augmented reality sandbox, created by Diego Porqueras from Deezmaker.

“Every student I talked to about the workshop had a great time,” said Dawson Ray, a YSP Teaching Assistant. “At the sandbox station, I was able to explain topographical maps effectively—something that trying to teach through pictures in a classroom setting would never achieve. All of the students I talked to the following day said they wished the workshop were a weekly event, which was likely due to the fun, hands-on nature of the stations.”

Ninety-two percent of the students rated the workshop as very good. One student said, “I did not know that there were deep sea animals on the bottom of the ocean or that scientists used underwater robots to “sea” into the sea.”

These experiments resonated among the young future scientists at Vermont Elementary. Andy Lopez, a Vermont student, said excitedly that scientists use robots to see in the deep sea and he now wants to show people how interesting deep sea science is. Another student said that the most interesting thing that she learned was that people used ROVs to detect or rescue things in the deep sea. Another student said, “I learned that scientists use robots to see in the deep sea and I want to learn how to do that.”

The contents of this workshop have been written up into lesson plans and will be distributed as professional development sessions to teachers participating in the program. The C-DEBI educator grant provided the opportunity for the underrepresented students participating in the Young Scientists Program to level the playing field in deep sea STEM fields one workshop at a time.

**DEEP SEA STATIONS**

Students learned how scientists explore the deep sea with underwater robots and tools. The workshop was comprised of three different stations: an underwater robot, a robotic arm, and an augmented reality sandbox.

In the first station, students constructed and piloted their own underwater robots using a small obstacle course. A temporary 150-gallon pool was set up at the school for underwater exploration by the robots made with waterproof motors, propellers, and PVC pipe. OpenROV (constructed by Roee Fung) provided a high-tech underwater robot for the event and videoed all of the students’ robotic creations. Students also recreeted and used tools that are found on more advanced underwater robots used for scientific research—like a robotic arm—and used straws to make each of the various joints. Afterward, they conducted an experiment to illustrate how the deep sea floor is measured by sonar, and how data collection occurs on the bottom of the ocean. This was done with an augmented reality sandbox, created by Diego Porqueras from Deezmaker.

“Every student I talked to about the workshop had a great time,” said Dawson Ray, a YSP Teaching Assistant. “At the sandbox station, I was able to explain topographical maps effectively—something that trying to teach through pictures in a classroom setting would never achieve. All of the students I talked to the following day said they wished the workshop were a weekly event, which was likely due to the fun, hands-on nature of the stations.”

Ninety-two percent of the students rated the workshop as very good. One student said, “I did not know that there were deep sea animals on the bottom of the ocean or that scientists used underwater robots to “sea” into the sea.”

These experiments resonated among the young future scientists at Vermont Elementary. Andy Lopez, a Vermont student, said excitedly that scientists use robots to see in the deep sea and he now wants to show people how interesting deep sea science is. Another student said that the most interesting thing that she learned was that people used ROVs to detect or rescue things in the deep sea. Another student said, “I learned that scientists use robots to see in the deep sea and I want to learn how to do that.”

The contents of this workshop have been written up into lesson plans and will be distributed as professional development sessions to teachers participating in the program. The C-DEBI educator grant provided the opportunity for the underrepresented students participating in the Young Scientists Program to level the playing field in deep sea STEM fields one workshop at a time.

**DIEUWERTJE J. KAST** is currently the manager of USC’s joint Educational Project’s Science, Technology, Engineering and Math (STEM) programs as well as the director of the Young Scientists Program. Science education is her main passion and her goal is to bring that to the masses and to be able to share her experiences with other STEM educators. She holds a bachelor of science degree in biological sciences from the University of Southern California (USC). There, she also earned her master of science degree in marine environmental biology and her master degree in education. She is currently enrolled in the Doctorate of Education program at USC and will be focusing her research on various aspects of STEM Education.
Understanding Changes in Seagrass Communities

BY SARAH NUSS AND CELESTE VENOLIA

ABSTRACT

Seagrass is an incredibly valuable habitat in the Chesapeake Bay. Students will use mock seagrass patches, modeled after a research transect along Goodwin Island, Virginia, to analyze change in seagrass percent cover during, and following, a major die-off event in 2010. Students also analyze water quality graphs from the same time period to help them determine why the die-off may have occurred.

