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Designing With an Ocean Literacy Approach: Towards the Definition of "Ocean Cycle-Centric Design"

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Abstract

The Ocean Decade has provided a unique framework for fostering science-informed practices that necessitate a rethinking of human relationships with the sea. The 2024 UNESCO *Venice Declaration for Ocean Literacy in Action* highlights the need to develop "ocean-centric design." While the environment-centred design is well-established, the ocean-centric design remains underexplored, particularly regarding its epistemological foundations. This article defines ocean-centric design as an approach to expanding ocean literacy dimensions and driving change across disciplines. Integrating design methodologies (civic design method) and concepts like bodies of water, Hydrocene, and perspectives from the blue humanities, the study proposes a framework and devises indicators to help designers ensure their practices are ocean-centric. These indicators aim to foster a stronger connection with the ocean among society while addressing the Ocean Decade's Challenge 10 "restoring society's relationship with the ocean." To validate these indicators, they are applied to a selection of ocean-design case studies to assess whether the designs are inherently ocean cycle-centric or merely contextualised within an ocean setting. Ultimately, the article seeks to expand the scope of environment-centred design by introducing and emphasising a blue epistemology. The article introduces ocean cycle-centric design, expanding environment-centred design and integrating ocean literacy into resilient design practices for a restored human-ocean nexus.

Keywords

civic design; human-ocean nexus; ocean citizenship; ocean cycle-centric design; ocean literacy

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1. Introduction

The ocean profoundly impacts humanity, transcending geographic and cultural boundaries as the primary regulator of the global climate (Tanhua et al., 2024). At the midpoint of the UN Ocean Decade (2021–2030), ocean literacy emerges as a critical mechanism for empowering society to act towards ocean sustainability and health (Buchan et al., 2023). Recent developments in ocean literacy encompass awareness, activism, and adaptive capacity, fostering "meaningful public participation in ocean issues" (McKinley et al., 2023, p. 3).

1.1. The Human–Ocean System as a Complex System Beyond Anthropocentric Views

The Human–Ocean System (HOS) is a complex whole of interdependent components. Understanding it requires examining both the entire system and its parts, incorporating multiple perspectives, interrelationships, and dependencies. Effective human–ocean management demands the ability to address uncertainty and the complexity of system-wide impacts and dynamics (Arnold & Wade, 2015, as cited in Brennan et al., 2019). This contribution transcends traditional extractive and anthropocentric ocean views, embracing HOS as a complex system requiring a holistic understanding. Water is a dynamic, relational entity: central to ecological, cultural, and social narratives, demanding urgency in crafting methodologies and narratives that accelerate adaptation and mitigation in response to the intertwined climate and biodiversity crises. Water's intrinsic structure underscores its unifying role: as all life shares molecules and geographies shaped by water, we are inherently interconnected as citizens and beings within global water ecologies. The sustainability of humans relying on the ocean depends on the ability to understand this systemic approach. As a metaphor and material for the Hydrocene era (Bailey-Charteris, 2024), water reframes the human–water nexus, inspiring dimensions to move beyond the anthropocentric dynamic that is leading to SDGs (UN, 2015) moving and missing targets.

1.2. The Role of Ocean Literacy and Design in Addressing Complexity

Research indicates a limited public understanding of the ocean's importance and functioning (Fauville et al., 2018). The ocean is the matrix of our blue planet, playing a central role in regulating planetary systems and mitigating climate impacts (Intergovernmental Oceanographic Commission, 2020; Larkin et al., 2022), while it is simultaneously a focal point for addressing major challenges, including climate change, pollution, and biodiversity loss. However, ocean ecosystems face extensive pressure and exploitation from human activity (O'Hara et al., 2021). Ocean acidification, driven by human-induced carbon emissions, is poised to surpass another critical planetary boundary (Stockholm Resilience Centre, 2023, as cited in Richardson et al., 2023), underscoring the urgency for systemic change (see Figure 1, Supplementary File).

The complexity of the HOS extends to communication, cultural, social, and emotional dimensions—all areas of concern for design disciplines. These align with the capacity of design to address complexity in innovative and illuminating ways (Brown, 2009; Martin, 2009; Paton & Dorst, 2011; Verganti, 2009). To facilitate the required paradigm shift, it is essential to craft narratives that embed and embody societal knowledge, enabling informed decision-making across multiple levels—from policy development to broader considerations of water systems. This article argues for the integration of ocean literacy into ocean cycle-centric design (OCCD). OCCD, as a transdisciplinary and society-oriented framework, intertwines ocean literacy with design principles, expanding its boundaries and epistemologies.

The expansion of ocean literacy to address communication, cultural, and emotional dimensions (McKinley et al., 2023) intersects significantly with design disciplines. Design, inherently transdisciplinary, has long grappled with integrating diverse knowledge systems and societal impact. This shared ground offers opportunities to deepen the dialogue between ocean literacy and design, enhancing their combined ability to address urgent global challenges in complex times. In this article, "design," as a diverse discipline, is addressed for its role as the discipline that embraces and incorporates sustainability into its way of being, operating "for the real world" (Papanek, 1971). Design must adopt ocean-relevant cycles, as a connector guided by social, ethical, and ecological imperatives, where every action considers its broader impacts on society and the environment, resonating across multiple scales, and becoming ocean cycle-centric.

OCCD, informed by expanded ocean literacy, aims to embed a framework for navigating the interwoven challenges of the Anthropocene and Hydrocene eras.

The urgency to strengthen and restore the human–ocean climate nexus is increasingly evident. Accelerating efforts to overcome the barriers that prevent humanity from re-establishing a balanced relationship with the ocean and its interconnected bodies of water is essential. Design thinking tools and methodologies offer multiple opportunities and chances to deal with "unexpected dimensions in practice as well as understanding" (Buchanan, 1992, p. 5), engaging society and restoring this nexus at multiple levels. As further explored in this article, OCCD is guided by the vision of blue futures, aiming for a balanced, sustainable, and resilient human–ocean society nexus as an interconnected system.

Addressing societal behavioural change directly is crucial to ensuring the ocean health nexus: this imperative is reflected in the rewording of Challenge 10 of the UN Ocean Decade in 2024. As of May 2024, Challenge 10 (see Figure 2, Supplementary File) has been revised from "change humanity's relationship with the ocean" to "restore society's relationship with the ocean," with an updated goal to:

> Ensure that the multiple values and services of the ocean for human well-being, culture, and sustainable development are widely understood; that society-ocean connections are strengthened; and that there is increased motivation, capability, and opportunity for people across all sectors of society to make decisions and behave in ways that ensure a healthy ocean. (Glithero et al., 2024, p.18)

This reframing emphasises the critical need to foster understanding, motivation, and actionable engagement across society, aligning individual and collective behaviours with the goal of sustaining a healthy and resilient ocean ecosystem.

