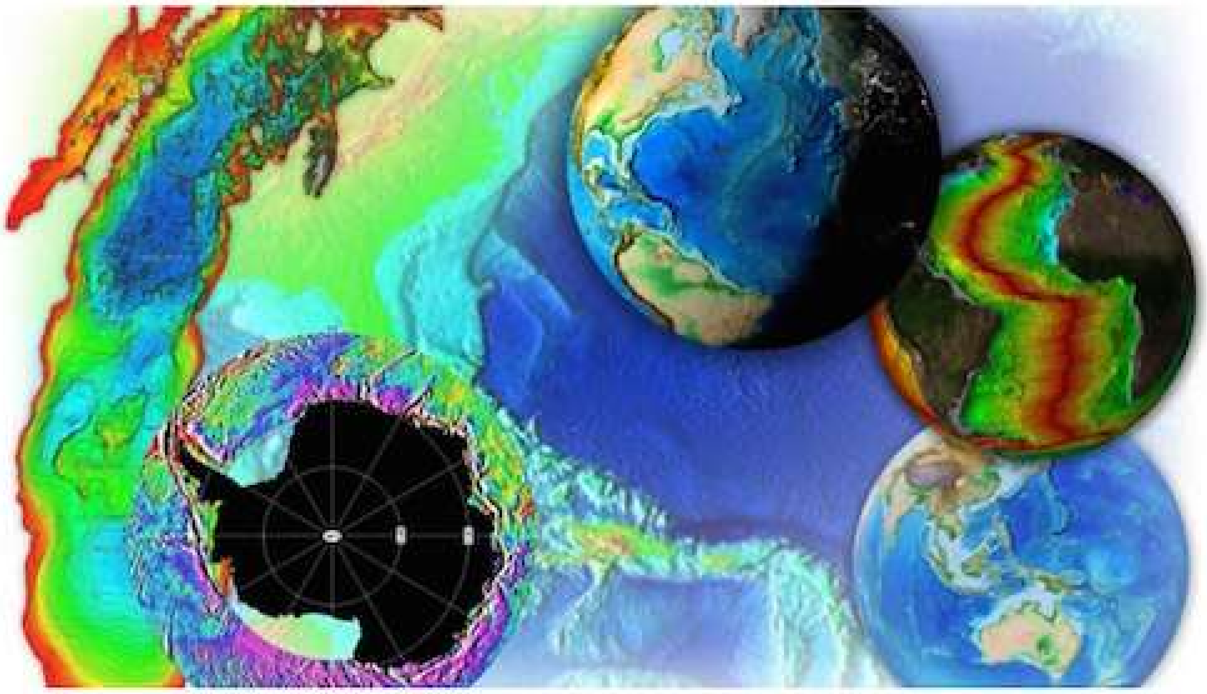


Global Ocean Science Education Workshop

June 26-27, 2015

Workshop Report

Gail Scowcroft [1], Romy Pizziconi[1], and Peter Tuddenham[2]
(1)Inner Space Center, University of Rhode Island
(2) College of Exploration

Acknowledgements

Thank you to all the participants and presenters who travelled from around the world to freely and openly contribute their knowledge, time, and energy to make this workshop a success. The general consensus at the conclusion was that the workshop should be continued annually around the globe. Thank you to the University of Rhode Island Graduate School of Oceanography for hosting the first GOSE Workshop and providing all the facilities. Thank you to the Consortium for Ocean Science Exploration and Engagement (COSEE) and College of Exploration teams for all the brainstorming, planning, organization, and logistical support that made the workshop a success. Finally, thank you to the U.S. National Science Foundation for over 10 years of funding that laid the foundation for a coordinated ocean science education network that can now pave the way for a new international effort, building a global ocean science education network.

Global Ocean Science Education Workshop
Workshop Report
June 26-27, 2015

Contents — Page

EXECUTIVE SUMMARY

The Global Ocean Science Education (GOSE) Workshop took place from June 26-27, 2015 at the University of Rhode Island's Graduate School of Oceanography (GSO) in Narragansett, Rhode Island. The workshop was organized by Gail Scowcroft, Associate Director of the GSO Inner Space Center (ISC) and Executive Director of the Consortium for Ocean Science Exploration and Engagement (COSEE); Peter Tuddenham, President the College of Exploration; and Romy Pizziconi, Communications Coordinator for the ISC.

The GOSE Workshop featured panelists and speakers from 15 nations and five continents and participants from 19 U.S. states. Over two days, invited speakers, panelists, and participants shared knowledge and discussed ocean science education. The workshop consisted of invited presentations, panels, discussions and working groups looking to the future.

There were 8 invited presentations on ocean science and ocean science education issues, research and international agreements. Four separate panels presented and discussed ocean science education across the K-12 pipeline, undergraduate and graduate education, and public education. Five separate working groups worked over 4 periods programmed for conversation and sharing and to work on ideas for the future of global ocean science education and how to be more mutually supportive, collaborative, coordinated, and connected. The workshop identified opportunities and steps for building international collaborations and establishing a foundation for an international ocean science education network.

The panelists and speakers addressed international and national ocean science research and education priorities, leveraging ocean research for education initiatives, and the integration of advanced communication technologies. The Working Groups identified priority ocean science topics, including Climate Change and Weather, Loss of Biodiversity, Dexoygenation of Coastal Waters, Microplastics/Pollution, Fisheries and Food Security, Water Availability, and Ocean Stressors. Consensus was reached on three major topical priorities for current ocean science education: 1. Fisheries and Biodiversity (including food security); 2. Climate Change (ocean's affect on climate and fresh water resources and the affect of climate change on ocean systems); and 3. Oceans and Human Health (including coastal resiliency).

The workshop participants identified major process priorities for the broad global ocean science education community to embrace, including communication and teaching training for scientists and graduate students; increasing diversity of the ocean science profession; educating decision makers; reforming undergraduate ocean science education; and supporting ongoing global ocean literacy efforts.

The U.S. National Science Foundation funded COSEE, and provided 12 years of funding to build and operate a national network in the U.S. COSEE has been very successful at forging a highly functional network with success around the country. This national network has now transitioned to an independent international organization – the Consortium for Ocean Science Exploration and Engagement (COSEE). A goal of the Consortium is to forge a global ocean science network that brings ocean scientists and educators together to enhance and promote ocean science education across the world. The GOSE Workshop is a first step toward reaching that goal.

The GOSE Workshop was possible due to the good will and efforts of ocean science research and education colleagues around the world. With so many pressing global environmental issues related to the ocean needing to be further researched, addressed, and mitigated, it is more imperative that we work together across national boundaries to increase awareness of the ocean and its processes, as well as its impacts on humanity and our impacts on the ocean.

GOSE Workshop Participating Nations

Australia, Bangladesh, Brazil, Canada, China, Denmark, France, Greece, Italy, Japan, Poland, Portugal, United Kingdom, United States

Fig. 1 Map of nations represented at the GOSE Workshop

WORKSHOP RATIONALE and GOALS

A key focus of the GOSE Workshop is to develop a pipeline in ocean education that will have a large impact internationally. This is particularly important for a number of reasons. There are now environmental issues that we are facing with the ocean that are global and will require a literate public to understand these issues. It's particularly important to educate our political leaders. It is a challenge that all nations face going forward. This effort is critical to addressing public ocean science education, including that of the world's political leaders.

Workshop Goals

- Forge an international ocean science education network focused on the education pipeline - elementary through graduate school and public education - with the full engagement of the ocean science research community.

- Broaden current ocean literacy initiatives by developing strategies for integrating undergraduate and graduate education, while leveraging international ocean science research initiatives.

- Promote dialog focused on the potential for international collaborations, the identification of goals and priorities for global ocean science education, and outline steps forward for the international community.

- Demonstrate and use different technologies to engage ocean scientists, ocean educators, and learners of all ages in ocean exploration and ocean issues and to create more networking opportunities globally.

DAY ONE

A. Welcome and Introductions

Dr. Bruce Corliss, Dean, Graduate School of Oceanography, welcomed the participants and provided an overview of the University of Rhode Island Graduate School of Oceanography (GSO). The campus is home to 30 ocean science faculty, ten additional marine research scientists, 60 graduate students, several post-doctoral fellows, and 150 staff members. GSO operates the *R/V Endeavor,* a 180-foot ocean going vessel that serves scientists conducting research throughout the Atlantic Ocean. GSO is also home to several large ocean science facilities and education/outreach programs. It is the hub for the National Science Foundation's University National Oceanographic Laboratory System (UNOLS), which coordinates the U.S. academic research fleet; the international COSEE office; Coastal Resources Center, an international hub for coastal management training and programming, and Rhode Island Sea Grant. GSO is also home to the Inner Space Center (ISC), a national hub for telepresence communications technologies. The ISC is capable of receiving live feeds of video, audio, and data from ships at sea and underwater remotely operated vehicles.

Participants introduced themselves and offered questions that they brought to the workshop. These questions set the stage for several workshop discussions. The questions included:

Graduate Education

- How can graduate students better communicate their research to the public? How can we better prepare our students?
- How can ocean science graduate programs better integrate coastal issues such as resource management?

Undergraduate Education

- How can we better integrate a more globally focused education program?
- How can undergraduate and graduate students develop their skills in outreach and education?

K-12 Education

- How can we better combine the research that is going on in our research institutions with the education efforts in K-12 education?

Public Education

- How can we better serve and reach those who use the ocean, such as fishers, boaters, and divers? How can we bring them into this global community to better understand the ocean?
- How can we connect people with the global ocean challenges?
- How can we collaborate to translate the language of scientists for the public?
- How do we explain to people that do not have access to the sea that they too have an impact on it?
- How we can use intergenerational learning to help promote an ocean literate society?

International Collaborations

- How is the ocean literacy theme related to TransAtlantic efforts. How we can collectively leverage projects?
- How can we forge an international network comprised of scientists, educational professionals, and learning scientists to promote and integrate ocean science research and education?
- How can members of a global ocean science education network work together to improve marine science education?
- What international programs have demonstrated success and how has their impact been measured?

