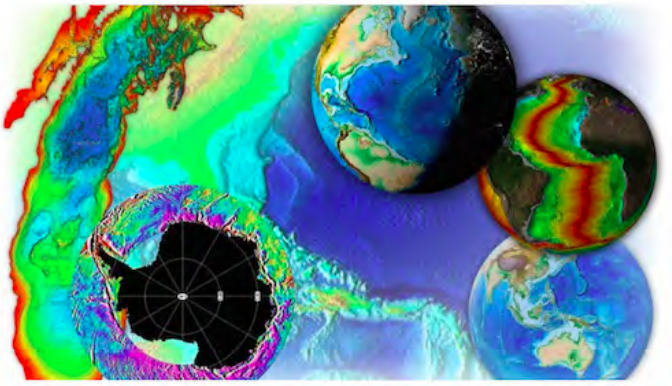
2016 Global Ocean Science Education Workshop

June 13-15
UNESCO Headquarters
Paris, France



Workshop Report

Gail Scowcroft, Francesca Santoro, Peter Tuddenham, and Andrea Gingras

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Executive Summary

The first Global Ocean Science Education (GOSE) Workshop in June 2015 brought together ocean scientists and education professionals from 15 nations. Panels discussed ocean science education across the K-12 pipeline, undergraduate and graduate education, and public education. Working groups discussed the future of global ocean science education, opportunities and steps for building international collaborations, and establishing a global network of networks.

During the 2015 workshop, consensus was reached on three major topical priorities for current international collaborative ocean science education efforts:

- The Ocean and Human Health, including Coastal Resiliency
- The Ocean's Role in Climate Change and the Effect of Climate Change on Ocean Systems
- Biodiversity, including Food Security & Fisheries

Priorities were identified for ocean science topics to be integrated into education initiatives:

- Climate Change and Weather
- Loss of Biodiversity
- Dexoygenation of Coastal Waters
- Microplastics/Pollution
- Ocean Stressors

Process priorities were identified for the global ocean science education community:

- communication and teaching training for scientists and graduate students
- education and resources for decision makers
- reform of undergraduate ocean science education
- support for ongoing global ocean literacy efforts
- increasing diversity in ocean science
- establishment of a network of networks

It was clear after the first workshop that for a truly global ocean science education network to be effective, other stakeholders needed to be part of the conversation. A conscious effort was made in planning the 2016 workshop to include policy makers and business/industry leaders in addition to scientists and education professionals.

The 2016 workshop was sponsored and facilitated by the global Consortium for Ocean Science Exploration and Engagement (COSEE), the UNESCO Intergovernmental Oceanographic Commission (IOC), and the College of Exploration (CoE). In addition, the workshop was supported by the European Commission and the Institute of Marine Engineering, Science and Technology (IMarEST). COSEE has grown from a national, United States (US) network, funded by the National Science Foundation, to an independent international organization that now accepts non-U.S. members. Since its inception, COSEE has focused on building strong working relationships between ocean science research and education, integrating current research into education initiatives and training scientists, teachers, and students of all ages. The Consortium is now building relationships with the ocean policy and industry sectors.

For 25 years, the College of Exploration (CoE) has been building global networks of ocean scientists and educators and learners of all ages around the world using technology to connect

and collaborate. The international community of ocean educators and ocean researchers working together is growing. The European Union, Canada and the USA signed the Galway Agreement in 2013 to encourage joint ocean science research projects and to work together to promote ocean literacy. CoE is working to support related initiatives world-wide.

The IOC was established by UNESCO in 1960 and currently has 148 Member States. The Commission assists governments to address their individual and collective ocean and coastal management needs, through the sharing of knowledge, information and technology as well as through the coordination of programs and building capacity in ocean and coastal research, observations and services. It is the only UN body specialized in ocean science and services. The IOC has been a key player in the recent international debate on sustainable development as it relates to the ocean, and in the international negotiation on climate change, highlighting the role of the ocean in the climate system.

In the spirit of engagement and exploration, the three hosting organizations encouraged participants of the 2016 GOSE Workshop to build stronger connections and professional working relationships throughout the global ocean science community - ocean scientists, students, ocean science education professionals, policymakers, and industry leaders. The workshop provided the opportunity to meet colleagues from across the globe, to engage in stimulating dialog, and contribute participant expertise. Sixty participants from 19 nations and 12 US states participated in the 2016 GOSE Workshop, held at UNESCO Headquarters in Paris. Represented countries included Algeria, Belgium, Brazil, Columbia, England, France, Germany, Greece, Ireland, Italy, Korea, Mexico, Peru, Poland, Portugal, Spain, Togo, and U.S. In addition, several national and international agencies were represented, including the European Commission (EC), the IOC, the US National Oceanic and Atmospheric Administration, the Italian National Research Council, and several research and academic institutions, NGOs, and businesses.

Workshop Goals

The goals for the 2016 workshop were focused on forging new connections within the global ocean science community. The goals were to:

- Bring together the ocean science, education, policy and business sectors;
- Form new partnerships to take action on global ocean science education priorities;
- Develop collaborative, cross-sector activities; and
- Identify next steps for the global ocean science education community, looking forward to 2017.

Ocean Science Community Challenges

Several challenges to the ocean science community cross national borders. GOSE workshops attempt to address these challenges through panel presentations and discussions.
The challenges include developing strategies to:

- Conduct ocean science research that benefits society
- Develop catalytic partnerships between ocean science sectors
- Foster communication and coordination among ocean science education programs
- Promote ocean science as an interdisciplinary tool for improving science education
- Increase the participation of students from populations that are under-represented in the ocean sciences

2016 GOSE Workshop Topics

To meet workshop goals and address community wide challenges, the following topics were covered during the 2016 workshop:

- The Role of Education and Capacity Development in International Ocean Governance
- Science, Education, Business, and Policy Roles in Implementing International Policies Related to the Ocean
- The Ocean and Human Health
- The Blue Economy and Workforce Needs
- Influence of Informal Science Education on Policy
- The United Nations Education for Sustainable Development Goal (SDG) 4 (Ensure inclusive and equitable education and promote lifelong learning opportunities for all), SDGs 14 (Conserve and sustainably use the oceans, seas, and marine resources for sustainable development), and SDG17 (Strengthen the means of implementation and revitalize partnership for sustainable development)
- Effective Practices in Ocean Citizen Science
- New Partnerships – Building on the Success of the *Galway Statement on Atlantic Ocean Cooperation*
- Goals and Next Steps for the Global Ocean Science Education Community

Key Workshop Outcomes

It is clear that a global ocean science education network is emerging, building on the work of the COSEE. All the reflective breakout groups expressed a need for ways to stay connected in between GOSE Workshops. Each group suggested that working groups would be a good way for participants to remain engaged throughout the year. Other themes that emerged over the course of the workshop included a need for GOSE community professional development in areas such as marketing strategies and developing messages that we could all use in our respective efforts. Future workshops should continue to include the four sectors of ocean science research, education, policy, and industry with goals to work more closely together to provide student internships and develop an ocean science certification program for industry professionals. Finally, a key recommendation emerged to develop and administer a survey that would identify the needs of the GOSE community to inform planning for the 2017 GOSE workshop.

This report provides a summary of the workshop presentations and discussions, organized by day. The appendix includes the workshop agenda and a list of meeting participants.

Gail Scowcroft
Consortium for Ocean Science Exploration and Engagement
University of Rhode Island Graduate School of Oceanography

Peter Tuddenham
College of Exploration

Francesca Santoro
Intergovernmental Oceanographic Commission of UNESCO

Monday, June 13, 2016

Plenary Session: The Role of Education and Capacity Development in the Context of International Ocean Governance

Claudia Delgado, Intergovernmental Oceanographic Commission

The Intergovernmental Oceanographic Commission (IOC) is the only intergovernmental organization mandated to promote marine science in all ocean basins. It has four high level objectives: to prevent and reduce impacts of natural marine hazards; mitigate impacts and adapt to climate change; safeguard the health of ocean ecosystems; and promote policies for sustainability. A key IOC goal is to build knowledge and capacity for sustainable ocean management. Five key areas have been identified in order to build capacity: ocean research, observing systems/data management, assessment to inform policy, sustainable management and governance, and early warning services.

Because of its position within the United Nations (UN) system, the IOC is well placed to play a significant role in supporting its Member States in national development efforts related to the ocean. The IOC has global programs that include ocean data information networks, the ocean teacher global academy project, and a tsunami warning program. An IOC strategy is to provide an opportunity to build partnerships, rather than to provide simple assistance in capacity development. Parallel to this, the IOC works with partner organizations, including the World Meteorological Organization, Partnership for Observation of the Global Oceans, the Scientific Committee on Ocean Research, the International Ocean Institute, IOI, the European Commission, etc. New IOC capacity building initiatives intends to build on and optimize these partnerships.

In 2012 during the RIO+20 conference, the IOC made a voluntary commitment to build global capacity for marine sciences, ocean observation, and transfer of marine technology. Between June 2013 and June 2014, during the 27th Assembly, the IOC established a working group for the development of its capacity development strategic plan. In July 2014 and February 2015, the representatives of this working group were identified. The final version of the capacity development strategy (CDS) was later approved in 2015. Central to the IOC's CDS is a commitment to enable all Member States to participate in, and benefit from, ocean research and services that are vital to sustainable development and human welfare on the planet. Six outputs are identified in the CDS:

1. Human resources developed
2. Access to physical infrastructure established or improved
3. Global, regional and sub-regional mechanisms strengthened
4. Development of ocean research policies in support of sustainable development objectives promoted
5. Visibility and awareness increased
6. Sustained (long-term) resource mobilization reinforced

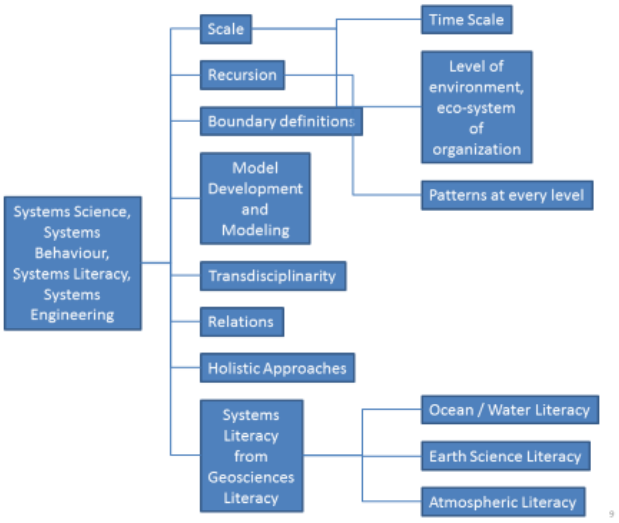
These outputs will be achieved through a number of targeted activities and related actions made possible by inputs such as funding, human resources, and institutional resources. Activities include support for higher education and gender balance in ocean sciences, the development of national marine science management procedures and policies, development of ocean literacy.

The IOC will promote and assist with the organization of training courses and workshops. It will also assist with the establishment of an internship/fellowship program, a visiting lecture program, regional training, and sharing of training materials.

In 2016, the IOC launched its Capacity Development website (www.ioc-cd.org). In addition to capacity development information, the site provides listings of education and proposal opportunities and events. The Capacity Development Fund is a new mechanism for supporting capacity development, training courses, workshops, travel grants. An IOC education initiative is the Ocean Teacher Global Academy, which provides an e-learning platform (www.oceanteacher.org) made available through ocean teacher video channel. Topics include Marine GIS, Biogeography, Cruise Planning, and Oceanographic Sampling. The program aims at having regional training centers around the world. Currently, ten regional training centers are in place and implementing their own training courses this year.

Plenary Session: Integrative and Innovative Systems Approaches to Volatile, Uncertain, Complex and Ambiguous (VUCA) Problems
Peter Tuddenham, College of Exploration (US and United Kingdom)
Global ocean science education is now increasingly important. Taking a global perspective changes the way we view our relation to each other as we move from a national and international perspective to a global perspective. The systems approach to understanding behavior of complex systems and relations offers global ocean science educators pedagogies, methods, techniques, and models to help address the issues identified in the GOSE 2016 workshop.

The U.S. Military coined the term VUCA to describe environments that we are now experience. VUCA stands for **Volatility,** that may lead to sudden, unpredictable, or explosive change. **Uncertainty** is related to unpredictability, indeterminacy, and indefiniteness. **Complexity** refers to increased numbers connections, interrelations, and indeterminate causal relations. **Ambiguity** is found in many issues and their possible remedies of interpretations in two or more distinct ways. Systems science can assist the global ocean science education community to design and implement education programs to address global ocean education priorities. The figure below illustrates a potential approach to incorporate lessons from systems science to assist with understanding and working on issues identified in this workshop:



Panel I: Science, Education, Business, and Policy Roles in Implementing International Policies Related to Ocean

Moderator: Francesca Santoro, Intergovernmental Oceanographic Commission
Panelists:
• Stephen Hall, National Oceanography Centre and IOC vice-chair (UK)
• Bev Mackenzie, Institute of Marine Engineering, Science and Technology (UK)
• Norma Patricia Muñoz Sevilla, Instituto Politechnico Nacional (Mexico)
• Françoise Gaill, Centre national de la recherche scientifique (France)

Stephen Hall
Claudia Delgado gave a good introduction to the IOC. It's the only intergovernmental body in the UN system that specializes in ocean science, services, observations, data exchange, and capacity development. As the advisory science body to the UN convention on the Law of the Sea (UNCLOS), it puts us in a key position. We have a 148 member states; and the main objectives are a healthy ocean, early warning for ocean hazards, resilience of society and ecosystems to climate change and variability, and knowledge of emerging issues.

The IOC has an executive council that meets each year with representatives of 44 of the 148 member states. The executive council has a chair and five vice-chairs, who are elected to represent a group of member states. As Vice-Chair of Group 1, I represent the US, Canada, Western Europe, Greece, Turkey, and Israel. It can be a challenge to be one voice representing multiple nations. The global oceanographic community is one of great diversity.

The IOC is the ocean science advisory body to the UNCLOS – we ensure that science underpins global ocean management decisions. All Members have the right to be heard and inform IOC policy and communication. The IOC secretariat is a servant of the 148 member states, and so it moves at the speed of the slowest member state. Face to face interactions and high-level networking with scientists, senior officials, civil servants, politicians, NGOs and other stakeholders remains the most effective tool for an IOC Vice-Chair. Building trust across Member States is often strongly linked to relationships and friendships. Technology and management tools are evolving rapidly. Together we can ensure clean, healthy, safe, productive and biologically diverse ocean science.