CBNERR scientists, led by Dr. Kenneth A. Moore, have monitored seagrass communities along fixed transects around Goodwin Island and the VIMS campus from 2004 to the present. The data used in this exercise is from a 700 meter transect branching out from Goodwin Island. Monitoring methods include taking the water depth every 10 meters along the transect line. Every 20 meters, percent cover of seagrass is estimated visually. A quadrat is then thrown three times randomly and with each throw, the scientists estimate percent cover of each species within the quadrat. A plastic circle is also placed around the densest patch of eelgrass, one of the more prominent species of seagrass, and the number of shoots within the circle is counted. This number allows for an estimation of density. The length of the longest eelgrass strand within the quadrat is also recorded. This methodology was simplified for this lesson plan.

Celeste Venolia, author of activity on the Bay. Courtesy of Erin Shields
BACKGROUND
Submerged aquatic vegetation (SAV) refers to angiosperm species that live underwater with a rhizome, a root-like system, buried in the sand. SAV species are often confused with algae, but algae lack advanced characteristics such as veins to carry molecules around the plant. Seagrass refers more specifically to SAV species that are found in marine or higher salinity brackish waters. Despite the word “grass” in seagrass, seagrass is more closely related to gingers and terrestrial lilies than terrestrial grasses (McKenzie and Campbell 2002). SAV species lack the waxy cuticle that keeps land plants from drying out. SAV blades contain specialized cells that retain gases and allow the blades to float up in the water column (“Submerged Aquatic Vegetation”). SAV species can reproduce both sexually and asexually. In asexual reproduction, the rhizome spreads along under the sand and new genetically identical shoots sprout upwards. In sexual reproduction, the SAV plants produce reproductive shoots with flowers (Eriksson 1989).

SAV is limited to water shallow enough to allow for adequate light absorption (“Submerged Aquatic Vegetation”). Epiphytes, such as algae and sponges, grow on the blades of seagrass. Algal epiphytes are normally kept in balance with the actions of grazers and predators, but in high nutrient conditions, they can seriously reduce the amount of seagrass surface area available for light absorption (Duarte et al. 2006).

Seagrass ecosystems are incredibly valuable in estuaries such as the Chesapeake Bay. Some key ecosystem services of seagrass include enhancing regional biodiversity, sequestering and exporting carbon, stabilizing sediment, mitigating the effects of eutrophication, absorbing wave energy, and serving as a nursery or food source for important fauna (Orth et al. 2006). Seagrass meadows are currently declining around the world due to both direct and indirect anthropogenic threats (Short et al. 2011). Examples of threats are high levels of nutrient and sediment run-off, elevated water temperatures, dredging and other detrimental fishing practices, and boat traffic (Orth et al. 2006). These valuable ecosystems are especially susceptible to reduced water clarity because of their high light requirements (Dennison et al. 1993). Understanding patterns of seagrass community change could help in analyzing the overall health of the saline portions of the Chesapeake Bay.

The two species of seagrass found in the brackish waters of the far downstream York River, a major tributary of the Chesapeake Bay in Virginia, are eelgrass (Zostera marina) and widgeon grass (Ruppia maritima) (Moore et al. 2014). The Chesapeake Bay is the southernmost limit of eelgrass distribution, as the species thrives in cool water and cannot survive temperatures above 25°C for extended periods of time (“Submerged Aquatic Vegetation”).

ACTIVITY
Students will work in groups to visually estimate percent cover of two seagrass species on mock seagrass patches, and then compile their data as a class. Students will use water quality data to interpret trends and their potential significance for the survival of seagrass. Finally, groups of students will present their hypotheses on the decline and transition of seagrass species in 2010-2011. This activity fits well with the National Science Content Standards for Life Science students in grades 6-12. The activity also addresses the concept that the ocean supports a great diversity of life and ecosystems, one of the literacy principles outlined by the Ocean Literacy Framework. The activity highlights three Climate Literacy principles: life on Earth depends on, is shaped by, and affects climate; human activities are impacting the climate system; and climate change will have consequences for the Earth system and human lives.