General

- What are the common challenges that we have and what are the ways that we can take each others' shared experiences to address those challenges?
- What outreach or education techniques are truly effective and have resulted in behavioral changes?
- How can we make knowledge about the impacts of climate change more accessible to the general population and students?
- How can we take the complicated ocean topics and break it down to teach to others?
- How can programs take advantage of live research and use it in education efforts?
- How can we can leverage resources and find funding?
- How do we take the lessons that we've learned in developing new technologies to build ocean observatories and expand that to capacity building?
- How do we transfer the knowledge that we individually have to each other?
- How can we forge a nexus between formal and informal education and research. How can we remove the barriers and make it more productive?
- How can we connect enhanced ocean science knowledge and behavior change?

B. Critical Ocean Science Topics

Dr. Francesca Santoro, United Nations Educational, Scientific and Cultural Organization (UNESCO), France

There have been a number of important events in 2015 related to ocean science and international policy, including the publication of the first World Ocean Assessment, the United Nations approval of the post-2015 agenda featuring a stand alone Sustainable Development Goal on oceans, and the December 2015 United Nations Framework Convention on Climate Change Conference of the Parties 21 in Paris.

The ocean regulates the climate at a global scale due to its continuous exchanges with the atmosphere, and it is the core of the climate system. As a result of the warming climate, marine waters are also warming, ocean acidification is on the rise, and there is a loss of marine biodiversity. Because so much of the ocean is only accessible with expensive technology and/or remote instrumentation, uncovering the extent of marine biodiversity has been and continues to be a slow and difficult undertaking, resulting in much of marine life remaining a mystery, and there are an unknown number of species yet to be discovered. Marine species that are relatively easily monitored are those restricted to near-shore habitats, especially if they are sedentary or attached, such as sea grasses and corals. Those that spend time at the sea surface or on land, such as marine mammals and seabirds, have created a common impression that those species and ecosystems are generally in good shape. However, there is increasing evidence that numerous marine species are, in fact, restricted to relatively small areas, which makes them more vulnerable to depletion or extinction.

Sea level rise also poses threats to coastal states and communities and in particular to small island developing states. Figure 2 shows the spatial distribution of the rates of sea-level rise for the 26-year period from January 1993 to December 2009. The map shows significant regional variation where some regions, such as the southwest Pacific, experienced about five times the global-averaged rate of rise.

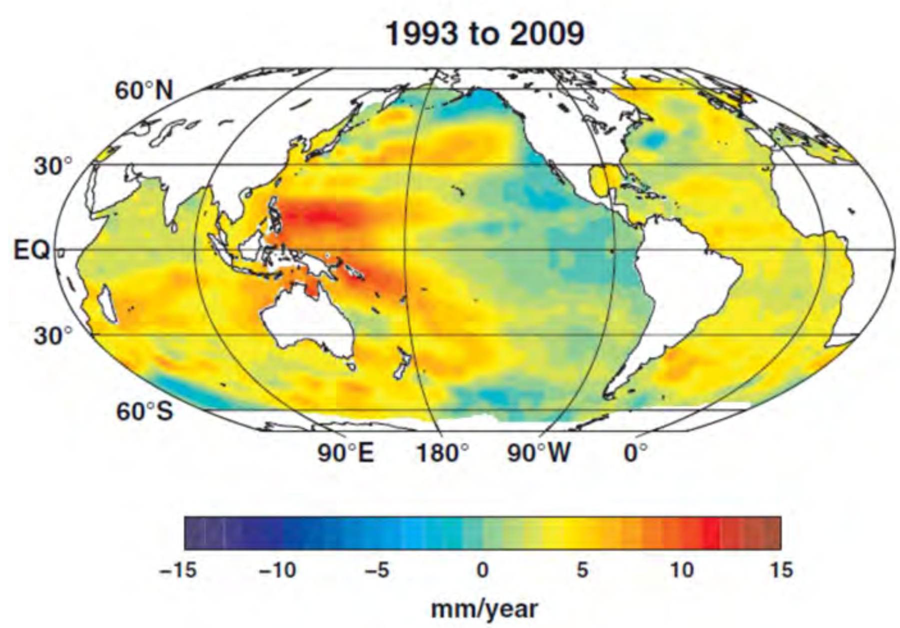


Figure 2. Rates of sea-level rise for the 26-year period from January 1993 to December 2009.

In addition to marine biodiversity loss and sea level rise, other global ocean priority issues include ocean acidification; deoxygenation, which causes hypoxic events in coastal areas; the proliferation of microplastics; and loss of fisheries. To address these key issues, the Intergovernmental Oceanographic Commission *Global Ocean Science Report: Progress,* *Challenges, Prospects* was published in March 2015. It provides an overview on nations' investments, resources, and scientific productivity in ocean science. It is intended to also provide a tool for mapping and evaluating the human and institutional capacity of member states in terms of marine research, observations and data/information management, as well as a global overview of the main fields of research interest, technological developments, capacity building needs, and overall trends. The report also addresses gaps in knowledge, research, capacity and technical infrastructure across the globe as well as opportunities for international collaboration.

Around the world, we need important momentum on ocean science. There is a need for better communication and education. We need to engage with society and prepare young scientists to do so. It is imperative that the global citizenry understands the societal impacts of ocean science research and pressing ocean issues.

C. Ocean Research Priorities
Dr. James Yoder, Woods Hole Oceanographic Institution, U.S.A.

The priorities for ocean research depend on a number of factors. In the U.S. there is basic research that is funded by the National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration, and the Office of Naval Research as well as some private foundations. Federal agencies expect that their funded research programs will demonstrate broader impacts to society. Federally funded research may lead to and/or support applications, operations, or commercialization. There is also corporate research that supports the blue economy. The processes for defining research priorities can differ between governmental agency, with NSF focusing on the science community and NOAA focusing on its congressionally approved missions.

There are basic research themes that have recently been identified as priority topics, such as those included in the 2015 National Research Council's *Sea Change: Decadal Survey for Ocean Sciences*, which includes priority themes and questions such as:

- How have ocean biogeochemical and physical processes contributed to today's climate and its variability, and how will this system change over the next century?
- How different will marine food webs be at mid-century? In the next 100 years?
- What is the geophysical, chemical, and biological character of the subsea floor environment, and how does it affect global elemental cycles and understanding of the origin and evolution of life?

With NOAA's oceanic and atmospheric research, there are basic research themes with ties to societal relevance:

- What is the state of the climate system, and how is it evolving?
- What causes climate variability and change on global to regional scales?
- How can NOAA best inform and support the Nation's efforts to adapt to the impacts of climate variability and change?

One branch of NOAA with a well defined mission is the National Marine Fisheries Service, which includes a mission to increase understanding about the impacts of climate and ocean acidification on fish and shellfish; the development of multi-species ecosystem and assessment models; and the impacts of by-catch on non-target species.

Corporate research to support the rapidly growing "blue economy" has become an increasing motivator for education and training. There is the need for research related to finding oil and gas, gold, diamonds, cooper, and other minerals and metals; finding alterative energy sources, such as those from wind farms and waves; and research and action related to protecting the environment as a catalyst for action.

In summary, science priorities may differ from the basic research versus mission-defined research versus corporate research perspective. However, ocean science does have a unifying priority encompassing all perspectives, particularly regarding how the ocean affects the Earth's climate system and the effects of a changing climate on the ocean, its chemistry, and its ecosystems.

D. Breakout Group Discussions on Setting Priorities for Ocean Science Education

Following presentations A and B, the GOSE participants broke into three groups to reflect on the presentations and address three questions. The discussions for each of the breakout groups are summarized below.

Group 1: What are key ocean science issues that connect the global citizenry on which the international community can collaborate?

The group discussed the key concept of the deoxygenation of coastal waters. This issue is relevant and tangible. It can be emotionally engaging as people understand the need for oxygen, and it has the potential to motivate behavior change leading to action. It is an intergenerational issue, fairly simple and straightforward to understand. Oxygen itself is understandable, and the fact that is the ocean is running out of oxygen in some locations can be a concept to "hook" citizens. There is potential for global engagement in this issue through citizen science, as people can measure dissolved oxygen in coastal waters and lakes. A potential links could be made with Ocean Sampling Day with OSD that already has worldwide, citizen involvement.

Food security is another link for many people. Across the world economies are dependent on fishing. Pollution, and particularly microplastics will also resonate with the public. Both of these issues relate to blue growth, economic growth related to the ocean, and the blue economy, and it is imperative that growth of the blue economy allow for the sustainability of the ocean's resources. In contrast and steering away from the terms blue growth/blue economy, what is the value of the ocean as an educational topic? Economics have not traditionally been a part of scientists' conversations, however, it's important to bring scientists into these discussions.

In lesser-developed parts of the world, there is a surging desire for Internet access, energy, new technologies, clean water, and efficient sewer systems. What role does the ocean play in those needs? How do we make these issues understandable for people trying to get their basic needs met? It is important to determine what citizens believe are the biggest issues – then educate to address these issues. It is important to make educational content culturally relevant and help citizens understand how they can use the content as a citizen, steward, or consumer of ocean resources.

This group identified the need for the global ocean science community to develop clear messages in simple terms that could be repeated often. These messages should promote the value of the ocean. For example, a mangrove forest protects the shoreline from storms and reduces flooding. This is a real value beyond just the harvest value. The public also needs to understand that we know little about any ocean regions, as most of the ocean has not been explored. Finally, messages need to be hopeful, not necessarily offering solutions, but lending hope that resources can be better managed.