Bev Mackenzie
The Institute of Marine Engineering, Science and Technology (IMarEST) is a professional body and learned society that brings together marine engineers, marine scientists, and marine technologist into one international, multidisciplinary body. At most recent count, we had just over 18,000 members based in 128 countries. Most of our members are employed within marine industries, rather than within the academic sector; but around 4,000 of our members are either students, cadets, or apprentices. One of IMarEST's most important roles is its contribution to ensuring that the development, implementation, and regulation of existing and emerging marine activities are safe and technically, environmentally, and economically sound.

IMarEST is a Non-Governmental Organization (NGO) - as recognised by the Economic and Social Council of the UN (ECOSOC), who has oversight of all the NGOs. We work with other

maritime organizations to develop capacity, and we have an active capacity development program. We are a strategic partner of the Global Maritime Energy Efficiency Partnerships Project, a UN Development Project/Global Environment Fund/International Maritime Organization capacity development project, which aims to support increased uptake and implementation of energy-efficiency measures for shipping.

Our mission is somewhat different than most NGOs. It is to work with the global marine community to promote the scientific development of marine engineering, science, and technology, providing opportunities for the exchange of ideas and practices and upholding the status, standards, and expertise of marine professionals worldwide. We undertake all our policy activities with our vision of "a world where marine resources and activities are sustained, managed, and developed for the benefit of humanity" – put simply, we want to achieve safe, sustainable seas.

We work with our members to make sure that any developing legislation is based on sound evidence. We provide neutral, objective advice. IMarEST is one of the few marine professional bodies set up with a view to offering this service. The opportunity to participate in this work is an important IMarEST membership benefit, for it is our members that will ultimately be responsible for the implementation of policy; so they have a vested interest in ensuring its sensible development based on sound science. Membership is open; however, we make sure that our members are experts, know what they are talking about, and keep up to date. Members sign a professional code of conduct.

Inputs to UN organisations are generated either by general open calls to the members or via our network of special interest groups (SIGS). SIGS are open to all IMarEST members and exist to enable the creation and sharing of knowledge in a specialist field. They allow members to explore ideas, about which they are passionate, with others that might share or challenge their views. The SIGs bring all the experts on a particular topic into one grouping so that they are the most often used source of inputs to UN organizations.

There are some challenges faced in providing input to UN organizations. These include:

1. Different UN organizations have very different processes of engagement and very different ways in which NGOs can engage.
2. With 18,000 members it's hard to reach a consensus.
3. NGO status is very difficult to gain, but quite easy to lose. One bad move and a Member State can seek for you to be removed.
4. Science and engineering typically moves at a much faster pace than the legislation.
5. NGOs cannot influence work programs – this power is only with the Member States.
6. Trust in science and scientists can be an issue at bodies where the representation is mainly composed of lawyers or civil servants with policy backgrounds.
7. Scientists and engineers are not great at speaking in terms that policy makers and regulators understand. Inputs to regulators need to be able to be translated into policy language in order to make them useful.
8. We need to ensure that the next generation of scientists, engineers, and technologist are equipped to undertake engagement, not only with policy makers, but also with industry and that they have a well-rounded, multi-disciplinary education.

Norma Patricia Muñoz Sevilla

I will discuss experiences we have had in Mexico related to ocean policies. Ocean science education is integrated into very small numbers of programs around the world. In my institution, we have none at the undergraduate level, only in Masters and Ph.D. programs. There are nineteen research centers around the country. The Instituto Politechnico Nacional is the second largest. Four are working in ocean, marine, or environmental science.

One research center started with education in 1976, the Marine Science Center in La Paz. In Mexico City, the research center offers a Master's Degree in management and environmental supervision. There are local, state, regional, and international councils that focus on ocean health. Ocean scientists give their time and work for free, going to meetings, doing papers, etc. We need to go further. Show people, show the young people that the ocean is not so blue.

Starting in 1998, members of the sustainability council developed the first national environmental policy for sustainable development of ocean and coast in Mexico. After 10 years, we have already made progress. It is an example of going from bottom to top - society decided together to develop the policy. Mexico is a country between two oceans. As scientists, we must conduct education and research together. We also need to learn from each other. If we make mistakes, we need to learn from them.

Françoise Gaill

The ocean-climate.org platform was established in June 2014 and officially launched on the World Oceans Day celebration in UNESCO Headquartes in Paris. It is an international, multi-stakeholder collaborative platform composed of scientific organizations, universities, research institutions, environmental and business associations, foundations and science centers, private foundations, and public institutions. One of the platform's key goals is to have the ocean included in the future climate change discussions and contribute to a successful outcome of the COP21 negotiations, as the ocean was absent to the text of the COP21 event. We also support the development of scientific knowledge related to the interactions between the ocean and climate and seek to raise awareness among the public and private decision-makers of ocean and climate concerns.

The platform's recent outcomes include a series of pedagogical fact sheets on the role of the ocean on climate and the impact of climate change on the ocean; an advocacy strategy to integrate the ocean into climate negotiations; and a unique scientific synthesis of the issues concerning the ocean and climate.

In 2015, we had a high level scientific meeting at UNESCO Headquarters and other sessions over two ocean days during the COP21. The Ocean was named as an ecosystem in the Paris COP agreement. This means that ocean is now identified as part of the biosphere. At its 43rd Session (Nairobi, Kenya, 11 – 13 April 2016), the IPCC Panel decided to prepare a special report on climate change and the oceans and the cryosphere. These steps represent important advancements for the ocean science research and education community.

Group Discussion: How the science, education, business, and policy sectors can effectively work together to advance ocean science education.

It is important to understand the role of the IOC, the link to the private sector, what is going on in a country, and then how do we create partnerships. The key challenge in promoting ocean science education, especially in how we move from policies to action, is the whole ocean literacy challenge. We are now in the anthropocene, in a geological time where humans are the dominant force. The 148 member states of the IOC all have a role to play in ocean governance and sustainability. By 2050, there will be 9 billion people on Earth, many of whom rely on the ocean. What we do in and to the ocean affects everyone else.

Science moves much more rapidly than policy and industry. Efforts must be made to bridge these sectors. How can we help young people and train them to communicate with both scientists and policy makers? To engage diverse audiences, it is important to have good marketing and communication ideas. To grow the GOSE community, all sectors must be engaged. Businesses are good with marketing. Engaging the business/marketing sector, will be of great value. It will be important to craft clear messages as we go forward.

From the IOC's perspective, ocean literacy is greatly needed, as humans are directly impacting the ocean and the climate. All IOC Member States have a role to play in ocean stewardship. They must not think of themselves in a cocoon - that these issues do not apply to them. Impacts of ocean degradation and climate change affect us all.

What is the role of training on how to bridge the gaps between policy, education and industry? There is a vital lack of understanding of how policy making works, especially on the international level, and lack of understanding of how industry works. Finding people who truly understand both sectors are rare. This disconnect can lead to an inherent level of conflict. How can industry/companies be engaged and not be viewed as "selling out." We need to have several sectors represented as well as a high number of companies to defray this perception. We need to consider networking with trade organizations and professional societies.

Tuesday, June 14, 2016
Panel II: The Ocean and Human Health

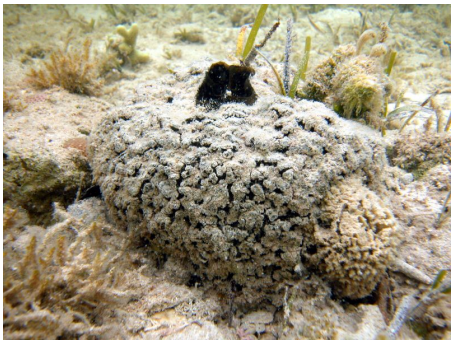
Moderator: Peter Tuddenham, College of Exploration
Panelists:
• Corey Garza, California State University Monterey Bay (USA)
• Nawel Khelil, International Ocean Institute (Algeria)
• Luis Icochea Salas, Universidad Nacional Agraria La Molina (Peru)
• Matthew While, University of Exeter (UK)

Corey Garza
There is a classic perception that the oceanic environment is a wide-open system, far removed from where many underrepresented communities live. There is little consideration of the potential relevance of the ocean to community health. Over the last 30 years, the impacts of a shifting climate have started to be observed in marine systems. These impacts, such as increasing ocean temperatures, ocean acidification (nominal rises in ocean pH), hypoxic events, and shifting species assemblages, all have the potential to affect human health.

Ocean ecosystems are host to a number of plants and animals that provide key medicinal uses for humans. Rising temperatures, fishing pressure, and ocean acidification are major threats to these resources. A good example is the Atlantic horseshoe crab (*Limulus polyphemus)*, which ranges from the US northeastern to southeastern Atlantic coast. It is a species of medicinal importance, as its blood is used to test for dangerous bacteria in pharmaceutical development and testing (clotting response). It is currently overfished as bait, and its range is being shifted due to climate change.

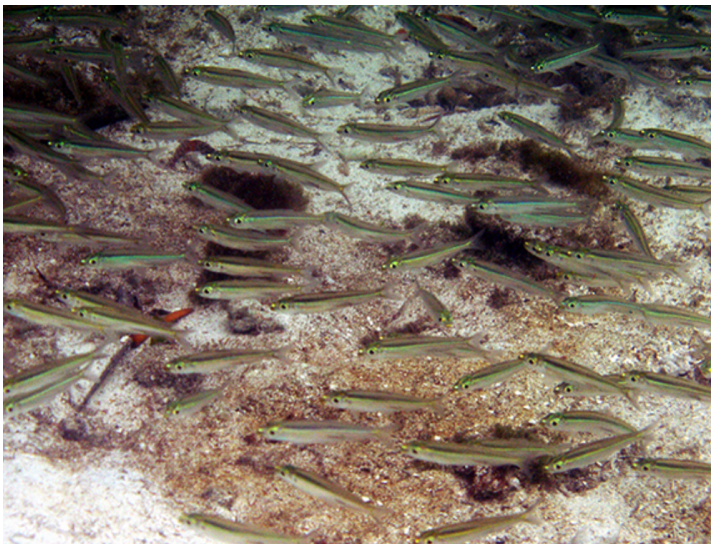
Horseshoe crab blood extraction (from: http://grist.org/animals/horseshoe-crabs-have-weird-bright-blue-blood/)

Another example can be found in tropical marine sponges, from which many antiviral drugs are synthesized. The most famously used sponge is *Tectitethya crypta*. Researchers first synthesized azidothymidine (AZT) from this sponge. AZT is s an antiretroviral medication used to prevent and treat HIV/AIDS. Ocean acidification threatens many species of sponges, including *T. crypta,* as increased calcification can interrupt the uptake of calcium in marine species such as sponges.


Tectitethya crypta off the Bahamas (from: http://www.spongeguide.org/speciesinfo.php?species=76)

Another impact of increasing ocean temperatures is the effect on species ranges. In Southern California a once dominant mussel bed community has converted to algae. Ecosystem services to people are lost through these types of shifts. Mussel beds support the lobster fishery in Southern California, as they are a key resource for reproductively active female lobsters. The lobster fishery is third largest in the state (300 + tons annually). Shellfish such as mussels also provide key ecosystem services. Shellfish can filter coastal seawater, thereby removing nutrients and pollutants from the water. This prevents hypoxic (low oxygen) events. Hypoxic events are now occurring world-wide. In Brittany, the excess algae that forms after hypoxic events can liter beaches and emit toxic gases as it decays. This phenomena can endanger human life and has been known to be the cause of death.

Low awareness of the connections between the ocean, its resources, and human health causes a lack of personal connection to the ocean; unclear understanding by the public; ineffective messaging and engagement, particularly early in the academic pipeline; and a historic overemphasis of certain fields chosen as undergraduate science and engineering majors. The ocean is a major resource. It contains the largest source of food on the planet. For centuries the shear vastness of the ocean and the fact that humans are naturally ill equipped to enter water kept many ocean resources safe from human impacts. However, advances in fisheries technology and shifts in the global climate in the twentieth century have changed all this. In the past, dependence on wind power and the lack of electronic equipment limited the effectiveness of fishing vessels. Modern vessels have greater range, speed, capacity, and, thanks to radar and sonar, the ability to track large schools of fish. Schools of herrings, sardines, and anchovies account for the largest tonnage of harvested fishes.



School of herring off Puerto Rico (NOAA CCMA Biogeography Team)

Oceans, seas, and coastal areas provide humankind with manifold goods and ecosystem services fundamental to human well-being, global food security, and nutrition. Worldwide, nearly three billion people receive 20 percent of their daily animal protein intake from fish. Every day, capture fisheries and aquaculture farms harvest more than 400,000 tons of fish. Some 40 percent of the world's population is estimated to live within 100 km of the shore. Employment in fisheries and aquaculture has continued to grow faster than in agriculture - providing about 55 million jobs worldwide. Including ancillary activities (e.g. processing and packaging) and dependents, these sectors support the livelihoods of 10-12 percent of the world's population.

Addressing issues related to the ocean and human health, as well as the health of the ocean itself, will require involving new and diverse approaches to the broader field of Ocean Science. Messaging that resonates with the cultural values of diverse student communities (e.g. service to community) will be key. It will be critical to develop new strategies that include diversifying the academic and career pathways for students from underrepresented communities. Finally, as a global community, we must assess the role we need to play in combating ongoing and emerging threats to the ocean.

Nawel Khelil

Historically, research and regulatory concerns have concentrated on the impact of human activities on the marine environment, particularly through anthropogenic pollution and the over-exploitation of marine resources. Over the last few decades, many health problems have appeared, which are related to human activities conducted all along the coastal zone. Over urbanization, waste water discharges, and industrial pollution have not only impacted the marine environment. They have also affected human health.

Algeria can be an example to understand the interaction between ocean and human health. It has 1622 km of coastline and a high diversity of marine ecosystems. One of the most important characteristics of the Algerian coastal zone is that it has a very high population. Over 40% of our population lives within 100 km of the coast, which represents only 2% of the nation's geographic area. This concentration of the population creates, necessarily, a high quantity of waste water, which in Algeria is still less treated before being discharged in the sea. It contains domestic and agricultural nutrients; pesticides; pollutants from road run-off, personal care products, disinfectants, and pharmaceuticals; and novel chemicals. There are high numbers of waste water discharges all along the Algerian coast. This has serious impacts on human health. Many beaches can no longer allow swimming.

