



OPINION PIECE

Making ocean literacy inclusive and accessible

Boris Worm^{1,*}, Carla Elliff², Juliana Graça Fonseca³, Fiona R. Gell^{4,5},
Catarina Serra-Gonçalves⁶, Noelle K. Helder⁷, Kieran Murray⁸, Hoyt Peckham⁹,
Lucija Prelovec¹⁰, Kerry Sink^{11,12}

¹Ocean Frontier Institute, Dalhousie University, Halifax, NS B3H4R2, Canada

²Instituto Oceanográfico, Universidade de São Paulo, São Paulo, SP 05508-120, Brazil

³Departamento de Biologia Marinha, Universidade Federal Fluminense, Niterói, RJ 24001-970, Brazil

⁴Department of Environment, Food and Agriculture, St. John's, Isle of Man IM4 3AS, British Isles

⁵University College Isle of Man, Douglas, Isle of Man IM2 6RB, British Isles

⁶Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS 7001, Australia

⁷Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada

⁸Fauna & Flora International, Phnom Penh 12302, Cambodia

⁹SmartFish AC, La Paz 23000, México

¹⁰Ocean School, Dalhousie University, Halifax, NS B3H4R2, Canada

¹¹Institute for Coastal and Marine Research, Nelson Mandela University, Port Elizabeth 6031, South Africa

¹²South African National Biodiversity Institute, Cape Town 7735, South Africa

ABSTRACT: Engagement in marine science has historically been the privilege of a small number of people with access to higher education, specialised equipment and research funding. Such constraints have often limited public engagement and may have slowed the uptake of ocean science into environmental policy. Recognition of this disconnect has spurred a growing movement to promote ocean literacy, defined as one's individual understanding of how the ocean affects people and how people affect the ocean. Over the last 2 decades, this concept has gained significant traction in marine biology and environmental education circles and now plays a prominent role in the UN's Decade of Ocean Science for Sustainable Development (2021–2030). Here, we argue that the ocean literacy agenda has largely been shaped and discussed by marine scientists and educators but needs to be expanded to a much larger constituency to be more effective, accessible and inclusive. We discuss diverse cultural settings from around the world and provide examples of indigenous, spiritual, art, ocean user and other groups that are already deeply engaged with the ocean and could provide a variety of perspectives to enrich the ocean literacy concept beyond an understanding of marine science. We suggest that such inclusiveness could remove the historic barriers that have surrounded the field, transform our collective awareness of and relationship with the ocean and help support ongoing efforts to restore marine biodiversity.

KEY WORDS: Ocean literacy · Diversity · Science–policy interface · Environmental education

1. INTRODUCTION

Whether we are aware of it or not, we are all ocean people. No matter where on Earth we live, the ocean touches every aspect of our lives, from the air we breathe and the climate we experience to the food we eat and the goods we consume (Worm et al.

2006). Conversely, much of what we do in our daily lives affects the ocean in turn, for example through the consumption of fish or fuel taken from the sea or the generation of waste products such as sewage, carbon dioxide and plastic, which may ultimately end up in the ocean. There is simply no way to fully understand and appreciate our place on this planet

*Corresponding author: bworm@dal.ca

without a deep knowledge of the ocean and our relationship with it (Santoro et al. 2017).

Some aspects of this relationship have shaped the consciousness of coastal peoples for millennia, often focused on extractive benefits, for example from fishing and collecting (O'Connor et al. 2011), as well as threats, for example from hurricanes and tsunamis (Scheffers et al. 2009), but also on the less tangible spiritual values (Bernard 2013, Torrente et al. 2018). Yet, the advent of marine science as a discipline is more recent, coinciding roughly with the onset of the Industrial Revolution in the 19th century (Adler 2019). For many years, formal marine science remained the preserve of a few privileged individuals, most of them of European or North American origin, with a more rapid expansion occurring since the mid-20th century (Adler 2019). This recent origin and somewhat insular nature of the field have undoubtedly slowed the uptake of relevant concepts by the public, which in turn may have contributed to the overuse and rapid deterioration of many marine ecosystems.

Partly as a result of such historical circumstances, a widespread gap in ocean literacy was identified by a coalition of US marine scientists and educators in 2002 to 2004 (Schoedinger et al. 2010). The same group formally coined and defined the term ocean literacy as 'an understanding of the ocean's influence on you and your influence on the ocean' (Cava et al. 2005, p. 5).