In the concept of Hydrocene (Bailey-Charteris, 2024), the water cycle highlights aspects deeply connected to design processes, particularly the life cycle of matter itself. Here, water is not merely "centric" but inherently "cyclic." Rather than being isolated or fixed, it is pervasive and dynamic. This paradigm shift is both multidimensional and transdisciplinary, functioning across diverse temporal and spatial scales while dissolving boundaries between disciplines and societal layers. As emphasised in the *Ocean Decade Vision 2030 White Papers*, societal engagement must go beyond the sustainable management of the ocean to encompass the management of human behaviour in ways that actively support ocean health. Ultimately, this focus underlines the critical need to reframe and nurture the human–water relationship as a cornerstone of global sustainability efforts. Design directly relates people to objects, systems, and environments through

porous projects, combining ways of knowing and acting from different traditions in design and social thought (DelSesto, 2022).

Drawing on the concept introduced in the June 2024 *Venice Declaration for Ocean Literacy in Action: How to Engage Society to Regenerate the Most Valuable Ecosystem on Our Planet*, this study seeks to establish a theoretical framework for understanding and defining this emerging idea. Specifically, it aims to address the following questions:

1. How can OCCD be defined?
2. How can we build a theoretical framework towards the applicability of OCCD?
3. What are the shared and overlapping dimensions between design thinking and ocean literacy?
4. Are there cases that align with the principles of OCCD when assessed using these indicators?

The framework proposed in this study aspires to clarify these questions and provide actionable insights, advancing the discourse on integrating design practices with the principles of ocean sustainability and regeneration.

2. Methods

The method outlined in this study (Figure 1) introduces OCCD, synthesising interdisciplinary frameworks from ocean literacy, design methodologies, and civic engagement. By combining models such as the double diamond and civic design method (Ross, 2022) with ocean literacy dimensions, the study creates a cohesive framework to bridge gaps in ocean-related design and human engagement. Central to this approach is the ocean cycle, which redefines human-environment interactions, integrating societal participation, ecological literacy, and innovative design. OCCD aims to be an enabler for emerging paradigms such as hydrofeminism, eco-aesthetics, and Hydrocene, weaving a blue thread across disciplines.

2.1. Conceptual Foundations and Definitions

The research begins by defining key concepts, such as the hydrological cycle, ocean citizenship, and Hydrocene, thereby establishing a theoretical foundation. The Hydrocene emphasises humanity's interdependence with aquatic environments (Bailey-Charteris, 2024), offering a lens for participatory governance and civic design. These concepts underpin the study's exploration of civic engagement and design innovation within the ocean society nexus.

2.2. Alignment Frameworks and Indicators

An alignment analysis of design methodologies—problem-solving, human-centred design, and OCCD—reveals their overlaps and differences in addressing societal and environmental challenges. The study proposes nine indicators for OCCD, tested through three case studies. These indicators are evaluated using the alignment table to demonstrate their practical application and alignment with ocean conservation goals.

2.3. Testing Indicators Through Case Studies

The case studies (As Close as We Get, the Whanganui River, and Explore the Ocean) validate the proposed indicators, bridging theory and practice to promote actionable outcomes. This approach demonstrates how OCCD can enhance societal understanding and responsibility toward ocean conservation. While challenges remain in balancing theoretical depth with practical impact, this framework offers a novel path for advancing resilient, ocean-centric design practices.

2.4. Strengths and Limitations of the Methodology

The interdisciplinary synthesis highlights the potential for integrating ecological and societal dimensions into design. However, relying on established frameworks may limit innovation, and S.M.A.R.T (specific, measurable, achievable, relevant, time-bound) criteria risk overlooking long-term, qualitative impacts. Despite these limitations, the study provides actionable insights, offering a unified framework that merges ocean literacy with design, advancing the goals of the *Ocean Decade Vision 2030 White Papers—Challenge 10*. The study's contributions lie in its creative integration of diverse frameworks and its emphasis on practical applications. The OCCD indicators aim to ensure a multi-perspective approach, addressing Challenge 10's objective of enabling existing knowledge to be used across society (Glithero et al., 2024).

By highlighting the synergies and overlapping points between existing ocean literacy frameworks (e.g., dimensions of ocean citizenship) and design methodologies (e.g., double diamond, civic design, and human-centred design), the study demonstrates how these can be combined to overcome disciplinary silos.
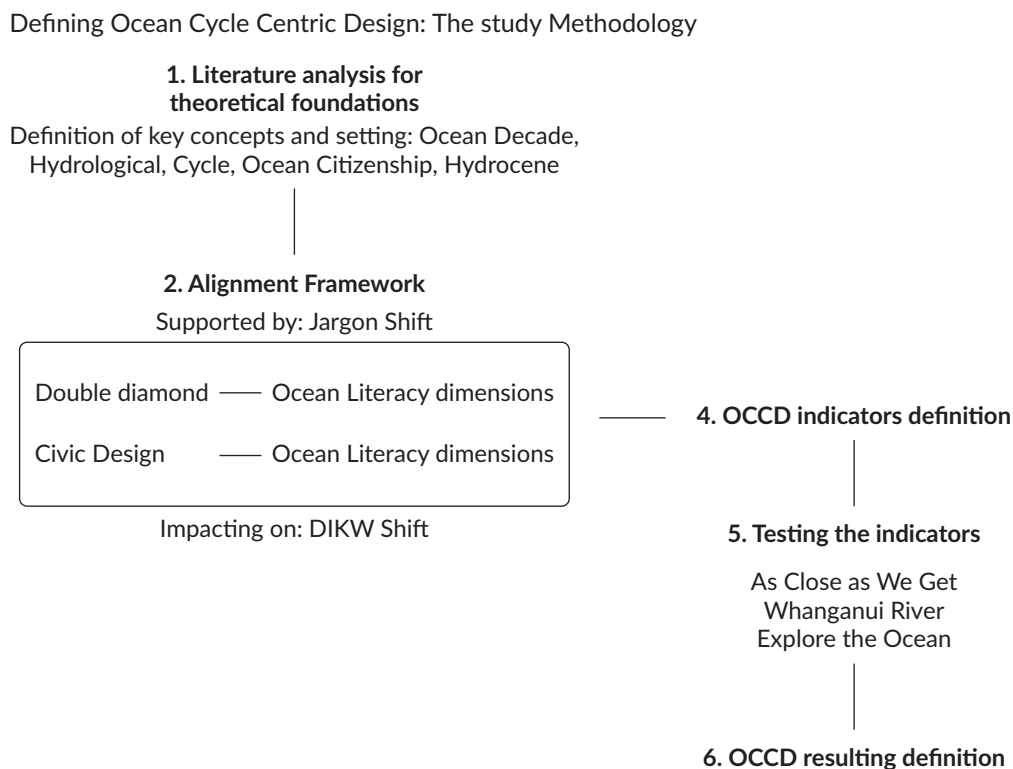

Figure 1. Study methodology Diagram. Note: DIKW stands for data-information-knowledge-wisdom.

