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THEMATIC SECTION

Let Them Dive into Ocean Science: The Role of Research Institutions in Public Engagement

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Abstract

Climate change and human activities are global challenges with remarkable impacts on oceans and marine resources. Raising awareness on these challenges can importantly contribute to the sustainable development of all countries. However, global development begins with local development, where knowledge is spread to formulate effective responses to global challenges. In this context the contribution of public institutions is fundamental in raising awareness in civil society, thus bringing scientific knowledge outside academia.

Keywords Climate change · Marine resources · Sustainable fishing · Ocean literacy · Game-based learning · Exhibitions · Marine science communication

Seas and oceans are threatened by waste, pollution, indiscriminate use of resources, climate change and damage to the marine ecosystem, and all this is posing significant risks to human health and ecosystem services in many direct and indirect ways. Ocean literacy and sustainable approaches to marine ecosystem management are, therefore, key elements to significantly reduce vulnerability and contribute to climate resilience, which can only be achieved through effective and equitable adaptation and mitigation actions to be taken at all levels, starting from local communities. From this perspective, and in order to contribute to the accomplishment of the United Nations Sustainable Development Goals (including the need for quality education to achieve sustainable development), it is necessary to carry out joint actions, involving the scientific community and civil society, where research and communication overlap to raise awareness for the conservation, restoration, and sustainable use of seas and oceans (Seys et al. 2022), in agreement with the UN Decade of Ocean Science for Sustainable Development. To be effective, science communication cannot follow preconceived models, but must adapt to the different needs of the public to be reached. Therefore, it is necessary to rethink marine science communication by using a new framework.

Research institutions can have a pivotal role in this process by setting innovative communication frameworks with sound scientific basis. In recent years, they have been increasingly committed to developing actions for the transfer of knowledge to society and have contributed to citizen awareness and involvement in current scientific and technological challenges.

As part of the mandate of the National Institute of Oceanography and Applied Geophysics (OGS), as defined in the Institute's statute and in one of its five missions of research and innovation,[1] free knowledge dissemination, without restrictions of any kind, is a clear contribution in terms of social inclusion and equity, as well as environmental education. Therefore, OGS promotes scientific communication and dissemination to raise awareness of the value of science among various user groups, such as public administrations, manufacturing companies and citizens, including children

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[1] https://www.ogs.it/en/missions/open-science accessed 5 May 2023.

and youth to be reached through specifically targeted training activities.

Science festivals and informal learning activities are only a few of the good examples of what research institutes can do to transfer knowledge to non-expert audiences and promote sustainable behaviours on a large scale and in local communities. This article provides an overview of the public engagement activities organized by OGS, together with other public and private entities, in the last 5 years and shows the effects of an institutional communication strategy that includes outreach initiatives on local communities.

The *MareDireFare*: Ocean Festival—An Example of a Science Festival on Marine Science

Science festivals are cultural events focused on a scientific topic and addressed to a non-expert audience. A science festival programme includes workshops and hands-on activities together with seminars, lectures and conferences. This growing cultural phenomenon has spread across Europe in recent decades. Evaluation studies show that, together with science engagement based on informal STEM education[2] and inquiry-based learning[3] approaches, it has an increasing impact: science festivals offer flexible and personal experiences, which offer visitors the possibility to identify their own individual path to engage with the scientific content (Bultitude 2014).

Trieste is a city, overlooking the sea, in North-eastern Italy, with an important scientific tradition. Its territory is home to several scientific institutions of international excellence which not only study the sea and its biodiversity but are also actively involved in public dissemination of science through the organization of events, workshops and seminars.

Two of Trieste's research institutions launched a festival in 2021 to mark the start of the Decade of the Oceans: the *MareDireFare* Ocean festival. Organized by OGS and the WWF Marine Protected Area of Miramare, the initiative puts the sea at the centre of its activities so as to reflect on its conservation and the future of marine resources.

In the first edition of the festival, widespread events were organized in Trieste. For 15 days the city was transformed into a debate, dialogue, storytelling and game centre concerning the sea. Theatrical performances, animated and itinerant readings, photographic exhibitions, creative workshops and book presentations were held in various parts of the city. Moreover, an exhibition dedicated to the microscopic marine world was organized in the Miramare historical stables, in the park of the nineteenth-century castle overlooking the Gulf of Trieste. The interweaving of art and science has allowed to broaden the collective perception of the sea to its less visible and less known dimension, yet fundamental to the existence of life on Earth.