Group 2: What ocean science topics should be a priority in ocean education for the next decade?
It is difficult to convey that everyone contributes to the impacts on the ocean, especially when a large number of people do not live along an ocean coast. It is imperative that ocean issues are connected to people. Themes such as human health and seafood supply can have a tangible impact. With issues related to these themes, including fisheries bycatch, fishing practice, and sea ice loss, there is a fine line between crisis and sense of urgency, and helping citizen to be aware of actions that can avoid the crises. Once a connection has been made, other topics can be introduced. For example, ocean acidification has a global cause and it is resulting in global impacts on seafood as well as local impacts.

It should be a priority to help citizens understanding that the ocean is part of a system, and thus, all issues are connected. Other priority issues for ocean science education include:
• Energy - alternative sources using marine locations and resources
• Overfishing and international collaboration
• Ocean policy – educate the public about policy in their own nation and educate policymakers so that they understand the science.

The global ocean science education community can work together to address these priorities. Finding partners internationally with similar problems would allow each to focus on a national regional, or local level, while connecting to the big picture. This would also help partners know what other people are doing and share resources related to specific issues. It should be a priority to reach out to least-connected people or countries where there is less awareness of the issues. All nations should have access to ocean science education. Steps to better link the global ocean science community could include the establishment of a long-term repository for sharing information and resources, such as an online resource center.

This breakout group was in agreement that the focus on positive actions through education was important and felt a focus is needed on how we can implement change rather than on the fact that a problem may not have a solution. A role of scientists and educators is to provide positive messages and examples to get "hope spots" into the general public.

Group 3: How can the global ocean science education community work together to address these priorities?
The ocean economy could be used as a globally relevant issue to connect the global citizenry. Many ocean issues can be tied to the economy, including the changing ocean chemistry, declining fisheries, and natural hazards.

The global ocean science education community could work together to address these priorities, but there needs to be more opportunities for communication and sharing. A curriculum focused that is focused on global ocean, system-wide issues and available on-line would be very beneficial. Group three considered a type of stakeholder meeting, such as those held by the United Nations, with discussions about regional level needs, with an added level of the involvement of industry. The ocean economy is massive, but it can be used to pull countries together. As we continue onto the next decade, there will be ever pressing issues for the world citizenry related to the global ocean and climate, and international collaboration will be essential in addressing and mitigating the impacts.

E. Communication Technologies – Opportunities for Virtual Engagement

Dr. Dwight Coleman, URI/GSO, Inner Space Center, U.S.A.

In regard to global ocean science, there is a need for a baseline of information. Without baseline data, we don't know what the starting point is for these issues. The Inner Space Center was designed in conjunction with the NOAA Ship *Okeanos Explorer*. We now also support the *E/V Nautilus* and other vessels in the U.S. research fleet. Both the *Okeanos* and *Nautilus* and their vehicle systems are part of a larger program of ocean exploration. Modern tools, including remotely operated vehicles and their instruments allow these vessels to make detailed maps of the ocean floor and discover new features that were previously undetected.

The ISC is a national hub for ship to shore telepresence communication technologies. Figure three portrays the process. Data, images, and high definition video captured by the ships and ROVs are sent to the ISC via a satellite connection. The ISC's high-speed network makes it possible to receive data and video streams from the bottom of the ocean via the ship's computers in less than two seconds.

With the use of remote facilities onshore, the ISC can have scientists on call, and can increase the number of participants in an ocean expedition. The onshore facilities mimic the facilities on the ship. Scientists can view the images, video, and data in real time, make decisions, and direct the expedition from shore. Figure 4 shows some of the high quality imagery available.

The ISC is currently expanding telepresence technology to other ships. In addition to Mission Control at the ISC, there are also exploration consoles or mini facilities in various locations around the country. Onshore at the ISC's main facility, there is a full production studio. With the studio, the ISC can have live and interactive programming and webcasting to accompany the expedition feeds, as well as during other times. In September 2015, the ISC will be working with GSO's ship, the *R/V Endeavor*, to dive on a German U-Boat that sunk on the last day of the World War II. This will be a cultural resource, and an outreach program is planned to accompany the expedition.

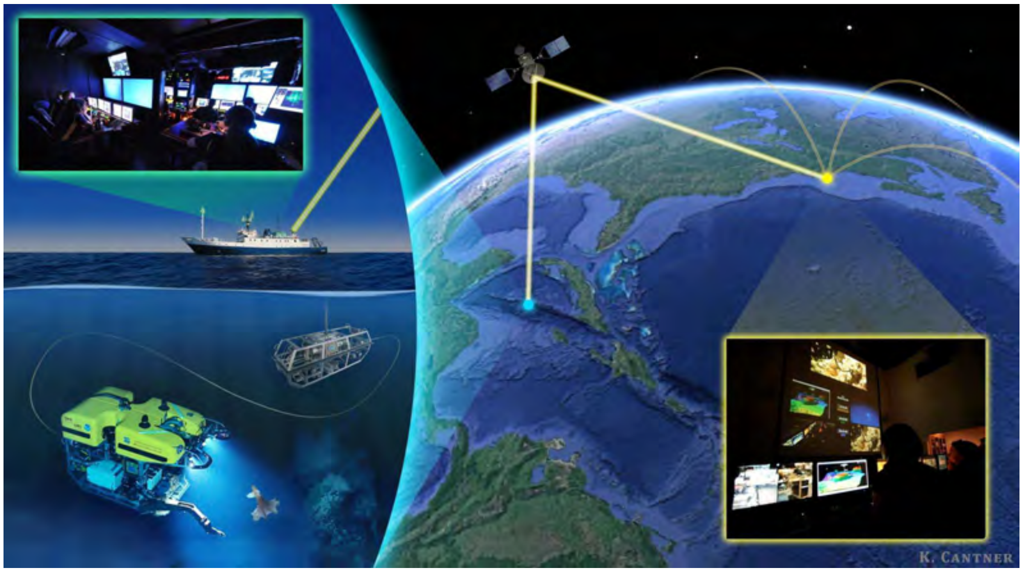
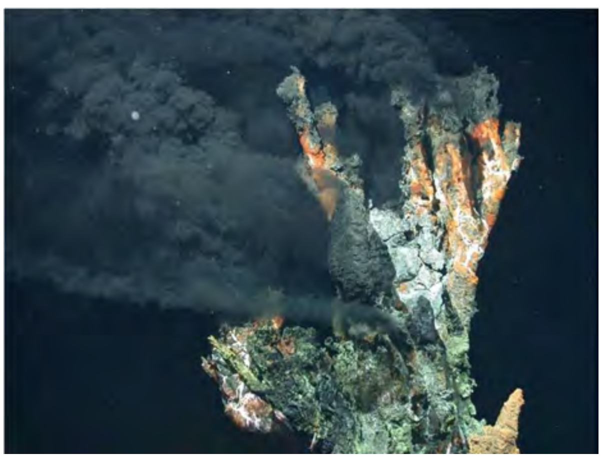
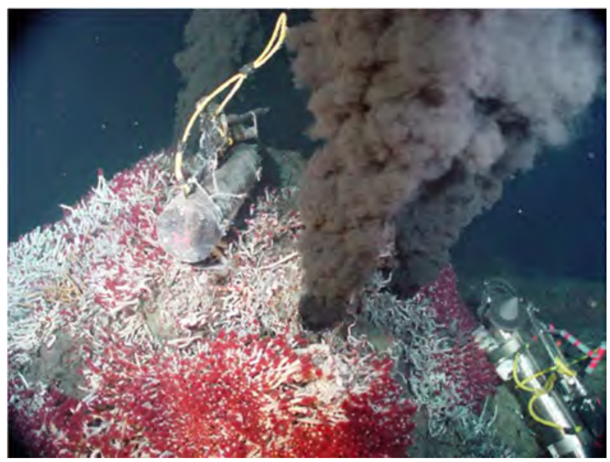


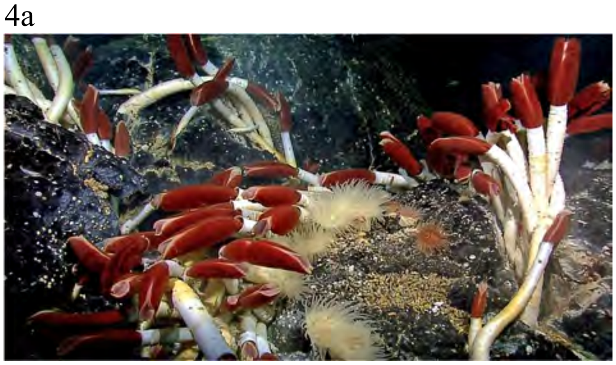
Figure 3. ROVs collect data using an array of sensor based instruments and high definition video, which is sent to the ISC via satellite. The ISC then distributes these feeds to other onshore facilities. It also streams these feeds via several websites in real time.



4a



4b



4c

Figure 4a-c. High quality images, such as these from the Galapagos Islands, reach the ISC in under two seconds.

F. Use of Communication Technologies Large Group Discussion

Following Dr. Coleman's presentation and a tour of the ISC, the participants discussed how modern communication technologies, including telepresence, could be used to support global ocean science education. A motivating factor to get students interested in science is the ability to be able to "join" a live mission or interact with scientists. In an evaluation study conducted for the ISC, data showed that having a live interaction, whether to a scientist in the Inner Space Center or on a ship, rated better among students than a regular non-live broadcast with no interactivity.

However, there are varying degrees of institutional bureaucracy with offering credit and courses that take advantage of modern communication technologies, but the possibility of offering data sets and video that faculty could use in undergraduate classes is encouraging. This is especially important with the need to integrate ocean science in undergraduate courses at non-research institutions, including two-year colleges.

Smartphones can access data, and students can use hand-held devices, including tablets, to broadcast from their classrooms. Phones and tablets can use apps for citizen science that can successfully engage learners. However, these programs do require some resources and an investment of time from institutional staff. The ocean science community now has the ability to broadcast from the bottom of the ocean to a smartphone. We need to map out a plan for how to effectively use this technology across the globe.

G. Leveraging International Ocean Research Technologies

Dr. Scott Glenn, Rutgers University, U.S.A.