3. Defining OCCD

3.1. Jargon Shift for Blue Humanities

The exercise proposed in this article establishes a foundation for defining a concept not yet present in the literature, identifying symmetries and connections between design dimensions and ocean literacy. It highlights the potential of navigating transdisciplinary correspondences between civic and ecosystemic design approaches and ocean literacy, moving beyond traditional disciplinary boundaries to embrace *ignotae aquae* (Latin for "unknown waters"). As illustrated by Annabelle Binnerts (Figure 2), this paradigm shift involves embracing uncertainty, "white space," and the boundaryless connector between entities—a porous, shared matrix traditionally represented in cartography through continents and countries.

The concept of OCCD is introduced by establishing essential terminology to characterise and frame this new idea. This framework addresses transformational challenges requiring a "fifth order of design," is the Planet, encompassing and expanding the four design orders: graphic, industrial, interaction, and system (Buchanan, 1992, as cited in Engholm, 2023). Addressing global challenges in this order involves integrating all artefacts and systems into strategic planning for a sustainable future, with heightened awareness of ecosystemic impacts (Engholm, 2023), and the complexity involved in the interconnectedness of the HOS.

McKinley et al. (2023) stress the need for new jargon and dimensions to expand ocean literacy across geographical and socio-cultural contexts. This article introduces a transdisciplinary vocabulary drawn from the blue humanities (Mentz, 2023b), emphasising word-building as a precursor to world-building. Extending
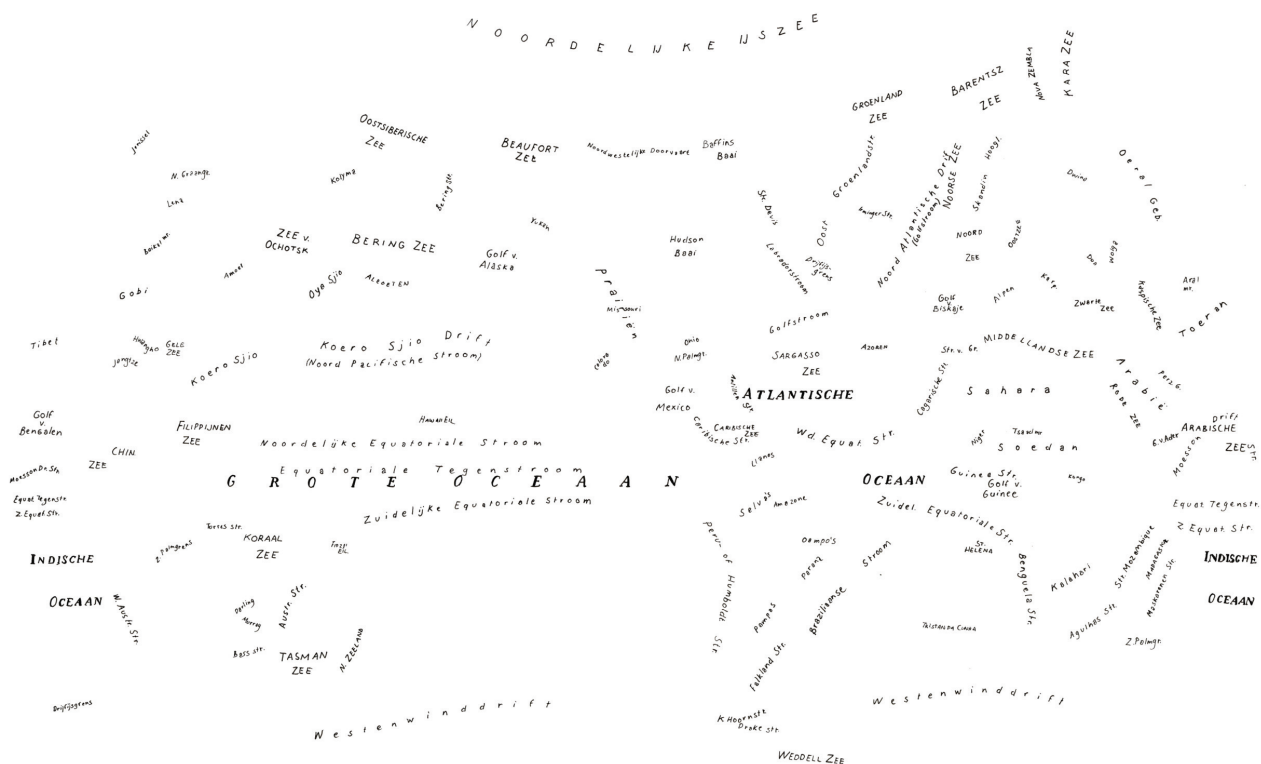

Figure 2. Wereldzeeën (in English, Seas of the World). Source: Binnerts (2017).

the hypothesis that "fluid-storied matter" can transform mindsets (Oppermann, 2023), towards a human-ocean-society nexus-balanced future.

