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The evolution of ocean literacy: A new framework for the United Nations Ocean Decade and beyond

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ABSTRACT

First introduced in the early 2000s, the concept of ocean literacy has evolved in recent years, not least since its inclusion as a mechanism for change within the United Nations Ocean Decade's goals. Building on early definitions of ocean literacy, there has been increasing recognition of a range of additional dimensions which contribute to an individual or collective sense of 'ocean literacy'. Drawing on existing research, and parallel and supporting concepts, e.g., marine citizenship, ocean connectedness, and public perceptions research, this paper proposes ten dimensions of ocean literacy: knowledge, communication, behaviour, awareness, attitudes, activism, emotional connection, access and experience, adaptive capacity and trust and transparency, and recommends expanding previously recognised dimensions, in a bid to ensure that ocean literacy encompasses diverse knowledges, values and experiences. The paper provides a useful framework for ongoing ocean literacy research, and highlights aspects of ocean literacy which have received limited focus to date.

1. Introduction

Despite growing interest into the relationships between people and the ocean, historically these complex and diverse relationships have been poorly understood. The last two decades have seen something of a 'turn to citizens', with human-ocean (and coast) connections being explored through a range of marine social science lenses (McKinley et al., 2020, 2022; Bennett, 2019). This has included, but is not limited to, the blue economy (Germond-Duret and Germond, 2022; Bennett et al., 2019), socio-cultural values of marine and coastal environments (Burdon et al., 2022; McKinley et al., 2019; Gee et al., 2017; Martin et al., 2016), public awareness and perceptions of marine topics (Jefferson et al., 2021; Potts et al., 2016; Gelcich et al., 2014), governance, management and decision-making (e.g., Marine Protected Areas; Ban et al., 2019; Mascia et al., 2010) and participation and engagement (Jarvis et al., 2015; Pomeroy and Douvere, 2008).

This growing research interest has been mirrored in the global ocean policy landscape. Most recently, for example, the United Nations Decade of Ocean Science for Sustainable Development (hereafter, the UN Ocean Decade), launched in January 2020, setting out a series of ambitious aspirations, including calls for improved integration of natural and social sciences and a transformational relationship between society and the ocean (Claudet, 2021). To achieve this, the UN Ocean Decade and ocean discourse generally has placed a growing emphasis on the concept of ocean literacy, in particular positioning the concept of ocean literacy as a mechanism for change. First developed in the early 2000s, ocean literacy is not a new concept. At its simplest, ocean literacy can be defined as 'an understanding of your influence on the ocean, and it's influence on you' (NMEA, 2020; Schoedinger et al., 2005); however, the simplicity of this definition belies the complexities of contemporary ocean literacy, and indeed, whether ocean literacy is an appropriate term (MacNeil et al., 2021). While the role and importance of ocean literacy in supporting and delivering effective global ocean governance has received increasing recognition in recent years (Kelly et al., 2022a; Paredes-Coral et al., 2021), to truly understand the role of ocean literacy for the UN Ocean Decade and beyond, it is first necessary to explore the evolution of the ocean literacy concept.

2. Evolution of ocean literacy

The term 'Ocean Literacy' was originally coined in 2004 by a group of ocean scientists and education professionals in the USA, who recognised a lack of ocean-related subjects in formal education and developed a comprehensive framework to encourage the inclusion of ocean

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sciences into national and state standard education (UNESCO, 2018; Santoro et al., 2017). As a result, the earliest versions of ocean literacy were developed for the education system, aimed at teachers and educators and built on traditional notions of 'literacy' (UNESCO, 2018). Ocean literacy has been firmly grounded in seven principles (NMEA, 2020) (i) The Earth has one big ocean with many features, (ii) The ocean and life in the ocean shape the features of Earth, (iii) The ocean is a major influence on weather and climate, (iv) The ocean made the Earth habitable, (v) The ocean supports a great diversity of life and ecosystems, (vi) The ocean and humans are inextricably interconnected and (vii) The ocean is largely unexplored. Building on early definitions of ocean literacy, an ocean-literate person was characterised as someone who: understood the importance of the ocean to humankind, could communicate about the ocean in a meaningful way and was able to make informed and responsible decisions regarding the ocean and its resources (Cava et al., 2005).