Another issue is the impact of the industrial pollution on human health. Fifty percent of the Algerian industrial units are located in the north of the country. A recent case, involving the paper industry, documented that the company had not yet correctly installed its industrial wastewater treatment facility. So they dumped the polluted water directly into the Bay of Bou Ismail. The paper industry is well know for producing very harmful contaminants, including chlorine dioxide (increases cancer risk), mercury, nitrates, methanol, and benzene. In addition to increasing cancer risks, effects on human health include reproductive problems, developmental problems, immune deficiencies, and hormone disruption.

Over the last few years, many harmful algal blooms (HABs) have been observed in the Algerian coastal zone and are found in the most urbanized regions, where waste water discharges are most present. In the summer, many vacationers get sick when they go to the beach. Unfortunately, there has been very little research related to the HABs and human health in Algeria. Since 2006, a monitoring system has been created to survey the apparition of HAB's during the year, and mainly in summer.

2013 Algae bloom, East Algiers coast

Marine litter, including microplastics, is also causing emerging health risks. The impact of marine litter on human health is very poorly understood. Only one study has been recently been conducted along the Algerian coast. The scientists conducting this study determined that the concentration of microplastics is 0.72 lower there than in the Northwest Mediterranean regions.

Climate change has better understood risks, including health problems from toxic invasive species and coastal flooding. It is imperative for more research to be conducted to increase the understanding of the connections between the ocean and human health and that these connections be communicated to communities.

Luis Icochea Salas

The El Niño Southern Oscillation (ENSO) is one of the most important oceanographic and meteorological events around the world that originates extremely strong oceanic changes. ENSO is caused by a relaxation of the westward blowing trade winds and a strong intensification of eastward winds. This event then allows warm water to "pile up" off the coast of Peru, deepening the thermocline and allowing an advance of warm water from the west toward the Eastern Pacific.

During the strong ENSO event 1991-92, Peru and many Latin American countries experienced serious cholera outbreaks. Thousands of people were sickened during this historic ENSO event, and this illness was extended until 1995 in many countries. It is imperative that we understand ocean circulation so that countries can better prepare for ENSO events. In addition, citizens must be better educated about the ocean and its processes.

Students of "La Molina" National Agrarian University conducting research in the Acapulco Port, Peru

What kind of Global Ocean Science Education could be conducted in strategic areas? It is important that the next generation of ocean scientists be prepared. Peru has an undergraduate course in oceanography, and during this course, scientists at the Universidad Nacional Agraria La Molina conduct hands-on research with their students. They conduct in situ, real-time measurements and analyze their data to see what is happening in their own country. This student-conducted research is providing important data about temperature trends in Peruvian ports.

The teaching about the importance of the ocean must begin in primary schools. Knowledge in oceanography could be introduced for all students, and ocean science needs to be related to other sectors, such as the economy, agriculture, political sciences, etc. A good method to teach oceanography is to provide opportunities for students to conduct research in real time. Finally, it is important to produce scientific publications about the ocean that are easy to read by non-experts.

Mathew White

The relationship between the ocean and human health has had a negative focus. Issues such as microbial pollution, fisheries destruction, man-made chemicals, Harmful Algal Blooms and other toxins, and climate change enhanced storms and floods all need to be addressed. The Rome Declaration, launched at the EurOCEAN 2014 Conference, has an important policy goal (Goal 1: Valuing the Ocean). This goal states that the European Union should implement and/or develop:

• a coordinated interdisciplinary and integrated programme on Oceans and Human Health, understanding and managing the risks and benefits of our interactions with the seas
• advanced and agreed mechanisms for attaching monetary and non-monetary value systems to marine ecosystem services and benefits for use in management and decision-making; and
• a major increase in the promotion of ocean education and literacy, using best practice in communication, training and social marketing.

The European coastline is approximately 89,000 km. It's a place where people live (~200 million inhabitants), work (~5.5 million jobs), and generate growth (~ €500 billion pa). Yet, "*many people have little understanding of the importance of our seas and oceans in their daily lives [and] the impact they have on human health and wellbeing*" (Draft Rome Declaration, 2014). The "Blue Gym" initiative, part of the EU funded European Centre for Environment and Human Health, has taken some early, tentative steps to address this gap. This initiative is a program of research intended to examine the question, "Will improving coastal access improve population health." An additional question being investigated is, "Can we bring the coast inland/indoors?"

Initial results have shown that human health is consistently better in the coastal zones – and when people move to the coast, their health can improve due to:

1) Relaxing atmosphere – relative to other natural environments, even if it is urbanized
2) People exercise more
3) Social relations seem to be more interactive
4) The richer the biodiversity, the better impact on human health

These effects are strongest in poorer communities. Other early results show that the coast encourages families to play together and that people who live near the (English) coast are healthier. In part this seems due to more exercise, less stress, positive social (family) experiences, and possibly a better environment. If these benefits can me better understood, there are potentially large financial implications.

In January 2016 the 'BlueHealth' initiative was launched. This is a 4.5-year (€6 million) pan European project to look at blue space and health across the EU. Several questions will be addressed through this study including:

• What is the optimal dose (of coastal exposure)?
• How long do effects last?
• What is the environmental impact?
• Can comparisons be made to drugs (e.g. depression)?

Summaries of Break-out Group Discussions: Prioritizing Educational Content Related to the Ocean and Human Health

Break out groups were asked to address the following question related to the topic of the ocean and human health:

1. What are the gaps in knowledge needed to inform ocean scientists, educators, policy makers and businesses about this topic?
2. What are key ocean science content topics (both basic ocean science and more in-depth content) necessary to increase citizens' understanding of the connections between the ocean and human health.
3. What can the global ocean science education community do to address SDG Goals 14 and 17 as they relate to this topic?
4. How could the GOSE workshop sponsors (IOC, COSEE, TCOE, and IMAREST) support future education activities related to this topic?

Question 1: What are the gaps in knowledge needed to inform ocean scientists, education, policy makers and business leaders about this topic?

Issues need to be made relevant to local communities, e.g. how flushing a wet-wipe or cotton bud down the toilet clogs up sewage systems. The 'Blue Gym' concept is based on good science – people are indeed healthier at the coast, but they still need to care. You have to love it before you can care for it. Change starts with individuals, but it has to grow through neighbours and larger communities to make a real difference. Education is key to helping people connect their local actions and issues with a wider perspective. Consistent, understandable messages from academics and informal learning providers are needed. We should raise the profile of *World Oceans Day*. One suggestion is to implement things like a global art competition. An example is how the US introduced computer coding to schools by a simple approach of just one hour of coding – it's been taken up by 250 million people. Small steps are effective at building momentum. The artwork displays at UNESCO last week featured images by school children from Small Island Developing States across the world (see photo for example of one of the panels) and common themes included entanglement of marine life in nets, oil spills, etc. However, there were also plenty of images of offshore wind turbines, artisanal fishing, sailing boats and tourism. There is a recognition by the students that the ocean is also a source of energy, food, recreation and employment.

Art displays at UNESCO Headquarters during World Oceans Day June, 2016

Gaps include the need for economic datasets. What is the financial value of a clean ocean? What is the value of a sea grass bed? Also, there's a gap in promoting positive messages, such as the effective clean-up of Boston Harbor or the Thames Estuary. Both were once badly polluted, but now they are thriving with marine life. Should the global ocean education community be developing 'marine marketing' – training scientists to sell the ocean to non-experts? A good example is the Horizon 2020 'Columbus' program that is developing metrics to assess success of knowledge exchange activities to industry and the public. Engagement with industry is essential.

We must increase citizen understanding of the ocean (increase ocean literacy). As a global ocean science education community, we need to recognise the difference between ecosystem goods vs. ecosystem services and people's perceptions (i.e. things you can see vs. things you can't). Awareness in general should be improved. Citizens need to know what is in medicine from the seas and what is marine pharmacology. People don't question what is in the little pills that they take. They just take them on the advice of medical professionals.

Question 2. What are key ocean science content topics (both basic ocean science and more in-depth content) necessary to increase citizens' understanding of the connections between the ocean and human health?

We treat land and ocean as separate systems - when people think water, they think fresh/drinking water. There needs to be a unifying approach, based not on fear, but on hope! Personal story connections can help people make connections between their lives and the ocean. Humanizing stories can target what individuals find personal to themselves, ensuring that we are speaking in a "currency" that those individuals understand. In this respect, knowledge is not the only key. The next step must be taken to making behavioral changes that are based on emotions. Examples include:

a. Beach closures;
b. Socio-economic factors – potentially more for decision makers not the public;
c. Obesity and diabetes - lean protein and vegetable connections with fish feed;
d. Personal health – marketing (for example spirulina to rich Londoners);
e. Mercury warnings on fish;
f. Clean beaches good for mental health, but polluted beaches can be stressful;
g. Algal bloom in Brittany got more press in the UK because of the death of horses, rather than people; and
h. Trust is important and detailed knowledge is not required if the knowledge is mediated by a trusted advisor.

There should be efforts to target an audience which already has a connection with the ocean-, such as those engaged in water sports and recreational fishers. They are more easily convinced of the benefits and challenges and can act as ambassadors. This would need to be "place-based," for example, targeting swimmers that visit Hawaii. These communities are pockets of real interest, and they might be better persuaded by actions rather than knowledge. A start would be to communicate with these groups via their community publications. Additionally, communicating with children is a way to get adults engaged. For example, teens are often the drivers for environmental considerations in their home. Campaigns such as *Kill the Lionfish* and the Asian Crab "derbys" were noted as examples of an unusual method of engagement on what is a serious

issue. Ocean science educators need some facilitation to help them access the educational material already in existence.

There is little information about the ocean in schoolbooks, and it is difficult to get students outside of the classroom (cost, reliability, etc. make this difficult). These are significant barriers of getting students to the coasts, as well as connecting human health to the ocean. However, the research about how visits to the ocean can be a stress reliever may be an easy hook. There is little to no interdisciplinary work on human health and ocean impacts. The science, education, and policy sectors need to work together on this issue.

Question 3: What can the global ocean science education community do to address the UN's Sustainable Development Goals 14 and 17 (SDG 14 and 17) as they relate to this topic?
To address SDG 14 and 17, we'll need better metrics. Are there common ones we should use? We need to determine things like 'How much economic benefit does a specific activity bring per km of coast?' We need health metrics, ways to measure how many people are reached by a given message, and metrics related to the number of jobs that are created by a new activity.

We also need to reach people who don't live near the ocean. People living in inland regions also need to understand the economic, climate, recreational, and health implications of a healthy ocean and seas. How do we ensure that the public knows what actions they should and should not take to ensure a healthier ocean? Do they know that when you wash microfiber clothing there are particles that shed and can end up in the tissues of marine animals. You could be eating someone else's underwear! Hitting the 'what's in it for me?' factor is important. Let's see more ocean-related art, metrics, images with impact, and more citizen science.

Question 4. How could the GOSE workshop sponsors (IOC, COSEE, TCOE, and IMAREST) support future education activities related to this topic?
The GOSE community could develop concise, simple messages/concepts similar to Corey Garza's story of the importance of sponges or horseshoe crabs. These messages could be online with little mini-chapters that link to more information. Perhaps cartoons with simple images or short "advertisement" clips could also be developed.

The GOSE organizers could focus the meeting on a yearly theme, such as marine microplastics or ENSO events so that there is one voice educating on a topic and many groups focusing on the same theme over a year. World Ocean Day has bi-annual themes and the IOC is developing a UN wide World Oceans Day portal. Perhaps GOSE themes could be tied to one or both of these. People not living along coasts need to be engaged in GOSE.

Panel III: Blue Economy and Workforce Needs

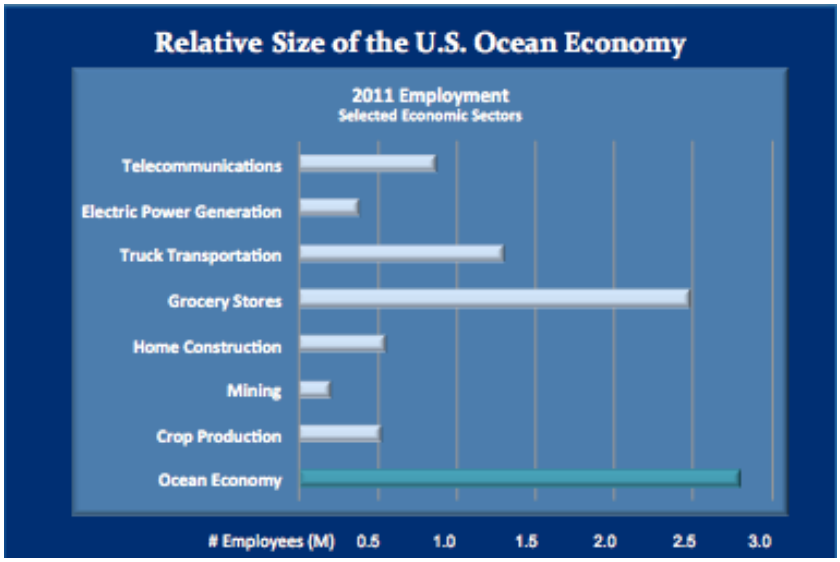
Moderator: Ivar Babb, University of Connecticut (US)
Panelists:
- Bryan Bjorndal, Assure Controls and The Maritime Alliance (US)
- Danilo Calazans, Instituto de Oceanografia (Brazil)
- Alessia Clocchiatti, European Commission Directorate-General for Maritime Affairs and Fisheries (EU)

• Luciana Ferraro, National Research Council (Italy)
• Liesl Hotaling, Eidos Education (US)

Bryan Bjorndal

As a participant in a maritime industry, I can attest that we are very interested in workforce development. The market has a lot to learn about education and the education system has a lot to learn about the market. Industry and education need to work together to ensure that maritime education and training are preparing students for the workforce – for the jobs that exist. Many mariners do not have education past high school level and speak English as a second language. Students need skills training, as well as an understanding of the appropriate behaviors needed for specific jobs - officers and crew are different. Thousands of existing crew members need to have training.

The maritime and ocean economy are large. The ocean economy includes the manufacturing of product and shipping things around the world. This may not be extremely obvious to educators, policy makers, or other sectors. When compared with other economic sectors, the U.S. employment in ocean related jobs outpaces all other major sectors, as shown in the figure below.