OBJECTIVES
• Describe basic seagrass biology, values of seagrass, and threats to seagrass
• Determine the interactions between water quality and seagrass
• Simulate an estuarine research method
• Evaluate community change with actual trends in seagrass cover from the Chesapeake Bay

MATERIALS
• 16 coated wire or plastic mesh squares (example shown in this article uses coated wire mesh with 1 inch by 1 inch squares, but this exact type of mesh is not necessary)
• Green ribbon (to represent Zostera marina)
• Green yarn (to represent Ruppia maritima)
• Clear tape
• Masking tape
• Marker

SEAGRASS SQUARES PREPARATION
1. Cut wire or plastic mesh into 16 squares of about a foot by a foot in size. Exact size is not important as long as you adjust the amount of ribbon and yarn you are using to create the correct percent covers. If using wire mesh, you may want to use rubber cement to cover up any sharp bits created in the cutting process.
2. Use the data in the table below when setting up the seagrass on the 16 mesh squares. For each month and year combination, there will be four squares, representing samples taken at 4 different distances from shore.

- Use tape and a marker to create a label, which includes the month, year, and distance from the shore of the seagrass patches.
- Tie ribbon (\( Z. \text{ marina} \)) and yarn (\( R. \text{ maritima} \)) of varying lengths to the mesh to reach the percent covers of \( Z. \text{ marina} \) and \( R. \text{ maritima} \) listed in the table below. Clear tape was used around the bases of the tied ribbons and yarn. The knot should be placed in the middle of the ribbon or yarn so that it more accurately mimics multiple blades coming out of the same shoot. The same species should generally be found close together on the mesh, as multiple shoots will branch out of the same rhizome.

An example of a finished product can be seen below (Figure 1).

<table>
<thead>
<tr>
<th>Month / Year</th>
<th>Percent Cover at 20m from shore</th>
<th>Percent Cover at 100m from shore</th>
<th>Percent Cover at 180m from shore</th>
<th>Percent Cover at 260m from shore</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2010</td>
<td>( Z. \text{ marina}: 5 ) ( R. \text{ maritima}: 75 )</td>
<td>( Z. \text{ marina}: 50 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 50 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 40 ) ( R. \text{ maritima}: 0 )</td>
</tr>
<tr>
<td>August 2010</td>
<td>( Z. \text{ marina}: 0 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 0 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 2 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 5 ) ( R. \text{ maritima}: 0 )</td>
</tr>
<tr>
<td>June 2011</td>
<td>( Z. \text{ marina}: 0 ) ( R. \text{ maritima}: 70 )</td>
<td>( Z. \text{ marina}: 10 ) ( R. \text{ maritima}: 0 )</td>
<td>( Z. \text{ marina}: 2 ) ( R. \text{ maritima}: 70 )</td>
<td>( Z. \text{ marina}: 15 ) ( R. \text{ maritima}: 0 )</td>
</tr>
<tr>
<td>August 2011</td>
<td>( Z. \text{ marina}: 0 ) ( R. \text{ maritima}: 75 )</td>
<td>( Z. \text{ marina}: 2 ) ( R. \text{ maritima}: 40 )</td>
<td>( Z. \text{ marina}: 0 ) ( R. \text{ maritima}: 80 )</td>
<td>( Z. \text{ marina}: 2 ) ( R. \text{ maritima}: 35 )</td>
</tr>
</tbody>
</table>

**TABLE 1.**

**PROCEDURE**

1. Lay down mock seagrass patches in a grid according to the respective dates and distances from shore (Figure 2). Each table should also have a data sheet (see Example Student Worksheet on page 29).

2. Compile the data the students collect into a comprehensive table, in a space viewable by everyone that allows for easy comparison of the percent cover of the two species at different points in time and distances from shore.

3. Divide students into four groups. Explain to students that the four different transects are all the same fixed transect, but at four different time periods. Clarify that the distances from shore are provided since the seagrass patches cannot be laid out to scale due to space constraints.

