OARS Outcome 6 White Paper

OARS Outcome 6: Increase public awareness of ocean acidification, its sources, and impacts, achieved via ocean literacy and public outreach.

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Introduction

Atmospheric CO_2 is increasing in unprecedented ways due to anthropogenic activities such as the burning of fossil fuels, deforestation, cement production, and large-scale land-use changes (Friedlingstein et al., 2020). The ocean absorbs the atmospheric CO_2 alleviating the greenhouse effect. However, such CO_2 absorption is changing seawater chemistry by lowering its pH and the carbonate ion (CO_2^{3-}) levels. This causes a fundamental shift in ocean chemistry, known as ocean acidification (Doney et al., 2020; Hassoun et al., 2022). Ocean acidification (OA) is threatening the overall structure of marine ecosystems (Beaufort et al., 2011; Gattuso and Hansson, 2011; Riebesell et al., 2013; IPCC, 2021) and resources on a global scale (IGBP et al., 2013). For example, OA effects cause a decline in shellfish calcification and growth rates (Talmage and Gobler, 2010; Wittmann and Pörtner, 2013), as well as of shell-forming marine plankton and benthic organisms including mollusks (Kroeker et al., 2013; Vargas et al., 2013), echinoderms (Dupont et al., 2010; Bednaršek et al., 2021), pteropods (Bednaršek et al., 2019), and corals (Beaufort et al., 2011; Kornder et al., 2018; Cornwall et al., 2021). The latter have already disappeared or are significantly damaged in some coastal areas around the world, including Indonesia, Hawaii, the Caribbean, Fiji, Maldives, and Australia (Erez et al., 2011). A 30% decline or damage of coral reef ecosystems is estimated worldwide, with predictions that as high as 60% of the global coral reefs may disappear by 2030 (Hughes et al., 2003), which might alter the ecological goods and services provided by these ecosystems (Moberg

and Folke, 1999) affecting thus more than 3 billion people who directly depend upon coral reefs for their livelihoods and food security (Hilmi et al., 2019).

OA is therefore a significant global menace that is threatening the livelihoods of millions of people relying on marine resources, as well as the future of crucial marine functions that are maintaining the global climate system that we currently know. Even with the availability of funding resources and a consensus for improved and coordinated OA governance, Hassoun et al. (2022) found that a lack of OA literacy (Fauville et al., 2013) can lead to a lack of consistent OA policies (Harrould-Kolieb and Hoegh-Guldberg, 2019) and OA regional governance (Galdies et al., 2020). We cannot engage with issues we don't understand and the OA literacy is key to educate the public and authorities on the complex consequences of OA and solutions to mitigate and/or adapt to future global changes.

What is the problem?

While the ocean provides tremendous services and value to humans (e.g., Costello et al., 2020; Worm et al., 2006), human activities are compromising its capacities to provide these services (IPCC, 2019). To avoid catastrophic consequences of anthropogenic impacts on the ocean, it is urgent to address these threats (Gattuso et al., 2015). As argued by Sterling (2001, p. 10) "The difference between a sustainable or a chaotic future is learning". In order for citizens to be responsibly involved in marine environmental issues such as OA, they need to understand the value and role of the marine environment, as well as how human activity is affecting, or potentially diminishing, that. Ocean literate people understand the influence the ocean has on them and their influence on the ocean. Ocean Literacy helps demonstrate the value of ocean science for sustainable economy and policy, helping to create a common baseline of understanding and a common set of values among societal actors and stakeholders (Eparkhina et al., 2021).

The original definition of ocean literacy covers three dimensions: (i) having knowledge about the functioning of the ocean, (ii) being able to communicate about the ocean in meaningful ways, and (iii) taking informed and responsible actions regarding the ocean and its resources (Cava et al., 2005). Lately, the concept of ocean literacy has been attracting more attention from the research community. Scholars argue for expanding the reach of ocean literacy beyond these three dimensions and suggest 6 dimensions (Brennan et al., 2019) and even 10 dimensions such as activism, emotional connections and adaptive capacity (McKinley et al., 2023).

Previous research has revealed a low level of knowledge about the ocean among the public: citizens have limited marine understanding (Guest et al., 2015), hold serious misconceptions about the ocean (Ballantyne, 2004), and have little understanding of marine environmental issues and protection (Eddy, 2014). To change this, it is not enough to provide information (Bray and Cridge, 2013; Clayton et al., 2015). Research has shown that focusing on a personal connection and relevance and agency of the learners is more efficient than sharing facts (Kollmuss and Agyeman, 2002; Bamberg and Möser, 2007). Also, direct experience of an environmental issue is more powerful than second-hand information (Spence et al., 2011).