Courtesy of NOAA Coastal Service Center, Charleston, SC

The Maritime Alliance (TMA) is the non-profit industry association and cluster organizer for the San Diego, California maritime technology community. It promotes the creation of "Blue Technology" and "Blue Jobs" by promoting sustainable, science-based ocean and water industries. TMA brings education, policy and technology resources together to promote innovation and economic development in the Blue Economy. The 2012 San Diego maritime industry report showed that within an hours drive from the city, there are over 1430 companies and organizations involved with water or maritime industries. These companies provide over 45,700 jobs and $14 billion in annual direct sales. Maritime technology industries (as a sub-group) are the fastest growing segment with 18,948 jobs and $6.2 billion in annual revenue.

TMA actively engages academics and policymakers. It sets up tours to visit the maritime companies. This enables the policymakers and education professionals to walk inside the

companies, talk to the executives, and discover the requirements and skills needed for specific jobs. One take home lesson learned in my own maritime company, Assure Controls, is that for every engineer hired, we need at least one technician to implement the work.

Danilo Calazans

In March 2005, the Executive Committee for Human Resources Formation in Ocean Science (PPG-Mar) was established in Brazil to support, consolidate and assess workforce needs, and improve undergraduate education. This committee has evolved to become one of the most important committees in ocean science, comprised of eleven governmental and six academic representatives, including Brazil's Ministers of Education; Science, Technology and Innovation; Environment; Agriculture; and Defense. In addition, there is a representative from Brazil's Navy.

The perception of institutions and research groups was that ocean science education opportunities in Brazil were below national needs. So an objective was established to develop professionals who are able to contribute to ocean science research and conservation of ocean resources. As of 2015, Brazil now offers 44 marine related undergraduate courses across five modalities: oceanography, fisheries engineering, aquaculture engineering, biological science, and ocean science. Over 2,605 students are enrolled in these courses across 38 universities.

Ocean science undergraduate courses across Brazil:

- Oceanography - 13 Courses
- Fisheries Engineering - 21 Courses
- Aquaculture Engineering - 2 Courses
- Biological Science – 7 Courses
- Ocean Science – 1 Course

PPG-Mar is now focusing on the promotion of research on marine environments. Working groups are developing and participating in Ocean Science events. The committee has established an Ocean Science database and website (http://www.cienciasdomarbrasil.com.br). The following working groups have been established:

- Students Training on Research Vessels
- Ocean Literacy
- Educational Material
- Teaching Qualification
- Journals
- Employment Market

• Entrepreneurship
• Technical Education
• Scientific Diving
• Environmental Education
This represents a significant advancement for the ocean sciences in Brazil.

To address student training on vessels, this working group succeeded in obtaining federal funding (in 2014) for the construction of four new research/education vessels that will be used for undergraduate marine education. These vessels are 32 meters long and serve as floating teaching laboratories. Students will be required to accomplish 120 hours at sea to finish their course work. The first sea trials were performed May 25-26, 2016.

The working group on Ocean Literacy has also been very active. The group has made several recommendations to the Brazilian government, including that the US Ocean Literacy Principles and Fundamental Concepts be adapted for a regional context; the key Brazilian stakeholders for Ocean Literacy be identified and provided a forum for communication between them; and a web-based platform offering educational resources be developed that is organized according to grade levels.

Research Vessels are to Ocean Science as Hospitals are to Health Science courses. Brazil's new vessels will provide hands on research experiences for all undergraduates enrolled in ocean science across Brazil.

Educational materials are very important, and students must have books in Portuguese. The PPG-Mar working group on Teacher Education has produced support materials for training teachers of undergraduate and graduate programs in ocean science. The Journals working group has reviewed and updated lists of Brazilian journals that focus on ocean science and has conducted training workshops for journal editors. The remaining working groups are also busy with similar scope projects. Meetings of undergraduate and graduate coordinators in ocean science are on-going as well as participation in national and international conferences.

The new ocean science database (http://www.repomar.com.br) currently contains over 4000 theses. Approximately 25% of this work was produced between 1998-2014. In addition, the ocean science website (http://www.cienciasdomarbrasil.com.br) had 32.353 visitors in 2015 with 93.57% of the traffic from Brazil.

Alessia Clocchiatti
In the European Union (EU) it is estimated that 5 million people work directly or indirectly for the blue economy, with about half of the work in the tourism sector. In 2012, the European

Commission (EC) developed a Blue Growth Strategy, which highlighted the need for a highly skilled and qualified workforce. Key questions for the EU include: Where is the knowledge gap and what can the EU do? How can we increase awareness of career opportunities in the blue economy?
The gap between education offerings and labor market needs is fueled by:

1. Lack of communication between industry and education sectors;
2. Fast technological development + soft skills + ICT skills + foreign languages >> difficulty for education to adapt curricula quickly;
3. A need for lifelong learning;
4. An ageing workforce;
5. Need for industry to play a more prominent role (i.e. by offering more trainings during the studies); and
6. Need for maritime clusters as suitable bodies to facilitate the business-education cooperation process.

The pupils of today are the workforce of tomorrow. The attractiveness of careers in the blue economy could be increased through ocean literacy activities and better career guidance (that should be better promoted by secondary schools in Europe).

To address skills gaps and labour market needs, the EC published under the *Work Programme 2016 of the EMFF* a call for proposals to promote blue careers. The intentions of this initiative are to strengthen cooperation between industry and educational providers, at local/regional/cross-regional levels and to design and implement concrete actions that will fill the skills gap and raise awareness of careers opportunities in the blue economy. The key idea is to set up cooperative activities between industry and education - connect industry with schools, develop new curricula, upscale programs, and develop awareness building activities.

The EC has also decided to establish an Expert Group on Skills and Career Development in the Blue Economy. This group will provide advice to the Commission on matters pertaining to the education, training, and career development within the blue economy. A New Skills Agenda for Europe was recently published by the EC. The goal is to translate the sectoral strategy into forecasts and actions on jobs and skills needs for the next 5 to 10 years. The hope is that key stakeholders will be mobilized at the European level. Among the six sectors covered in the report, the initial pilot program will focus on maritime technology. This is great news for the EU's blue economy sector.

Luciana Ferraro
The National Research Council (CNR) is the largest public research organization in Italy, supervised by the Ministry of Education, University and Research (MIUR). CNR has four main goals to:

- promote innovation and competitiveness of the national industrial system,
- promote the internationalization of the national research system,
- provide technologies and solutions to emerging public and private needs, and
- contribute to the qualification of human resources.

The scientific network of CNR is organized into seven departments around Italy, and half of the Council's over 8.000 employees are researchers and technologists. The CNR Marine Sciences are developed by two institutes located in north and south of Italy, the Institute of Marine Science (ISMAR) and the Institute for Coastal Marine Environment (IAMC) located in the north and south of Italy (Venice and Naples), which combined have 400 researchers in marine science. The Institute for Coastal Marine Environment (IAMC) has its Headquarters located in a strategic position within the Harbor of Naples and deals mainly with marine science and technologies (geology, geophysics, oceanography, fisheries, aquaculture, biology, coastal management). Over four years (2007-2013), the CNR marine science education and training program was funded by the National Operative Program "Research Competitiveness" by the Ministry of Education, University, and Research. This strengthened research and training on the marine environment in southern Italy through a constellation of five scientific-technological projects called PARFAMAR assigned to IAMC of Naples. Activities include research grants, and fellowships. Funding for research and training projects totaled 64 million Euros.

One of the PARFAMAR projects is *New Technologies for Situational Sea Awareness* (TESSA). The project focuses on the development of products and services of operative oceanography and technological platforms aimed at improving "situational sea awareness" in the Mediterranean Sea. It aims to create 66 new professionals in the field of operational oceanography and maritime security through a two-year training program. The skills gained in the training program are crucial to many industrial sectors (maritime transport, tourism, maritime safety, etc.), and, in the near future, it will have a high potential for development.

Other two important technological projects Pitam "Technology Platform for advanced measurements of geophysical and parameters and environmental conditions in the sea" and Stigeac "Systems and integrated technologies for the detection and monitoring of advanced geophysical and environmental parameters in marine-coastal areas", have their overall mission to promote:

- development of new technological sensors & systems
- new strategies and methods of observation
- technology transfer & training of new specialized technicians and researchers.

These training programs were created to develop a total of 14 new professionals able to work with cutting edge technological infrastructures and with systems applicable to the development of the marine sector. Program structure was organized in two theoretical module and practical activities and a final workshop, in which students presented their training activities. The training program was addressed to both high school graduate students, on issues relating to transport and logistics in the maritime field - shipbuilding, electronic problems, electrical and mechanical engineering and for acquisition and processing of oceanographic data (organic, biological, chemical and physical data), and to graduate degree students for interpretation of geological data (sedimentological, biological, oceanographic, geophysical data). Practical activities were strictly developed in collaboration with two specialized companies located in south and north Italy. This was a first step to build bridges with marine science policy and industry sectors.

Advanced technological systems for coastal and marine environmental survey designed and built by the Institute for Coastal Marine Environment Center of Naples (National Research Council of Italy) in the frame of the National Operative Programme Projects Pitan and Stigeac.

A future initiative is the Smart Bay Concept (SBC), developed to combine scientific knowledge with technological infrastructure and systems applicable to development sectors and to the local economy. The aim of the SBC project is to integrate the Gulf of Pozzuoli (Souther Tyrrhenian Sea) as a physiographic unit of considerable environments, cultural, and socioeconomic value, in a virtual circle between research, technology, and the economy. The SBC integrates a technological system for the collection of environmental, social, and economic data, melded in multidisciplinary indicators, updated in real-time, and readable on dashboards specially crafted for museums and science centers. The SBC generates virtual development of scientific, cultural, industrial, tourist, and economic paths, contributing significantly to the definition of the model of the bay as a driver for sustainable territorial development growth.

Liesl Hotaling

Many things are needed to create and cultivate a workforce to support the blue economy. To tackle these needs effectively, partnerships between the research, business, military, and education communities are necessary to provide skills development opportunities. To be inclusive, these opportunities must also encourage transnational, inter-sectoral, interdisciplinary mobility and address the two workforce pools (professional and technicians).

Transnational approaches reflect our own national interests. Since we do share one ocean, we do need to prepare a like-minded workforce. We also share the problems associated with the ocean, such as the economic impacts of sea level rise, storm surge, and pollution. We need to address these issues together.

Because the blue economy inveritably involves several different sectors coming together, an opportunity exists for the blue economy to lead other sectors and build bridges to do the same. The interdisciplinary nature of this field, also promotes cross sector collaborations. Many skills are needed by the blue economy and these skills can transfer to other sectors.

The workforce pools need to apply general principles. Vocational school students need to be better prepared to enter the blue economy workforce. Our STEM workers enjoy the lowest unemployment rate and the highest salaries. As has been already stated, we need to prepare both

a professional and technician workforce pool. The professional pool needs to diversify its skills. For example, STEM professionals can no longer graduate with merely science training. They need other skills, such as communication skills, the ability to work in teams, computing skills, etc.

The US federal government is investing $4.5 billion into STEM education programs. However, the output is still not meeting current workforce needs. We are spending money to produce STEM workers, but not coordinating efforts. The investments are highly skewed towards bachelor degrees and higher STEM education. This overemphasis on the 4-year and higher degrees neglects the less expensive, wider pathways of 2-year technical degrees and vocational training.

Federal Government Funding for STEM Education Programs by Primary Objective	Approx. Amount (in millions)	Share Of Total
Bachelor's degree or higher STEM education	$1,942	45%
Training or sub-bachelor's level degree education	$940	22%
Education research and development	$519	12%
Pre- and in-service educators	$312	7%
Public learning	$296	7%
Engagement of children	$162	4%
Institutional capacity	$137	3%
Total federal funding for STEM training or education	$4,308	

Source: National Science and Technology Council, Department of Labor, Brookings Institution

Sectors of blue economy include:

- *Harvesting of Living Resources* - Fisheries, Aquaculture, Marine Biotechnology
  Drivers: Food Security, Pharmacology Research and Development
- *Extraction of non-living resources* - Seabed Mining, Oil and Gas, Alternative Energies, Fresh Water
  Drivers: Minerals, Energy Sources, Freshwater Shortages
- *Commerce* - Shipping, Ports, Tourism, Coastal Development
  Drivers: Growth in Shipping, Global Tourism, Coastal Urbanization
- *Ocean health challenge* - Monitoring, Coastal Protection, Carbon Sequestration, Waste Disposal
  Drivers: Research and Development in Ocean Technologies, Conservation Activities

The majority of these fields do not need graduate degrees to work in the industries. Flip the model. Look at who and why we are preparing these students. Alternatives include reaching out to naval institutions, which have people who are coming through, highly skilled.

For the blue economy to grow and for us to meet the workforce needs, we must address some key questions:

- How can we best work together to create bridges for retiring and separating service people to more easily transition into industry?
- How do we expose/inform students of OceanSTEM opportunities at the K-16+ level knowing that regular coursework is not doing this job for us?
- How can we better leverage vocational and technical training programs?

Summaries of Break-out Group Discussions: Adapting Ocean Science Education to 21st Century Workforce Needs

Many marine tech companies are small. What are the challenges and advantages of working with a small company? A small company can get involved with unique projects. They can be nimble and respond to the market more quickly than a large company. A smaller company can more easily advocate for funding and policy. They can provide great opportunities for internships.

What role do you think a cluster should play in terms of the development of workforce? A maritime cluster can be a key player in all of these processes, but coordination is essential. If we have a cluster group talking to a federal government and participating in groups and meetings, it is easier for federal agencies to work with them and foster a message to the small companies. The global ocean science education community should be in contact with maritime clusters.

Brazil provides a great opportunity for undergraduate students on ships. This is an exemplary example of using marine science and technology to engage students. These kinds of experiences offer more opportunities to learn practically and collaboratively. Many people are underprepared to do that when they enter the workforce, and yet, that is what we critically need. Those types of activities are seen in less than 20% of U.S. classrooms.

Vocational, technical, and undergraduate education all need to have engineering and technology skills integrated into STEM content. No job does just science; science integrates technology now. The converse is that it is important not to teach the technology skills in isolation from how they will be applied.

Many skills need to be developed to support the blue economy, one of the largest sectors in the world. What is the potential for international collaborations to support the training? Are there partnerships to be formed and how can we do it? There is a push in industry and academia for internships. We could work together to collaborate internationally on placing students in internships.

Open Space Session

An Open Space session is a self-organizing, or minimally facilitated, practice of inner discipline and collective activity, which releases the inherent creativity and leadership in people. By inviting people to take responsibility for their own interests, Open Space establishes a marketplace of inquiry, reflection, and learning, bringing out the best in both individuals and the whole. Open Space sessions rely on the "Law of Two Feet" - individuals take responsibility for what they care about - stand up for that and use their own two feet to move to whatever place they feel can best contribute and/or learn. If an individual feels that they are not learning or contributing, then they should move to something more productive. The Law of Two Feet gives

participants freedom to move at any time to another discussion. Caring creates common ground, and helps to remind participants of higher purpose.