4. Give students tips on how to most effectively visually estimate percent cover:

- Percent cover is usually less than you think.
- Suggest dividing the larger area into smaller areas, so that it is easier to focus (with the 1 inch by 1 inch wire...
mesh, look at squares that are 2 inches by 2 inches).

- Explain to students how they can use these divisions to set up a fraction of sections with seagrass over the total number of sections to get a percent cover.

Provide students with examples, on an overhead, of grids with a percentage of the squares filled in with a color. Students should try a few examples to estimate percent cover as a group before working with the seagrass squares.

5. As the students work through the steps, check-in with each group to make sure the percent coverage data they are collecting is reasonable. For example, 100 meters from shore in August of 2011, they should find about 2% eelgrass cover and 40% widgeon grass cover.

6. Have students add their group’s data to the larger table. Discuss the trends in the percent cover data they have just collected:

- The June 2010 data reflects a standard zonation pattern when *Z. marina* is present in high densities. *R. maritima* dominates close to shore and *Z. marina* dominates farther away from shore.
- There is a major loss of seagrass from June to August of 2010.
- *Z. marina* remains in the region in 2011, but at greatly reduced percent cover.
- In 2011, *R. maritima* colonizes the space previously occupied by *Z. marina* in June 2010 and recolonizes inshore space that it had disappeared in August of 2011.

7. Have the students split into pairs and give each pair the temperature and turbidity data. Ask the students to look for trends in the water quality data, which could explain the major loss of *Z. marina* in 2010. Explain to the students that they have been given 2009 in addition to 2010 and 2011, so that 2009 can serve as further evidence of what normal conditions might be. Remind them that finding no trend is still an important result in the scientific process.

8. Come together as a group and discuss the trends found and their potential to explain the patterns of change in the seagrass:

- There are no major trends in turbidity that should have an influence on a long enough time scale to make a difference in the big picture trends.
- The primary trend students should notice in the temperature data are that there were hotter temperatures in June of 2010 than in June of 2009 or 2011.

- In general, the influences of high temperatures and high turbidity can have a compound negative effect (Moore et al. 2012), but for the purposes of this time period, temperature is the more important variable.

9. Below are some potential discussion questions:

- Why was widgeon grass able to colonize the substrate after the eelgrass had died-off?
- In the typical zonation pattern present in the Chesapeake Bay, widgeon grass dominates the near shore waters. If widgeon grass was artificially excluded, do you think eelgrass could grow there?
- Within its Chesapeake Bay range, do you think eelgrass has been disappearing equally from all regions, or more in its upriver or downriver sections?
- Do you think, based on the physical shape of the two seagrass species, that one might be more valuable as a habitat?

**EXTENSION**

Rising temperatures are a result of anthropogenic climate change. Since the Chesapeake Bay is currently the southernmost point of eelgrass distribution along the East Coast of the U.S, it could potentially be lost from the Bay as temperatures continue to rise. Activities dealing with global climate change and increases in ocean temperatures would be a good follow up to this activity. Please visit http://www.vims.edu/cbnerr/_docs/education_docs/SAVLessonPlan.pdf for the full activity.
REFERENCES


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SARAH NUSS obtained her master of science degree in environmental studies from the College of Charleston. She is the education coordinator for the Chesapeake Bay National Estuarine Research Reserve in Virginia, and the primary supervisor for NOAA Hollings interns.

CELESTE VENOLIA is a biological sciences and environmental science and policy double major working to obtain her bachelor of arts degree from Smith College. She worked at the Chesapeake Bay National Estuarine Research Reserve as a Hollings Scholar in the summer of 2016.
GROUP 1: 20 METERS FROM SHORE

Group Members: ____________________________________________________________

You are a team of marine scientists surveying seagrass along a fixed transect off of Goodwin Island in the York River, VA. Repeat steps 1-3 at all four locations in space and time that are found in your data table below.

1.) Visually estimate the percent cover of the *Zostera marina* (ribbon).

2.) Visually estimate the percent cover of the *Ruppia maritima* (yarn).

3.) Combine these numbers to get overall percent cover of seagrass.