According to the definition, 'An ocean-literate person understands the fundamental concepts about the functioning of the ocean, can communicate about the ocean in a meaningful way, and is able to make informed and responsible decisions regarding the ocean and its resources' (Cava et al. 2005, p. 5).

Since then, the concept of ocean literacy has been discussed and amplified in marine science, education and policy circles, particularly in North America and Europe (Schoedinger et al. 2010, Guest et al. 2015, Mogias et al. 2019). Most recently, the concept was included in the UN's Call for Action for Sustainable Development Goal 14: Life Below Water and will be an important cornerstone of the UN's Decade of Ocean Science for Sustainable Development (2021–2030) (Claudet et al. 2020). Specifically, the current implementation plan for the decade (UN 2020) denotes one of 7 key outcomes by 2030 as follows:

'Outcome 7: An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development. In order to incite behaviour change and ensure the effectiveness of solutions developed under

the Decade there needs to be a step change in society's relationship with the ocean. This can be achieved through ocean literacy approaches, formal and informal educational and awareness raising tools, and through measures to ensure equitable physical access to the ocean (...)' (UN 2020, p. 9).

Accordingly, ocean literacy is now seen as an important component in our efforts to improve humanity's relationship with the ocean environment (see also ocean citizenship sensu Fletcher & Potts 2007) and transition society towards a more sustainable future (UN 2020). In support of this emerging agenda, we offer some thoughts and concrete examples on how to make ocean literacy more inclusive, effective and accessible, especially given the historical constraints discussed above. Herein, we do not wish to imply that earlier efforts were designed to exclude others but simply to build upon these efforts that necessarily started from a relatively small group of actors with limited representation.

2. OCEAN LITERACY IN DIFFERENT CULTURES

As the term ocean literacy was originally coined and first used in North America, it does not necessarily translate easily into other languages and cultures (Table 1). For example, although the word literacy has a direct translation into Portuguese and Spanish, it does not necessarily hold the same interpretation. In Brazilian Portuguese, a person who is ocean literate is understood as someone who has special expertise on the subject, such as a scientist or other ocean professional. By using this term uncritically, we would go against the core intent of ocean literacy: to connect society in all its diversity to the ocean. Thus, when the Intergovernmental Oceanographic Commission of UNESCO launched Portuguese and Spanish translations of their Ocean Literacy for All toolkit, the term was adapted to *cultura oceânica* and *cultura oceánica*, respectively (UNESCO 2020a,b). Both translate back into English directly as ocean culture and reflect well the original concept in their regional settings. The term also implies that the relationship with the ocean should involve diverse forms of knowledge, values and customs and be part of our daily lives (see Table 1 for other regional examples).

More generally, unique needs are associated with ocean literacy work in different cultures. For example, as highlighted in the bylaws of the Asian Marine Educators Association, 'Because it is so multi-cultural, Asia needs special resources tailored to its

Table 1. Ocean literacy concepts in different languages and cultures

Name	Language	Direct translation into English	Used in country	Defined by
Ocean literacy	English	Ocean literacy	USA	National Marine Science Association
Cultura oceânica	Portuguese	Ocean culture	Brazil	UNESCO-IOC
Connaissance de l'océan	French	Ocean knowledge	Canada	Canadian Coalition on Ocean Literacy
Cultura oceánica	Spanish	Ocean culture	Spain	UNESCO-IOC
Educazione all'oceano	Italian	Ocean education	Italy	UNESCO-IOC
海洋リテラシー	Japanese	Ocean literacy	Japan	Centre for Ocean Literacy and Education
Świadomość morską	Polish	Sea awareness	Poland	European Marine Science Educators Association
সমুদ্র সাক্ষরতা / বঙগোপসাগর-সাক্ষরতার	Bengali	Sea literacy/Bay of Bengal literacy	Bangladesh and India	Bay of Bengal Literacy Network
znanje o moru	Croatian	Knowledge about the sea	Croatia	European Marine Science Educators Association and social media
Γραμματισμός ως προς το Ωκεάνιο Περιβάλλον	Greek	Ocean environment literacy	Greece	International Ocean Literacy Survey
Cultura oceànica	Catalan	Ocean culture	Catalonia	International Ocean Literacy Survey
Elimu ya bahari Ujuzi wa bahari	Swahili	Marine education/ marine skills	Tanzania	European Marine Science Educators Association and social media