Although the environment-centred design is well-established, the ocean-centric design lacks a defined epistemology. Mentioned in UNESCO's 2024 *Venice Declaration for Ocean Literacy in Action*, it catalyses a shift from humanity-centred design (Norman, 2023), broadening it to include species-wide relationships with ecosystems, and extending ocean literacy across education, science, policy, and culture. The Declaration asserts the need to:

> Launch transdisciplinary programs to better understand and inform our behaviour; merge natural, social, and behavioural sciences with humanities, spirituality and *ocean-centric design* in joint projects and studies. This approach values traditions but also evaluates them according to recent scientific findings. By fostering collaboration with non-academic stakeholders, Indigenous Peoples, coastal and local communities, we develop opportunities such as citizen science and nature-based solutions centred around knowledge, ethics, and experience. (IOC, 2024, p. 3)

Epistemologically, as emphasised by Mentz (2023a, 2023b) and McKinley et al. (2023), approaching new concepts requires the development of a new language. Bartlett et al. (2012) similarly challenge single-perspective frameworks, proposing a "two-eyed" approach integrating diverse knowledge systems. This article suggests shifting from "centric" semiotics to "cycle-centric" design. Commoner, in *The Closing Circle* (1972), considers how, in nature, all cycles are closed and balanced, forming a pillar of sustainability. Building on this, the ocean cycle is presented as a closed system, integral to and balancing planetary health. The term "cycle" refers to processes in the hydrological cycle, recycling water through evaporation, condensation, and precipitation across states and bodies of water—from droplets to rivers, oceans, and clouds (Inglezakis et al., 2016, pp. 137–212). This shift underlines how OCCD is confronted on a temporal and spatial scale (in terms of longevity and engagement) that transcends the sole human life and scale.

Embedding "cycle" into the design lexicon aligns with the continuous, interconnected nature of oceanic systems, encompassing temporal and spatial dimensions that are relevant on a planetary scale. As detailed in Part 4, the cyclical nature of oceans—evident in mechanisms like currents and water cycles—reflects processes with no definitive beginning or end. These cycles, extending from local to global scales, impact communities from coastal regions to urban areas. The cyclical process ensures that matter, whether autochthonous (originating within the system) or alien (introduced, like plastic pollution transforming into microplastics), persists within the system, undergoing constant transformation.

Operating within the ocean-cycle design implies that any introduced action, product, or process remains within the system, often for periods exceeding human lifespans. These actions cascade across geographic and ecological scales, amplifying the interconnectedness of all water bodies. Within cycles, exchanges between actors—human or natural—are inherently mutual, with varying but always-present porosity in human–ocean interactions.

As Mentz (2023b) suggests, adopting a "non-terrestrial" lexicon is necessary to immerse oneself in the blue humanities, smoothing the Human–Ocean Nexus starting with semantics. Moving from a centric to a cycle-based perspective represents a radical transformation in temporal, spatial, and material scales. These

dimensions, rooted in Mentz's (2023b) *New Dictionary of the Ocean*, demand rethinking design thinking, emphasising the interconnected and transformative nature of OCCD.

Table 1. Jargon shift for blue humanities (after Mentz, 2023b).

Dimension	Before	Now (Mentz, 2023b)	Extent/Scale
1. Space	Field	Current	Local to global scales
2. Time	Progress	Cycle and fluxus	Centuries, ages, and geological eras
3. Water	Soil	Water	Bodies of water (Ocean)
4. Humans	Individual (centric)	Community (interconnected)/ Society-Siphonophora	Society–humanity

The lexical shift towards currents, fluxes, and cycles is fundamental to addressing the needs of an ocean society, which is interconnected through the common matrix of water bodies and characterised by behavioural transformations that extend from individuals to entire societies.

3.2. Water Epistemology and Ocean Society

The HOS operates as a complex system of interdependent components. Understanding such a system requires examining its holistic structure and constituent parts. Humans' multifaceted engagement with the ocean necessitates an appreciation of multiple perspectives, interrelationships, and dependencies (Brennan et al., 2019). Within this framework, "cycle-centric design" is introduced to emphasise humanity's intrinsic connection to the ocean from multiple perspectives, highlighting the cyclic implications that extend from the scale of an individual human lifespan to that of future generations. It also acknowledges the broader, multi-scalar reality of belonging to a collective—society and humanity—that depends on the ocean for survival (ocean society).

Water, as the connective tissue of life, is foundational to this concept. The human body, composed of 60% water, parallels Earth's surface, which is 70% water. This symmetry underscores humanity's profound ties to the hydrological cycle. The continuous movement of water—through rivers, seas, clouds, and human bodies—creates a dynamic web of interactions, dismantling the notion of water as a static resource and reimagining it as a living system transcending boundaries. This perspective is visualized in Binnerts' (2017) conceptual "Wereldzeeën" (Figure 2), which maps water's interconnected flows and unseen connections.

Epistemologically, water's transparency, uncertainty, and fluidity support systemic thinking, while ontologically, these properties de-territorialize knowledge and practices (Mentz, 2023b). A single water sample—laden with chemical compounds, isotopes, and microplastics—encodes narratives that span local and planetary scales. This delayering transforms data into stories, dissolving traditional boundaries and fostering rethinking of spatial and cultural relationships.

Water functions as a living archive, reflecting the influence of human actions and cyclic natural processes. From ancient trade routes to acidified oceans, it bears witness to human and ecological narratives. These histories demand ethical care, accountability, and the construction of cartographies integrating ecological and cultural systems. The Hydrocene reframes water as both a participant in and witness to, the challenges of the Anthropocene (Bailey-Charteris,2024; Neimanis, 2012, 2017; Neimanis & Walker, 2014). This approach

aligns with marine citizenship, which extends Fletcher and Potts' (2007) concept to collective political actions. Knowledge, paired with rights, transforms ocean literacy into a tool for fostering sustainable practices and ethical human–ocean relationships (Buchan et al., 2023).

3.3. OCCD Dimensions

To explore intersections between ocean literacy and design, we used a visual overlap method (Figure 3) to support the integration of ocean literacy dimensions (McKinley et al., 2023) with the double diamond framework (Design Council, n.d.). This model includes four stages: discover, define, develop, and deliver, which emphasise deep engagement, collaborative idea generation, and iterative improvement. The double diamond has been utilised as an approach to integrate and trace a correspondence of ocean literacy dimension into process and design decision-making. The diamond, as with all design and strategic thinking, starts with a preliminary moment of "orientation and vision setting," which is a *sine qua non* of our envisioned action for the future we want. It prioritises people, inclusive communication, collaboration, and continuous iteration. The framework's success depends on strong leadership and stakeholder involvement, aligning with OCCD principles.

3.3.1. Knowledge, Access, and Experience: Explore

Figure 3 situates knowledge and access/experience within the "explore" phase, corresponding to the divergent opening of the double diamond. This phase broadens perspectives to gain insights into a given context, embracing a multi-perspective approach like "two-eyed seeing" (see Table 4). This implies a shift to a more active "explorer" role, which is characteristic of the "ocean citizen."