Since the coining of the ocean literacy concept in 2004, ocean literacy has surpassed the borders of the USA and is increasingly recognised as a global movement (EMSEA, 2021). Various associations have been established to promote and enhance ocean literacy in society including the European Marine Science Educators Association (EMSEA), Canadian Network for Ocean Education (CaNOE), International Pacific Marine Educators Network (IPMEN), and the Australian Association for Environmental Education (AAEE). As explored above, the initial concept of ocean literacy was predominantly applied in formal education and training contexts (Bishop et al., 2015; Donert et al., 2015). This resulted in ocean literacy being framed as a relatively linear relationship between people and the sea (Stoll-Kleemann, 2019; Jefferson et al., 2015). In particular, the ocean literacy concept assumed that by increasing public knowledge and awareness (via education) about the ocean, pro-ocean behaviour changes could be achieved (i.e., knowledge-deficit approach; Kollmuss and Agyeman, 2002). Early models of ocean literacy assumed that people need to reach a threshold of knowledge to be ocean literate (MacNeil et al., 2021). However, increasingly this knowledge-deficit model of understanding individual and societal behaviour change has been questioned, with only a small fraction of pro-environmental behaviour directly linked to ocean knowledge and awareness. This echoes findings in other environmental awareness studies, which frequently indicate a discrepancy between having knowledge and supportive attitudes and behaving pro-environmentally (Heimlich and Ardoin, 2008; Hungerford and Volk, 1990; Hines et al., 1987). A move away from this solely education-based concept of ocean literacy has led to the evolution of ocean literacy and the development of more contemporary models. "*Ocean Literacy as a concept and approach is radically evolving from being a tool to be applied in formal education and training contexts to a tool and an approach for society as a whole, aimed at triggering actions towards Ocean sustainability*" (UNESCO, 2020, p1).

There are three main changes in these contemporary models. Firstly, contemporary models have shifted the field of ocean literacy from a knowledge-centric model to one which draws on and fosters active participation, connection, and engagement from the diversity of audiences across society (McKinley and Burdon, 2020). The models are now underpinned by the recognition that attitudes and behaviour are influenced by more than knowledge and highlight that behaviour change requires an understanding of how audiences connect with a particular topic, place or issue (Kollmuss and Agyeman, 2002). Secondly, these evolving models have drawn on other relevant fields including climate literacy (Azevedo and Marques, 2017; USGCRP, 2009), environmental literacy (McBride et al., 2013; NAAEE, 2004) and health literacy (McKinley and Burdon, 2020). Finally, they incorporate multiple important parallel concepts, including marine citizenship (McKinley and Fletcher, 2010, 2012; Fletcher and Potts, 2007), stewardship (e.g., coastal and ocean, place and planetary stewardship; Steffen et al., 2011; Griffis and Kimball, 1996), public perceptions research (Jefferson et al., 2015, 2021; Glithero and Zandvliet, 2021) and nature and ocean connectedness (Martin et al., 2020; Howell et al., 2011).

The ongoing evolution of ocean literacy was explored in depth in a 2019 Special Issue of Frontiers in Marine Science in which Brennan et al. (2019) expanded the original education based framing of ocean literacy, proposing six dimensions of ocean literacy: (i) awareness, (ii) knowledge, (iii) attitude, (iv) communication, (v) behaviour, and (vi) activism. Stoll-Kleemann (2019) adapted the behaviour change model, first developed by Kollmuss and Agyeman (2002), for use in an ocean setting; their updated model highlights key internal (e.g., emotions and values) and external factors (e.g., socio-cultural and politico-economic), as well as the internal (e.g., social norms and moral involvement) and external drivers (e.g., economic incentives) that impact behaviour change and can therefore increase the effectiveness of ocean literacy (Stoll-Kleemann, 2019). Overall, it is increasingly evident that the concept of ocean literacy has moved past having a sole focus on increasing public awareness of the state of the ocean, our impacts upon it and its impacts upon us. Instead, contemporary definitions of ocean literacy are increasingly expansive and complex, moving towards the development of effective tools and approaches to transform ocean knowledge into meaningful behaviour change and action for ocean sustainability (McKinley and Burdon, 2020). Despite this extensive evolution, ocean literacy is a fast-moving concept, with further developments taking place in the last few years. With this in mind, the next section explores the existing ocean literacy dimensions, expanding these to ensure their fit-for-purpose, and crucially, recommending the introduction of additional dimensions into models of ocean literacy.

3. Redefining ocean literacy

Recent years have seen a growing interest in ocean literacy research which has highlighted the need for further examination of the terminology and concept of ocean literacy. While the six dimensions of ocean literacy proposed by Brennan et al. (2019) provided the most comprehensive insight into the multiple drivers of levels of ocean literacy since its original inception, here we draw on emerging literature to expand the working definition of these dimensions (summarised in Table 1), and propose four additional dimensions of ocean literacy, with a view to more accurately encapsulating the human-ocean relationship.