particular characteristics'. As an example, the island nation of Taiwan is highly dependent on the ocean and has included marine education in the national school curriculum for some time. Ocean literacy guidelines in Taiwan were developed specific to a Chinese language cultural context (Tsai & Chang 2019). It was recognised that key components of ocean literacy were missing from Taiwanese students' understanding and from their textbooks (Tsai & Chang 2019). Furthermore, the level of parental education was found to be a highly influential factor in ocean literacy and attitude towards the ocean. The researchers suggest that parental encouragement of developing scientific interest in Taiwanese society creates this intergenerational effect. As such, it was suggested that encouraging parents to instil enthusiasm for marine science in their children could help support ocean literacy in the region (Tsai & Chang 2019). To this day, however, ocean literacy is still believed to be limited in China and Taiwan (Umuhire & Fang 2016, Tsai & Chang 2019), highlighting the need for further approaches tailored to Chinese languages and corresponding cultures and societies.

Unique challenges and opportunities also exist across the African continent, where there is a great diversity of ocean-related cultural practices. Examples include the recognition of marine species as traditional medicine and in rituals (Prins et al. 2003),

regionally adapted fishing methods (Bruton 2016), target species and culinary practices. African ocean culture evidently dates back to the origin of early humans, with remains of ancient tools, ornaments and art from coastal caves providing compelling narratives of our evolving relationships with the sea (Parkington 2006, Marean 2010). Notwithstanding some national efforts, there has only been limited progress towards conceptualising this rich landscape and coordinating ocean literacy efforts across the continent (Stevens in press). Several projects are currently under development, although the framing and principles of ocean literacy in an African context have been questioned, calling for an enlarged context that accounts for contrasting poverty levels, basic literacy (reading and writing) challenges, language barriers and broader perspectives in terms of ocean heritage, value and knowledge (Stevens in press).

Many coastal regions around the world are also inhabited by indigenous people, often displaying a great complexity of ocean knowledge and culture that needs to be recognised and integrated within existing ocean literacy efforts. For example, a diverse group of indigenous minority people colloquially known as sea nomads is found in parts of Indonesia, Malaysia and the Philippines. The Bajau, Moken and Orang Suku Laut people spend most of their lives at sea in floating habitations and primarily rely on sub-

sistence fishing (Shepherd & Terry 2004, Clifton & Majors 2012). The Bajau have a deep understanding of the ocean, with complex ancestral and spiritual beliefs related to ocean life and a cyclical concept of time that falls in line with tidal movements, weather patterns and fish life cycles (Clifton & Majors 2012). However, they lack a concept of ocean literacy, as their lives are inseparable from the ocean, and the loaded term literacy creates a perceived barrier, as these indigenous minorities disproportionately lack formal education. Despite much potential for maritime nomads to be ambassadors for marine conservation, there has been friction between the Bajau and conservation organisations due to the former's use of controversial fishing techniques; because of this, much of their marine knowledge has been dismissed (Clifton & Majors 2012).

It is imperative to recognise that ocean literacy is a relatively novel Anglo-Saxon term for a process that has been practised in diverse cultures for centuries. Concepts of connectedness to both land and sea are prevalent in many indigenous traditions, ceremonies, laws, stories, artworks and songs and are shared across generations (Maffi 2001). Traditional ecological knowledge reflects these connections and poses an alternative, often experiential way of knowing and learning about our environment (Berkes et al. 1995). Where appropriate, integrating science education with such other ways of knowing will provide a more holistic and inclusive approach to ocean literacy.

3. ENGAGING DIVERSE AUDIENCES

In addition to diverse regional and language cultures, the ocean literacy movement also needs to include audiences from ocean user, faith, art and other communities that engage in ways that are not necessarily scientific but shape people's understanding of and appreciation for the ocean (Fig. 1).