The second edition of the festival was held in 2022 and was dedicated to the seven principles of ocean literacy: seven basic concepts that every citizen should know to understand the relationship between human being and the ocean. Seven artists, selected through a national competition for illustrators, created their illustrative works after attending workshops, with researchers and educators, where they trained on ocean literacy. The artists' works were displayed in seven locations, including city bookshops, libraries and cafes, so that the exhibition was spread throughout the territory. In addition to the exhibition, a series of events for adults and children, focused on sea science, history and culture, enlivened the city for 15 days.

In 2023, the third edition of the festival will focus on the sea boundaries, to underline that the sea begins in our cities. As in previous editions, the aim is to communicate science through artworks and, particularly, through the language of street art, a popular art form with the specific intention of conveying social messages.

Informal Learning: The Example of Scientific Dinners

Starting from the traditional event of Dinner with the Scientist, the format of the scientific dinner was introduced in our events in Trieste in 2019. As part of the *Mare e Salute* project activities, a scientific dinner programme was organized to promote an informal way to disseminate the close relationship between human health and the sea. The events have been structured to strictly link the convivial part with the scientific topic and research activity, with the served dishes being the starting point to deepen the scientific ecological aspects hidden in the dish. An example is the Marine Food Chain Dinner in which dinner and scientific explanations are scientifically and creatively integrated in the menu to unveil primary producers, herbivores and carnivores among the marine species we consume. The products served during the dinner are located in the complex marine food web, and

[2] 'Informal STEM education' refers to lifelong learning in science, technology, engineering, and math (STEM) that takes place across a multitude of designed settings and experiences outside of the formal classroom. https://www.informalscience.org/what-informal-stem-learning accessed 5 May 2023.

[3] 'Inquiry based learning' refers to the pedagogical approach in Science Teaching promoted by European Commission. https://www.eesc.europa.eu/en/documents/rocard-report-science-education-now-new-pedagogy-future-europe#downloads, accessed 05 May 2023.

thanks to a specially designed menu, the guests understand the ecological footprint of the seafood on their plate.

GAME-BASED Learning and Games for Social Changes

Game-based learning is an educational approach that uses games and game-like experiences to increase engagement with scientific topics. This approach, using games and gaming tools (board games, video games, role-playing games, etc.), has gained popularity in recent years as it offers numerous advantages over traditional teaching methods. Games and gaming are very powerful learning and educational tools: they increase intrinsic motivation and help people to better focus on a topic, often through problem solving (Kailani et al. 2019). Moreover, they can engage people in a way that traditional learning methods cannot. Games also provide a safe and low-risk environment in which one can experiment, try and make mistakes without the fear of failure. Another advantage of game-based learning is that it offers wide space for personalized and adaptable learning experiences. Games can be designed to suit individual abilities and preferences, thus offering a more personalized and effective learning experience. Games can also provide instant feedback and assessment, allowing educators to identify and address learning gaps more quickly and effectively. With games, educators can create more immersive and interactive learning experiences that are more likely to be remembered. This can lead to deeper and more meaningful learning outcomes that extend beyond the educational experience.

Although simulated, games also allow citizens to be involved more directly by stimulating critical thinking and gaining knowledge on different topics, including scientific ones, with repercussions on everyday life. This is the perspective of the Games for Social Change, which aims both to raise awareness on important community issues and, at times, change people's perceptions on a topic (for example, on gender bias in STEM education[4]).

Specifically, sustainability education has employed games as a learning tool for several reasons, among which their compatibility with effective instructional design practices, their integration of hands-on learning via real-world problems and situations (Bilancini et al. 2023), and their ability to function as intricate systems that enable the comprehension of environmental systems and the effects of diverse behaviours on the ecosystem.

Many different studies prove the effectiveness of Game-Based Learning (GBL), showing a statistically significant effect of its implementation on the learning outcomes of primary and secondary school students (Setiawan and Phillipson 2019).