3.1. Knowledge

Defined by Brennan et al. (2019) as "what a person knows about an ocean related topic and the links between topics" (p3), knowledge is perhaps one of the better understood, and potentially easier to measure, dimensions of ocean literacy, evidenced by the numerous studies conducted on the ocean knowledge of different actors (Ashley et al., 2019; Guest et al., 2015; Steel et al., 2005, for example). One example is the Global Ocean Literacy Survey which assesses the ocean knowledge of 15–17-year-olds around the world (Fauville et al., 2019). For instance, the survey asks about the influence of the ocean on weather and climate, the influence of anthropogenic activities on the ocean and the diversity of life and ecosystems. Knowledge has long been recognised as having a potential role in fostering ocean stewardship, encouraging marine citizenship (McKinley and Fletcher, 2012) and encouraging pro-environmental action or engagement more generally (Polonsky et al., 2012; Mostafa, 2007). However, as aforementioned, there have been increasing moves to shift away from the historical knowledge deficit style approach to ocean literacy – and with this shift, there needs to be a re-evaluation of how knowledge is defined for contemporary ocean literacy models. There is a need to expand the definition of 'knowledge' beyond the academic and Western interpretations of knowledge 'of the ocean', which have historically been grounded in predominantly natural and physical ocean sciences to increase understanding of ocean processes and ecosystems (Glithero and Zandvliet, 2021). Echoing calls in the UN Ocean Decade, knowledge in the context of ocean literacy must acknowledge, integrate and value different types of knowledge, including and championing local and Indigenous knowledge, and

Table 1
Summary of the ten proposed dimensions of ocean literacy (adapted from Brennan et al., 2019; McKinley and Burdon, 2020).

Dimension of Ocean Literacy	Description
Knowledge	Knowledge has multiple aspects. In the first instance, knowledge is what a person knows about an ocean related topic and the links between topics. Knowledge also refers to the knowledge a person has about ocean decision-making, opportunities to participate and engage in ocean decisions and behaviours and where/ how to get information about ocean issues.
Awareness	Awareness is the basic knowledge and understanding that a situation, problem or concept exists. Awareness should also include knowledge and understanding of the solutions and behaviours that may exist to address these problems in order to foster ownership and empower society to take action.
Attitude	Attitude is related to a level of agreement with or concern for a particular position. Attitude should also include consideration of perceptions, values, and views towards an ocean issue, and how these can lead to policy and societal change.
Behaviour	Behaviour relates to decisions, choices, actions, and habits with respect to ocean related issues at a range of scales, including from individual, sector and policy actors and institutions with a view to bringing about whole system change.
Activism	Activism is the degree to which a person engages in a wide range of activities, which can constitute activism, such as campaigning (for example through social media, attending public rallies or writing to elected officials) to bring about changes in policy, attitudes, behaviour, etc. Understanding this dimension must also take account of who gets to participate in activism and what the barriers might be.
Communication	Communication in the context of ocean literacy must be considered from multiple perspectives. 1) Communication is the extent to which a person communicates with others, such as family and peer groups, on ocean related topics. 2) Communication should also consider how/ where people get their information about ocean issues from –What methods of communication are most effective? 3) At an organisational level, communication needs to consider how institutions and organisations are communicating to different audiences about ocean issues.
Emotional Connections	Emotional connections is about how a person feels and emotionally responds when they think about, are near/ within, or consider issues relating to the ocean, coasts and seas. Emotions can be positive, negative or neutral and are all valid responses and will all contribute to behaviour change.
Access and Experience	Access and experience relate to a person's real or artificial (through Virtual Reality, for example) experiences and engagement with the ocean, and the various ways in which they can access these experiences. Barriers to ocean access and experiences should also be considered within this dimension.
Adaptive Capacity	Adaptive capacity relates to a person's capacity to adapt and respond to changing conditions relating to their ocean (e.g., relating to climate change, change in ocean economies, or changing ecosystem structure or function).
Trust and Transparency	Trust and transparency relate to the level of trust a person places in sources of ocean information and knowledge, and their perception of how transparent information and associated platforms and processes are.

recognising that diversity of knowledges and 'ways of knowing' the ocean should be encompassed within ocean literacy discourse.

To achieve the desire to support and foster meaningful public participation in ocean issues, society will need to be aware of the opportunities for engagement with the ocean (e.g., within public consultation, maritime careers), ocean issues and wider ocean governance and decision-making. This is reflected in current environmental policies, such as the EU Aarhus Convention (2005/370/EC), which calls for the public to have access to environmental information, participate in environmental decision-making, and have access to justice with regard to the environment. In the context of ocean literacy, knowledge, therefore, needs to include traditional definitions of ocean knowledge, but should also be expanded to recognise: (i) the existence of multiple types of ocean knowledge and (ii) individual and communities' knowledge of how to engage with ocean issues, be that through participation in ocean governance and decision making, in community initiatives, or within the maritime sector.