For example, people who engage in marine recreation, such as open-water swimming, diving, boating, surfing or recreational fishing, can be important stakeholders and change-makers. Surfers, for instance, raise ocean awareness through organisations such as the Surfrider Foundation

(<https://www.surfrider.org/>) and Surfers Against Sewage (<https://www.sas.org.uk/>). In some cases, this work has even led to changes in legislation to protect nearshore habitat, such as recently in Chile (Lara 2020). In a recent literature review on marine ecosystem services, the most assessed class of services was that of ocean recreation and leisure (Garcia Rodrigues et al. 2017), indicating the growing importance of this sector. However, while some leisure organisations indicate concern about environmental degradation, not all are willing to change their practices for improved ocean conservation (Holland-Smith et al. 2013). This dilemma illustrates the complexity of the issue of environmental education and the question of how greater understanding and engagement can affect behaviour change (Kollmuss & Agyeman 2002). Clearly, one important measure of successful engagement will be a shift towards more sustainable practices, both individually and collectively.

In this regard, commercial fishers are another important group around the world. Fishers often have a deep understanding of marine systems, but this does not automatically motivate sustainable practices in this sector. Programmes which have assisted commercial fishers to augment their existing knowledge with additional scientific understanding of fisheries



Fig. 1. Diverse approaches to ocean literacy, learning and engagement. (A) Connecting with marine life through public aquaria (Germany); (B) learning about sustainable ocean use through intergenerational harvesting practices (Heiltsuk First Nation); (C) experiential learning through virtual reality (Canada); (D) celebrating the ocean through faith-based gatherings at the festivities of Iemanjá (Brazil). Photo credits: Percy Vogel (A), Nick Hawkins/Ocean School (B,C), Carla Elliff (D)

science, ecology and oceanography have proved valuable in improving the sustainability of fisheries and development of fisheries co-management schemes. For example, residential fisheries science courses on the Isle of Man helped engage fishers in sustainable management and helped facilitate a high level of co-management and fisher-led research in Manx waters.

Newer research on environmental education and behaviour change suggests that a combination of environmental knowledge and a personal connection to nature are most likely to elicit pro-environmental behaviour (Otto & Pensini 2017). Often, this combination is found in experiential learning that may foster personal connections as well as new knowledge, for example, through visiting the educational offerings in public aquaria (Fig. 1A), participating in traditional ocean use practices (Fig. 1B) or engaging with experiential learning tools that include actual or virtual visits to the ocean (Fig. 1C). A strong personal connection can manifest over time in deeply held personal beliefs that may motivate pro-environmental behaviour. This in turn can support growing efforts to conserve and restore marine life at a larger scale (Duarte et al. 2020)

Religious and other spiritual groups often hold strong personal beliefs related to the environment. For example, followers of the Afro-Brazilian religions Umbanda and Candomblé are closely tied to environmental beliefs and symbols, where sacred nature is represented by deities (orixás) (do Rosario 2006). Ecological faith is based on the belief that each point of nature has the strength of an orixá (Prandi 2001). For instance, Iemanjá (Queen of the Sea) represents the ocean (Camargo & Calloni 2012) and is the best known deity of African-origin religion in Brazil (do Rosario 2006). The Queen of the Sea is represented in many cultural expressions that promote ocean values. The annual celebration of Iemanjá (Fig. 1D) is a day of purification in the sea, where thousands of people go to the beaches to celebrate the Queen of the Sea by offering flowers, perfume and other goods placed on small wooden boats (do Rosario 2006). Despite the spiritual connection to the ocean, the use of non-biodegradable material as offerings is common, reflecting a lack knowledge that could be addressed by an integrated ocean literacy effort. At the same time, it is crucial to respect and account for local beliefs and practices to propose meaningful educational strategies. Such spiritual beliefs and practices are found around the world. For example, some Polynesian and African cultures consider the sea as a place of residence for ancestors, and as such

the ocean is revered and regarded as sacred (Bernard 2013, Torrente et al. 2018).

Engaging people via the arts may offer another pathway for advancing environmental awareness and pro-environmental behaviour (Harrison & Harrison 1993, Jackson 2005, Harrower 2019). Such efforts may come from professional art associations such as the Ocean Artists Society, who use ocean art to inspire people to preserve our natural world, or fine art academies such as Ocean Space, which is designed to catalyze ocean literacy, research and advocacy through the arts (<https://www.tba21.org/#item--academy--1819>). Mainstream media such as television documentaries have also fostered ocean and environmental literacy (Mogias et al. 2019). Notably, the BBC's Blue Planet II triggered widespread public and political interest in marine plastic pollution in the UK after airing in 2017, when previous efforts to promote the issue had garnered little response (Males & Van Aelst 2020). Likewise, in Scotland, Hynes et al. (2020) also documented an increased level of concern about the health of fish stock and plastic pollution in people who had watched Blue Planet II compared with those who had not. Popular nonfiction writing has also increasingly introduced the general reader to ocean science, building on the legacy of Rachel Carson's writing (Carson 1962), among others. For example, general marine conservation texts such as Sylvia Earle's *The World is Blue* or more specific works on ocean topics such as Helen Scales' *Eye of the Shoal*, with its focus on fish, have introduced marine science and conservation to much wider audiences.