However, experiencing environmental issues that take place in the ocean is complicated. Few people have the ocean in their backyard and exposure to the ocean is rarely a significant part of formal education in secondary schools. First-hand exploration of the ocean is a challenge in terms of time, safety, and budget (Fauville et al., 2018). Even for citizens living by the ocean, most of the marine environment remains hidden under the surface and far away from the coastline, leading to a situation where only a small fraction of the marine biodiversity and processes can be encountered and experienced directly. As

expressed by Longo and Clark (2016, p. 465), "the ocean is commonly viewed as something far removed from human society. In some way, it is deemed 'out of sight, out of mind'".

When it comes to increased OA literacy, the research is in its infancy. Teaching OA is made difficult by the lack of general scientific literacy, an unprepared field of education, the complex and invisible nature of this issue, and the lack of personal connection with the ocean (Fauville et al., 2020). The educational strategies developed thus far to address this issue have been limited in their approach. Moreover, the strategies adopted to teach OA have lacked proper research on their impact on knowledge, attitude, and behavior related to the health of the ocean (Fauville et al., 2013).

1. Briefly describe the outcome and how it contributes to the overall OARS objective, the ultimate impacts and benefits with respect to the Ocean Decade, as well as the environment and society at large.

Outcome 6 is to Increase public awareness of ocean acidification, its sources, and impacts, achieved via ocean literacy and public outreach. By taking steps to achieve this outcome, distinct benefits will be realized:

a) Increase Ocean Literacy in general, and OA Literacy in particular: Ocean Literacy has been recognized as an important skill of the 21st century in order to reach the sustainability goals set by the UN, including but not limited to SDG 14 (Life Below Water), to the 7 UNESCO essential principles of OL[1] and to the Ocean Decade Challenges[2]. As this is a global issue, it is critical to reach many sectors and demographics to create change, including policy and decision-makers, the public, industry, and young people. In collaboration with various national, regional, and international initiatives[3], strategies to improve Ocean Literacy among key targets will be developed. ***It will be more widely understood that OA is directly linked to climate change and requires urgent attention.***

b) Implement innovative strategies to overcome barriers to teaching OA: OA is a complex issue grounded in chemical reactions and complex equations. Engaging communication will require emotional connection between the public and the ocean, to overcome this complexity and trigger interest and involvement. This can be achieved, for example, through teaching about charismatic ocean and/or cryptic fauna that are affected by OA (e.g., pteropods, corals, crustaceans, and molluscs). Storytelling and focus on heroes as model characters can be another approach to trigger emotional connection with the ocean. ***More sectors of humanity will have a more innate understanding of why ocean change can have significant and relevant consequences.***

c) Focus on positive actions rather than on negative impacts: This can be conducted through science-based messages highlighting solutions or inspiring the audiences to suggest their own. Within this initiative, it is deemed important to engage with OA skeptics who obfuscate by citing uncertainties around OA. It is important to clearly explain uncertainties and highlight risks. This will require collaboration between sectors such as health, insurance, security, banks and businesses that are ready to support the mitigation of OA in a tangible and sustainable way. There must be a much more visible connection between the science of OA and the public's lifestyle in order to help citizens make informed choices in relation to the ocean and its resources. ***In this way, the public will see how positive changes in their daily life can help fight OA.***

d) Work on key take-home messages to various audiences: The messages will aim at four target groups: policy and decision-makers, general public, educators, students. Appropriate language and narratives will

[1] Principles - Ocean Literacy Portal (unesco.org)

[2] Challenges – Ocean Decade

[3] For example: OARS outcomes 2 and 7: GOA-ON : OARS - Outcomes

be used to reach out to each of the target groups. Activities and tools will be designed for each target group but in such a way that they can be repurposed to another group if possible. ***This will enable a common language and understanding between disparate sectors.***

e) Tailoring indicators/metrics of progress and success: In collaboration with various types of experts, we will provide metrics that can be regularly used during and beyond the UN Ocean Decade to monitor the progress of our activities and the success of the strategies implemented. ***This will provide common knowledge of whether efforts are reaching the intended level of change.***

2. Prepare a preliminary list of key outputs and products that will need to be produced in order to deliver the desired outcome.

In this outcome, we aim to provide the following outputs:

1. Various ***communication strategies*** will be proposed to reach our audiences. These strategies might include mainstream and engaging documentaries and/or animated short films (i.e., teacher at sea[4], citizen-science[5]) and participation in international short film festivals, Virtual or Augmented Reality (VR, AR), celebrity interviews about OA to be shared on social media with catchy titles (e.g., What will OA do to Aquaman?).
2. ***Professional development*** for educators will be provided to give them adequate knowledge to teach about the OA in their classrooms (e.g., through knowledge exchange and training-of-trainers initiatives).
3. ***Scientifically vetted take-home messages*** underlining sources, impacts, solutions, and required actions will be co-created with science communicators, artists, and marketing experts.
4. We will promote the ***use of high-tech tools*** to improve OA awareness. The use of immersive technologies such as VR and AR have already been demonstrated to have potential to impact public environmental literacy (Fauville et al., 2020; Pimentel, 2022). These tools can help make the process of OA visible to the human eyes but also to develop empathy for the species negatively impacted by this problem. These species can be either animals the public is familiar with and feel connected with through, for example, their diet, or species that are not well known but can be discovered through Ocean Literacy (e.g., pteropods).
5. ***Citizen-science campaigns*** will be launched. In fact, all the aforementioned initiatives can be refined by mapping out various audiences' knowledge, and launching citizen science campaigns. This kind of campaigns could involve divers, students building a mini-boat to sail on the open ocean[6], or adopting a float that collects OA data that can be analyzed in school.
6. An ***OARS Education website*** will be set-up where the material generated and existing resources can be accessed. OA scientists and educators from around the globe will be invited to interact with students using these materials.
7. We will create a ***comprehensive OA training programme***, both virtual and in-person, that can be utilized globally.