3.2. Awareness

Often studied alongside the dimension of knowledge, awareness is probably the second most frequently studied ocean literacy dimension. Awareness is described by Brennan et al. (2019) as "the basic knowledge that a situation, problem or concept exists" (p3) and has been perhaps borne from the same knowledge deficit model from which ocean literacy originated. The dimension as it stands is currently based on an individual having knowledge about a particular ocean topic (e.g., marine plastics or marine biodiversity). However, we argue that the dimension should not solely focus on awareness of problems, but that it must also encompass ways of identifying problems and developing appropriate solutions and, of course, of available actions and behaviours that can be taken by an individual or society. If there is only focus on the problem, how can behaviour change be encouraged? Measuring awareness generally is relatively commonplace within ocean literacy research – for example, awareness is included in the Canadian Ocean Literacy Coalition's national study through questions which asked about respondents' awareness of threats to the ocean. However, there is a need to understand, and perhaps, raise awareness of what can be done, of the actions that can be taken at a range of scales and to foster a sense of ownership and empowerment (Kelly et al., 2022a, 2022b).

3.3. Attitude

As defined by Brennan et al. (2019), the dimension of attitudes relates to "[an individual's] level of agreement with or concern for a particular position" (p3). While this definition importantly recognises the need for consideration of social acceptability and public concern, we propose that this definition be further expanded to include the multiple facets of attitudes typically encompassed within public perceptions research. Public perceptions research has gained growing attention in recent years in environmental management and conservation (Bennett et al., 2017; Jefferson et al., 2015) and there has been increasing emphasis on perceptions and attitudes in a marine and coastal context (Jefferson et al., 2021; Potts et al., 2016; Gelcich et al., 2014). This information can provide: (i) insights into the social impacts of ocean management interventions (e.g., area-based management and Marine Plans), (ii) an in-depth assessment of community and stakeholder support for ocean conservation, management and policy priorities (e.g., Marine Protected Areas and renewable energy), (iii) an understanding of attitudes towards governance processes and how these are perceived by different actors, allowing issues to be addressed as required and; iv) information on the social acceptability of management, development and decision-making (Bennett et al., 2018; Carpenter et al., 2018; Potts et al., 2016). With this in mind, we suggest that ongoing ocean literacy work further explores how attitudes and perceptions insights can be used to support design, delivery and implementation of effective ocean literacy initiatives, identifying pathways for policy change and maximising impact.

3.4. Behaviour

Increasingly behaviour change at different scales is being positioned as the desired outcome of ocean literacy initiatives (Stoll-Kleemann, 2019), meaning behaviour and related changes in behaviour must

remain a crucial component of contemporary models of ocean literacy. Brennan et al. (2019) suggest that behaviour can be considered to be an individual's "decisions, choices, actions, and habits with respect to ocean related issues" (p3). Typologies of pro-environmental behaviour often differentiate between private-sphere and public-sphere actions (Larson et al., 2015; Stern, 2000). Private-sphere actions occur in households on a daily basis and involve the purchase, use, and disposal of personal and household products that have impact on the marine environment (e.g., buying sustainable fish, recycling and switching to renewable energy). Participation in behaviour that involves direct changes between buying/purchasing choices may be more common within populations (Barreiro-Gen et al., 2019). This may contrast with engagement with public-sphere actions which involve more active involvement and seek to influence public policy, through petitioning governments, donating to advocacy organisations, or participating in activism (e.g., voting for political parties who support marine issues and donating to ocean conservation charities; Dean et al., 2020; Hofman et al., 2020; Barreiro-Gen et al., 2019).

However, given the scale of the challenges facing the global ocean, the focus of individual action as the solution is waning, with growing emphasis on calls for systemic behaviour change (Leakey, 2022). For this to be realised, widespread change is needed at a sector and policy scale, representing wholescale change to current systems and ways of thinking. While this may seem ambitious, the concept of ocean literacy should not be limited to individual behaviours and actions. By recognising that 'behaviour' needs to include institutions and their processes, structures and, not least, their own levels of ocean literacy, the 'turn to the ocean' (i.e., a consideration of ocean issues within all decision-making) that is required is more likely. Ocean issues need to be integrated into all scales of decision-making, across all sectors and all policy areas (e.g., health and transport, as well as the more obvious topics of biodiversity and climate change). By expanding the application of ocean literacy, there are perhaps opportunities for it to be a pathway to achieving this integration (Britton et al., 2021).