The intended outcomes for the 2016 GOSE Workshop Open Space session were to build energy, commitment, and shared leadership and have action plans and recommendations emerge from discussions as appropriate. The participants were asked to select a focusing statement or question for discussion. Their statements/questions should frame the higher purpose and widest context for the discussion in a positive way. All the participants were then invited to add their statement(s) or question(s) to one of the large sheets of paper placed on the meeting room wall. Once all the offerings concluded, the participants were invited to sign up for the topics they in which they were interested. The group then spent some time combining similar topics and choosing those with the highest number of interested people for discussion groups. Each discussion group chose a reporter, who would submit the discussion notes to the facilitator. The participants reconvened after the discussion groups wrapped up to share highlights, "ahas," and key points.

2016 GOSE Workshop Open Space Session

Thirty-three statements/questions were proposed by the participants, who then grouped the statements/questions into 5 “spaces.”

<u>Space One</u>

1. Creative approaches to reach global audiences, film/animations/PK3
2. How to increase industry jobs for new ocean science professionals
3. How can we implement concretely ocean literacy subjects in schools worldwide in a systematic way?
4. How to make ocean as “cool” as space adventure
5. Empowering people: How concrete actions can change things. Making the link between science and people, local and global.

<u>Space Two</u>

6. Identifying ways in which we can collaboratively share the resources we have.
7. Road map from GOSE 16 to GOSE 17.

8. Better define the "it" of GOSE. What does this group want to accomplish? What metrics will be used?
9. Goals for the next GOSE meeting.
10. What is our key message as a group? What do we want to achieve in the next 12 months and beyond 2020?
11. Network? Partnerships? Shall we set some goals? Online Portal. Mind map.
12. How to keep momentum going and achieve real outcomes between opportunities to talk at global level.
13. Simple, clear messages for GOSE.
14. Examples of how ocean improves human health - to give clear message to general public.
15. Marketing and communication.

Space Three

16. How to reach those out of the education system? Adult, young?
17. The sea on the ring road (Blivi).
18. One stop shop of best practices
19. What is the most effective way to keep all those efforts coordinated and avoid duplication?
20. Creating online portal for international collaboration (opportunity database).
21. Growing the Global Ocean Science Network.
22. Case Studies of inspiring ocean activities.
23. How do we expand the GOSE Network to effectively, mutually include industry?
24. What strategies can be put in place by this group to develop student interest in Blue Economy careers at K-12, community college, university?
25. Link between Scientists and Industry – Ph.D. program with industry, supported by National Council of Science and Technology. 50% University 50% Industry, at the end the professionals will work for industry.
26. Technical staff working with high schools.

Space Four

27. Professional Development for GOSE Members? e.g., in marketing and communication.
28. Formal qualification with global recognition – industry engaged – attaining "professional status."
29. How can we optimally interact with ocean recreationists (surfers, sailors etc.) to advance the case for ocean literacy and conservation.
30. University Course Accreditation: Setting consistent standards and learning outcomes and a mechanism for developing appropriate skills for the blue economy.

Space Five

31. More interchange of graduate students and scientists between Europe, Latin America, and North American countries.
32. Increase the opportunity to encourage ocean science and fisheries oceanography for young researchers.
33. Think about a common international activity for the World Ocean day to raise awareness and increase ocean literacy (global impact at a local scale).

Outcomes, recommendations, and key "take home points" for the discussion groups were as follows:

A. Professional Development for GOSE participants

1) Establish a GOSE accreditation program for those that attend certain professional development (PD) activities so that they can gain trust and recognition.
2) Prioritize the following PD topics for GOSE participants: Marketing and Messaging/Communication.
3) Facilitate a session to develop the GOSE marketing strategy and simple messages that avoid bias (i.e. gender, cultural, disciplinary).
4) Offer session on entrepreneurship and working in developing countries.

B. Strategies for Infusing Ocean Science into K-16

1) Connect to existing curricula/standards.
2) Make connections to the local marine area related to that which children care or to which they can connect.

C. Creating Global Awareness Through Creative Media

1) GOSE could create an accessible platform for communication and to share information with a wider global audience.
2) Example initiatives could include a global picture competition; creating a silent movie; developing an award program for schools, students, and teachers related to ocean stewardship; and promoting World Oceans Day by presenting prizes on this day.

D. Development of Ocean Science Education Case Studies

1) Establish a working group to develop case studies, i.e. 10 coastal success stories and 10 career pathways stories.
2) IMarEST might be able facilitate and on-line platform for the case studies.
3) Consider themes at GOSE meetings, giving specific activities and strategies to include an audience (e.g., industry, educators, policymakers). One meeting might have two or three themes.

E. Getting Messages to Busy People not Already Actively Engaged in Ocean Related Topics

1) Develop clear, coordinated messages – a priority.
2) Develop novel ideas for targeted audiences.

F. GOSE: What are we trying to achieve? What is the legacy and/or action plan?

1) Promote and offer career professional development.
2) Expand the number of countries attending the GOSE Workshop and joining the network.
3) Find ways to fund conference and travel (corporate sponsorship - industry can donate not just money but also skills and expertise).
4) Establish working groups to achieve outcomes by the 2017 GOSE workshop, e.g., groups focused on industrial and policy partnerships.
5) Make 'Blue solutions' as well-known as green solutions.
6) Invite industry representatives to give talks at the GOSE workshops - either physically or virtually. Put aside a half day to focus on industry.
7) At the end of each GOSE workshop - send delegates away with 3 strong key messages or products (so that we can speak with one voice)
8) Develop a discussion forum to keep the group motivated.

G. Link between Scientists and Technical Staff with Industry

1) Work to develop an industry sponsored Ph.D. program (to be offered by the universities). The programs should be validated and endorsed by a central global entity.
2) Promote existing programs across the Blue Education platform.

H. GOSE Messaging

1) Better define GOSE as an organization/community.
2) Define what the GOSE community wants to do.

I. Making the Ocean As Cool As Space, Short Term and Long Term Goals for Enhancing Global Ocean Literacy.

1) Create an online 'ocean channel' (like Netflix) that provides short educational videos to be viewed by teachers/children (similar to Bill Nye the Science Guy - a specialist speaking on specific topics)
2) Create a mini-series like 'Man from Atlantis', where each program would have a problem solving/forensic/investigative theme related to the ocean.

J. How to Optimally Interact with Ocean Recreationists (surfers, sailors, divers, etc.) to Advance Ocean Literacy and Ocean Conservation

1) Target recreational ocean user segments separately.
2) Use existing organizations (e.g. sport federations and sport clubs) to communicate our messages.
3) Communicate with growing marine tourism segments (e.g. cruise tourism or marine tour operators).
4) Provide instructional videos and information for particular ocean recreationists that can be used by clubs or shops.
5) Provide education to instructors of particular sports activities.
6) Target specialized press (magazines, blogs etc.) with articles and media in which the user segment is interested.
7) Collaborate or gain inspiration from existing NGO's (e.g., Surfriders Foundation, Project Aware).
8) Look at opportunities for citizen science projects with ocean recreationists.

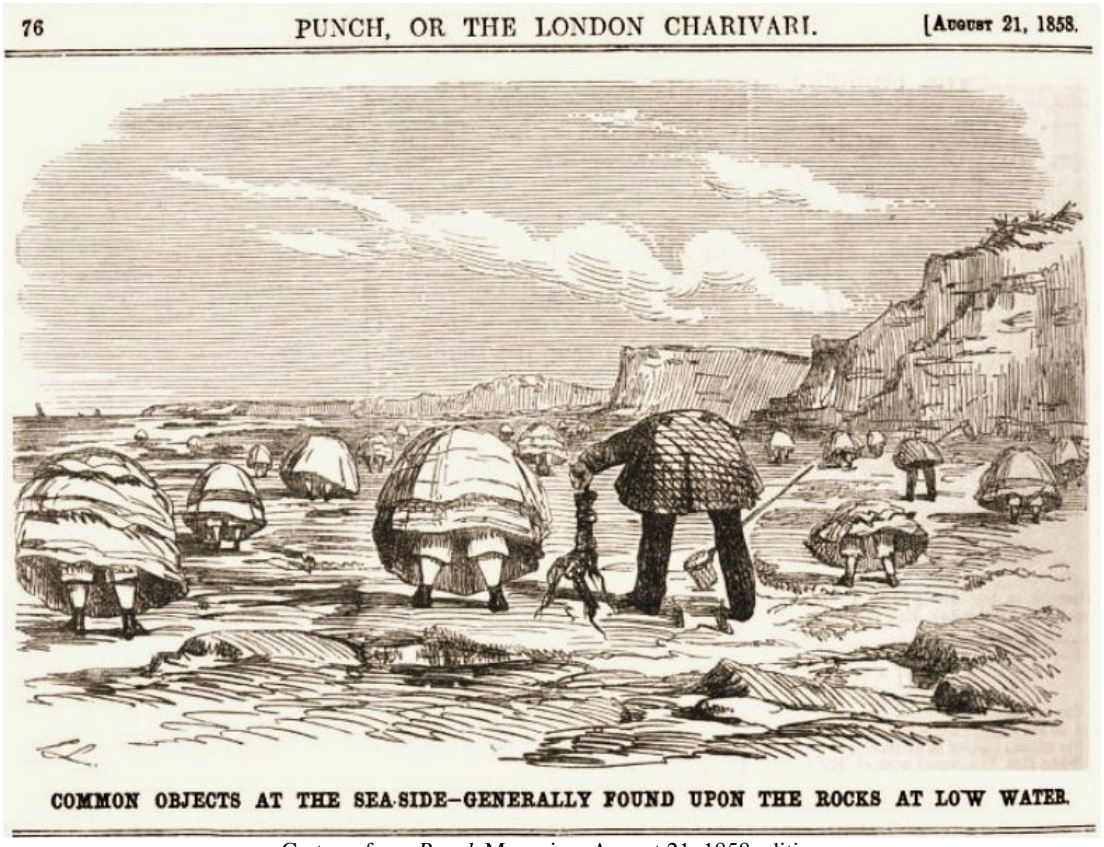
Wednesday, June 15, 2016

Effective Practices in Ocean Citizen Science

Robert Chen, University of Massachusetts Boston and COSEE (US)
Fiona Crouch, Marine Biological Association and Sea Change (UK)
Judy Lemus, University of Hawaii and COSEE (US)

The COSEE and the EU's Sea Change project co-led a hands-on session on ocean citizen science (CS). The objectives of the session were to provide opportunities for the GOSE participants to engage in two kinds of CS activities, assess CS opportunities and challenges, and for participants to design their own CS project. For this session, citizen science was defined as scientific work

undertaken by members of the general public, often in collaboration with or under the direction of professional scientist and scientific institutions. Citizen science (CS) is not new. In 1442, Shinto priests in Japan began keeping records of the annual freeze dates of a nearby lake. In 1693, local merchants in Finland recorded the date the ice broke up each spring. The Victorians were, in their day, citizen scientists. Trips to the seaside were popular, driven by a curiosity for nature and the opportunity to discover new species that could be named after them; many publishing their records in Journals. Two large CS efforts involving bird species include the Audubon Society Christmas Bird Count (ASCBC) in the U.S. and Royal Society for the Protection of Birds (RSBP) in the U.K. The ASCBC began in 1900, and over 58.5 million birds have been counted. The RSPB began in 1979. Over 519,000 people took part in 2016, and 8 million birds were counted.



Cartoon from *Punch* Magazine, August 21, 1858 edition

Why is CS now on the rise? There is a growing need for the production of large data sets, an increased availability of the Internet and hand-held technologies, and an increased emphasis on increasing the public's appreciation of science. Also, budget cuts for long-term monitoring and gathering of data over large geographical areas have encouraged the enlisting of citizen scientists across the globe. There are significant benefits of CS – a large labor pool that is nearly free; diverse input into a problem; scale of reach that is otherwise not possible; involvement in new types of projects/questions; promotion of science; and the enhancement of the public's understanding of science.

There are several barriers and challenges to be overcome if CS is to be successful:

- Data quality and biases
- Peer review/mistrust
- Requirement of specialist knowledge/equipment
- Time and resource issues
- Politics
- Scientists uncomfortable and unprepared to work with the public

Challenges vary whether they are for the scientist or the stakeholder. Data quality is the responsibility of professional scientists to check, and this can be an overwhelming task with a large input of CS data. There are additional challenges for ocean CS. Much of what we want to observe is underwater and there is a general lack of public knowledge related to the marine environment. There are unique health and safety issues to consider as well as environmental conditions, such as, tides. Finally ocean science can be expensive, especially if it involves the use of ships and specialized equipment.

Several types of projects are well-suited to CS. Projects that require large numbers of quantitative measurements and observations are good options for CS, especially if data collection protocols are well-designed and easy to learn and execute. Internet-accessible data submission that allow for streamlined entry into existing databases are very useful. There are many resources now available for CS projects, however, most are designed for the terrestrial environment. Some generally applicable resource can be found at http://www.ukeof.org.uk/resources/citizen-science-resources.

One large ocean CS project is the REEF (Reef Environment Education Foundation) project. This project Channels the enthusiasm of the marine diving community to become stewards of marine ecosystems and citizen scientists. REEF links the diving community with scientists, resource managers and conservationists. REEF was founded in 1990, out of growing concern about the health of the marine environment, and the desire to provide the SCUBA diving community a way to contribute to the understanding and protection of marine populations. REEF achieves this goal primarily through its volunteer fish monitoring program, the REEF Fish Survey Project. Participants in the project not only learn about the environment they are diving in, but they also produce valuable information. Scientists, marine park staff, and the general public use the data that are collected by REEF volunteers. The project has expanded to include internships and programs for classrooms.

A unique ocean CS project that exemplifies the integration of science research and traditional knowledge is the Laulima A ‘Ike Pono (Working Together for the Collective Vision) project conducted by the Hawaii Institute of Marine Biology. Laulima A ‘Ike Pono is a research and training program offered to community members at a 600 year old Native Hawaiian fishpond. The community group managing the fishpond is focused on restoring the pond into a community resource for cultural, spiritual, and physical sustenance. With a goal of improving the functioning of fishpond over time, the project has provided science research opportunities for local students and community members; raised community awareness and support of Native Hawaiian fishponds; increased the understanding of the biogeochemical dynamics within He‘eia Fishpond; strengthened relationships between science and traditional knowledge systems; and provided opportunities for University of Hawaii researchers to participate in community outreach. The fish pond project has allowed community members to create information that feeds

back into the community. This is a great example of how CS can benefit science and community at the same time.