4.) Once you have completed steps 1-3 at all four sites, add the data you have just collected to the larger table on the board.

### EXAMPLE STUDENT WORKSHEET

<table>
<thead>
<tr>
<th></th>
<th><em>Z. marina</em> percent cover</th>
<th><em>R. maritima</em> percent cover</th>
<th>Overall seagrass percent cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2010 (20m from shore)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2010 (20m from shore)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2011 (20m from shore)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2011 (20m from shore)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### EXAMPLE WATER QUALITY DATA

2011 Data

- **Goodwin Water Temperature June-August 2011**
- **Goodwin Turbidity June-August 2011**
Using TV to Teach Ocean Science and Promote STEM Careers Across the Pacific: *Voice of the Sea*

**BY KANESA DUNCAN SERAPHIN, JOANNA PHILIPPOFF, AND THOR SERAPHIN**

**INTRODUCTION**

**Learning from TV.** Smart phones, computers, and TV have a direct effect on the way we gather information and socialize (Samaneigo and Pascual 2007). In fact, electronic media serves as a primary source of knowledge for many viewers (Dhingra 2006). Moreover, the power of broadcast TV remains strong even in the age of online media; TV watching is down only 19 minutes per week since 2015 (Nielsen 2016). Americans watch an average of 4.3 hours of broadcast TV each day, and when digital video recordings (DVR) of TV is included, viewing time is over five hours (Nielsen 2016).

The ability of media to couple the excitement of discovery with appropriate role models is postulated to improve viewers’ interest in ocean-based science, technology, engineering, and mathematics (STEM) careers. Indeed, students’ choice of a college major is based largely on prior knowledge of professions (Robinson and Kenny 2003). By extension, students’ hesitancy to pursue ocean science careers is related to 1.) lack of role models, 2.) lack of guidance from adults knowledgeable about opportunities; and 3.) psychological barriers from culturally prescribed roles (Low et al. 2005).

Recent studies suggest that increasing awareness of STEM careers—through video—can improve the accuracy of students’ perceptions of science careers (Kier et al. 2014) and enhance students’ desire to pursue STEM careers (Wyss et al. 2012). Media that is grounded in research-based instruction principles can also increase positive social behaviors, content knowledge, and problem-solving skills (Wainwright and Linebarger 2006). In the classroom, media can increase student achievement by 1.) enhancing student comprehension and discussion; 2.) accommodating diverse learners; and 3.) increasing motivation and enthusiasm (Grunwald Associates 2010; Linebarger 2011).

Due to its wide reach, TV provides a bridge between researchers, community groups, cultural organizations, and professionals (Dhingra 2006). TV reaches segments of the population with less access to digital technology and high-speed internet. Targeting this TV-watching adult population is vital because it provides an opportunity to connect with adults who may not otherwise learn about marine science, but who provide career advice to youth.

**A lack of appropriate ocean science content on TV.** Producers choose TV topics based primarily on ratings and shelf life (Palfreman 2002). This results in a lack of ocean science content on TV and topics that fall short of the depth and breadth needed for ocean literacy. As an example, the top 100 TV programs of 2016 are marginally related to ocean science: *The Big Bang Theory (#5), The X-Files (#7)*, and *Criminal Minds (#20)* (Nielsen 2016).

In addition, the portrayal of scientists and the scientific process on TV often perpetuate rather than correct misconceptions. For example, crime scene investigation-type dramas promote unrealistic expectations of scientific practice, speed, and relevancy (Deutsch 2006). And, medical and criminal TV series often highlight the uncertainty of science—with multiple interpretations and solutions that lack scientific reasoning (Dhingra 2006). Moreover, the STEM professionals portrayed on TV are not often ethnically diverse, even though we know that showcasing experts of all ages, ethnicities, and culture is important when trying to connect with and influence a diverse audience (Wyss et al. 2012).

**Voice of the Sea TV.** *Voice of the Sea* allows viewers to engage in complex concepts and delve deeply into the practices of science (Figure 1 and here’s a link to watch the episode depicted in this figure). *Voice of the Sea* airs on TV in Hawai’i as well as in U.S. territories and affiliated Pacific regions: Guam, American Samoa, Palau, the Federated States of Micronesia, and the Marshall Islands. The TV stations airing *Voice of the Sea* are accessible to 90% of the 1.8 million regional population.