3.5. Activism

Activism, in the context of ocean literacy, is defined by Brennan et al. (2019) as "the degree to which a person engages in activities such as campaigning (for example through social media) to bring about changes in policy, attitudes, and behaviours" (p3). Activism, which can range from lobbying activities, participating in online campaigns to participating in marches or large scale events, to varying degrees is increasingly central to the ocean literacy movement, hence, it is important to question and perhaps challenge how activism is being defined, what constitutes an act of activism, and whose activism is valued and recognised as valid. Furthermore, to ensure the ongoing evolution of ocean literacy is one that is socially inclusive (Worm et al., 2021), it is perhaps timely to redefine what is meant by ocean activism. Ocean activism needs to embrace a wide range of approaches and disciplines including, for example, viewing art installations (Chung and Brown, 2018; Dupont, 2017), sport (Wheaton, 2007) and education (Tabuenca et al., 2019) as interventions, provocations and mechanisms for activism at a range of scales.

Moreover, in response to calls for action, there is also a need to reflect on who has the opportunity, capacity, and, indeed, privilege to be able to participate in environmental activism for the ocean (Bennett et al., 2021; Taylor, 2016; Gibson-Wood and Wakefield, 2013). Hence, ocean literacy initiatives and policies need to empower people and institutions, and crucially, this empowerment must include people from communities who have been historically under-represented, or completely excluded, from ocean discussions, for example, youth groups (Kelly et al., 2022a, 2022b; Russell, 2019) and minoritized groups. For example, Indigenous communities (Wehi et al., 2021; Parsons et al., 2021; Von der Porten et al., 2016), communities from the Global South (Shellock et al., 2022; The Guardian, 2021; Stefanoudis et al., 2021), youth groups (Halstead et al., 2022) and members of LGBTQI+ communities (Ocean Wise, 2021). Further, when considering activism in the context of societal ocean literacy, we should therefore not only focus on what activism activities people have undertaken, but also what opportunities they had to participate in ocean activism and the barriers which influence participation, so that participation and engagement can be facilitated.

3.6. Communication

In the context of ocean literacy, communication is a complex, multifaceted, yet fundamental dimension (Zielinski et al., 2022). From early models of environmental and marine citizenship, communication has been recognised as being a core component of environmental literacy and action (McKinley and Fletcher, 2012; Fletcher and Potts, 2007; Hawthorne and Alabaster, 1999). Communication with respect to ocean literacy has been described as "the extent to which a person communicates with others, such as family and peer groups, on ocean related topics" (Brennan et al., 2019; p3). However, focusing solely on the extent to which a person communicates with others does not capture the complexity of ocean communication; depending on the actor in question, ocean communication can have a myriad of meanings. For example, in addition to understanding how ocean literate people communicate with others, there is also a need for insight into the sources of information (e.g., social media, print media, broadcast media) about ocean issues, topics, and management strategies used by different actors, individuals, populations, countries and regions.

It is important to ensure that communications about the ocean are suitable and effective. A growing body of research suggests that communities, are facing "eco-anxiety", which is a chronic fear of environmental doom (Clayton et al., 2017). Specific groups such as young people, Indigenous groups, and those connected to the natural world (e.g., for cultural or personal reasons) are most impacted by eco-anxiety (Coffey et al., 2021). If communications are not designed appropriately, they could disengage and disempower the very audiences and actors it seeks to attract and mobilise into action and change, thereby negatively impacting levels of ocean literacy rather than enhancing them. In line with previous studies, we suggest that communications create a balance between constructive hope, responsibility, and well-being (e.g., human progress and bright spots in the marine environment; Cvitanovic and Hobday, 2018) and with elements of constructive doubt (e.g., the reality of the threat facing the marine and coastal environments and the need for more action), to mobilise for the ocean (Aruta and Guinto, 2022; Marlon et al., 2019). There has been growing support for approaches which move away from a communication echo chamber of 'ocean calamities' and instead embraces realistic, solution driven ocean optimism (Borja et al., 2022).

In addition, it will be important to use approaches which tell meaningful stories that resonate with people on different scales, reducing the often expansive psychological and geographical distance between everyday life and the issues facing the global ocean (Bearzi, 2020; Kolandai-Matchett et al., 2021; Schuldt et al., 2016). Furthermore, given the increasingly diverse community of stakeholders being drawn into ocean literacy initiatives globally (as evidenced, for example, by the recent IOC-UNESCO series on Ocean Literacy for the Finance Sector webinar series; IOC-UNESCO, 2022), the dimension of communication should also consider pathways of communication, building on emerging research on values based and research led communication approaches for different audiences (Savoie, 2022; Chambers et al., 2019; Kopke et al., 2019). For example, organisations such as the Marine CoLAb and the One Ocean Flotilla launched the Ocean Visuals campaign in September 2022, which explored the use of images in ocean communication and the need for specific, contextualised imagery within ocean communication (Climate Visuals, 2022). It is important to build capacity around ocean communication, as it will be a core aspect of global ocean literacy efforts. However, there is also a need for a more

detailed understanding of the complexity of ocean communication media and pathways, as well as their intended audiences.