Exploration expands knowledge systems by incorporating diverse data, including Indigenous and overlooked knowledge, to develop a holistic understanding. Accessibility and experience should span disciplines and communities, enabling participants to interact with ocean knowledge via various media and platforms. Horizontal access to knowledge is critical, empowering non-specialist audiences to make informed decisions. Building trust across scales hinges on this access, linking knowledge, experience, and trust in meaningful ways. The process also acknowledges the unique languages and mediums of different knowledge systems, emphasising inclusive approaches to expand exploration and deepen understanding.

3.3.2. Awareness: Reframe

Awareness is positioned within the reframe phase, reflecting its dual role: awareness gain involves fostering societal recognition of humanity's interconnectedness with the ocean, from relying on it for oxygen and climate regulation to understanding it as part of a broader adaptive system. Achieving this awareness encourages a shift from an ego-centric to an eco-systemic worldview. Awareness in reframing uncovers the problem behind the problem (Paton & Dorst, 2011). Awareness gained through exploration aids in reframing challenges, fostering innovative solutions and actionable outcomes.

3.3.3. Attitudes and Emoceans: Connections and Relationships

Attitudes and emoceans (emotional connections to the ocean) align with the connections and relationships phase. This phase mediates between individual and collective scales, fostering societal understanding of how behaviours impact communities and the ocean.

Emotional connections to the ocean, referred to as "emoceans" (McKinley et al., 2023), are recognised as critical drivers of behavioural change (Jacobs et al., 2012). Research highlights how positive emotions enhance memory, learning, and engagement (Natalini, 2022; Pekrun, 2004; Pekrun et al., 2002), influencing attitudes and decision-making. Strengthening emotional ties to the ocean deepens individual and societal commitments to ocean health.

3.3.4. Trust and Transparency: Creation

Trust and transparency are integral to the creation phase, although they intersect with multiple dimensions of the double diamond. Their placement here is deliberate, building on connections and relationships to support processes that foster societal trust.

As Mentz (2023a) highlights, water's physicality is a metaphor for transparency in societal processes. Trust and transparency strengthen connections between scientific communities and non-specialist audiences. This is vital in the disinformation era—identified as a top risk in the *Global Risk Report 2024*. To counter this, fostering trust-building processes through transparency becomes a cornerstone of effective communication strategies.

3.3.5. Activism and Behaviour: Leadership and Storytelling

Activism and behaviour are situated within the leadership and storytelling dimension, recognising leadership as a means of transitioning from passive to active ocean citizenship. Activism is the degree of engagement in activities—such as campaigning for policy change (Brennan et al., 2019; McKinley et al., 2023). Leadership encourages collective action for societal transformation.

Storytelling plays a pivotal role in fostering engagement and connecting individuals with larger societal and ecological narratives. It bridges personal and collective scales, enhancing understanding and empathy (McDowell, 2021). As a tool for envisioning future scenarios, storytelling builds resilience and inspires behavioural change (Vervoort, 2014), making it central to cultivating a healthy society–ocean nexus.

3.3.6. Adaptive Capacity: Continuing the Journey

Adaptive capacity aligns with the continuing the journey phase, reflecting the need for societies to adapt to evolving challenges. Coastal communities depend on resilience and adaptive capacity to navigate the dynamic relationship between the ocean, climate, and coastline (McKinley et al., 2023).

This phase represents the culmination of the design process, encompassing acquired knowledge, emotional connections, and collaborative storytelling. Adaptive capacity emphasises the iterative, nonlinear nature of the journey, where feedback loops foster learning and continuous improvement. By weaving together diverse

knowledge systems and active participation, this phase operationalises a human–ocean nexus that is informed and responsive.

3.3.7. Communication: Core Dimension

Communication is positioned as a cross-cutting dimension, central to all phases of the double diamond. As an essential component of environmental and marine citizenship, communication connects communities, knowledge systems, and societal scales (McKinley et al., 2023).

Communication serves as the "delta," the liminal space where different knowledge systems converge and knowledge "catalyses." It encompasses both the content ("what") and the medium ("how") of knowledge transmission, employing traditional and innovative methods such as new media, technologies, and art-science. Effective communication fosters porosity between disciplines, enhancing information exchange and cultivating deeper connections between society and the ocean. It is integral to both the continuity and success of the journey.

Through these dimensions, OCCD reframes the human–ocean relationship, fostering ethical, ecological, and cultural sustainability.
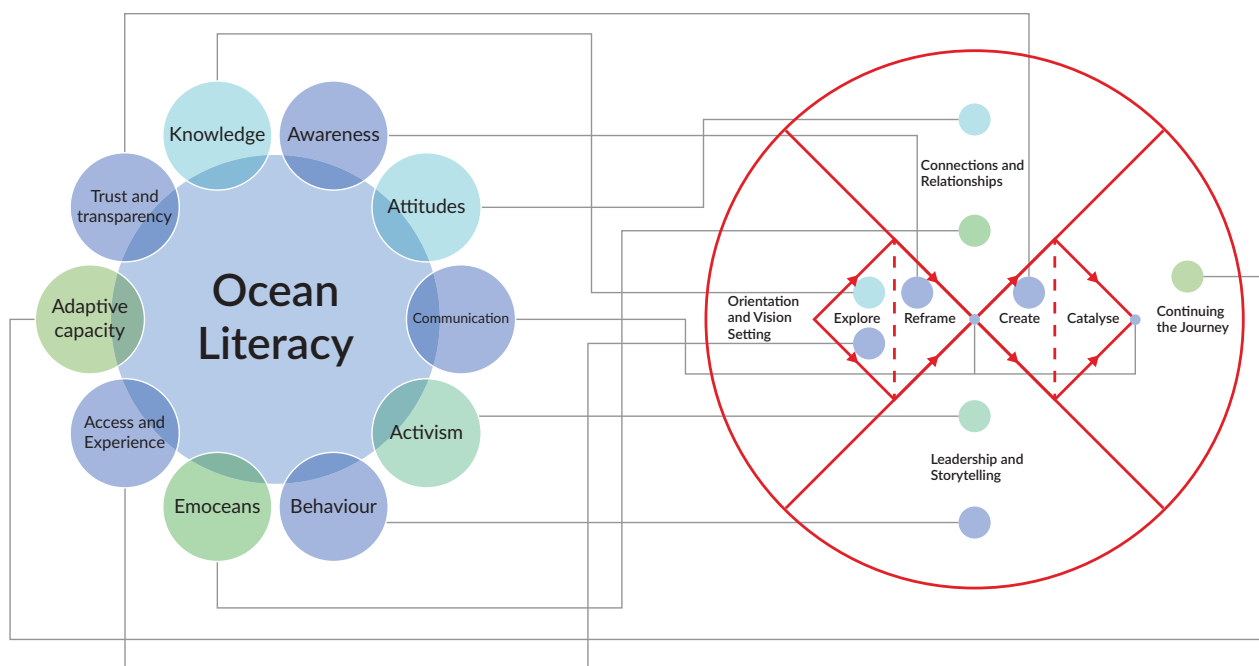

Figure 3. Ocean literacy dimensions and interaction within the systemic design framework. Based on McKinley et al. (2023) and Design Council (n.d.).