He'eia Fishpond, Kaneohe, Oahu

GOSE participants immersed themselves into two types of CS activities. First, small groups of participants explored on their computers ways to analyze images of whales, ship logs, or plankton within the umbrella of Zooniverse. Next, participants went outside risking the elements in the UNESCO garden looking for, finding, and identifying laminated models of crabs to simulate the CS activity to be launched soon on UK beaches by the SeaChange project. These experiential, hands-on activities engaged all participants in CS, and gave them a diverse array of ideas to consider when designing CS projects.

Following the two CS activities led by the session facilitators, the GOSE participants discussed how the group could collaborate on future CS activities. It was noted that a global citizen science project would need to apply to different cultures. Protocols are needed to work with different audiences. It is also important for the learning to be put into a context and for participants to understand what their data means. With a limited number of scientists and potentially thousands of citizen scientists, the two-way communication becomes difficult, if not impossible. However, science educators are exploring solutions to this challenge, such as one of the EU's CS projects conducted by the UK's Marine Biological Association. Citizens send pictures of sea life to the scientists, and then they get verified. This provides records of the distribution and abundance of native and non-native crabs in Europe. Contributors can understand how the data they are collecting is informing science and policy.

Panel IV: Influence of Informal Science Education on Policy

Moderator: Cynthia Hagley, Minnesota SeaGrant (US)
Panelists:
• Bernard Combes, UNESCO (France)
• Christos Ioakeimidis, Hellenic Centre for Marine Research (Greece)
• Douglas Meyer, The Ocean Project (US)
• Grażyna Niedoszytko, Gydnia Aquarium (Poland)
• James Wharton, Seattle Aquarium (US)

Bernard Combes

UNESCO has been recognized globally as the lead agency for Education for Sustainable Development (ESD). As such, it focuses on addressing sustainability issues and the Sustainable Development Goals (SDGs) through ESD. Target 4.7 of the SDG on Education states that "by 2030 all learners will acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development." Furthermore in order to help combat climate change, Target 13.3 of SDG 13 (on climate change) stresses the need to improve education, awareness raising, and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.

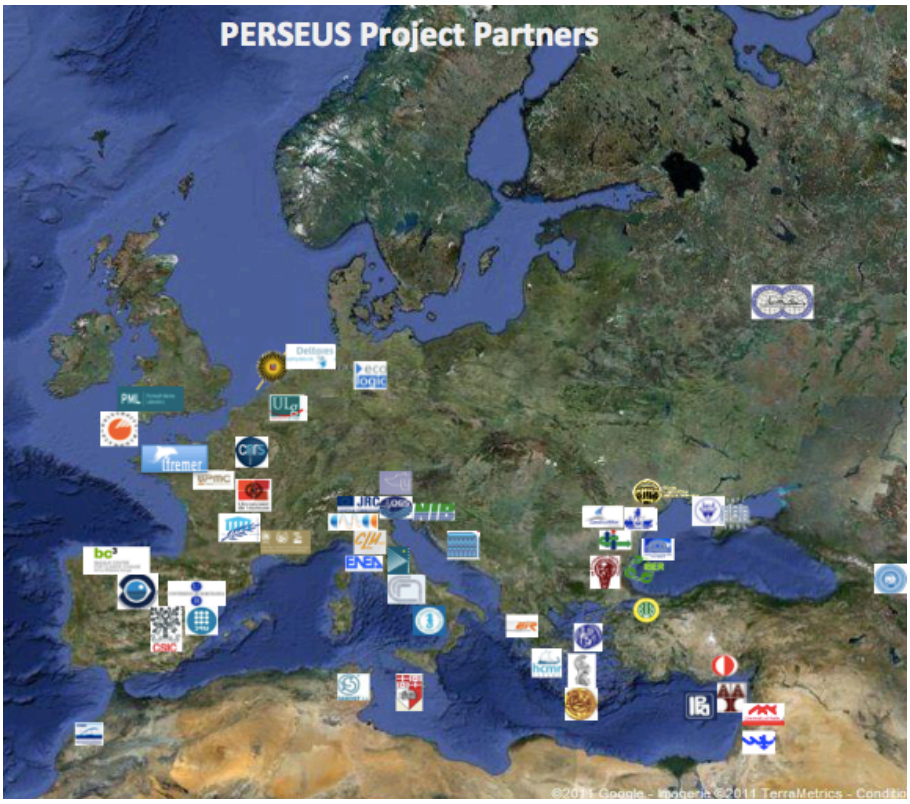
Education for Sustainable Development requires educators and learners to:

- reflect critically on their own communities;
- identify non-viable elements in their lives;
- become empowered to develop and evaluate alternative visions of a sustainable future;
- assume responsibility for creating and enjoying a sustainable future; and
- work to collectively fulfill these visions.

Several projects have been initiated to support these objectives, including flagship projects of the UNESCO Associated Schools Network (http://www.unesco.org/new/en/education/networks/global-networks/aspnet/flagship-projects/) and the UNESCO Green Citizens initiative (http://en.unesco.org/greencitizens), which helps a variety of programs to share knowledge and experiences.

Christos Ioakeimidis

There are global threats and pressures related to the marine environment that are affecting people across nations. These include the effects of climate change, marine litter, seabed mining, invasive species, erosion, overfishing, harmful algal blooms, and industrial and chemical wastes. Informal science education offers a way to address these threats and pressures by increasing science literacy. The PERSEUS Project (Policy-oriented marine Environmental Research for the Southern EUropean Seas) involves 21 countries, 53 partners, >300 scientists, 65 Institutes and Universities. It was conducted over four years from 2012 through 2015 with an EU investment of 13M €. PERSEUS grew to be the EU's largest marine environmental research project for the Mediterranean and Black Seas. PERSEUS merges natural and socio-economic sciences to predict the long-term effects of these pressures on marine ecosystems. The project aimed to design an effective and innovative research governance framework, which would provide the basis for policymakers to turn back the tide on marine life degradation. Among the project activities was an effort to inform the public about the changes that are occurring in our marine ecosystems through informal science education. PERSEUS helped citizens understand the role they can play as a concerned citizen towards saving the seas, as well as the changes they can make in their daily life that will make a difference.



The project has several ongoing activities that engage the public, including an online mechanism to report jellyfish marine litter sightings and a program for the sailing community that encourages that adoption of eco-friendly sailing behaviors. These programs contribute to public awareness that in turn influence policy developments.

Douglas Meyer

The Ocean Project advances ocean conservation in partnership with aquariums, zoos, museums, and other visitor-serving organizations (VSOs), as well as clubs and groups, around the world. We conduct regular public opinion research on ocean issues and help organizations develop and test approaches to visitor engagement through programs such as our Innovative Solutions Grants +. Since 2002, we also have coordinated World Oceans Day.

Our initial public opinion survey was conducted in 1999, and then between 2008 and 2014, we conducted a series of in-depth surveys of a representative sample of the U.S. population, with some additional sampling in Canadian cities. To give a sense for the size of these surveys, the initial 2008 survey included 22,000+ adults, plus a smaller scale study of youth, and there have been annual follow-up surveys. A summary report was published in 2015 and is available online at http://theoceanproject.org or http://theoceanproject.windrush.org/researchsummary. For this discussion, I am highlighting three relevant findings from our research:

1. Newsworthy events (as well as visits to aquariums, zoos and science centers) can increase people's underlying concern for the ocean, albeit fleetingly;
2. When visiting aquariums, zoos and science centers, people *expect, trust & appreciate* conservation information, seeking ways to be part of the solution; and

3. People are more likely to be inspired by emotional stories about helping animals, than facts and figures about impacts on "the ocean."

One of our recent pilot projects in partnership with Sea Life Aquariums and the Sea Life Trust explored the possible implications for advancing policy, and the findings suggested that on-site inspiration from a visit to an aquarium or zoo can carry over to support for ocean related policy proposals. A random sample of guests at two participating Sea Life Aquariums were asked about their support for a proposal to expand America's network of marine protected areas, and the agreement was overwhelmingly high. See also http://theoceanproject.org/2016/08/sea-life-centers-find-public-support-for-marine-protected-areas. This exemplified the role that ISE institutions can play in not only educating the public, but inviting them into the discussion of policy and documenting their support for conservation proposals.

Grazyna Niedoszytko

The Gdynia Aquarium's collection includes unusual species of fish, amphibians, and reptiles from different parts of the world, such as Africa, North America, and northern parts of Europe. In addition to the interesting marine biology, the Aquarium has a very active Education Center. Groups that benefit from our educational offerings can gain knowledge through experiential and unconventional lessons taught by specialists, in the field of oceanography, biology, and the environment. The Education Center was established in 1998. From that time to the present, students of the surrounding areas, and school groups from across the Poland, have taken part in numerous educational projects. Each year the Gdynia Aquarium benefits over 35,000 participants in its educational programs.

Ninety percent of a person's life is spent outside of school. Watching TV, reading books, talking to people, and visiting places. Therefore, free-choice learning makes up a larger share of what people know, think, and feel than formal schooling does. It can make a strong impact on policymakers, as well as on the voters. Scientists and policymakers don't often share a common vocabulary. Informal science education institutions (ISEs) have the experience in using comprehensive language that is understandable by a variety of audiences and in creating attractive stories for the media. The majority of the decision-makers, now working at the national and international level, have started their careers at the local level, and many have visited a zoo, aquarium, or science museum.

Education program in the Gydnia Aquarium

An example of how influential ISEs are can be found in the shark fin issue. Slicing off a shark's fins and discarding the body at sea has been banned in the EU since 2003. Yet, exemptions in the law have made a mockery of the ban. Thanks to the alliance led by the European Elasmobranch Association, The Pew Charitable Trusts, Project Aware, and Shark Trust, in November 2012, after six years of debate, the EU Parliament voted to close loopholes. As of July 6, 2013, sharks caught by EU vessels anywhere in the world must be landed with their fins naturally attached. This important legislation was due to the cooperation of the alliance partners, several of whom are actively engaged in ISE, and public pressure. For example, during just one week in 2011, over 165,000 signatures were collected from all EU member states during 150 ISE events in 19 countries.

The equation for ISE activities that successfully inform policy is as follows:
One clearly defined goal/key message + Edutaining tools + Interdisciplinary collaboration of people with passion + Storytelling + Time = Success.

James Wharton
It is important to form partnerships if policy is to be informed by ISE institutions. Seattle Aquarium has recently joined an Aquarium Conservation Partnership (ACP). The ACP is a two-year (2016-17) pilot project designed to enhance the ability of U.S. aquariums to work together to accomplish meaningful policy-related conservation goals, and in turn, increase the collective conservation impact of U.S aquariums. The ACP was founded by Monterey Bay Aquarium, Shedd Aquarium, and National Aquarium in 2015, and since then, 18 additional aquariums, including Seattle Aquarium, and Association of Zoos and Aquariums have joined the ACP as either Sponsoring or Associate Institutions.

The ACP has developed a Conservation Action Agenda, which lays out conservation goals, activities, and outcomes for the two-year pilot period. The primary ACP goal is to leverage the power of U.S. aquariums to reduce the sources of ocean and freshwater plastic pollution. The ACP also serves as a "strategic table" for aquariums to take coordinated action on other conservation policy goals: increasing ocean and freshwater ecosystem protection; protecting threatened global shark and ray species; and improving the sustainability of fisheries. By partnering, these institutions and organizations are hoping to have a more significant voice in policy – a coordinated force to rally around an issue but not through one "mouth piece." This December 5-7, 2016, the ACP is holding the first Aquarium Plastic Pollution Symposium at the Monterey Bay Aquarium. The symposium will include an overview of the science and policy of ocean plastic pollution, communications best practices, and sessions for four areas of action: institutional, policy, market, and community engagement.

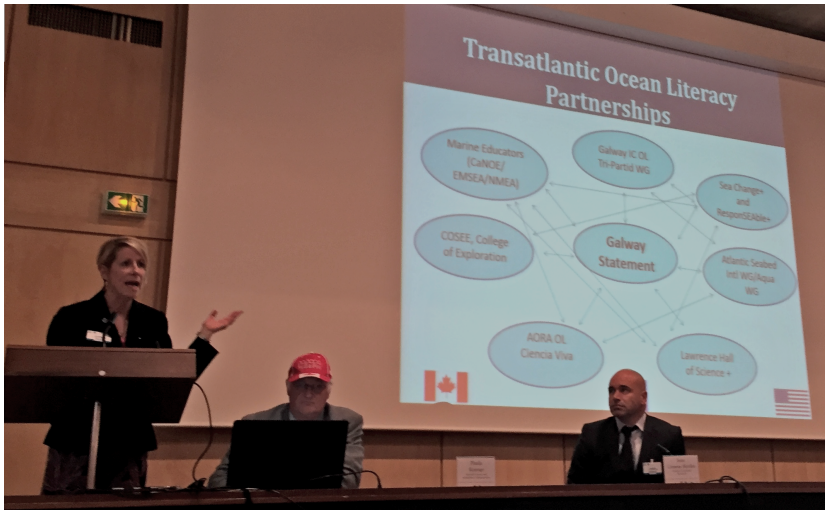
Plenary Session: New Partnerships – Building on the Success of the TransAtlantic Galway Declaration

Paula Keener, National Oceanic and Atmospheric Administration (US)
Ivan Conesa-Alcolea, European Commission Directorate-General for Research and Innovation (EC)
Peter Tuddenham, College of Exploration (US and UK)

In May 2013, at the Marine Institute in Galway, Ireland, Commissioner Máire Geoghegan-Quinn and Commissioner Maria Damanaki, on behalf of the European Union, together with high level representatives the from United Stated of America and Canada signed the *Galway Statement on Atlantic Ocean Cooperation* to launch the Atlantic Ocean Research Alliance (AORA). The goal of AORA is to work together in order to better understand and "increase our knowledge of the Atlantic Ocean and its dynamic systems - including interlinks with the portion of the Arctic region that borders the Atlantic" and to promote the sustainable management of its resources. The AORA recognizes that Atlantic research will in many areas be more effective if coordinated on a transatlantic basis.