3.7. Emotional connections

The first of the additional dimensions proposed for inclusion in future ocean literacy discourse is emotional connections to the ocean (hereafter referred to as '*Emoceans*'). Although a relatively nascent field of inquiry in the context of ocean and coastal systems, there is increasing evidence which recognises the fundamental role of emotional connection, including empathy, apathy, fear, enthusiasm etc., in driving behaviour change (Jacobs et al., 2012). Given the current climate of eco-anxiety and grief in response to the ecological and climate emergencies (Cunsolo et al., 2020), it is perhaps not unexpected that emotion would become a more prominent theme within ocean literacy research. This is particularly in relation to developing improved understanding of strength of emotional connection an individual may have and how this relates to their behaviours and decision-making. Recent years have witnessed a growth in attention being given to concepts such as nature and environmental connectedness and emotions (Halstead et al., 2022) and more recently, ocean connectedness (Nuojua et al., 2022). However, emotional connection to the ocean has received relatively limited attention (see for example Insinga et al., 2022; Lotze, 2020; Dean et al., 2018, and Capstick et al., 2016).

The role of emotion in driving behaviour and action of any sort should not be underestimated. A study by Kals et al. (1999), found emotional affinity to be on a par with other more traditionally recognised drivers of behaviour change, such as knowledge or interest. In a more specific ocean context, Kearns and Collins (2012) state that to fully understand the human-ocean relationship, there is a need to take 'people's feelings as well as their perceptions into account', whilst Lotze (2020), emphasises the importance of both love and knowledge to deliver long-lasting change for the ocean. Recent work from the European Mission Board on Healthy Oceans, Seas, Coasts and Inland Waters, further recognises the importance of emotions in ocean behaviours and the need for an understanding of the relationship between people and the ocean (McKinley et al., 2020). Neglecting to consider the role of emotions in decision-making and behaviour has perhaps limited the potential for ocean literacy initiatives to deliver meaningful behaviour change (Bearzi, 2020). For the ocean literacy movement to realise its full potential, the dimension of 'emocean' must be a fundamental component of the concept.

3.8. Access and experience

The access, exposure and experience individuals have to the ocean, whatever that might look like, can shape their attachment and connection, their desire to learn more and ultimately their ocean literacy. Hence, it is an important, albeit new, dimension of ocean literacy. Although sometimes considered in assessments of ocean literacy, access and experience is often explored through questions on how and when people might visit coastal spaces, the kinds of activities that they might engage in during their visit and collecting information on how exposure to marine and coastal environments affects human health and wellbeing (i.e., the 'Oceans and human health' agenda; Fleming et al., 2014; White et al., 2013). The inclusion of access and experience as a dimension of ocean literacy can help to provide an opportunity to better understand the barriers to ocean access and experience (e.g., cost of travel, lack of access due to transport infrastructure or inaccessible coastal paths) and how this may impact individual and community levels of ocean literacy. However, this requires the traditional definitions of ocean access and experience to be challenged.

When assessing access and experience as a dimension of ocean literacy, metrics should move away from focusing on traditional definitions, which rely only on gathering insight on physical access and experience. This is because the relationship between proximity and connection may be less linear than perhaps expected. It is often expected that those living in coastal areas are more aware and have a greater connection to the ocean. However, many do not exhibit these traits (Stoll-Kleemann, 2019). Furthermore, there are increasing technological advances, which can help connect people with the ocean, regardless of their location, setting or physical ability to access the coast or ocean (e.g., the use of virtual reality; White et al., 2018; Newell and Canessa, 2018). These digital experiences can create access and foster ocean literacy. For ocean literacy to be truly inclusive and for all people, there is a need to look beyond historically expected and accepted experiences, to embrace the technological innovations that are available and to recognise that access and experience of the ocean, or indeed ocean education, is not currently equitable (Bennett et al., 2021; Clarke and Kast, 2020; Newell and Canessa, 2017; Bennett et al., 2017). Moreover, by expanding the definition to consider different types of access and experience, traditional descriptions of coastal communities can also be challenged, moving away from a focus on communities which are geographically proximate to the coast to include those who may experience the ocean on annual holidays, on a once in a lifetime adventure or through technology. This is something that feels particularly necessary for transforming relationships between people and the ocean on a global scale.