Fish n' Ships: A Card Game on Sustainable Fishing

Fishing is a direct anthropic activity on marine life that can adversely affect ecosystems through the use of impactful fishing gear, illegal and unreported catches, and excessive exploitation. Excessive exploitation, or overfishing, occurs when the extraction of resources from the seas and oceans exceeds their renewal capacity that is also influenced by other anthropogenic threats (climate change, pollution, and habitat modifications).[5]

One of the United Nations Sustainable Development Goals[6] is to effectively regulate the use of marine resources and put an end to overfishing, illegal, unreported and unregulated fishing, and destructive fishing practices, as well as to implement science-based management plans to restore, as quickly as possible, fish stocks to levels that can produce at least the maximum sustainable yield according to their biological characteristics.

In general, raising public awareness can support the achievement of the sustainable fishing goal, while increasing awareness specifically in the future generation, through educational activities and the use of teaching tools that effectively communicate key concepts, can promote sustainable behaviours.

Fish n' Ships is a card game[7] developed as part of the Interreg Italy-Croatia FAIRSEA[8] project (and later improved through the TECHERA[9] project) to provide participants with knowledge on the marine ecosystem and sustainable management of its resources. The game maps the complexity of the marine food web and fisheries in the Adriatic as well as other Mediterranean Seas. It deals with key concepts such as trophic levels, the ecological pyramid, discards and management of socio-ecological systems in a simple and

[4] European Free to Choose Project about gender stereotypes in STEM education https://www.iresfvg.org/free-to-choose/.

[5] Proportion of fish stocks within biologically sustainable levels (1974–2020). 14.4.1 Fish stocks sustainability | Sustainable Development Goals | Food and Agriculture Organization of the United Nations (fao.org), accessed 5 May 2023.

[6] Conserve and sustainably use the oceans, seas and marine resources for sustainable development https://sdgs.un.org/goals/goal14

[7] The game is also available in digital version at: https://fishnships.it, accessed 5 May 2023.

[8] https://www.italy-croatia.eu/web/fairsea/docs-and-tools-details?id=1433067&nAcc=1&file=16, accessed 5 May 2023.

[9] https://www.italy-croatia.eu/web/techera, accessed 5 May 2023.

intuitive way. Each set of cards contains a total of 120 species cards representing 36 different species belonging to 16 ecologically similar species groups (functional groups); each species is briefly described with its main ecological, biological or trophic characteristics. The fishery cards represent the eight fishing methods in the Adriatic and the other Mediterranean Seas and include a brief description to increase knowledge of the complexity of fishing and extent of the damage it can cause to the ecosystem.

In the first part of the game, players must build their marine ecosystem, which must include organisms from all trophic levels. There is no limit to the number of species cards in each player's marine ecosystem, although subsequent trophic levels can have at most one less card than the trophic level below. A healthy sea must include all trophic levels, from primary producers to top predators. Players with a healthy sea can begin the second phase of the game and use the fishing cards to fish in their sea, using the appropriate tools to fish for target species, while being mindful of the damage that fishing activity can cause to the marine ecosystem. Random events representing other impacts on the ecosystem, such as invasive species, climate change, illegal fishing etc., may come into play and should be considered for a sustainable exploitation.

Impatto: Sustainable Research

Sustainability is a political concept that should be part of the scientific research process to promote growth while protecting the planet. A wide range of public (governments, institutions, international organizations) and private (companies, NGOs) actors, as well as civil society, are called to propose and adopt policies and strategies that ensure adequate coherence with the 2030 Agenda for Sustainable Development.

To promote sustainable development strategies, a board game called *Impatto* was created as part of the DIVERSO project funded by the Friuli Venezia Giulia Region. *Impatto* explains, in a simple and intuitive way, all the activities of a research institution, including the search for resources, research and innovation. The objective of the game is to find the resources necessary to develop projects and collect as many points as possible to win the game. Although competitive, the game has an educational value given by its strategy. In fact, the player can choose to carry out network actions for the benefit of the other players and, above all, must carry out his/her projects in a sustainable manner, since victory is achieved not only by the score of the projects developed, but also by having maintained a high sustainability level during their development.

The projects that players can develop during the game are represented by playing cards and focus on a group of Sustainable Development Goals (SDGs). Each card briefly explains the project to be undertaken to achieve a particular goal and the positive or negative impact that the project may have on the players. The board game is designed to easily add new SDGs and be adapted to different learning needs.

The Icebreaker: An Educational Role-Play Game

One of the targets of SDG 13 is to raise awareness of the impact of climate change on the environment and people. Therefore, to achieve this goal, it is fundamental to increase the education level of the population (especially of the younger generations) and provide the skills and knowledge of how human activities affect the environment.