To fulfill the goals of AORA and support full implementation of the Galway Agreement, a Galway Implementation Committee (Committee), co-chaired by Canada (represented by the Department of Fisheries and Oceans), the European Union (represented by the European Commission) and the United States (represented by NOAA) was established. From the Galway Agreement, the Committee identified ocean research and observation efforts in which they agreed to work through the AORA and established the following priority areas of cooperation:

- Atlantic Seabed International Mapping and Characterization
- Aquaculture
- Ocean Literacy, including Information Management and Dissemination
- Ocean Health and Stressors
- Ocean Observation and Prediction



Paula Keener, Peter Tuddenham, and Ivan Conesa-Alcolea

Formal Working Groups have been established in each of these areas of cooperation to improve efficiencies and effectiveness by:

- Organizing, aligning and leveraging research activities in ways that take advantage of opportunities for synergies in work already underway and through the use of existing infrastructures or installations;
- Better coordination of data sharing, interoperability and coordination of observing infrastructures;
- Promoting researcher mobility; and

- Coordinating the planning and programming for better alignment for relevant activities and resources.

The Committee's Ocean Literacy Working Group (OLWG) plays a key role in encouraging alignment and collaboration among key strategic partners working in Canada, the US and the EU in support of transatlantic ocean literacy. It also ensures, where feasible and appropriate, other ocean literacy efforts within Canada, the US and the EU are leveraged to support further implementation and expansion of the Galway Statement's reach. Through networking among change agents (and potential change agents), the OLWG helps build the capacity for Transatlantic Ocean Literacy (TOL) through the development of strategic partnerships. Building effective partnerships to advance transatlantic ocean literacy is critical to building capacity for sustainability of transatlantic ocean literacy - building capacities together to reach mutual goals together in support of one shared Atlantic ocean.

Completion of the Transatlantic Implementation Strategy and developing a process for formal review and approval by the Galway Implementation Committee, co-development of the Transatlantic Ocean Literacy Bibliographic Reference, support for Sea Change through the International Advisory Group, population of the AORA website with ocean literacy resources and graduate student and early career scientists blogging during transatlantic international mapping missions are just a few examples of capacity-building through the OLWG and its partners. The GOSE 2016 Workshop cohosted by COSEE, the IOC, and the College of Exploration is another great example of transatlantic partnerships.

Additionally, the OLWG has been charged by the co-chairs of the Committee to further integrate ocean literacy into other priority thematic Working Groups, namely the Atlantic Seabed International Mapping Working Group (ASIMWG) and the Aquaculture Working Group. From May through August 2016, AORA launched the second year of transatlantic seabed mapping surveys on board the R.V. *Celtic Explorer* and the Canadian Coast Guard Ship *Louis S. St-Laurent* to map some 12,000 km^2 of un-surveyed seafloor from the deepest parts of the Atlantic Ocean. The OLWG worked closely with the ASIMWG to place graduate students and early career scientists representing EU, Canada and the US on both transatlantic expeditions to produce web logs that chronicled the missions through daily updates and reflections on their experiences, the science, technology, and other elements of the expeditions (see http://www.atlanticresource.org/aora/aorablog).

The OLWG is also working with the Aquaculture WG to host a workshop for educators during the European Marine Science Educators Association 2016 Annual Conference in Belfast to address public perception issues in aquaculture. The OLWG also has the capacity to network to integrate other ocean literacy efforts where appropriate to support the Galway Implementation Committee to increase public awareness of the Atlantic as a shared resource. This is enhanced through its involvement with the Sea Change International Advisory Working Group and AORA-SA, including the GOSE Workshop, UNESCO IOC, and others.

Looking forward and building on the success of Galway, the OLWG is in conversation to hold a North American TOL forum. It will be further developing the TransAtlantic Bibliographic

Reference and working with other Galway Implementation Committee working groups over the next year. We would like to see a continuation of what we are building here at GOSE 2017.

Summaries of Reflection Discussions: ***Goals and Next Steps for the Global Ocean Science Education Community***

To address this topic, break-out groups were asked to address three questions:

1. How can we move the global ocean science education community forward?
2. What partnerships can be developed to build knowledge, share knowledge, and take action?
3. What new platforms are needed to share ocean science education knowledge globally?
4. 4. How could the GOSE Workshop sponsors build and or support partnerships?

The following is a combined summary of the three breakout group recommendations.

How can we move the global ocean science education community forward?

• Develop a global ocean science education community identity and purpose
• Message forum/platform for communication to foster the sense of community
• Produce a newsletter every few months through email
• Initiate working groups with assignments
• Analyze what other STEM communities have done to communicate successfully with general public/schools
• Create an online portal to help share good practices – with good filters
• Invite more industrial partners to the 2017 GOSE Workshop
• Invite marketing specialists to the 2017 GOSE Workshop
• Conduct webinars in between workshops

What partnerships can be developed to build knowledge, share knowledge, and take action?

• Facilitate educational audiences to share best practices, specifically through university settings
• Foster blue economy and NGO partnerships via internships
• Present workshop minutes to research funders and industry for management board meetings
• Form partnerships with Marine Labs
• Form partnerships with Marine Protected Areas
• Communicate with colleagues within a different discipline

What platforms exist to share knowledge globally on this topic? What new platforms need to be created?

This discussion focused on needs:

• Coordination of platforms
• An email listserv
• Online portal for sharing best practices that can be applied on a smaller than global scale
• Use all communication methods to reach people who may not have Internet
• Survey among meeting attendees
• Accredited qualification for marine education - development of course/qualification to be guided by industrial partners

How could the GOSE workshop sponsors build and or support partnerships?

- Develop survey tool for attendees and potential GOSE attendees for needs assessment - How would you describe our mission, what skills/resources do you bring? What are you looking for/what are your needs? What working group can you contribute to? Make progress between now and the next meeting.
- Focus on a global presence at other conferences and workshops
- Translations of ocean literacy materials (both language and by sectors via working groups)
- Coordinate partner expertise
- Include a new co-convener each year for GOSE to expand partnerships

Conclusions

It is clear that a global ocean science education network is emerging, building on the COSEE Network. All the reflective break-out groups expressed a need for ways to stay connected between GOSE workshops. Each group suggested that working groups would be a good way for participants to remain engaged throughout the year. Working groups could tackle specific issues and themes and work on projects directed at specific audiences.

Other themes that emerged over the course of the workshop included a need for a GOSE sponsored professional development opportunity focused on marketing strategies and developing messages that we could all use in our respective efforts. Ocean science, in general, has no global message. Citizens of the world do not understand why ocean science research and education are necessary.

It is clear that future workshops should continue to include the four sectors of ocean science research, education, policy, and industry. A future goal of the GOSE Workshops should be to provide a platform for these sectors to work more closely together to provide student internships and develop an ocean science certification program for industry professionals. Finally, a key recommendation emerged to develop and administer a survey that would identify the needs of the GOSE community to inform planning for the 2017 GOSE workshop.

APPENDIX

A. 2016 Gobal Ocean Science Education Workshop Participants

B. 2016 Global Ocean Science Education Workshop Agenda

C. Ocean Citizen Science Resource List

Appendix A.
2016 GOSE Workshop Participants

Name	Affiliation	Country
Ahanhanzo, Justin	Intergovernmental Oceanographic Commission	EU
Babb, Ivar	University of Connecticut	USA
Bjorndal, Bryan	Assure Controls	USA
Blakeman, Ann	Redrose Developments Ltd	Ireland
Blivi, Adotè	Université de Lomé	Togo
Calazans, Danilo	Universidade Federal do Rio Grande, Instituto de Oceanografia	Brazil
Campillo Campbell, Carolina	S'Agulla	Spain
Chen, Robert	University of Massachusetts Boston	USA
Clocchiatti, Alessia	DG Maritime Affairs and Fisheries	EU
Combes, Bernard	UNESCO	France
Conesa-Alcolea, Ivan	European Commission	EU
Crouch, Fiona	Marine Biological Association, University of Plymouth	UK
Decker, Marilyn	University of Massachusetts Boston	USA
Delgado, Claudia	Intergovernmental Oceanographic Commission	EU
De Moor, William	JPI Oceans	Begium
Eparkhina, Dina	EuroGOOS	Belgium
Ferraro, Luciana	National Research Council	Italy
Frashure, Kim	Bunker Hill Community College	USA
Françoise Gaill	Centre National de la Recherche Scientifique	France
Garza, Corey	California State University, Monterey Bay	USA
Gin, Iwona	NAUSICAA	France
Gingras, Andrea	University of Rhode Island and COSEE	USA
Hagley, Cynthia	University of Minnesota Sea Grant	USA
Hall, Stephen	National Oceanography Centre	UK
Henderson, David	IMarEST	UK
Hotaling, Liesl	Eidos Education and COSEE	USA
Huron, Florence	Nausicaa, Centre National de la mer	France
Icochea, Luis	Universidad Nacional Agraria La Molina	Peru
Ioakeimidis, Christos	Hellenic Centre for Marine Research	Greece
Keener, Paula	National Ocaenic and Atmospheric Administration	USA
Khelil, Nawel	International Ocean Institute	Algeria
Kowalski, Juliette	World Ocean Network	Belgium
Lee, Byung-Gul	Jeju Sea Grant Center/Jeju University	Korea
Lemus, Judith	Hawaii Institute of Marine Biology, University of Hawaii	USA
L'Hermitte, Gaelle	Nausicaa, Centre National de la mer	France
Mackenzie, Bev	IMarEST	UK
Mata, Bernardo	EMEPC	Portugal
Meyer, Douglas	The Ocean Project	USA
Morisseau, Francois	Agence des aires marines protegee	France
Munoz Sevilla, Norma	Instituto Politecnico Nacional	Mexico
Niedoszytko, Grazyna	National Marine Fisheries Research Institute, Gdynia Aquarium	Poland
Oghenekaro, Efeturi	National Ocaenic and Atmospheric Administration	USA
Papathanassiou, Martha	Hellenic Centre for Marine Research	Greece
Paterson, Arthur	National Ocaenic and Atmospheric Administration	USA
Podlesinska, Weronika	National Marine Fisheries Research Institute, Gdynia Aquarium	Poland
Rosales Quintana, Gandy	Universidad Nacional Agraria La Molina	Peru
Russell, Annie	Newcastle University	UK
Santoro, Francesca	Intergovernmental Oceanographic Commission	Italy
SCHEURLE, Carolyn	UPMC Observatoire Océanologique	France
Schiebel, Hayley	COSEE OCEAN	USA

Scowcroft, Gail	University of Rhode Island and COSEE	USA
Selvaraj, John Josephraj	The National University of Colombia	Columbia
Sevin, Marie-Aude	Agence des aires marines protegee	France
Tuddenham, Peter	College of Exploration	USA
Uiterwyk, Kristin	Urban Harbors Institute, University of Massachusetts Boston	USA
Wharton, Jim	Seattle Aquarium	USA
White, Mat	University of Exeter Medical School	UK

Appendix B.
Global Ocean Science Education Workshop
June 13-15, 2016
UNESCO Headquarters
Paris, France

AGENDA

Monday, 13 June

1:00 pm Welcome and Introductions

1:30 pm Review of 2015 GOSE Workshop Outcomes

1:45 pm Goals for 2016 GOSE Workshop

2:00 pm Plenary Session: *The Role of Education and Capacity Development in the Context of International Ocean Governance*
Claudia Delgado, International Oceanographic Data and Information Exchange, Intergovernmental Oceanographic Commission (Science, Eductation, and Policy)

3:00 pm Plenary Session: *Building a Global Ocean Science Education Network*
Gail Scowcroft, Consortium for Ocean Science Exploration and Engagement (COSEE) and University of Rhode Island (USA, Science and Education)

3:15 pm Plenary Session: *Integrative and Innovative Systems Approaches to Volatile, Uncertain, Complex and Ambiguous (VUCA) Problems*
Peter Tuddenham, College of Exploration (USA, UK) (Education and Policy)

3:30 pm Coffee Break

4:00 pm Panel I: *Science, Education, Business, and Policy Roles in Implementing International Policies Related to the Ocean*
Moderator: Francesca Santoro, Intergovernmental Oceanographic Commission (Science and Policy)
Panelists:
- Stephen Hall, National Oceanography Centre and IOC vice-chair (UK, Policy and Business)
- Bev Mackenzie, Institute of Marine Engineering, Science and Technology (UK, Business)
- Norma Patricia Muñoz Sevilla, Instituto Politechnico Nacional (Mexico, Science and Education)
- Françoise Gaill, Centre national de la recherche scientifique (France, Science and Policy)

4:45 pm Discussion: *How the Science, Education, Business, and Policy Sectors Can Effectively Work Together to Advance Ocean Science Education*

5:15 pm Cocktail Reception

7:00 pm Adjourn

Tuesday, 14 June

9:00 am Welcome

9:05 am — Panel II: *The Ocean and Human Health*
Moderator: Peter Tuddenham, College of Exploration (USA & UK, Education and Policy)
Panelists:
- Corey Garza, California State University (USA, Science)
- Nawel Khelil, International Ocean Institute (Algeria, Science and Policy)
- Luis Icochea Salas, Universidad Nacional Agraria La Molina (Peru, Science and Education)
- Matthew While, University of Exeter (UK, Science)

10:00 am — Discussion: *Prioritizing Educational Content Related to the Ocean and Human Health* (Break Out Groups)

10:30 am — Coffee Break

11:00 am — Panel III: *Blue Economy and Workforce Needs*
Moderator: Ivar Babb, University of Connecticut (USA, Education and Science)
- Danilo Calazans, Instituto de Oceanografia (Brazil, Science and Education)
- Alessia Clocchiatti, European Commission Directorate-General for Maritime Affairs and Fisheries (Policy)
- Luciana Ferraro, National Research Council (Italy, Science and Policy)
- Liesl Hotaling, Eidos Education (USA, Education)
- Bryan Bjorndal, Assure Controls and The Maritime Alliance (USA, Business) (invited)

12:15 pm — Discussion: *Adapting Ocean Science Education to 21st Century Workforce Needs*

1:00 pm — Lunch

2:00 pm — Open Space Session

3:30 pm — Coffee Break

4:00 pm — Open Space Session continued

5:00 pm — Adjourn

6:00 pm — Optional River Cruise

Wednesday, 15 June

9:00 am — Welcome

9:05 am — Hands-On Session: *Effective Practices in Ocean Citizen Science*
Robert Chen, University of Massachusetts Boston and COSEE (USA)
Fiona Crouch, Marine Biological Association and *Sea Change* (UK)
Judy Lemus, University of Hawaii and COSEE (USA)

11:00 am — Coffee Break

11:20 am — Hands-On Session: *Effective Practices in Ocean Citizen Science* (continued)

12:20 pm — Lunch

1:15 pm — Panel IV: *Influence of Informal Science Education on Policy*
Moderator: Cynthia Hagley (USA, Education and Policy)
Panelists:
- Bernard Combes, UNESCO (Education & Policy)
- Christos Ioakeimidis, Hellenic Centre for Marine Research (Greece, Science) (invited)
- Grażyna Niedoszytko, Gydnia Aquarium (Poland, Education)

- Bill Mott, The Ocean Project (USA, Policy)
- James Wharton, Seattle Aquarium (USA, Education)

2:30 pm Discussion: *Connections Between Citizen Science, Informal Science Education, and Policy*

2:50 pm Plenary Session: *New Partnerships – Building on the Success of the TransAtlantic Galway Declaration*

Paula Keener, National Oceanic and Atmospheric Administration (USA, Education and Policy)
Ivan Conesa-Alcolea, European Commission Directorate-General for Research and Innovation (Science & Policy)

3:20 pm Break

3:40 pm Discussion: *Goals and Next Steps for the Global Ocean Science Education Community*

4:45 pm Reflection and Adjourn

Citizen Science Resources
Global Ocean Science Education Workshop
UNESCO Headquarters, Paris, France
Effective Practices in Ocean Citizen Science
Wednesday, June 15, 2016

Books and Reports about Citizen Science

Education

Bonney R, Ballard H, Jordan R, McCallie E, Phillips T, Shirk J, et al. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. Center for Advancement of Informal Science Education (CAISE), Washington D.C.