4. CASE STUDIES AND EXAMPLES

A key aspect of ocean literacy is that it should include diverse perspectives upon human interactions with the ocean and should be tailored to regional cultural contexts. There is no shortage of such perspectives, approaches and initiatives, regardless of whether they have been labelled as ocean literacy. In the following, we provide some case studies of initiatives that highlight the diversity of approaches and stakeholders that we now see and that should be recognised as part of a globally inclusive ocean literacy movement.

Many efforts are being directed at the formal education system. For example, the Blue School programme in Portugal (<https://escolaazul.pt/en>) encourages schools to explore ocean issues through multidisciplinary marine education programmes.

Blue schools aim for social impact through the involvement of local communities as well as partnerships with a diversity of cultural and scientific organisations connected to the sea. More recently, the Network of European Blue Schools has brought this model to other regions.

In Canada, a freely available audiovisual resource called Ocean School (<http://oceanschool.ca>) is using a combination of visual storytelling, scientific inquiry and indigenous knowledge to foster ocean literacy and engagement. No new curriculum is created, but existing curriculum content is reframed with an ocean lens, providing educators with new tools to engage students with the ocean while checking core learning outcomes. Interactive augmented and virtual reality resources are used to allow students who may not have direct access to the ocean to dive in and experience the ocean firsthand.

More generally, the Internet has greatly improved access to ocean literacy resources. As an example, the Massive Open Online Course entitled Exploring Our Oceans (<https://www.futurelearn.com/courses/exploring-our-ocean>) was developed by the University of Southampton specifically around concepts of ocean literacy and has received more than 40 000 registrations from 183 countries since its launch in 2014 (Fielding et al. 2019). Free registration and direct input from diverse marine scientists represent an accessible way of fostering ocean literacy training — at least in regions that have appropriate Internet access.

Areas without reliable Internet or with basic literacy challenges require different approaches. In South Africa, for example, outreach programmes that transport marine specimens into rural communities have been very successful (Stevens in press). In this country, experienced educators emphasised the importance of accessible products to support ocean engagement and education and called for reduced reliance on the Internet as a major education tool.

Wherever possible, giving young people the opportunity to get hands-on experience of marine life and marine science is a very valuable way of engaging them, their families and the wider community. For example, the Club Mer initiative of Shoals Rodrigues, a non-governmental organisation on the island of Rodrigues in the Indian Ocean, provides a space for children and young people to learn about the sea, swim, snorkel and encounter marine life. As they progress through the programme, young people can become actively involved in marine conservation initiatives on the island or elsewhere (www.shoalsrodrigues.com/).

Traditionally, experiences of live marine animals are provided to the public by aquaria, although typically at a cost to the visitor and only with regional access. Increasingly, these resources are modernised to represent our contemporary understanding of marine life and the diversity of approaches to learn about it. The Two Oceans Aquarium in South Africa, for example, now places a strong emphasis on marine science literacy (<https://www.aquarium.co.za/content/page/education-foundation>). Efforts include environmental education outreach programmes, early childhood development, free courses via the Marine Sciences Academy and hosting volunteers and school classes at the aquarium. Similar programmes are available in aquaria elsewhere and often include hands-on activities aimed at improving ocean conservation, such as the Vancouver Aquarium's shoreline cleanup programme (<https://www.shorelinecleanup.ca/>) or Monterey Bay's trailblazing consumer awareness programme (<https://www.seafoodwatch.org/>).

Another way of bringing marine life to communities and providing a focus for ocean literacy events is through using life-size models of marine life. The Whale Workshop in the UK takes models of basking sharks, leatherback turtles and a range of marine mammals to schools around the UK (www.whaleworkshop.org/). These are used to educate scholars and communities about local marine life and more specific issues including plastic pollution and underwater noise. In 2009, a 9 m basking shark model from the Whale Workshop formed the centrepiece for the first international basking shark conference, which included a weekend of community basking shark education activities (www.isleofman.com/News/details/33281/spotlight-on-sharks-first-international-basking-shark-conference-begins-).