3.4. From Ocean Literacy and Civic Design towards OCCD Dimensions

In the following paragraphs, we present a set of tables (Tables 2 and 3) to facilitate the comparison of ocean literacy and design assets. Firstly, aligning ocean literacy with civic design extends its connection to the societal dimension. The comparison of design-based approaches, particularly problem-solving and

human-centred design, provides an opportunity to illustrate how OCCD contrasts with and expands upon these traditional frameworks.

Together with Table 1, these tables offer a structured overview of key elements and terminology encountered in OCCD. Table 1 aids in understanding the conceptual shift in terminology proposed by Mentz (2023b) and the scale of its impact. Table 2 enables a comparison of ocean literacy and civic design dimensions, derived from two key studies on societal engagement and impact, which, when integrated, contribute to the definition of OCCD. Finally, Table 3 refines OCCD indicators by evolving existing design approaches to better align with contemporary challenges.

The second part of the section is dedicated to the definition and representation of OCCD, embedding all the previous steps, to seek to foster societal behavioural shifts and overcome current limitations.

In Table 2, ocean literacy dimensions are compared to civic design dimensions (Fagnoni, 2022), considering civic participation fundamental to leverage existing knowledge to ensure a healthy ocean, supporting sustainable decision-making and the co-creation of actionable solutions.

Table 2. Comparison between ocean literacy dimensions (after McKinley et al., 2023) and civic design (after Fagnoni, 2022).

Ocean literacy dimensions (McKinley et al., 2023)	Civic design dimensions (Fagnoni, 2022)	Definition
Knowledge	Holistic approach	Practices/projects tend to consider systems and services as a whole, combining actions across multiple scales. No level of scale distinguishes these projects, nor a typology (span from product design, service design, communication design, and interior design)
Awareness	Civic engagement	Practices aiming to increase civic engagement and citizen involvement in decision-making. Participation is inherent in assumptions of what counts as civic (DiSalvo & Le Dantec, 2017)
Attitude	Interaction	Practices that maintain high interaction between people, between people and material or digital things; focusing on everyday interactions, whether between humans, with bureaucracies, or in groups
Behaviour	Ethic as material	Design as free from values and power, a form of innovation philosophy, and a set of heuristics for working with change in any context
Communication	Living futures	Exploration of alternative scenarios for design in 2050 revealed radically different possibilities for future societies. The role of designers varies depending on context, but ethics, as a system of guiding principles, is a common aspect (Bason, 2022)

Table 2. (Cont.) Comparison between ocean literacy dimensions (after McKinley et al., 2023) and civic design (after Fagnoni, 2022).

Ocean literacy dimensions (McKinley et al., 2023)	Civic design dimensions (Fagnoni, 2022)	Definition
Emotional connections	Design compelling communication and exchange	Design can inspire engagement and action around water bodies. Leveraging emotional responses by creating inclusive spaces, storytelling platforms, and participatory experiences that encourage empathy, collective responsibility, and co-creation, promoting behaviour change for marine preservation
Access and experience	Inclusive ocean experiences	Creating opportunities for people to engage with the ocean, physically or virtually, ensuring access regardless of location, gender, physical limitations, or cultural background. Design removes barriers such as cost and social factors while enhancing emotional connections to the ocean.

The co-creation of actionable solutions, embedded within all civic design dimensions, necessitates the positioning and sustaining of co-design processes in which citizens play a crucial role (Dal Buono et al., 2020). Citizens have the potential to contribute local knowledge and perspectives on civic issues, synthesise data, and innovate new solutions (Reynante et al., 2021). Co-design involves integrating local knowledge as a fundamental component of design actions for the "real world" (Papanek, 1971) while also reframing civic participation as the primary challenge in driving behavioural shifts across society.

The comparison of design-based approaches (Table 3), particularly problem-solving and human-centred design, provides an opportunity to illustrate how OCCD contrasts with and expands upon these traditional frameworks. This highlights the distinct characteristics of OCCD, emphasising its ecological interconnectedness, systemic thinking, and emphasis on sustainability—elements that extend beyond the traditional scope of problem-solving and human-centred approaches. From this alignment, the identified indicators in Table 3 are then integrated and expanded into the eight dimensions of OCCD (Sections 3.4.1–3.4.9).

Table 3. Comparison of design-based approaches' indicators, after Junginger (2014) and identified indicators of OCCD.

Problem-solving approach	Human-centred design approach	OCCD
Concerned with isolated problems	Concerned with indeterminate situations	Concerned with interconnected issues that threaten the marine environment and humans. It considers humans as part of the marine biome. It involves porosity between disciplines as a complex system Identified indicators: Embracing uncertainty and interconnectedness

Table 3. (Cont.) Comparison of design-based approaches' indicators, after Junginger (2014) and identified indicators of OCCD.

Problem-solving approach	Human-centred design approach	OCCD
One-directional, linear, top-down, though with feedback loops	Works simultaneously in several directions, neither top-down nor bottom-up but rather crisscrossing through an organizational system (Junginger, 2009), thereby mixing its elements	Transdisciplinary, crisscrossing, and circular Identified indicators: Transdisciplinarity and porosity
Frames policymaking as a response mechanism; policymakers passively wait for a problem to appear and then respond, promoting reactive rather than proactive policy design	Envisions futures and develops scenarios to bring them to life	Is able to embrace radical paradigm shifts and scenarios. It works on anticipative futures Identified indicators: Blue futures and radical scenarios
Predominantly a discovery and selection of already existing alternatives	Begins with inquiry, includes discovery and selection, but also promotes invention	It is based on research and feeds new inquiries, but invention and innovation are a needed asset in its inception phases. It encompasses uncertainty and the unknown Identified indicators: Circular innovation and multi-perspective
Fragments the design process Treats policymaking as one design activity: the policy is the primary designed product, while policy implementation is the secondary	Integrates the different design efforts through participatory, collaborative, and co-designing methods that inquire into all elements of a system (cf. Sanders & Stappers, 2008; Bason, 2010)	A holistic approach that takes into consideration the complexity of the process in a system. The system is intended as more than the sum of the parts, bringing added value and mechanisms (Brennan et al., 2019; Meadows, 2009) Identified indicators: Holistic and systemic
Presents policymaking as an abstract exercise centred on decision-making, without considering the experiences and realities of the people affected by the policy—citizens, external stakeholders, and public employees	Includes and involves people to learn about issues and opportunities for improvement in particular situations. Civil servants, ordinary citizens, external stakeholders, public managers, and others relevant to a situation, product, or service often participate, collaborate, and co-create toward a solution	Citizens and communities are actively involved in decision-making, policymaking, and scenario ideation. Solutions, services, projects, and processes are based on the involvement of multi-stakeholders. This involves non-humans as a community that holds rights and needs at the consultation tables Identified indicators: Connecting communities and ocean citizenship
Values design solely for its problem-solving ability, using it only as an instrument for policy implementation	Covers the whole range of designing, including inquiry, discovery, and invention	Embraces the multiple perspectives crossing scales and dimensions (two-eyed seeing method; Glithero et al., 2024) Identified indicators: Multi-perspective