The goals of *Voice of the Sea* are to 1.) improve viewer’s understanding of marine environments and the connection
between human health and the health of the ocean; 2.) develop viewer’s connection, identification, and empathy for scientists and cultural practitioners; and 3.) create interest in the processes of science and in STEM careers.

In 60 episodes, *Voice of the Sea* has profiled 110 experts across a range of careers (Table 1). The series covers topics of high-interest (e.g. fisheries, sharks, and endangered marine mammals) as well as topics that are important but lesser-known (e.g. marine toxins, plankton, and the deep sea; Figure 2 and here’s a link to watch the episode depicted in this figure). The length of each *Voice of the Sea* episode allows viewers to hear from a number of experts on each topic. For example, in the episodes about preserving Palau’s marine ecosystem, viewers meet graduate students, university researchers, conservationists, fishermen, and even the president of Palau. In the Global Tara Oceans Expeditions episodes, viewers meet the ships’ chief scientist, technician, and engineer. In the episode Navigation and Traditional Sailing viewers meet NOAA scientists, boat builders, canoe voyagers, and cultural practitioners. Each of these experts provides a unique perspective, exemplifying the diversity of careers and the interdisciplinary nature of ocean and STEM research.


<table>
<thead>
<tr>
<th>Profession / Role in Episode</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional Scientist</td>
<td>33</td>
</tr>
<tr>
<td>Student (graduate or undergraduate)</td>
<td>21</td>
</tr>
<tr>
<td>Cultural Practitioner</td>
<td>20</td>
</tr>
<tr>
<td>Engineer or Technician</td>
<td>19</td>
</tr>
<tr>
<td>Ocean Educator</td>
<td>10</td>
</tr>
<tr>
<td>Science and Policy Expert</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>119</strong>*</td>
</tr>
</tbody>
</table>

*9 experts are cultural practitioners in addition to another role.

**FIGURE 1.** *Voice of the Sea* host, Kanesa Duncan Seraphin, and UC Santa Barbara graduate student, Sammy Davis, examine fish exclusion cages in Moorea, Tahiti in the episode “Macrolalgae Attack!” Courtesy of Thor Seraphin

**FIGURE 2.** Deep sea viper fish from the episode “Strange Fish of The Deep.” Courtesy of Brian Berkowitz

*Voice of the Sea* episodes have passed one million views on TV in Hawai‘i (population of approximately 1.47 million); each week 8,000-10,000 people view *Voice of the Sea* episodes on our Hawai‘i TV partner station KFVE (Nielsen and Marshall Marketing 2016). Marshall Marketing surveys show that the *Voice of the Sea* TV viewing audience in Hawai‘i is made up of 55% home owners, is primarily female (75%), is mostly non-college educated (75%), and has lived in Hawai‘i for more than 16 years (95%). Viewership in the other regions of the Pacific (total population approximately 300,000) has not been surveyed, but the small number of TV channels in these areas means that programming gets a higher per capita viewership. For example, *Voice of the Sea* airs on the most popular channel in American
Samoa. And, in Palau, *Voice of the Sea* is on the default channel when TV is turned on. In recognition of the show’s level of excellence, *Voice of the Sea* was awarded 14 Telly Awards (premier TV awards for regional programming).

**METHODS**

Our study was a pilot investigation on the impact of viewing *Voice of the Sea*. We used questionnaires to examine adult, college student, and youth content knowledge, perceived understanding, and interest before and after watching an episode of *Voice of the Sea*. The questionnaires included five multiple-choice content items for each episode, which were administered immediately before and after episode viewing. Additionally, two retrospective Likert-scale type items (about interest and understanding pre-post) and an open-ended item (about something that “stood out” from the episode) were administered after episode viewing.