3. Describe research and outreach activities that are needed to create the outputs and products listed in section 2.

The outreach activities utilized must be guided by a clear answer to each of these three questions:

[4] https://saltwaterprojects.squarespace.com/two-bays-2014

[5] Citizen Science at NOAA

[6] https://educationalpassages.org

- What are the expected learning outcomes? (i.e., what are the take-home messages we are hoping the learners will get?),
- Who are the learners? (i.e., what is their socio-demographic profile, their lifestyle, their profession?)
- In which context is this outreach activity taking place (i.e., in school, at work, in the (social) media, outdoors, in science museums)?

Analysis of these answers will need to guide the way in which the activity is implemented.

While OA is a psychologically distant issue (due to its invisible nature and its distance in terms of impact), it is essential to invest in solutions that have the potential to decrease this distance. One way is to engage people in the issue.
Strategies developed must give learners as much involvement as possible. This can be done during a series of activities with opportunities to get close to the marine environment first hand or to build and deploy tools to collect their own OA data. Moreover, the learning outcome should be grounded in practical solutions and actions that the learners can engage in. Solution-oriented education will help avoid generating a doom and gloom feeling and help develop a sense of ownership. The OARS efforts should also spread across various international networks of marine educators (e.g., AMEA, EMSEA, CaNOE, IPMEN, NMEA, RELATO and AAEE) and the UN Decade programmes and projects addressing ocean literacy (e.g. OLWA and Scientists for Ocean Literacy).

The proposed OA literacy activities can engage people in an unusual and creative way and become widely spread via social media (e.g., Tiktok, Instagram, Facebook, etc.), or in public areas (e.g., malls or pubs). There are also opportunities to develop instructional material for schools, train the teachers, and promote the inclusion of OA in the curriculum. No matter what tactics are used to educate people, these activities should be developed and tested in an iterative way with the audience they target to ensure that these learning tools address the needs of their specific learners. The strategies developed should also be investigated from a qualitative and quantitative perspective in order to develop an in-depth understanding of their impacts and try to improve the evaluation of activities in innovative ways (e.g., using indicators of success and progress).

4. Comment on the key enablers that will influence the likelihood of successfully delivering the outcome.

The creation of OA literacy strategies and tools will require a multidisciplinary approach. Expertise from fields such as storytelling, art, marketing, journalism, social media, communication, and education are essential to make sure that the focus is not only on the scientific accuracy but also the mode of delivering the message. Moreover, in addition to academic science Traditional Ecological Knowledge (TEK) must also be considered in developing the science base for the OA literacy. Many coastal communities rely on the ocean for their livelihoods and are highly impacted by OA. It will be important to engage indigenous coastal communities and traditional knowledge holders from around the world, preferably with the support of their central/regional governments, to empower their voices and enhance awareness and actions.

As one of the programmes endorsed by the UN Ocean Decade, OARS will establish synergies with other Decade actions, towards a stronger joint impact. Among others, this will include collaborating with programmes Ocean Literacy With All, Decade for Ocean Empathy, and ECOP.

Finally, we need to take a critical look (e.g., through meta-analyses and systematic reviews) into systemic inequities embedded in the field of OA and environmental education in order to ensure diversity, equity, and inclusion in OA research (Hassoun et al., 2022), OA resilience, in our goal to increase OA literacy.

5. Identify the key inputs that will be needed to support the activities and outputs described above.

There needs to be an increased focus on this specific outcome, OA literacy, combining many perspectives and melting several expertise. A forum to focus this activity is lacking, because the needed inputs span diverse disciplines. Sub-working groups will need to be established to guide the outputs and make the preliminary analyses to guide them. Lastly, a way to institutionalize the activity, so the good bursts of energy don't wither on the vine after a year or so is needed. This will help sustain this outcome's outputs beyond the UN ocean decade.

Timeline

This is a live section that will be updated regularly based on the announcement of key events that might be a great occasion to implement our Outcome 6 strategies, such as:

- Our Ocean Conference (2024 - Greece)
- UN Ocean Conference (2025 - France)

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