The Green Fins programme (<https://www.greenfins.net/>) empowers members of the diving and snorkeling industry to help reduce pressures on coral reefs by offering practical, low-cost alternatives to harmful practices — such as anchoring, fish feeding and chemical pollution — as well as providing strategic support and educational resources. UN Environment and the Reef-World Foundation founded this initiative, and there are currently 11 countries and nearly 600 individual marine tourism companies participating. As a further strength, data collection and citizen science efforts conducted by divers are encouraged and coordinated through the programme, creating additional benefits for ocean resource monitoring and awareness.

The Women's League for the Ocean in Brazil (<https://www.mulherespelosocianos.com.br/>) is a net-

work movement that seeks to enhance engagement, actions and ideas for the protection of the ocean from a female perspective. Comprising over 2000 members with diverse backgrounds, including scientists, divers, athletes, artists, environmentalists and other professionals, it seeks to increase awareness of ocean environmental problems and promote different ways to solve them. Similar female-led initiatives include the global Women4Oceans network (www.women4oceans.org/) and the eXXpedition network of all-female explorers, who organise sailing voyages to explore the impact of plastic and toxic pollution while promoting environmental awareness (<https://exxpedition.com/>).

Finally, there are many emerging synergies between marine artists and scientists documenting changes in our ocean and our evolving relationship with it. As a localised example, Lalela uLwandle, which means listen to the sea in isiZulu, is a transdisciplinary research-based theatre project. The project emulates the sensation of standing quietly on a beach and listening to stories of the ocean and the people who have an intimate relationship with it. The production explores themes of intergenerational environmental injustices, ocean heritage, marine science and contemporary threats to ocean health and thereby invites a participatory public conversation on ocean governance in South Africa (<https://www.empatheatre.com/lalela-ulwandle>).

The combination of art and ocean science may also provide an opportunity to engage those in the community who might not seek out ocean learning but are interested in the arts. The Fun Palaces concept (<https://funpalaces.co.uk/>) started in the UK but is now used in France, Norway and further afield. The ethos of Fun Palaces is that everyone can be an artist and a scientist, and by creating free, pop-up community workshops, everyone can have access to learning new skills and make positive changes in their community together. New skills and experiences on offer include marine poetry writing, dramatic performances inspired by the sea, marine-themed art and learning how to identify and assess marine species and habitats from survey videos from marine nature reserves.

5. CONCLUSIONS

In this paper, we suggest that the concept of ocean literacy originated within a relatively small circle of marine scientists and educators, whose mission to enhance the US science curriculum has

largely shaped the emerging ocean literacy movement. This reflects a broader insularity of the field of marine science that has been dominated by European and North American interests for most of its short history. Today, this field has broadened considerably, and marine science and ocean education have become much more diverse and inclusive. Over the last decade, the concept of ocean literacy has been translated into other languages and cultures (Table 1) and is increasingly embraced by a diverse set of initiatives that include a much broader constituency than originally imagined. Clearly, an expanded understanding of what ocean literacy is, and how it can be achieved, is required. This expansion is well underway, as seen by the recent text adopted in the UN implementation plan (see Section 1). Many of the initiatives discussed in this paper contribute to ocean literacy. They do not necessarily operate under that specific banner but have evolved independently and in parallel with the original ocean literacy movement.

It may be interesting to reflect on how different cultural values shape our regional understanding of ocean literacy and how it can be improved upon. For example, scientific understanding is a strong unifying value in Western culture, i.e. the specific heritage of social norms, ethical values, traditional customs, belief systems and technologies that originated in Europe. It is not surprising that this value system is reflected prominently in the educational approaches that gave rise to the ocean literacy movement in North America and Europe. Other regions may put greater emphasis on ocean culture, spiritual values or traditional knowledge as ways of gaining a deeper understanding of, and appreciation for, the ocean (see Section 3). Clearly, none of these approaches is inherently better or worse and ideally can be combined in a culturally appropriate way to foster greater ocean literacy around the world.