Table 3. (Cont.) Comparison of design-based approaches' indicators, after Junginger (2014) and identified indicators of OCCD.

Problem-solving approach	Human-centred design approach	OCCD
Takes policy design out of its context, suggesting that a policy problem can be treated in isolation	Situates and integrates the design of policies and policymaking in organizational life, but also within the human experience of everyday people	Policymaking aligns and is designed through civic active participation, local communities' needs, and is based on ecological impact and scenarios Takes into consideration how local and global issues are deeply interconnected. Every solution needs to be context-specific but must benefit its next scale (e.g., river to the sea and sea to the ocean) Identified indicators: Multi-scalar and local to global
Relies on abstract data drawn from the past	Relies on actual and present human experiences	Relies on practical data, human experiences, values, and behaviours. Citizen science is integrated into local cartography. Local and indigenous knowledge is embedded to expand it. Mapped perceptions and emotions are taken into consideration. Data is harmonised and open access Identified indicators: Harmonised DIKW-A (data, information, knowledge, wisdom, and action)
—	—	The use of resources takes into account the cyclicity of the water cycle, its temporality, and its extent Identified indicators: Matter-cyclic and multi-species

3.4.1. Multiscalar

The term multiscalar refers to the various governance levels that influence and shape actions centred on the ocean cycle. A multiscalar approach to policy and governance is increasingly recognised as essential in strategic planning (Sorensen, 2018). Ensuring harmony and compliance across governance scales—from global to local—can enhance the likelihood of success. This alignment not only supports the implementation of ocean-related initiatives but also improves access to financial resources, fostering more effective and integrated outcomes.

In OCCD, policymaking is shaped by and aligned with civic participation, responding to the needs of local communities while being grounded in ecological impact assessments and scenario planning. This process recognises the profound interconnection between local and global challenges, acknowledging that environmental and societal issues do not exist in isolation but rather form part of a larger, interdependent system. The overarching aim is to foster alignment with the principles of an ocean society, where human activities are harmonised with ocean health and sustainability. Achieving this vision requires co-design as a

fundamental approach, enabling collaboration across different sectors of society and ensuring that diverse voices and knowledge systems contribute to decision-making. Effective policymaking must, therefore, be both context-specific and scalable, addressing immediate local concerns while also fostering solutions that benefit interconnected systems. For instance, interventions at the river level should not only resolve localised issues but also support the health of downstream ecosystems, from the sea to the ocean, reinforcing a holistic and integrated approach to sustainable governance.

3.4.2. DIKW-A

Building on the imperative of fostering an ocean-informed society, it is crucial to examine how knowledge and information shape decision-making (Sinni, 2023). The DIKW chain (Figure 4) structures our understanding of the ocean, yet knowledge alone is insufficient for meaningful action. Blue epistemology highlights the gaps in defining data and wisdom while underscoring the challenge of fostering engagement towards blue citizenship. Knowledge enables process understanding, informing individual and collective actions. Through synthesis, reflection, and the application of lessons learned, wisdom emerges, integrating ethical and aesthetic values into decision-making (Ackoff, 1989). Expanding the DIKW model to include action (DIKW-A) reinforces the link between wisdom and purposeful action, creating a dynamic, circular system aligned with long-term goals (Ackoff, 1989; Rowley, 2007). However, this progression is complex, as data collection can reflect biases (D'Ignazio & Klein, 2020), and excessive information may lead to polarization rather than clarity (Cairo, 2016). To address these challenges, DIKW-A integrates inclusivity, infrastructure, and storytelling to present knowledge effectively and stimulate behavioural change (Mitra & Sameer, 2022).
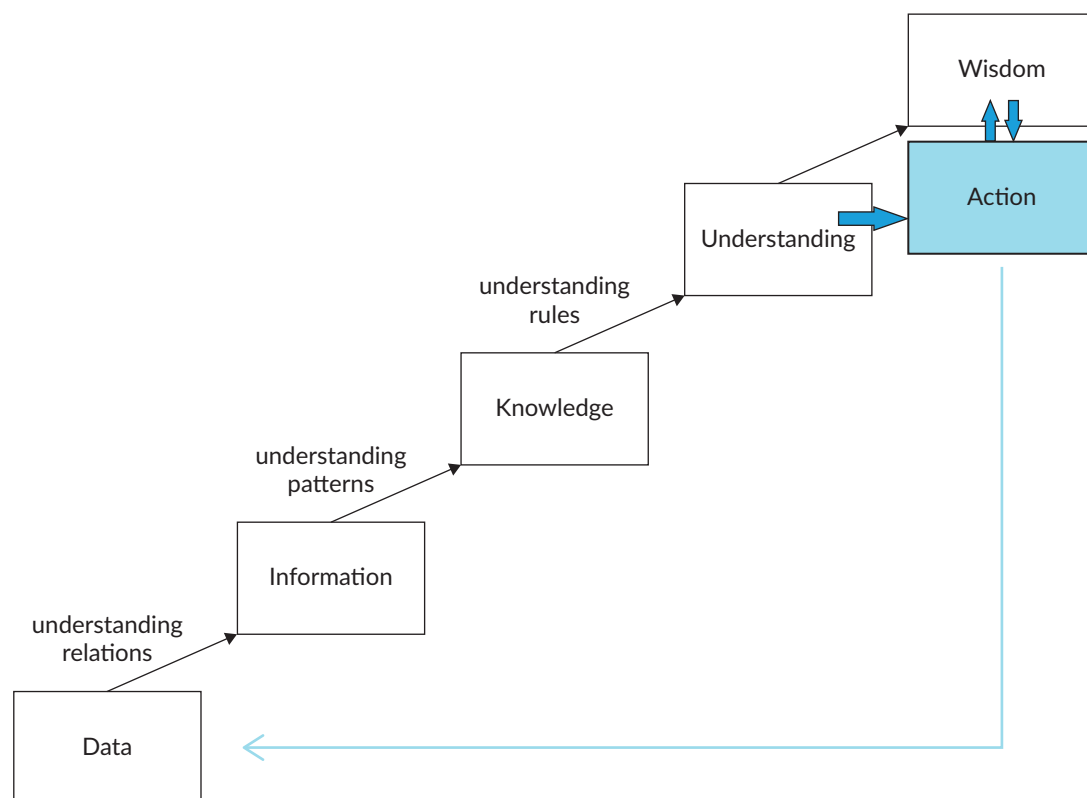