3.9. Adaptive capacity

Since the initial conception of ocean literacy in the early 2000s, the global ocean and communities worldwide have experienced, and are continuing to experience, unprecedented levels of change (Lubchenco and Gaines, 2019). Adapting to these changes is a matter of increasing urgency; however, capacity to respond to this change varies globally. Furthermore, individual or personal adaptation will be influenced by a wide range of social, political, cultural and economic characteristics (e.g., age, gender, education, opportunities to participate in ocean decisions and more; Cinner et al., 2018; Cinner et al., 2015). Termed adaptive capacity, this relates to a community or system's ability to respond proactively to a change, stressor or opportunity (Whitney et al., 2017). Until relatively recently, adaptive capacity had received limited research attention within environmental spheres generally (Engle, 2011), and even less so in relation to ocean or coastal environments (Tiller and Richards, 2018; Cinner et al., 2015). In the context of ocean literacy, we suggest that capacity to adapt to a changing ocean is directly linked to other ocean literacy dimensions including knowledge, awareness, behaviours and trust and transparency.

However, more research is required to truly understand what drives adaptive capacity and to glean lessons from where attempts to adapt have been both successful and not. In addition, while a changing climate is without a doubt one of the primary drivers of change and adaptation globally, adaptive capacity in the context of ocean literacy must also recognise other changes impacting the ocean. For example, the growing focus on a global blue economy may bring about a whole host of changes for communities across the world in terms of employment opportunities, access to resources and more. By evaluating adaptive capacity as a core dimension within ocean literacy, future ocean literacy initiatives can have a clear role in ensuring that the transition to a blue economy, whatever that looks like, is one that is sustainable, socially just, and inclusive (Bennett et al., 2019). Finally, there is a need for more research which looks beyond individual adaptive capacity and considers the capacity of governance institutions and processes to adapt to change proactively, sustainably and in a timely manner.

3.10. Trust and transparency

Finally, the tenth proposed dimension of ocean literacy relates to aspects of trust and transparency. As with each of the previous nine dimensions, this is not a simple dimension to unravel and has clear interconnections with a number of the other ocean literacy dimensions. In

the first instance, there is a need to consider how much people trust ocean information from a multitude of sources. For example, formal education (e.g., schools, colleges and universities) to the more informal knowledge and communication pathways (e.g., television, social media, mainstream media). Numerous scholars have recognised the potential role of the media on public perceptions of environmental issues (Santos and Wong-Parodi, 2022), with recent years seeing a growth in the role of social media as a way of communicating and spreading information rapidly around the world (Lyon and Montgomery, 2013).

With this in mind, there is a need to consider not only how and if people trust information they receive, but also if they have trust in the platform or media it is delivered through, and how perceptions of trustworthiness might impact an individual or collective sense of ocean literacy. In the context of assessing ocean literacy, the perceived reliability of information may influence an individual's desire to learn more about the ocean, or opportunities they might have to engage in ocean literate behaviours. Given the importance of communicating ocean science and knowledge within the construct of ocean literacy, this dimension of trust and transparency must be considered at all stages of ocean research and practice, from project design, implementation, stakeholder and community engagement and dissemination or application of results (e.g., Archibald et al., 2021 on the importance of this in the context of fisheries management). Furthermore, trust and transparency of ocean information, ocean research and ocean governance is an inherent aspect of other ocean literacy dimensions, namely activism, behaviour and communication, with indirect links to each of the other dimensions described above. To foster a more ocean literate, engaged global society, there is a need to understand if people trust the information they are receiving, whether opportunities to participate in trusted and transparent ocean governance processes are available, and how ocean literacy initiatives can support further development of trust where it is perhaps weak or limited (e.g., Costa et al., 2022; Haas et al., 2022; Blasiak et al., 2019; Bennett, 2018).

4. Discussion and concluding remarks

As we look to the future of ocean literacy, and its role in delivering international ocean commitments, it is crucial to recognise that ocean literacy is a continually and rapidly evolving concept, one that will shape and shift across time and space. With this in mind, despite calls to raise ocean literacy globally, it is important to recognise that there is no one size fits all model or quick solution to address current and future challenges. Crucially, however, the complexity of ocean literacy as a concept must be recognised. This paper presents an updated framework which can be used to better understand the multiple dimensions increasingly recognised as having an impact and influence on levels of ocean literacy, and how these might vary with different audiences. The ten dimensions set out in this paper should be used as a cornerstone for future ocean literacy assessments to ensure that ocean literacy research evolves alongside the concept, and that there is more consideration given as to how each of the ten dimensions can be measured and monitored. These dimensions should also be accounted for when designing ocean literacy initiatives and interventions, ensuring that knowledge development is not the sole focus of initiatives. Efforts to better integrate these multiple dimensions into ocean literacy assessments are already underway – examples include the UK's recent ocean literacy assessment carried out in 2021 and 2022 through a collabortion between Defra, Natural Resources Wales, Marine Scotland, and the Ocean Conservation Trust, which included assessment of eight out of the ten dimensions proposed here.