The four *Voice of the Sea* episodes studied included a variety of careers (Figure 3 and here’s a link to watch the episode depicted in this figure):

1) *Aquaponics and Wind Turbines* (Aqua Wind): engineering professional (male)
2) *Deep Sea Lab* (Deep Sea): mid-career university professor (male)
3) *Restoring a Hawaiian Fishpond* (Fishponds): two cultural practitioners (one male, one female)
4) *Saving Hawaii’s Beaches* (Beaches): early-career university researcher (female)

The questionnaires were administered to approximately 150 adults, 150 college students, and 300 youth in Hawai‘i between 2015-2016. Some participants viewed more than one episode, and overall we had 881 questionnaires returned post-viewing (195 adult, 192 college, and 494 youth). Adults watched episodes at outreach events. College students from the University of Hawai‘i (Manoa, Windward, and Maui campuses) watched episodes as part of course work. Youth (grade 6-9 students at a local public charter school) viewed episodes during class.

**FINDINGS**

Viewers demonstrated significant gains in content knowledge, interest, and self-perceived understanding across episodes and audiences. Viewers also reported affinity for episode experts and the environment.

**Content knowledge.** The mean number of correct content scores increased for all groups on all four episodes studied (pairwise t-tests, \( p < 0.000 \), Figure 4). Adults had the highest pre-content scores (52-59% correct), followed by college students (34-53% correct), and then youth (26-43% correct). Adult and college students increased more than youth in their content knowledge pre-post (Welch ANOVA, \( p < 0.000 \)), with an average increase in 29% correct responses (1.5 questions), compared to youth with an average increase of 19% (0.85 questions; see Figure 5 on page 34).

**Perceived understanding.** Perceived understanding of the content addressed in each episode improved across audiences, with a starting average of 2.6 (SD = 1.4) growing to 4.0 (SD = 1.6) from a max score of 6 (paired t-test, \( p < 0.000 \)). Average pre-perceived understanding ranged from 1.8 (students, Beaches) to 2.9 (college, Deep Sea). Average post-perceived understanding ranged from 3.1 (students, Beaches) to 5.0 (adult, Fishpond). Adults and college students reported a larger increase in perceived understanding of episode content than youth (Welch ANOVA, \( p < 0.000 \), see Figure 6 on page 34).

**Interest.** There was a significant increase in self-reported interest about the content in each episode across audiences, with average interest starting at 2.8 (SD = 1.6) and growing to 4.0 (SD = 1.6) from a max score of 6 (paired t-test, \( p < 0.000 \)). Average pre-interest ranged from 2.0 (students, Beaches) to 4.4 (college, Deep Sea). Average post-interest ranged from 2.9 (students, Beaches) to 5.2 (college and adult, Deep Sea). Adults and college students reported that their interest in episode content increased pre-post more than youth (Welch ANOVA, \( p < 0.000 \), see Figure 7 on page 35).

Participants were also asked to describe one thing that “stood out” from each episode; responses covered a broad range,
from content understanding, to practices of science and connection to experts. Some of the responses were off topic (especially for the youth), noting details such as an ice truck in the background of a scene. However, the vast majority of comments were substantive and showed a positive, growing connection to marine organisms, researchers, and traditional knowledge experts. Example responses include (small changes made to enhance readability):

One thing that stood out the most in the Voice of the Sea episode was how she [the scientist] talked about human impact on the beaches. Walls made by humans actually don’t allow the sand behind all the rocks and underneath the wall to circulate back into the ocean. Sea walls destroy and dissipate beaches.  
– College, Beaches (content)

Learning about the cookie cutter shark and how the marine scientists hypothesize about how they hurt their prey, what the steps are. Also about how they [cookie cutter sharks] use light organs to “trick” the swordfish or the other types of fish into coming up and then [the cookie cutter] strikes.  
– Youth, Deep Sea (interest)

How long the fishponds have been used by locals [Hawaiians] for sustainable fishing/harvesting. Tied into lunar cycle.  
– Adult, Fishponds (culture)

**DISCUSSION**

As ocean science educators, we seek to improve people’s understanding of, and interest in, ocean science issues. Much of the time, we turn toward classroom or informal education

![FIGURE 4](image-url)  
**FIGURE 4.** Mean number of correct multiple-choice content questions (with standard error bars) pre-post by episode (audience: adult in black, college in blue, and youth in red). All Pre-post differences are statistically significant (pairwise t-tests, \( p < 0.000 \)).
experiences, such as special events or science centers, like aquariums, where large numbers of people can be reached in organized ways. Although important, this type of outreach leaves out a significant component of the population—namely those who are no longer in the formal education system and those who do not often attend science-themed events. Regional TV programming, like Voice of the Sea provides a way for a wider audience to learn about ocean science concepts and research happening in their area.