At the same time the earth's climate is changing, the global population is growing, particularly in developing countries, and these stressors will cause significant impacts. We have to mitigate the impacts as we adapt to a changing climate. The ocean is a key factor in climate and in carbon dioxide sequestration. It is important that we improve severe weather warnings and coastal resiliency. We will also have to look toward a physically complex ocean for food, water, energy, and security.

To answer pressing questions about climate change and prepare for what is to come, we need to go below the surface of the global ocean, of which 95% still needs to be explored. There are not enough ships available to research and explore the world ocean. We need other ways to observe the ocean, and this is where the leveraging tapes place. There are currently networks of observation instruments deployed in the global ocean, including drifting buoys, XBTs (sub-surface temperature instruments) and Argo subsurface drifters. However, the rapid advancements in robotics have provided autonomous underwater vehicles (AUVs), such as gliders, which are commercially available and cost about $150,000. This is relatively inexpensive compared to the costs of building a ship and ship time. Gliders have the ability to stay underwater for a long period of time and can contain a wide array of sensor-based instruments. In addition, because they are capable of traveling in deep and shallow waters, gliders can fill the coastal ocean profile sampling gap.

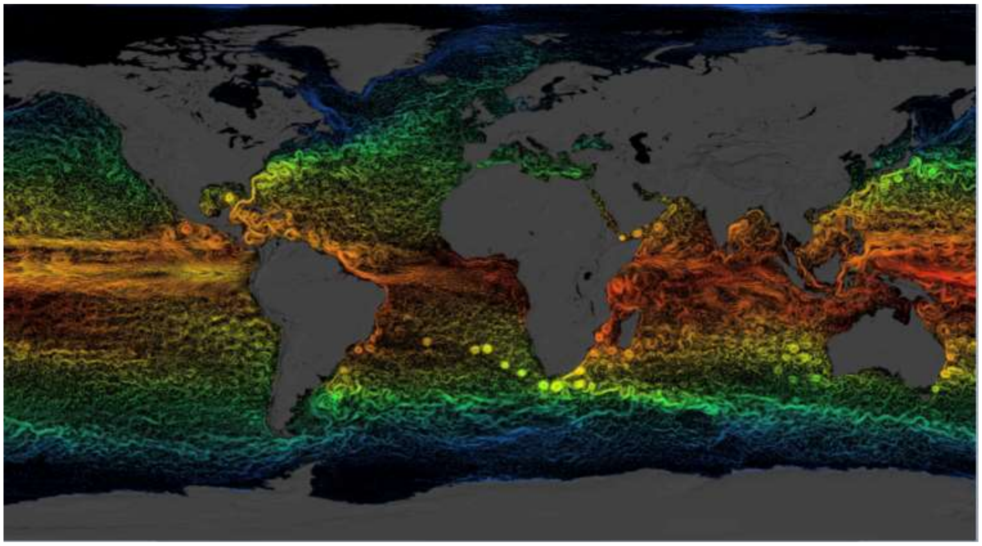


Figure 5. Technological advancements have provided more refined maps of global ocean circulation.

Other recent technological advancements have been supported by the National Science Foundation's Ocean Observing Initiative (OOI), a sustained at-sea scientific observing presence on a global scale. The OOI has several focus areas for observations and research: climate change, carbon cycle, coastal upwelling, seismic activity, dissolved oxygen, ocean acidification, gas hydrates, subduction zones, and spreading centers. The OOI platforms will provide over 2,500 data product streams. There is great potential to leverage these research assets for education. Currently, an OOI education and public engagement initiative is producing tools to enable the use of real-time OOI data in undergraduate classrooms. These tools include the capacity to create data visualizations on a smart phone or web-based browser. There are intentions of quarterly education events, including conferences and webinars. Having highly trained staff and scientists helps to get young people engaged in visualization, data collection, and model building, ensuring that society will benefit from investments in research and technology.

In 2009, my team at Rutgers University flew a glider from New Jersey to Spain, across the Atlantic Ocean for the first time, 7,400 km in 221 days. In 2013, a glider was launched in the South Atlantic from South Africa. It traveled to Ascension Island and then continued on to Brazil, flying over 10,000 km. These expeditions can inspire students from all continents.

H. Panel I: Undergraduate Ocean Education Across the Ocean Basins

Tsuyoshi Sasaki, Tokyo University of Marine Science and Technology, Japan

An ocean literate person has the ability to think of the human and emotional connection, not only knowing the fundamental ocean knowledge, but also human customs, including local and traditional knowledge. Ocean literacy can enhance people's autonomy and inspire them to take action. We can solve the problems caused by the isolation of humans from nature, but it is important to be locally literate. Local ocean literacy education is still not a focus in Japan. It's an improvement to have engagements with other countries.

Dr. Harry Briedahl, Nautilus Educational, Australia

Australia has the same landmass as the continental United States, and our population is approaching 25 million, with 85 percent of people living along the coast. Most people do not know how the ocean affects them, or how they affect the ocean. In Australia, the word "ocean" appears once in the new national curriculum science standards. This is both a threat and an opportunity. The problem is that marine themes and ocean literacy are concerns, but no one is talking to each other. Marine educators (and scientists) are no longer unified. The teaching of marine science in our schools and the teaching of marine (i.e. ocean) science education at our universities are haphazard and fragmented.

In Australia we generally use the term marine (and coastal) education as opposed to ocean science education. A unit called EDF 4219, offered at Melbourne's Monash University between 1998 and 2014, was the only dedicated marine (ocean) science education unit available to undergraduates in Australia. However, marine themes have been and still are included in some environmental education and outdoor education undergraduate units and Ocean Literacy has a minor impact here. EDF4219 was initially an elective unit for a range of undergraduates from a number of Melbourne universities. Over the years, EDF4219 morphed a number of times, and from 2011-2014 it was based on the 7 ocean literacy principles. Despite ranking in the top 3 out of almost 200 units offered by the faculty of education, EDF4219 was not offered in 2015. Despite this, I believe that this unit, EDF4219, offers a great model for marine (ocean) education units globally.

Dr. Jan Hodder, University of Oregon, U.S.A.
In the United States, undergraduates have a wide range of choices for ocean science education, including certifications, associate's degrees, and various bachelor's degrees. In four-year schools, 88 have an undergraduate major in marine biology, and 42 have a major in oceanography. Degree requirements and courses offered vary widely. Forty-five percent of all undergraduates in the United States attend over 960 community colleges (two-year schools), due to the open admission policies and drastically lower tuition rates. These students tend to be older, more diverse, and more likely to be a first generation college student, but tend not to be engaged in ocean science as much. In the United States there are increasing efforts to support pathways to ocean science, including National Science Foundation Sponsored Research Experiences for Undergraduates (REUs) and internships.

Dr. Danilo Koetz de Calazans, Instituto de Oceangrafia Rio Grande, Brazil
We were the first university to introduce an oceanography course in 1970, and after six years we incorporated a research vessel to do studies on the southern shelf of Brazil. Then in 1996, a new discipline was established for undergraduate students: Technical Practices and Oceanographic Equipment. This discipline is characterized by its multi- and interdisciplinary nature. It enables students to expand, in a practical way, with technical activities. Students collect and analyze biotic and abiotic data with a research vessel serving as an advanced oceanographic laboratory. However, students faced difficulties with only two university-owned research vessels, berth space availability on scientific cruises, a fishing fleet with poor accommodations, and lack of financing for student trips. In 2006, with the support of the Forum of Coordinators of Oceanography courses and funding from the Ministry of Aquaculture and Fisheries, "Blue Amazon: On Board Experience" was introduced with nine oceanography courses. By 2014, there were 650 new undergraduates and 240 new graduate students each year. By 2015, four new 32-meter research vessels are to be built. Brazil has been divided into four coastal regions, and each is assigned one of these vessels. All undergraduate students participating in the marine

sciences courses will be required to complete a five-day research cruise. We hope to use the new vessels for 28 weeks per year and will be collecting data during this time.

Figure 6: One of Brazil's research and teaching vessels, dedicated for undergraduate education.

I. Panel II: Graduate Ocean Education Across the Ocean Basins

Dr. Jacqueline Dixon, University of South Florida, U.S.A.

At the University of South Florida we have had great success in underrepresented minority graduate rates, with 7 out of 8 Ph.D. candidates from underrepresented populations. Graduates in the STEM fields have mentorship and one-on-one training. We have been conducting practical training and focusing on how to expand graduate education and opportunities outside of academia. We've utilized the COSEE Florida Presentation Boot Camps to train our students, and we've made it mandatory for new graduate students. The Boot Camp two-day workshops provide content on how to give clear presentations, develop effective posters, and engage in outreach. In its 20th year, our Oceanography Camp for Girls provides graduate students with a chance to gain communication and teaching skills through a successful outreach program. Associated with this program is a certificate course for graduate students in communicating science.

Dr. S. Bradley Moran, University of Rhode Island, Graduate School of Oceanography (GSO), U.S.A.

The United States, the National Ocean Policy and the World Ocean Assessment have initiated a new normal. Here at GSO, with federal support declining and only eight percent of our funding coming from the state of Rhode Island, we have to think creatively on how to deliver our graduate programs and determine the best tool set for the students. What is the best tool set that will support society? At GSO, we've had 50 years of successful ocean science research and graduate education, and now we have a challenge due to the funding situation. In the mid- to late-90s, a master's of oceanography was introduced, and at the time, it was designed for working professionals. Currently, we are looking to reinvigorate this program. We are focusing on fisheries, coastal management, ocean data, and sensors so that we can boost the program's student population.

Another emerging need is building bridges between ocean scientists and the business community. With the inception of GSO's "Blue MBA" – a combined graduate degree in oceanography and business - we've built this bridge through education. It is currently the only program of its kind. The "Blue Economy" is developing rapidly, and there are now U.S. federal agencies looking to examine the value of ocean sciences and the economic returns. This is also a significant movement in the European Union and China. A suggestion for a future workshop would be to engage the National Ocean Industries Association, which represent oil, gas, and commercial fisheries organizations, as they need to be engaged with the academic field.