Reflecting the broader diversity of ocean perspectives to include multi-cultural and spiritual significance of the ocean can help lead to more inclusive, accessible and effective ocean literacy efforts. These broader perspectives are not only important for our collective understanding of the relationships between humans and the ocean, but they also shape our individual and collective decision making. We recognise that increased knowledge and awareness are only 2 of the many factors that influence pro-environmental values and behaviour (Jensen 2002, Kollmuss & Agyeman 2002). Yet, as we enter the UN Decade of Ocean Science for Sustainable Development, we feel hopeful that a broader understanding

and practice of ocean literacy will help to transform our relationship with the sea and enable us to restore and rebuild marine biodiversity at a much larger scale (Duarte et al. 2020, UN 2020).

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LITERATURE CITED

- Adler A (2019) Neptune's laboratory: fantasy, fear, and science at sea. Harvard University Press, Cambridge, MA
- Berkes F, Folke C, Gadgil M (1995) Traditional ecological knowledge, biodiversity, resilience and sustainability. In: Perrings CA, Mäler KG, Folke C, Holling CS, Jansson BO (eds) Biodiversity conservation: problems and policies. Springer, Dordrecht, p 281–299
- ✦ Bernard PS (2013) 'Living water' in Nguni healing traditions, South Africa. *Worldviews Glob Relig Cult Ecol* 17: 138–149
- Bruton MN (2016) Traditional fishing methods of Africa. Cambridge University Press, Cape Town
- Camargo T, Calloni H (2012) O sagrado e o profano presentes na festa de Iemanjá: uma leitura possível de educabilidade ambiental. *Rev Eletr Mestr Educ Amb* 28: 344–356
- Carson R (1962) *Silent spring*. Houghton Mifflin, Boston, MA
- Cava F, Schoedinger S, Strang C, Tuddenham P (2005) Science content and standards for ocean literacy: a report on ocean literacy. Consortium for Ocean Science Exploration and Engagement. https://coexploration.org/oceanliteracy/documents/Lit2004-05_Final_Report.pdf
- ✦ Claudet J, Bopp L, Cheung WWL, Devillers R and others (2020) A roadmap for using the UN Decade of Ocean Science for Sustainable Development in support of science, policy, and action. *One Earth* 2:34–42
- ✦ Clifton J, Majors C (2012) Culture, conservation, and conflict: perspectives on marine protection among the Bajau of Southeast Asia. *Soc Nat Resour* 25:716–725
- do Rosario CC (2006) The ladies of the water: Iemanjá, Oxum, Ooiá and a living faith. *Wagadu* 3:142–154
- ✦ Duarte CM, Agusti S, Barbier E, Britten GL and others (2020) Rebuilding marine life. *Nature* 580:39–51
- ✦ Fielding S, Copley JT, Mills RA (2019) Exploring our oceans: using the global classroom to develop ocean literacy. *Front Mar Sci* 6:340
- ✦ Fletcher S, Potts J (2007) Ocean citizenship: an emergent geographical concept. *Coast Manage* 35:511–524
- Garcia Rodrigues JG, Conides AJ, Rivero Rodriguez S, Raicevich S and others (2017) Marine and coastal cultural ecosystem services: knowledge gaps and research priorities. *One Ecosyst* 2:e12290
- ✦ Guest H, Lotze HK, Wallace D (2015) Youth and the sea: ocean literacy in Nova Scotia, Canada. *Mar Policy* 58: 98–107
- ✦ Harrison HM, Harrison N (1993) Shifting positions toward the earth: art and environmental awareness. *Leonardo* 26:371–377
- Harrower JT (2019) Species interactions and climate change in the loss of Joshua trees and the role of eco-arts for understanding multispecies connections. PhD dissertation, University of California, Santa Cruz, CA
- Holland-Smith D, Love A, Lorimer R (2013) British surfers and their attitudes and values toward the environment. *Ecopsychology* 5:103–109
- ✦ Hynes S, Ankamah-Yeboah I, O'Neill S, Needham K, Xuan BB, Armstrong C (2020) The impact of nature documentaries on public environmental preferences and willingness to pay: entropy balancing and the Blue Planet II effect. *J Environ Plan Manage*, doi:10.1080/09640568.2020.1828840
- Jackson T (2005) Motivating sustainable consumption. *Sustain Dev Res Net* 29:30–40
- ✦ Jensen BB (2002) Knowledge, action and pro-environmental behaviour. *Environ Educ Res* 8:325–334
- ✦ Kollmuss A, Agyeman J (2002) Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ Educ Res* 8:239–260
- Lara E (2020) Para cuidar el surf y la biodiversidad: aprueban creación de santuario costero Piedra del Viento. <https://www.biobiochile.cl/especial/aqui-tierra/noticias/2020/08/17/para-cuidar-el-surf-y-la-biodiversidad-aprueban-creacion-de-santuario-costero-piedra-del-viento.shtml> (accessed 17 Sep 2020)
- Maffi L (ed) (2001) *On biocultural diversity: linking language, knowledge, and the environment*. Smithsonian Institution Press, Washington, DC
- Males J, Van Aelst P (2020) Did the Blue Planet set the agenda for plastic pollution? An explorative study on the influence of a documentary on the public, media and political agendas. *Environ Commun* 15:40–54
- ✦ Marean CW (2010) Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: the Cape floral kingdom, shellfish, and modern human origins. *J Hum Evol* 59:425–443
- Mogias A, Boubonari T, Realdon G, Previati M, Mokos M, Koulouri P, Cheimonopoulou MT (2019) Evaluating ocean literacy of elementary school students: preliminary results of a cross-cultural study in the Mediterranean Region. *Front Mar Sci* 6:396
- ✦ O'Connor S, Ono R, Clarkson C (2011) Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans. *Science* 334:1117–1121
- ✦ Otto S, Pensini P (2017) Nature-based environmental education of children: environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Glob Environ Change* 47:88–94
- Parkington J (2006) Shorelines, strandloppers and shell middens: archaeology of the Cape coast. Southern Cross Ventures, Cape Town
- Prandi R (2001) *Mitologia dos orixás*. Companhia das Letras, São Paulo
- Prins F, Mkhize N, Mander M, Herbert D, Hamer M (2003) Invertebrate animals as a component of the traditional medicine trade in KwaZulu-Natal, South Africa. *Afr Invertebr* 44:1–18
- Santoro F, Selvaggia S, Scowcroft G, Fauville G, Tuddenham P (2017) Ocean literacy for all: a toolkit. UNESCO, Paris
- ✦ Scheffers SR, Haviser J, Browne T, Scheffers A (2009) Tsunamis, hurricanes, the demise of coral reefs and shifts in