Our findings suggest that Voice of the Sea is a valuable contribution to educating about ocean science; the Nielsen and Marshall Marketing data demonstrate that local TV viewership of Voice of the Sea is strong and growing. Results from our questionnaires provide evidence that viewers of Voice of the Sea increase their understanding, interest, and personal connection to ocean science. We make this assertion with the caveat that there were differences in audience responses and limitations to our study. Adults were surveyed from populations attending free-choice learning events or were volunteers at ocean centers; college students were enrolled in marine science courses; and youth filled out surveys as a required part of a general science class. Adults and college students in our study understood at higher levels and were more interested than youth. This may be due to a number of factors: 1.) there was a gradient of apriori interest among questionnaire participants, which paralleled their responses; 2.) the show profiles adults, reducing the potential connections between profiled scientists and younger students; and 3.) the questionnaires were designed for and piloted with adults (even though the reading level was appropriate for grade 6). The age range of youth surveyed (grades 6–9) also leaves a gap between grade 9 and college.

Thus, although we have evidence showing that Voice of the Sea episodes are effective in classrooms as young as grade 6, in future studies we hope to further examine age group effects, and explore how we can better engage youth. We are also interested in the ability of Voice of the Sea to influence viewer behaviors over time and whether there is a duration effect (e.g. regular vs. one-time viewer). In addition, the Marshall Marketing survey hints at some interesting TV viewing population demographics. For example, why is our TV viewing population mostly female? Having a better understanding of our viewing population will allow us to align our topics to the population we are reaching and may provide information about how to draw in additional viewers from other populations.

In summary, we offer Voice of the Sea as not only an existing product for educators to use directly with their own audiences (via our online archive), but also as a conceptual springboard for other outreach programs. We encourage our colleagues to partner with video production experts, such as independent local producers, universities, and student media trainees to develop TV programming. Regional TV stations may have directives for airing locally produced content, which provides a unique opportunity for sharing ocean science concepts and careers.
RESOURCES

• **Voice of the Sea** online. To view promos and episodes, visit voiceofthesea.org.

• **Voice of the Sea** in the classroom. Episodes are integrated into the online Exploring Our Fluid Earth curriculum for middle and high school: exploringourfluidearth.org.

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**KANESA DUNCAN SERAPHIN** is producer and host of *Voice of the Sea*, director of the Hawai‘i Sea Grant Center for Marine Science Education, and a professor in CRDG in the College of Education at UH. She is passionate about exploring the ocean through research, education, and sport.

**JOANNA PHILIPPOFF** is an assistant specialist at CRDG. She designs, implements, evaluates, and does research on and about science professional development and science curricula projects. She was recently profiled in a *Voice of the Sea* episode about citizen science in *Our Project In Hawaii’s Intertidal* (watch a clip here).

**THOR SERAPHIN** produces, films, and edits *Voice of the Sea*. He is a communications fellow with the Hawai‘i Sea Grant College Program and TV producer at Kauai Sound & Cinema. He specializes in telling educational and scientific stories through digital media.

REFERENCES


**FIGURE 7**. Mean increase in interest by audience (adult, college, and youth) across all four episodes, on the retrospective, six-point Likert-scale question (with 95% confidence intervals based on individual SD). Adult and college interest increases were both higher than youth (Welch ANOVA, $p < 0.000$).
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Beauty and the Beak is a Junior Library Guild selection, and California Reads recommended title by the California Teachers Association. A free, downloadable Educational Guide and links to STEM activities are available at the authors’ websites deborahleerose.com or birdsofpreynorthwest.com. The book will be published later this summer.

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