Emily King, Xiamen University/COSEE China, China
In 2011, Xiamen University split into two colleges, and the College of Oceanography and Environmental Science includes all the ocean science disciplines. The university has 600 graduate students pursuing higher-level ocean science degrees, as well as post-doctoral programs. Masters level students must pass an exam and go through an oral exam before a group of professors. They must complete 22 credit hours and their thesis work. The masters program takes about three years. Ph.D. students must complete their research and dissertations, which takes about four to seven years. The culture and life within an ocean science lab is quite collaborative. Our graduate students are not as involved in education and outreach as our undergraduates are, mostly due to time.

Dr. Ivo Grigorov, Technical University of Denmark, Denmark
At our university, graduates have excellent, background and science skills, yet they still fail at securing research funding. We have to train them beyond research excellence, and give them a set of skills that includes successful communication funding of their future research. Our graduate students are not involved in outreach, but they are the ones who should be doing it. These skills will make them more competitive. They may be amazing at their research, but they cannot explain or communicate what they do, or why they should be funded.

What are the other skills that should be part of the graduate training curriculum? Ocean science gives access to the latest research to companies and public at large. Science literacy works both ways. You have to train graduates on how to support science literacy. It helps them expand what they know, figure out what they do, why they should be funded. Well-rounded graduates with better skills bring career benefits. Ocean literacy is not just a concept; it is also a real service. We need to train graduates on how they can contribute to ocean literacy on a daily scale.

Group Questions and Discussion
• *Six hundred graduate degree students in ocean science at one university is staggering. Are there other universities in China that are also educating Ph.D. and master's level students. Will there be jobs? How do you see that manifesting after school?*
China is in a very interesting position at the moment in terms of how it views the ocean. There is a lot of mental energy and some spending to grow the field. I do not see the graduate students going into academia. A lot of them will go into academia, but more will go into jobs in business and development. The jobs are there, but not necessarily what you'd think of as a typical post-graduate path in the U.S.

• *Is the university model of graduate school the best way to prepare future marine scientists?*
Universities are changing their view on how to best educate their students. Curriculum is changing toward a more active learning process. Graduate student education is becoming more

independent and providing a broader experience. Many U.S. programs teach graduate students how to communicate and how to do outreach, giving them a broader base of knowledge.

J. Panel III: Elementary and Secondary Ocean and Great Lakes Education

Dr. Susan Gebbles, Dove Marine Laboratory, United Kingdom
Lyndsey Manzo, Ohio Sea Grant, U.S.A.

It is important to integrate marine education in primary and secondary schools. There are critical issues, such as climate change and the loss of habitats, while we depend on so many resources from the ocean. Actions have an influence on the ocean, and unfortunately school children have less understanding about the marine environment. One way to increase this is with intergenerational learning, where young people are passing along their knowledge to adults. In the United Kingdom, marine education is not part of the curriculum and is only taught on a theoretical level. There has been a loss of field work and loss of opportunities, and ultimately a loss of affinity with nature. In the U.K., a majority of the children visit the beach once a year, but there are many who have never been. Unfortunately, many teachers do not have the knowledge to teach marine science topics – there's a fear of "out of doors" learning and problems with funding for bussing and sharing resources. Teacher training programs can provide the confidence to take a class outside. Teachers can then work with the teachers in their schools and use their experiences in their communities.

In the U.S. we forget about the North Coast, our freshwater Great Lakes. We have a longer shoreline on just the U.S. side of the lakes than any of the other three saltwater coasts. We have a significant portion of the US shoreline; 39% of the population lives along the coast. Twenty percent of the worlds' freshwater comes from the Great Lakes. It is important to have Great Lakes science included. Educational standards and testing are driving education. Ocean and Great Lakes education are typically not a major component of any set of educational standards. While we have made the effort to get them incorporated into the Next Generation Science Standards, only a 12 out of 52 states have adopted this educational framework. A reality for teachers is that if something is not in the standards, then it likely won't be addressed in the classroom.

A complicating factor for both the U.K. and U.S. is that in pre-service teacher education, very few student teachers are exposed to ocean science. There is a big gap in the skill set necessary to teach ocean topics. Pre-service teachers don't have the opportunity for field research or to develop lab skills. The ocean literacy movement made major advances in incorporating marine science into K-12 education. The same vision needs to transform teacher preparation to get teachers to "experience" marine science.

K. Education Pipeline Collaborations Breakout Group Discussions

Following Session I, the GOSE participants broke into three groups to reflect on the presentations and address three questions. The discussions for each of the breakout groups are summarized below:

Group 1: How can elementary and secondary ocean science education programs/activities better prepare students for undergraduate and graduate education?

There's great importance in pre-service teacher training in terms of having teachers understand the research process, participate in science, and act like a scientist. These students should have opportunities to visit universities and see how labs work. It would also provide time to met scientists and initiate relationships, which could create connections for scientists to visit schools.

Teachers need opportunities for effective professional development. They also should have mentorship and be trained to be mentors. Teachers need to keep their skills up to date so that they can help prepare students for higher education. They can do this through fellowships, research experiences, and summer internships.

Within education, students should learn the importance of mentorship, relationships with their peers, and the importance of role models, especially those that are diverse. There are key 21st century skills in the realms of cognition, communication, and intrapersonal that will help create a better more informed citizenry. Not all students need to be scientists, but an ocean literate person is a better citizen.

Group 2: How can students be better prepared for the ocean science workforce?
Teaching students to be active learners and helping teachers teach science, as a process, will create a new paradigm for learning. Students need early exposure to the scientific method, posing problems, and getting solutions to research questions, but without the fear of failure. There are cultural changes that occur between middle school and high school, where students go from lots of open questions to always looking for the right answer. Undergraduate and graduate students also need to prepare for the ocean science workforce outside of academia and connect with non-traditional schools. Opportunities exist throughout the pipeline for students to engage with ocean science outside of school, such as education programs offered by COSEE, Sea Grant, and the National Ocean Science Bowl. Universities could offer more work-study programs related to ocean science.

There is potential for international participation/collaboration across the ocean science disciplines. Oceanographic data, such as remote sensing data, could be integrated into education settings where students compare their work with peers in other countries. Interactions could be made available online, where students could share their interpretations and data products.

Group 3: What is the potential for international collaborations that support the engagement of undergraduate and graduate students in elementary, secondary, and public ocean science education?
Schools should have a strong emphasis on providing authentic hands-on experiences, starting at the elementary level, as a way to maintain students' interest in ocean science. A program such as the NSF funded GK-12 (now over) brought graduate students into classrooms. The young scientists actively engaged with the students a minimum of 10 hours per week. This generated a good deal of excitement and interest in the K-12 students, while giving the graduate student training in communicating science.

For the next global ocean science education workshop, industry representatives could assist the community in addressing bigger issues related to ocean related careers and job opportunities to support the blue economy.

DAY TWO

L. Panel IV: Public Ocean Education Across the Ocean Basins

Grazyna Niedoszytko, Gdynia Aquarium, Poland

At the Gdynia Aquarium an active bridge is being built between scientists and the public. The Aquarium has almost 100 years of scientist research history as part of the National Marine Fisheries Institute. The Gdynia Aquarium is the biggest center of informal ecological education, with 400,000 visitors per year, in a town of only 250,000; and the aquarium's web portal is accessed 170,000 times per day. Aquarium staff members have created different programs dedicated to specific audience groups, such as children, school teachers, students of higher education, and senior citizens. Presenting animals is not enough. The aquarium's philosophy is that scientists must be engaged with the public.

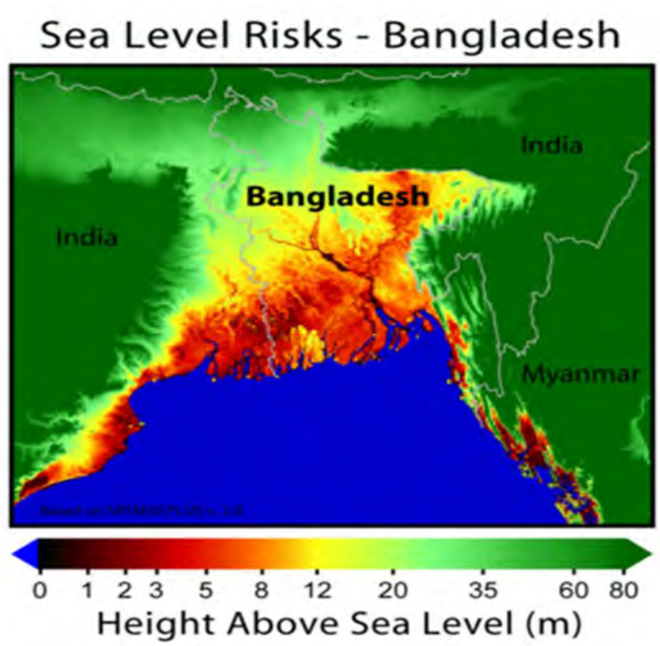
Figure 7. Gdynia Aquarium in Northern Poland serves 400,000 visitors per year

Fiona Crouch, Marine Biological Association, United Kingdom

At the Marine Biological Association (MBA) in the United Kingdom citizen science engages participants from "K to gray", with the involvement of volunteers. Projects, such as eOceans and iSpot, allow the public to upload marine photos and experts can identify them. With the monitoring project, The Shore Thing, MBA is looking for climate change indicators, and the impact of warming seas on the changing geographical range of species. Within the new European Union Sea Change project, there is a citizen science recording process, and stakeholders are engaged to help design monitoring protocols. All of these projects take on a bottom up approach. The MBA philosophy is that the collection and analysis of data relating to the natural world by members of the general public must take place as part of a collaborative project with professional scientists. With Sea Change, MBA is working to bring about a fundamental "Sea Change" in the way European citizens view their relationship with the sea, by empowering them – as 'Ocean Literate' citizens - to take direct and sustainable action towards healthy seas and ocean, healthy communities and, ultimately, a healthy planet

Dr. Mohammad Muslem Uddin, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh
Bangladesh has the highest population density in the world, and with threatening sea level rise, 60 percent of the country could be underwater. In 1971, the University of Chittagong started a marine science education and research program. Out of 35 public and 57 private higher education institutions, only four universities in Bangladesh offer fisheries degrees. Ocean scientists and educators struggle with getting people concerned about oceanography and ocean literacy. So last year, the University of Chittagong organized programs and public lectures. However, when programs were brought to coastal areas, university staff realized that people living there were not literate, and they needed to start with a science literacy campaign first. With the Nano Global Ocean Education Project, University of Chittagong staff members are encouraging alumni to become engaged in outreach to improve their project's management and organization skills. The program scientific content is based on the U.S. Ocean Literacy Principles, and the program has initiated an ocean literacy campaign for Bangladesh.