The Icebreaker role-playing game is set in Antarctica, a key role player in climate balance. Every change that this continent undergoes affects the planet's thermal balance, atmospheric and oceanic circulation, ecosystem and sea level. The pristine environment of this continent makes Antarctica a natural laboratory for scientific research and for studying the effects of climate change. The game, developed with the *Genitori di ruolo*[10] association, simulates a research activity on board the oceanographic research vessel, *Laura Bassi*, and players, divided into teams, must collect data on the sea and complete their mission, which is to provide evidence of climate change to the Commission for the Conservation of Antarctic Marine Living Resources. During the game, players will have to face many dangers, both real and sci-fi, making the game more addictive. The main enemy is Syktaria, a fictional nation that opposes the expansion of the marine reserve boundaries in Antarctica and will do anything to hinder the scientists' work. The game aims to promote knowledge of the Antarctic environment and clearly explain what chemical and physical parameters are collected during an oceanographic campaign and what indication they provide about sea health. In addition, the game is designed to promote the development of soft skills such as teamwork, problem solving, critical thinking and creativity.

Conclusions

Scientific progress has enabled us to study and understand the impact of human activities on the sea and the consequences for the planet and people, while highlighting the need to protect the marine environment. However, the protection of the ocean and sustainable use of its resources is a global task that requires a behavioural change involving the entire population. Therefore, making science accessible,

[10] https://www.genitoridiruolo.com/ accessed 5 May 2023.

adopting practices to transfer knowledge in engaging ways, and creating teaching tools to be utilized in a variety of formal and informal educational contexts, are essential to reach diverse audiences and achieve sustainable behaviours on a large scale.

Over the past 5 years, OGS joined forces with other public and private institutions to launch a number of initiatives aimed at non-expert audiences. These include a science festival focusing on marine science (the *MareDireFare*—Ocean festival), science dinners and three game-based learning projects (Fish 'n Ships, *Impatto* and The Icebreaker).

The examples given in this article show how institutional science communication activities, based on scientific research and designed with different pedagogical approaches, help to raise public awareness of marine science and sustainable development.

Declarations

Conflict of interest The contribution is free from any conflicts of interest, including all financial and non-financial interests and relationships.

References

Bilancini, Ennio, Leonardo Boncinelli, and Roberto Di Paolo. 2023. Game-Based Education Promotes Practices Supporting Sustainable Water Use. *Ecological Economics* 208. https://doi.org/https://doi.org/10.1016/j.ecolecon.2023.107801, accessed 5 May 2023.

Bultitude, Karen. 2014. Science Festivals: Do They Succeed in Reaching beyond the 'Already Engaged'? *Journal of Science Communication* 13(4). https://doi.org/10.22323/2.13040301, accessed 5 May 2023.

Kailani, Shweta, Rhonda Newton, and Susan Pedersen. 2019. Game-Based learning and problem-solving skills: A systematic review of the literature. *EdMedia+ innovate learning*, 1127–1137. https://www.learntechlib.org/noaccess/210119/, accessed 5 May 2023.

Setiawan, Heru, and Shane Phillipson. 2019. The Effectiveness of Game-Based Science Learning (GBSL) to Improve Students' Academic Achievement: A Meta-Analysis of Current Research from 2010 to 2017. *Research and Evaluation in Education* 5(2): 152–68. https://doi.org/10.21831/reid.v5i2.28073, accessed 5 May 2023.

Seys, Jan, Lucy Cox, Ezgi Şahin Yücel, Daria Ezgeta-Balić, Marco Faimali, Francesca Garaventa, M. Carmen García-Martínez, Claudia Gili, Kathrin Kopke, Francesca Petrera, Dominique Simon, Andreas Villwock, Tymon Zielinski, Kelle Moreau, Angel Muñiz Piniella. 2022. Marine Science Communication in Europe – A way forward, Muñiz Piniella, A., Kellett, P., van den Brand, R., Alexander, B., Rodriguez Perez, A., Van Elslander, J., Heymans, J. J. (Eds.) *Future Science Brief of the European Marine Board*, no. 8, 48pp. Ostend, Belgium, ISBN: 9789464206166, ISSN: 2593-5232. https://doi.org/10.5281/zenodo.6444143, https://zenodo.org/record/6444143#.ZFT38XZBxPY, accessed 5 May 2023.