Efforts to raise, enhance and foster ocean literacy across each of the ten proposed ocean literacy dimensions will need to take account of the breadth, depth, and diversity of varying social, cultural, economic, geographical, and ecological contexts through which society interacts with the ocean, coasts and seas (Jefferson et al., 2021). There is a need to truly understand what motivates and triggers behaviour change and action within different communities and actors, on a range of scales and in varying contexts. This will be central to achieving the goals of ocean literacy, and indeed those set out by the UN Ocean Decade and other global initiatives. Further, it should be noted that any effort to foster and raise ocean literacy must be cognisant of social justice and equality issues that may be relevant in different global contexts, including recognising a growing debate regarding the origins of the term and whether it is appropriate for all communities and contexts (Bennett et al., 2021; MacNeil et al., 2021; Worm et al., 2021; Bennett, 2018). For example, MacNeil et al. (2021) argue that ocean literacy is unable to capture the scope of experiences with the ocean, is inadequate in encapsulating different worldviews and across different linguistic communities and can be seen as an instrument of power, colonialism and oppression.

As we look to the future of ocean literacy, efforts must be underpinned by an international and interdisciplinary programme of ocean literacy research. As the dimensions of ocean literacy continue to evolve, the directionality and interlinkages between them must be explored and better understood. In addition, there is an urgent need to respond to resounding calls for better understanding of the relationships between people and the ocean, and for a more comprehensive investigation into how diverse social values, knowledges and connections experienced around the world can be integrated into ocean literacy initiatives in order to ensure its goals are achieved. Crucially, we must challenge who is being considered when we talk about ocean literacy, amplifying the voices and values of those who have historically been excluded or underrepresented in ocean literacy discourse. Further, while ocean literacy originated in the realm of civil society, to deliver a truly transformed relationship between society and the ocean, everyone must be involved. This means questioning ocean literacy at a range of scales, including decision-making institutions and businesses, and ensuring that the dimensions of ocean literacy are at the centre of ocean governance and decision-making. Finally, while some of the ocean literacy dimensions have been well studied (e.g., knowledge and attitudes), there are significant knowledge gaps in our understanding of how to measure, assess and increase the other dimensions, particularly those which are newly discussed dimensions of ocean literacy (e.g., emotions, access and experience, adaptive capacity, and trust and transparency). To truly deliver “ocean literacy for all’, a new model for ocean literacy must pave the way. This research proposes the following recommendations regarding the evolution of ocean literacy dimensions:

- Investigation into how terminology and dimensions can be modified, re-framed and contextualised for different geographical and sociocultural contexts. This will ensure that ocean literacy and derived terms recognise and incorporate multiple ways of knowing, different cultures and justice and equality issues.
- The dimensions of ocean knowledge must include multiple knowledge types, including local and Indigenous knowledge, as well as knowledge of *how* to engage in ocean issues.
- Awareness must focus on problem solving, recognising that while awareness of an issue is needed, awareness of solutions and actions to be taken must be understood.
- Ongoing ocean literacy work should determine how attitudes and insights can influence design, delivery and implementation of effective ocean literacy initiatives.
- To deliver the behaviour change aspirations of ocean literacy, the dimensions of behaviour must not only consider individual behaviours, but also recognise the need for behaviour change at an institutional and systemic scale.
- Our understanding of activism must expand to not only include gathering data on the activism activities that people take part in, but also what influences their opportunity and capacity to participate in ocean activism.
- The dimension of communication must incorporate the multifaceted nature of this dimension, encompassing not only whether individuals communicate their ocean knowledge, but also develop our

understanding of the complexity of ocean communication media and pathways, as well as their intended audiences.

- 'Emoceans' should be recognised as a central component of ocean literacy, recognising its role in behaviour change, experience and memory making and how this might influence ocean connections.
- The dimension of access and experience must expand its definition to consider different types of access and experience, embracing different communities and media or platforms of experience.
- Concepts of adaptation and resilience are increasingly important when considering how people live and work around coastal and ocean spaces. As a result, there is a need for ocean literacy to consider how ready people are to adapt i.e., what is their adaptive capacity in the face of a changing climate and coastline.
- Finally, for ocean literacy initiatives to result in a more ocean literate, engaged global society, the levels of trust and transparency assigned to ocean information, institutions and processes must be considered within contemporary models of ocean literacy.

Declaration of competing interest

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Data availability

No data was used for the research described in the article.

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