Figure 8. The threat of sea level rise in Bangladesh is serious, and citizens must become ocean literate if they are to understand the consequences.



Jim Wharton, Seattle Aquarium

The Seattle Aquarium (SA) is focused on inspiring the conservation of the marine environment, and this mission guides all aquarium activities. All of the aquarium's key organizing principles are intended to reflect excellence in practice through the evolution of ideas, diversity of culture and experience and evaluation to ensure that aquarium experiences are mission-driven. The SA has identified the following outcomes for its programs: ocean literacy, science literacy, conservation literacy, and affect and behavior change. The aquarium experience is intended to change what the audiences know about the ocean, how they feel about the ocean, and what they're willing to do about ocean conversation. The SA is currently in the process of implementing its strategic plan (a work in progress).

Anne Stewart, Canadian Network for Ocean Education (CaNOE), Pearson College, Canada

The public education system in Canada is not federal but is instead controlled by provinces and territories. In addition, education curricula are not as standards-driven as in the American system, due partially to a difference in the pedagogical approach by teachers. In spite of and perhaps because of these factors, Canada ranks well ahead of many countries in math and science.

However, this doesn't mean that Canadian youth are ocean literate. Canada has issues similar to other countries, and the word "ocean" does not often appear in Canadian curriculum, textbooks, or exam questions.

A particular aspect of education in Canada is that First Peoples have one of the fastest growing school-aged populations. This is a group that has been poorly served by colonial-style, science education and a recent national reconciliation process heralds changes. A shift is happening towards more local control of First Nation and Inuit education, and this is resulting in new realities, including changes to marine science public education and outreach. For example, researchers permitted to work in Canada's Nunavut Arctic region are required to do public education and outreach about their research in arctic communities. This results in deeper dialogue, new partnerships, and an exchange of knowledge, instead of a one-way flow. Marine science camps run by Uu-a-thluk, a council of First Nation chiefs in British Columbia, provide another good example of ocean science education. These marine science camps feature traditional ecological knowledge. Elders are involved in both the development and delivery, and campers receive hands-on, experiential ocean science learning with a different worldview.

Although, studies of youth in urban areas show they understand more than adults about the relationship between climate change and oceans, a recently published study on high school student ocean literacy in Nova Scotia indicates a low level of ocean literacy. Other provinces may be similar. More work needs to be done to determine the baseline status of ocean literacy. In Canada as elsewhere, in an increasingly globalized world, there is a need for ocean science literacy that is decolonized and includes different perspectives. CaNOE is working to raise the profile of ocean literacy in Canada by strengthening the network of ocean educators and scientists educating and communicating about the ocean. CaNOE also helps Canada contribute to global Ocean Literacy efforts, and through its membership, engages diverse audiences from sea to sea to sea.

M. Leveraging International Ocean Research Programs for Education Breakout Group Discussions

The GOSE Workshop participants divided into three groups to reflect on panel presentations and day one discussions and address three questions. The discussions for each of the breakout groups are summarized below.

Group 1: How can ocean science educational content and programs be better integrated with ocean science research and exploration?

Group one discussed how the former U.S. NSF-funded Graduate Teaching Fellows in K-12 Education Program (GK-12) was a good example of integrating ocean science educational content with ocean science research. It provided an opportunity for young scientists to engage with educators and students over extended periods of time, while having the opportunities for training and skill building in science education and communications. This group felt that training for scientists related to education and communication skills should be a requirement of their graduate degree programs. It is important that scientists and those with expertise in translating science for the public work together to interpret research results – particularly those published in peer-reviewed journals – in an effort to systemically address important global, ocean-related issues. The group agreed that aquariums and science centers are a great place to bridge ocean science research with education activities. The Census of Marine Life, Gulf of Mexico Initiative, Ocean Observing Initiative, and Ocean Networks Canada are all great examples of international research initiatives that can engage the global ocean science education community. The group suggested that it would be good for the global ocean science education community to work with UNESCO to help reach smaller nations and help disseminate resources more broadly, as well as identify areas for cross-pollination of ideas. This group suggested how building a Web-MD type of portal for the ocean would be a good resource for people to be access information through communication technology.

Group 2: What major international research initiatives might serve as a platform for engaging the global ocean science education community?
Group two suggested that because researchers do not always see the value in communicating results to educators, graduate students are a good resource and may be more receptive to working with those outside their discipline. They also discussed that communication "boot camps" for training scientists are a great way to bring research and education together and show positive results. These types of programs can help retain interest in ocean science education activities and provide opportunities to share and communicate knowledge. Research initiatives such as GLOBE, iNaturalist, and C-DEBI are able to serve as platform for engaging the global ocean science education community. Lastly, the group discussed the idea of an international clearinghouse for ocean science education activities that is both easily accessible and internationally compatible across languages.

Group 3: How could observing technologies and related networks along with communication technologies be used to support ocean science education?
This group discussed a bottom-up approach where citizen science programs could collaborate with scientists in a two-way process as a way to integrate ocean science educational content with research and exploration. Involving scientists in public education has actually changed the kinds of questions scientists ask and resulted in graduate students moving into education. Participants in this group noted that understanding the need to communicate and how to communicate effectively is critical, but a big part is also the need to listen. One suggestion is using the Alan Alda Foundation recommendations for communicating science, such as the development of one-liners for scientists to effectively communicate their work. Another recommendation is for scientists to communicate by doing short video clips, such as those featured in the Ocean 180 Video Challenge. Global observing systems and local ecological field labs can serve as platforms for engaging the global ocean science education community, as it connects to the communities where the labs are located. Crowd-sourced citizen science identification programs like Sea Life Tracker, iSpecies, iNaturalist, and Digital Fisheries are other options as well. This group noted that bringing scientists and educators to a "think tank" to work together would be beneficial, and that's a role that COSEE does well. Perhaps this sort of function could be internationalized. In regard to observing technologies being used to support ocean science education, group three offered the idea of students building "ROVs in bag" and adding cameras, like Go-Pros. Also, instead of recreating the wheel, using readily available observing data visualizations from NOAA, Ocean Networks Canada, and Science on a Sphere should be explored.

N. Advancements in Tropical Hurricane/Cyclone Forecasting

Dr. Isaac Ginis, University of Rhode Island Graduate School of Oceanography
The connection between ocean science and tropical cyclones is that cyclones develop over the ocean, and disintegrate once they make landfall, with the most active region being in the western Pacific. Hurricanes gain energy from the ocean through evaporation, and lose energy through friction at the sea surface. The most recent tropical cyclone or hurricane that made landfall in the U.S. was in 2012, Hurricane Sandy. The media called it a "super storm." A few things were unusual about the storm, especially the size. The diameter was about 1000 miles, and when it made landfall it affected 21 U.S. states. Sandy had an unusual track and path, made a sharp turn, and made landfall in New York and New Jersey. Sandy ended up being the second most costly storm to ever hit the U.S. The most significant impact was the storm surge and coastal flooding.

Figure 9. Unmanned drones, *Global Hawks* can over-fly hurricanes at altitudes greater than 60,000 feet with flight durations of up to 28 hours.

Hurricane Sandy can be used to show examples of how forecasting was made. On August 26, the National Hurricane Center predicted that the moving northward storm was going to turn to the left, and one day later the forecast clearly showed that Sandy would make landfall in the New Jersey and New York area; but how does the National Hurricane Center predict a storm's path? They use computer models to forecast tropical cyclones. The intensity of the storm is estimated from space, which is very useful for forecasting. Aircrafts investigate storms and make measurements that are used by computer models, but now drones can be flown directly into hurricanes. They can stay in the air for a much longer time than manned hurricane hunter aircraft. Scientists use all the data gathered from satellites and direct airplane measurements to understand the physics of hurricanes - how they are born, how they move, and how they intensify, weaken and die - and then translate their knowledge into mathematical equations that can be used for forecasting. Another critical aspect of the ocean/atmosphere interactions is the temperature of the water. It drives how a hurricane changes over time. If the temperature of the water changes, so does the intensity of the hurricane, and this helps to understand the future intensity of the storm.

Climate models do global projections 50-100 years into the future. When many computer models converge on a similar scenario, scientists have confidence that their projections are reasonable. The number of category 3 and stronger tropical cyclones are projected to increase due to the warming ocean. The climate models also predict 20 percent more rain during tropical storms, leading to more inland flooding. Tropical cyclones generate significant storm surges and coastal flooding that will increase due to sea level rise. Coastal regions have a precarious future, and we need to be prepared to deal with high intensity storms in the future.