- prehistoric human populations in the Caribbean. *Quat Int* 195:69–87
- Schoedinger S, Tran LU, Whitley L (2010) From the principles to the scope and sequence: a brief history of the ocean literacy campaign. *NMEA Spec Rep* 3:3–7
- ✦ Shepherd S, Terry A (2004) The role of indigenous communities in natural resource management: the Bajau of the Tukangbesi Archipelago, Indonesia. *Geography* 89:204–213
- Stevens RA (in press) Two Oceans Aquarium Academy: an introduction to ocean literacy programs and a marine sciences curriculum. Springer
- ✦ Torrente F, Bambridge T, Planes S, Guiart J, Clua EG (2018) Sea swallows and land devourers: Can shark lore facilitate conservation? *Hum Ecol* 46:717–726
- ✦ Tsai LT, Chang CC (2019) Measuring ocean literacy of high school students: psychometric properties of a Chinese version of the ocean literacy scale. *Environ Educ Res* 25: 264–279
- ✦ Umuhire ML, Fang Q (2016) Method and application of ocean environmental awareness measurement: lessons learnt from university students of China. *Mar Pollut Bull* 102:289–294
- UN (2020) United Nations Decade of Ocean Science for Sustainable Development 2021–2030 implementation plan, version 2.0. <https://www.oceandecade.org/resource/108/Version-20-of-the-Ocean-Decade-Implementation-Plan-> (Accessed 2 March 2021)
- UNESCO (2020a) Cultura oceánica para todos: kit pedagógico. <https://unesdoc.unesco.org/ark:/48223/pf0000263062> (accessed 17 Sep 2020)
- UNESCO (2020b) Cultura oceánica para todos: kit pedagógico. <https://unesdoc.unesco.org/ark:/48223/pf0000373449> (accessed 17 Sep 2020)
- ✦ Worm B, Barbier EB, Beaumont N, Duffy JE and others (2006) Impacts of biodiversity loss on ocean ecosystem services. *Science* 314:787–790

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