Phillips T, Furguson M, Minarchek M, Porticella N, Bonney R (2014) Users guide for evaluating learning outcomes from citizen science. Cornell Lab of Ornithology, Ithaca, NY.

European Perspective on Citizen Science for the Environment

Roy HE, Pocock MJO, Preston CD, Roy DB, Savage J, Tweddle JC, et al. (2012). Understanding citizen science and environmental monitoring. Final report on behalf of UK Environmental Observation Framework. Centre for Ecology & Hydrology, Wallingford.

Tweddle JC, Robinson LD, Pocock MJO, Roy HE (2012). Guide to citizen science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK. Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF. Available online: www.ukeof.org.uk

Science Communication Unit, University of the West of England, Bristol (2013). *Science for Environment Policy In-depth Report: Environmental Citizen Science*. Report produced for the European Commission DG Environment, December 2013. Available at: http://ec.europa.eu/science-environment-policy

Pocock MJO, Chapman DS, Sheppard LJ, Roy HE (2014). A Strategic Framework to Support the Implementation of Citizen Science for Environmental Monitoring. Final report to SEPA. Centre for Ecology & Hydrology, Wallingford, Oxfordshire.

Haklay M (2015) Citizen Science and Policy: A European Perspective https://www.wilsoncenter.org/sites/default/files/Citizen_Science_Policy_European_Perspective_Haklay.pdf

Key Scientific Papers about Citizen Science

Bonney R., Cooper CB, Dickinson J, Kelling S, Phillips T, Rosenberg KV, Shirk J (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience*, *59*(11), 977-984.

Cohn, J.P (2008). Citizen science: Can volunteers do real research?.*BioScience*, *58*(3), 192-197.

Conrad CC, Hilchey KG (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environmental monitoring and assessment*, *176*(1-4), 273-291.

Cooper CB, Dickinson J, Phillips T, Bonney R. (2007). Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society*, *12*(2), 11.

Cox J, Oh EY, Simmons B, Lintott C, Masters K, Greenhill A, ... Holmes K. (2015). Defining and Measuring Success in Online Citizen Science: A Case Study of Zooniverse Projects. *Computing in Science & Engineering*, *17*(4), 28-41.

Danielsen F, Burgess ND, Balmford A, et al. (2009) Local participation in natural resource monitoring: a characterization of approaches. Conserv Biol 23: 31–42.

Delaney DG, Sperling CD, Adams CS, Leung B (2007) 'Marine invasive species: validation of citizen science and implications for national monitoring networks'. Biological Invasions 10 (1), 117 – 128.

Dickinson JL, Zuckerberg B, Bonter DN (2010) Citizen science as an ecological research tool: challenges and benefits. Annual Review of Ecology, Evolution, and Systematics. 41:149–72.

Gommerman L, Monroe MC (2012). Lessons Learned from Evaluations of Citizen Science Are Data Collected by Citizen What Contexts Are Most, (May), 1–5.

Haklay M. (2013). Citizen science and volunteered geographic information: Overview and typology of participation. In *Crowdsourcing geographic knowledge* (pp. 105-122). Springer Netherlands.

Kullenberg C, & Kasperowski D (2016). What Is Citizen Science?–A Scientometric Meta-Analysis. PloS one, 11(1), e0147152.

Pandya RE (2012). A framework for engaging diverse communities in Citizen science in the US. *Frontiers in Ecology and the Environment*, *10*(6), 314–317. http://doi.org/10.1890/120007

Pocock, MJ, Roy HE, Preston CD, Roy DB (2015). The biological records centre: A pioneer of citizen science. Biological Journal of the Linnean Society, 115(3), 475-493.

Silvertown J (2009) A new dawn for citizen science. Trends in Ecology & Evolution. 24(9):467–71.

Theobald EJ, Ettinger AK, Burgess HK, DeBey LB, Schmidt NR, Froehlich HE ... Parrish JK (2015). Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. *Biological Conservation*, *181*, 236-244.

Wiggins A, Crowston K (2011, January). From conservation to crowdsourcing: A typology of citizen science. In *System Sciences (HICSS), 2011 44th Hawaii international conference on* (pp. 1-10). IEEE.

Other Sources of Information About Citizen Science

Journal

Citizen Science: Theory and Practice sponsored by the Citizen Science Association

Collections of Papers

1) Biodiversity and Conservation (2005) Volume 14, Issue 11 DOI 10.1007/s10531-005-8375-0.
2) e-Science Workshops (eScienceW) (2011) IEEE Seventh International Conference on Citizen Science, Stockholm Sweden, 5-8 Dec. 2011.
3) Frontiers in Ecology and the Environment, August 2012, Volume 10, Issue 6.
4) Human Computation (2014) Volume 1, No 2.
5) Biological Journal of the Linnean Society, July 2015, Volume 115, Issue 3.
6) Journal of Microbiology & Biology Education, March 2016, Volume 17, Issue 1.
7) Conservation Biology, June 2016, Volume 30, Issue 3.

Websites that have general information about citizen science

Citizen Science Toolkit	http://www.birds.cornell.edu/citscitoolkit/toolkit
Scistarter	https://scistarter.com/
Wilson Center	https://www.wilsoncenter.org/research/Commons%20Lab
US Government	https://www.citizenscience.gov/
Monitoring Matters	http://www.monitoringmatters.org/
UK EOF	http://www.ukeof.org.uk/resources/citizen-science-resources/guide-to-citizen-science-form

Blogs

http://blogs.plos.org/citizensci/

Twitter Accounts

@SeaChange_EU

@SealifeSurvey

@ShoreThing_MBA

@CapturingRCoast

List Serves

extvolmonnetwork@list.uvm.edu
citizenscience@extension.org
citsci-discussion-l@cornell.edu

Associations

Citizen Science Association	https://citizenscienceassociation.org/
Australian Citizen Science Association	http://csna.gaiaresources.com.au/wordpress/
European Citizen Science Association	http://ecsa.citizen-science.net/
Citizen Science Alliance	http://www.citizensciencealliance.org/ (runs Zooniverse projects)

(Check each Association's websites for information about meetings)

Citizen Science Websites

Citizenscience.gov – http://www.citizenscience.gov

CitSci.org – http://citsci.org

Citizen Science Alliance – http://citizensciencealliance.org

Citizen Science Association – https://citizenscienceassociation.org/

Discover Magazine – http://blogs.discovermagazine.com/citizen-science-salon

European Citizen Science Association – http://ecsa.citizen-science.net/

European Environment Agency – http://www.eea.europa.eu/themes/biodiversity/biodiversity-monitoring-through-citizen-science

Jelly Watch -- http://www.jellywatch.org/

Marine Debris -- http://www.marinedebris.engr.uga.edu/

Scientific American – http://www.scientificamerican.com/citizen-science/

SciStarter – http://scistarter.com

Seafloor Explorer https://www.seafloorexplorer.org/

Socientize – http://www.socientize.eu

Zooniverse – https://www.zooniverse.org/

Technical Aspects: Software & Informatics Resources

Citizen Science Platforms

Zooinverse
CitSci.org
iNaturalist
iRecord
ISpot
Sealife Tracker
iSeahorse

Platforms to build collection apps for Citizen Science

ArcCollector
CitSci.org
Cybertraker
EpiCollect
FieldScope
GIS Cloud
OpenDataKit

Standard Terms for Citizen Science

https://www.wilsoncenter.org/article/ppsr-core-metadata-standards

Examples of Citizen Science Projects

I) REEF (Reef Environmental Education Foundation; www.reef.org)
Over 13,000 volunteer divers and snorkelers have participated, and collectively they have submitted over 7.8 million records of fish, invertebrate, and algae sightings from 11,353 sites worldwide. The database includes sightings information on over 3,400 marine species. REEF receives an average of 862 surveys per month, with peak submissions exceeding 1,200 in the summer months. Chief Scientist: Christy Semmens, christy@reef.org

II) Sea Change Project (www.seachangeproject.eu)
One of the tasks under the EU H2020 funded Sea Change project is to develop a Citizen Science project across Europe that will collect data on the distribution and abundance of native and non-native crab species. For more details contact Fiona Crouch (Sea Change Project Manager), Marine Biological Association, ficr@mba.ac.uk

III) He'eia Fishpond (http://laip-heeia.blogspot.com/)
The Laulima A ‘Ike Pono (LAIP) program at He’eia Fishpond introduced Hawaiian and Pacific Island students and community members to authentic geoscience research within a local ecosystem that holds high cultural significance. LAIP established a collaborative model for community science education through place-based biogeoscience research and training. Over the course of the program, six cohorts of interns completed 200 hours of work during six-month sessions. (http://www.hawaii.edu/himb/Education/lokoiaapp/)

IV) The Shore Thing Project (www.mba.ac.uk/shore_thing)
The Shore Thing is an initiative of the Marine Biological Association, working with schools and community groups around the British Isles to collect information on rocky sea shore life. The project follows on from the UK’s Marine Biodiversity and Climate Change Programme (MarClim). MarClim provides evidence that recent climate change has altered the abundance, population structure and biogeographic ranges of a number of intertidal indicator species. The survey protocol and methodologies have been developed from MarClim. All the information collected by volunteers is available online and will help to build a picture of the present state of UK rocky shores and measure change in the future.

V) Capturing our Coast (www.capturingourcoast.co.uk)
This project aims to develop a network of citizen scientists who can help us build an accurate picture of marine life all around the UK - a baseline against which we can better understand the impact of climate change and other environmental and human factors.

VI) Seasearch (www.seasearch.org.uk)
Seasearch is a project for volunteer sports divers who have an interest in what they're seeing under water, want to learn more, and want to help protect the marine environment around the coasts of Britain and Ireland. The main aim is to map out the various types of sea bed found in the near-shore zone around the whole of the Britain and Ireland. In addition we are recording what lives in each area, establishing the richest sites for marine life, the sites where there are problems and the sites which need protection.

VII) ShoreSearch
Shoresearch is a user-friendly and fun method of exploring the shore and recording the species and habitats found there.

VIII) Wakame Watch (www.wakamewatch.org,uk
Wakame (*Undaria pinnatifida*) is a large species of seaweed originating from the Pacific and is considered by the IUCN Invasive Specialist Group to be one of the 100 'world's worst' invasive species, due to its potential to impact ecological and economic interests. Scientists do not currently believe that the true spread of the species is known for Great Britain and North West Europe. Producing an accurate distribution of this species is important in terms of managing and controlling spread. Wakame Watch has been established in order to generate an up-to-date picture of the distribution of the species by encouraging recording of sightings from the public. In particular, we are asking divers, snorkelers, recreational boat users, fishermen and environmental surveyors to let us know when they encounter the species.

IX) Chinese Mitten Crab Recording (www.mittencrabs.org.uk)
Chinese mitten crabs are officially listed as one of the World's 100 worst invasive species. They can cause damage to fishing gear and river banks, block intake screens, modify natural habitats and compete with native species. It is this economic and ecological damage that makes this crab such an unwelcome arrival. The full extent of these exotic pests in English and Welsh waters is currently unclear and a consortium of research institutes is requesting mitten crab sightings from members of the public, anglers and waterway workers, to clarify the distribution of this species.

X) Sealife Survey (www.mba.ac.uk/recording)
Warming seas, non-native invaders and human activities are all affecting our marine environment. Records of marine life are needed to inform decision-makers, to track changes, to find out why things are changing and, let's not forget, because recording is fun!

XI) Great Eggcase hunt (www.sharktrust.org/en/great_eggcase_hunt)
The Great Eggcase Hunt aims to get as many people as possible hunting for eggcases that have either been washed ashore, or are found by divers and snorkelers underwater. In recent decades, several species of shark, skate and ray around the British coast have dramatically declined in numbers. The empty eggcases (or mermaid's purses) are an easily accessible source of information on the whereabouts of potential nursery grounds and will provide the Trust with a better understanding of species abundance and distribution.

XII) BioLit (www.biolit.fr)
BioLit is a network of men and women involved in environmental management and protection. BioLit partners hope to share their knowledge of the coastline with the local community and help you to record what you see on the shore.

EUROPEAN CITIZEN SCIENCE ASSOCIATION

Ten principles of citizen science

Citizen science is a flexible concept which can be adapted and applied within diverse situations and disciplines. The statements below were developed by the *'Sharing best practice and building capacity'* working group of the **European Citizen Science Association**, led by the Natural History Museum London with input from many members of the Association, to set out some of the key principles which as a community we believe underlie good practice in citizen science.

1. **Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.**
   Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.

2. **Citizen science projects have a genuine science outcome.**
   For example, answering a research question or informing conservation action, management decisions or environmental policy.

3. **Both the professional scientists and the citizen scientists benefit from taking part.**
   Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy.

4. **Citizen scientists may, if they wish, participate in multiple stages of the scientific process.**
   This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.

5. **Citizen scientists receive feedback from the project.**
   For example, how their data are being used and what the research, policy or societal outcomes are.

6. **Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.**
   However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.

7. **Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format.**
   Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.

8. **Citizen scientists are acknowledged in project results and publications.**

9. **Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.**

10. **The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.**

September 2015, London