O. Collaborations Among the Pacific Islands

Dr. Judy Lemus, University of Hawaii

The Pacific Islands make up three million square miles; it's a huge area with a lot going on in ocean science education. The Pacific Islands Ocean Observing System, or PacIOOS is an example. There are seven general PacIOOS regions involved, and Hawaii is the hub. One of the most useful resources is the PacIOOS Voyager, which has some data streaming through websites. There's the Mo'orea Coral Reef Long-Term Ecological Research, which focuses on advanced understanding that enables accurate forecast of behavior of coral reef ecosystems to environmental forcing. CReSCyNT (Coral Reef Science and Cyber Infrastructure Network) is working to standardize and visualize the huge variety of data on coral reefs to better meet the needs of both researchers and users; one of the core disciplinary nodes is education. The Polynesian Voyaging Society Malama Honua Worldwide Voyage is a three-year Hawaiian canoe voyage to spread the message of "caring for our island earth", with education being done in every single port. NOAA Sea Grant has two programs in the islands, which a focus on biodiversity, sustainability climate change, coastal storms, and hazards. The Voices of the Sea program is a 30-minute TV series with online companion extensions. PCEP or Pacific Islands Climate Change Education Partnership is NSF funded and works to empower students and communities to address the urgency of climate change within the Pacific Islands. COSEE Island Earth conducts Climate Science Teacher Institutes for PCEP, as well as Communicating Ocean Science Workshops in Hawaii and Guam. In addition, the All Things Marine Science monthly radio show airs in Hawaii and recordings will soon be available in American Samoa.

Figure 10. Observation Systems in the Pacific offer opportunities to engage the public in ocean science research.

P. Ocean Science for Coastal Resiliency

Judith Swift, Coastal Institute, University of Rhode Island

Here in Rhode Island, we are concerned with sea level rise, especially with the increased number of storms and the intensity of those storms. Unfortunately, the adaption and mitigation tools are not enough, because the whole system is designed to respond after the fact, when effective interventions to overcome risk, understanding barriers to mitigation and adaption, and creating redeveloped regulations should be in place for effective resiliency.

After each storm, the politicians come out and say we will rebuild and come back stronger than before. However, the real question is, what do we do to get people think more about this? It is important to communicate risk and use a Communicative Risk Motivation Action model to move people from understanding to action.

With resiliency models, we have to ask ourselves, "How do we educate the public?" The Coastal Institute works with scientists and encourages them along with other stakeholders through field trips to learn each other's "language." Ultimately, education and the correct use of language will help to bring people together and build resilient coastal communities.

Q. Trans-Atlantic Update on the Galaway Agreement

Paula Kenner, NOAA Office of Education

The European Union and United States Science and Technology Cooperative Agreements built the framework and the basis for a successful collaboration in commonly determined areas of interest. They identify priorities and possible instruments for joint cooperation and are a privileged platform for political dialogue. In the case of the U.S., the European Union has a Science and Technology Agreement from 1998, which was renewed in 2004, 2009, and just recently in 2014. The EU-US Joint Consultative Group decided there was a need for a Marine and Artic Working Group, and there are five themes that exist within the working group: ocean stressors, ocean observing systems, marine microbial ecology, aquaculture, and ocean literacy. In May 2013, *The Atlantic: A Shared Resource* was finalized, creating the Galway Agreement between the European Union (EU), Canada, and the United States. With the incorporation of ocean literacy into the Galway Agreement, there have been complementary activities such as Ocean Sampling Day, and online workshops through the College of Exploration, and more involvement in the European Marine Science Educators Association conference, which consequently led to the Trans-Atlantic Workshop on Ocean Literacy. With Horizon 2020, the EU launched a grand Blue Growth initiative to support efforts within the EU related to ocean research. One of the Horizon 2020 projects, *Sea Change*, has an International Advisory Group (IAG) with 12 members from nine countries, which is tasked with sharing knowledge and providing guidance and feedback. The IAG members are intended to act as ocean science education liaisons and advocates. A Trans-Atlantic Ocean Literacy meeting has been planned in Copenhagen for fall 2015.

R. Building a Global Ocean Science Education Network

After the completion of all the presentations, the GOSE participants, panelists, and speakers discussed what it would take to build an international global ocean science education network. It was suggested that a COSEE-type network could provide best practices across the globe, as well as vetting those practices, and provide ocean science education resources to those who are interested. With there being so many national networks and organizations related to ocean science, an international network, such as COSEE, could work to act as the connector between the national organizations and serve as platform for connecting activities, resources, and ideas. For such an international network to be effective, there is a need for making an impact on decision makers. Considerations include how to operate within the rules and regulations for each country. As a whole, the GOSE participants acknowledge the need to broaden the participation in subsequent workshops with the involvement of more countries and more voices. Other important considerations include identifying the needs for the global ocean science education network and mapping out a strategy for the future. It was suggested that this could be accomplished through a needs assessment followed by developing the structure of the network. Then the structure of the network could be developed. The group agreed that a united voice, common messaging, and a deliberate strategy would be powerful.

S. Next Steps: Reports from Working Groups

The final agenda item for the GOSE Workshop was for participants to break into five groups, reflect on the past two days of presentations and discussions, and address the following questions, in regard to producing the GOSE Workshop Report.

Group 1: Summarize the priorities for global ocean science education identified on day one and provide specific examples of how these priorities can be addressed through international collaborations in the next few years.

Objective: Identify the science concepts for informed decision-making with a two-tiered approach: (1) very large global issues and (2) connected regional/local issues

Priority topics include:
Dexoygenation
Climate Change and Weather
Biodiversity
Microplastics/Pollution
Fisheries and Food Security
Water Availability
Ocean Stressors

Major topical ocean priorities are:
1. Fisheries and Biodiversity (including food security)
2. Climate Change (ocean's affect on climate and fresh water resources and climate's affect on ocean systems)
3. Deoxygenation of coastal waters
4. Oceans and Human Health (including coastal resiliency)

Major process priorities include:
1. Communication and teaching training for scientists
2. Increasing diversity of the ocean science profession
3. Educating decisions makers
4. Reforming undergraduate ocean science education
5. Support ongoing global ocean literacy efforts

These priorities can be addressed through:
- international collaborations such as Ocean Sampling Day or other international citizen science events
- the coordination of regional scale network meetings (IPMEN and EMSEA) around common themes
- better use of and coordinated efforts in using social media
- engaging UNESCO

Group 2: Provide specific examples of how international ocean science research programs or large national programs could be integrated with/connected to elementary, secondary, and undergraduate ocean science education initiatives. Provide action steps for how this can be achieved in the next few years and how international collaboration could support these steps.
Recommendations from this group are:
- Make available real time data sets and lessons plans to the public (such as OOI data)
- Promote a clearinghouse for ocean science resources (such as The Bridge)
- Encourage, coordinate, and advocate for program, such as GK-12, to train young scientists

The important notion is to find programs that work and are scalable to a national and international level.

Group 3: Provide specific examples of how international ocean science research programs or large national programs could be integrated with/connected to public ocean science education. Please provide action steps for how this can be achieved in the next few years and how international collaboration could support these steps.
This group recommended that available online resources that already exist, such as the International IODP, GOOS, Ocean Portal, and World Ocean Observing websites, could be collected and/or modified and made more globally available. The group also felt that citizen science programs are an important tool for reaching the public.

Group 4: Provide recommendations for building the global network focused on ocean science education. Please include specifics, such as membership suggestions, other networks with whom to connect, organizational structure, next steps for the community, meeting frequency, etc.

This group's recommendations are:

- Address the need for an international network of networks and develop formal structure and guidance
- Groups such as the International Ocean Council should be involved
- More nations and other parties (such as policy makers, business leaders, and funders) need to be present at future meetings and involved in conversations such as those in the workshop
- Reinforce the model of IPMEN, and how collective expertise engages with the community
- Explore the potential of a global convening organization (perhaps COSEE).

Group 5: Provide some examples of local issues that are affected by ocean processes and how these could be made relevant within and across national boundaries. Please brainstorm about how these issues could be made relevant to individuals to increase individual understanding, motivate action, and change behaviors.

Group 5 recommends that common threads need to be identified among participants from different states and countries, which meet the criteria of both locally relevant and place-based relevancy. These issues include:

- Seafood availability and affordability
- Loss of maritime knowledge
- Extreme weather and natural hazards
- Marine pollution
- Harmful algal blooms
- Sea level rise
- Beach closures

Other recommendations include:

- Use unifying themes that focus on family, health, and economics as ways to get people invested
- Bring social scientists into the conversation to discuss how to achieve behavioral change
- Develop strategies to connect individual ocean science and education institutions and organizations around the world so that the collective becomes stronger than the sum of individuals
- Build a global network of networks

Appendix A
GOSE Workshop Agenda

Friday, June 26, Priorities for Ocean Science Research and Education

8:15	Participant pick up at Hampton Inn hotel
8:15	Registration
9:00	Welcome, Graduate School of Oceanography Dean, Dr. Bruce Corliss
9:15	Introductions, Gail Scowcroft, URI/GSO Inner Space Center, and Peter Tuddenham, College of Exploration
10:00	Meeting Goals and Orientation, Peter Tuddenham, College of Exploration, U.S.A.
10:10	Critical Global Ocean Science Topics, Francesca Santoro, United Nations Educational, Scientific and Cultural Organization (UNESCO), France
10:25	Ocean Research Priorities, Dr. James Yoder, Woods Hole Oceanographic Institute, U.S.A.
10:40	Setting Priorities for Ocean Science Education, Breakout Groups
11:10	Coffee Break
11:30	Breakout Group Reports and Discussion of Global Ocean Science Education Priorities
12:30	Communication Technologies – Opportunities for Virtual Engagement, Dr. Dwight Coleman, URI/GSO, Inner Space Center, U.S.A.
12:45	Lunch and Tours of the Inner Space Center
14:00	Use of Communication Technologies
14:20	Leveraging International Ocean Research Technologies, Dr. Scott Glenn, Ocean Observing Initiative, Rutgers University, U.S.A.
14:45	Panel I: Undergraduate Ocean Education Across the Ocean Basins Dr. Harry Briedahl, Nautilus Educational/Monash University, Australia Dr. Danilo Koetz de Calazans, Instituto de Oceanografia Rio Grande, Brazil Dr. Jan Hodder, University of Oregon, U.S.A. Dr. Tsuyoshi Sasaki, Tokyo University of Marine Science and Technology (TUMSAT), Japan
15:30	Coffee Break
15:50	Panel II: Graduate Ocean Education Across the Ocean Basins Dr. Jacqueline Dixon, University of South Florida, U.S.A. Dr. Ivo Grigorov, Technical University of Denmark, Denmark Emily King, Xiamen University/COSEE China, China Dr. S. Bradley Moran, URI/GSO, U.S.A.
16:35	Panel III: Elementary and Secondary Ocean and Great Lakes Education Dr. Susan Gebbles, Dove Marine Laboratory, United Kingdom Lyndsey Manzo, Ohio Sea Grant, U.S.A. Dr. Martina Milanese, Studio Associata Gaia, Italy

17:15	Education Pipeline Collaborations, Breakout Group Discussions
17:45	Reflections on the Day
18:00	Dinner, Mosby Center
18:00	Shuttle to Hampton Inn hotel
20:00	Shuttle to Hampton Inn hotel for dinner participants

Saturday, June 27, International Collaborations

8:30	Participant pick up at Hampton Inn hotel
8:30	Registration
9:00	Panel IV: Public Ocean Education Across the Ocean Basins Fiona Crouch, Marine Biological Association, United Kingdom Dr. Mohammad Muslem Uddin, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh Grazyna Niedoszytko, Gdynia Aquarium National Marine Fisheries Research Institute, Poland Anne Stewart, Pearson College, Canada James Wharton, Seattle Aquarium, U.S.A.
9:45	Leveraging International Ocean Science Research Programs for Education, Breakout Group Discussions
10:30	Breakout Group Reports
11:00	Coffee Break
11:20	Advancements in Tropical Cyclone/Hurricane Forecasting, Dr. Isaac Ginis, URI/GSO, U.S.A.
11:40	Collaborations Among the Pacific Islands, Dr. Judy Lemus, University of Hawaii, U.S.A.
12:10	Ocean Science for Coastal Resiliency, Dr. Judith Swift, Coastal Institute, URI/GSO, U.S.A.
12:30	Lunch
13:30	Trans-Atlantic Update on the Galway Agreement, Paula Keener,
National	Ocean and Atmospheric Administration (NOAA), U.S.A.
14:00	Building a Global Ocean Science Education Network, Group Discussion, Gail Scowcroft, URI/GSO Inner Space Center, U.S.A.
14:45	Workshop Report: Setting the Course, Working Groups
15:30	Coffee Break
15:50	Workshop Report: Setting the Course, Working Groups, continued
16:30	Reports from the Working Groups
17:15	Final Reflections, Gail Scowcroft, URI/GSO Inner Space Center, U.S.A.
17:30	Adjourn
18:00	Shuttle to Hampton Inn hotel

Appendix B: GOSE Workshop Participants

Babb, Ivar
Northeast Underwater Research Technology & Education Center
University of Connecticut
babb@uconn.edu

Bastidas, Carolina
Massachusetts Institute of Technology
Sea Grant College Program
bastidas@mit.edu

Batista, Vanessa
Ciencia Viva Agência Nacional para a Cultura Científica e Tecnológica
vbatista@cienciaviva.pt

Bishop, Tina
College of Exploration
tina@coexploration.net

Bissonnette, Jennifer
Nature Lab
Rhode Island School of Design
jbissonn@risd.edu

Breidahl, Harry
Nautilus Education
Monash University
nautilus.ed@me.com

Brown, Shelley
Sailors for the Sea
shelley@sailorsforthesea.org

Calazans, Danilo
Instituto de Oceanografia Universidade Federal do Rio Grande
doclarva@furg.br

Chan, Steve
Sensemaking U.S. Pacific Command Fellowship
stevechanksg@gmail.com

Chilton, Linda
University of Southern California Sea Grant Program
lchilton@usc.edu

Coleman, Dwight
Graduate School of Oceanography
University of Rhode Island
dcoleman@uri.edu

Cooper, Sharon
Consortium for Ocean Leadership
sCooper@oceanleadership.org

Corliss, Bruce
Graduate School of Oceanography
University of Rhode Island bcorliss@uri.edu

Couchon, Kathleen
Narragansett High School
kcouchon@narragansett.k12.ri.us

Crouch, Fiona
Marine Biological Association, United Kingdom
ficr@MBA.ac.uk

DeCarlo, Linda
Sawgrass Springs Middle School
linda.decarlo@browardschools.com

Diederick, Laura
Smithsonian Marine Station
dierderick@si.edu

Dixon, Jacqueline
College of Marine Science
University of South Florida
jdixon@usf.edu

Duncan Seraphin, Kanesa
University of Hawaii Sea Grant, Curriculum Research & Development Group, COSEE Island Earth kanesa@hawaii.edu

East, Jenny
Hatfield Marine Science Center
Oregon Sea Grant
east.jenny@gmail.com

Franks, Valerie
Lexington Public Schools
vfranks@sch.ci.lexington.ma.us

Gebbels, Susan
Dove Marine Laboratory
susan.gebbels@ncl.ac.uk

Gingras, Andrea
Graduate School of Oceanography
University of Rhode Island
agingras@uri.edu

Ginis, Isaac
Graduate School of Oceanography
University of Rhode Island
iginis@uri.edu

Glenn, Scott
Rutgers University
glenn@marine.rutgers.edu

Govenar, Breea
Rhode Island College
bgovenar@ric.edu

Greely, Teresa
College of Marine Science
University of South Florida
greely@usf.edu

Grigorov, Ivo
Technical University of Denmark
ivgr@aqua.dtu.dk

Hagley, Cynthia
Minnesota Sea Grant
University of Minnesota
chagley@d.umn.edu

Haynes, Susan
NOAA Office of Ocean Exploration and Research
susan.haynes@noaa.gov

Hodder, Jan
Oregon Institute of Marine Biology
University of Oregon
jhodder@uoregon.edu

Kablik, Diane
Concord Public Schools
dkablik@colonial.net

Keener, Paula
NOAA Office of Ocean Exploration and Research
paula.keener@noaa.gov

King, Emily
Xiamen University

COSEE China
ehk_cosee_china@xmu.edu.cn
Kirch, Christine
West Warwick High School
ckirch@westwarwickpublicschools.co
m

Knowlton, Sarah
Rhode Island College
sknowlton@ric.edu

Kuzmickas, Alison
Sensemaking- U.S. Pacific Command
Fellowship
ali.kuzmickas@gmail.com

Leavitt, Kate
Seacoast Science Center
k.leavitt@seacentr.org

Lemus, Judith
University of Hawaii
Hawaii Institute of Marine Biology
jlemus@hawaii.edu

Lockwood, Lucy
University of Massachusetts Boston
coastalsci@verizon.net

Mace, Trish
Smithsonian National Museum of Natural
History
macet@si.edu

Manzo, Lyndsey
Ohio Sea Grant
ManzoL@westerville.k12.oh.us

McLaughlin, Diana
The Prout School
dmclaughlin@theproutschool.org

Michalopoulos, Christos
NOAA Office of Education
christos.michalopoulos@noaa.gov

Milanese, Martina
Studio Associata Gata
m.milanese@studioassociatogaia.com
Miller, Ashley
Fairfax County Public Schools
amiller121@gmail.com

Moran, Brad
Graduate School of Oceanography
University of Rhode Island
sbmoran@uri.edu

Morin, Holly
Graduate School of Oceanography
University of Rhode Island
holly_morin@uri.edu

Niedoszytko, Grazyna
National Marine Fisheries Research
Institute, Gdynia Aquarium
gniedoszytko@mir.gdynia.pl
Papathanassio, Martha
Hellenic Centre for Marine Research
mpapath@hcmr.gr

Parson, Karen
Chariho High School
karen.parson@chariho.k12.ri.us

Payne, Diana
University of Connecticut
Connecticut Sea Grant
diana.payne@uconn.edu

Peri, Francesco
University of Massachusetts Boston
francesco.peri@umb.edu

Romy Pizziconi
University of Rhode Island
Graduate School of Oceanography
romy@uri.edu

Repa, J Theodore
Darling Marine Center

University of Maine
jtheodorerepa@gmail.com

Podlesinska, Weronika
National Marine Fisheries Research Institute, Gdynia Aquarium
wpodlesinska@mir.gdynia.pl

Rotatori, Jeanne
The Prout School
jr81796@verizon.net

Santoro, Francesca
United Nations Educational, Scientific and Cultural Organization (UNESCO)
f.santoro@unesco.org

Sasaki, Tsuyoshi
Tokyo Unviersity of Marine Science and Technology
t-sasaki@kaiyodai.ac.jp

Schiebel, Hayley
University of Massachusetts Boston
hayleyschiebel@gmail.com

Scholl, Maryann
Graduate School of Oceanography
University of Rhode Island
mscholl@uri.edu

Schroeder, Stephanie
Center for Dark Energy Biosphere Investigations
University of Southern California
slschroe@usc.edu

Scowcroft, Gail
Graduate School of Oceanography
University of Rhode Island
gailscow@uri.edu

Skrabal, Stephen
University of North Carolina Wilmington
skrabals@uncw.edu

Spousta, Robert
Network Science Research Centre
Swansea University
spousta@mit.edu

Stewart, Anne
Canadian Network for Ocean Education
Pearson College
astewart.bamfield@gmail.com

Swift, Judith
Graduate School of Oceanography
University of Rhode Island
jswift@uri.edu

Tuddenham, Peter
College of Exploration
peter@coexploration.net

Uddin, Mohammad Muslem
Institute of Marine Sciences and Fisheries
University of Chittagong
mmu_ims76@yahoo.com

Wharton, Jim
Seattle Aquarium
J.Wharton@seattleaquarium.org

Yarincik, Kristen
Consortium for Ocean Leadership
kyarincik@oceanleadership.org

Yoder, James
Woods Hole Oceanographic Institution
jyoder@whoi.edu

Zettler, Erik
Sea Education Association
ezettler@sea.edu