Figure 4. DIKW-A chain. Note: Adapted from Bellinger et al. (2004).

The knowledge pyramid in OCCD is expanded to emphasise the flow between wisdom and action (DIKW-A), with particular attention to fostering behavioural change (see Section 4). OCCD incorporates a broader spectrum of data and knowledge, harmonising diverse knowledge systems to create actionable insights. This aligns with the Challenge 10 white paper, which stresses the necessity of integrating varied knowledge types for broader societal application. The DIKW-A chain is a transformative process that accelerates transitions to informed decision-making, innovative solutions, and increased awareness and attitudes towards the ocean and water systems. The shift from data to wisdom and action is enabled through tools such as the European Digital Twin of the Ocean and the Atlas of the Seas. These tools facilitate transdisciplinary collaboration (Glithero et al., 2024) and connect diverse scientific datasets through harmonised infrastructures. Importantly, these tools must also remain accessible to non-specialists and other stakeholders, fostering widespread engagement. Citizen science data, for example, offers additional layers of understanding, enriching cartographic efforts while promoting civic participation. Similarly, emerging narratives and new media formats (e.g., AR, VR, XR, data physicalization, and sonification) make information and knowledge more engaging and experiential, enhancing accessibility for non-specialist audiences (McKinley et al., 2022). These methodologies aim to accelerate adaptation and mitigation efforts in response to the climate and biodiversity crises, highlighting the interconnected nature of ecological challenges and emphasising shared responsibilities across society.

3.4.3. Blue Futures

OCCD's time horizon must extend beyond immediate human lifespans to account for future generations. This approach aligns with the concept of "continuing the journey" from systemic thinking, emphasising the development of anticipatory futures and forward-looking scenarios. Creative and radical paradigm shifts are central to this methodology, offering scientifically grounded narratives of potential future oceans. A pertinent example is the Radical Ocean Futures (n.d.) project, which uses these narratives to focus attention and drive behavioural change by illustrating the long-term implications of today's actions. Specifically, blue futures could be assimilated and aligned to the "preferred future" axis as depicted in the cone of possible futures by Voros (2003, 2020).

3.4.4. Holistic and Interconnected

OCCD broadens the design scope from local to global scales, reflecting the interconnected nature of water systems. This holistic approach recognises the inextricable linkages between different bodies of water—including rivers, lakes, seas, and ice formations—through the global water cycle. These entities are ecologically interconnected, either directly or indirectly, through processes such as evaporation and condensation. Additionally, a holistic approach challenges traditional geopolitical boundaries. Water bodies, and their associated environmental challenges, often extend beyond political borders. For instance, rivers serve as major conduits of ocean plastic pollution (The Ocean Cleanup, 2024). Inland waterways transport pollutants from urban areas to oceans, exemplifying the interconnectedness of terrestrial and marine systems and underscoring the need for comprehensive, boundary-crossing solutions.

3.4.5. Embracing Uncertainty and Multiperspective

The society-ocean nexus is a highly interconnected and complex system, linking human life, marine health, and environmental processes through the hydrological cycle. Addressing these interconnections requires

OCCD to engage with the inherent uncertainty of this multidimensional system. An approach rooted in embracing, rather than limiting, uncertainty expands the capacity to navigate "uncharted waters," epistemologically and practically speaking. Designing for uncertainty fosters interdisciplinary collaboration and facilitates the integration of diverse perspectives (Overbeek & Bessembinder, 2013). OCCD calls for a multiperspective framework, such as the "two-eyed seeing" approach (Glithero et al., 2024), which combines Indigenous and Western knowledge systems. Extending this concept, OCCD proposes a "hundreds-eye seeing" perspective, inspired by multi-species collectives like Siphonophorae. This approach leverages insights from diverse human and non-human viewpoints, emphasising collective and systemic interdependence.

3.4.6. Matter-Cyclic

In cyclic systems, interactions between actors are reciprocal. Actions—whether human or natural—create impacts that ripple across assets and processes. The concept of cyclic matter in OCCD centres on water, the primary material of the hydrological cycle. As an "infinite-cycle" resource, water continuously flows and transforms within natural cycles. However, human activities introduce non-cyclic materials, such as pollutants and microplastics, which persist in these systems long after their initial introduction. These long-term consequences necessitate careful consideration of spatial, temporal, and material flows that transcend the human scale, impacting deeply marine ecosystems and non-human life.

3.4.7. Ocean Citizenship: Community Engagement

Ocean citizenship emphasises active participation in informed decision-making and behavioural change. Being a citizen of the ocean entails adopting a "blue-informed" societal mindset, which fosters actions that contribute to ocean health from individual to collective action. This concept underscores the collaboration between diverse communities to build relationships across societal layers, strengthening OCCD processes. A metaphor for this concept is the Siphonophorae, a marine collective organism (a zooid colony) composed of interconnected individuals and communities. Harmonising individual, community, and societal actions fosters resilience and sustains the entire system's health.

3.4.8. Multi-Species

OCCD acknowledges that human societies coexist with an array of non-human actors, including animals, ecosystems, and technologies (Giaccardi et al., 2024). This perspective is particularly critical for marine ecosystems, which face overexploitation and endangerment due to human activities. The multi-species approach broadens the traditional human-centred perspective to include non-human viewpoints, fostering a deeper understanding of marine biodiversity and its interconnectedness. Notably, despite the ocean being Earth's largest ecosystem, only 5% of it has been explored (National Oceanic and Atmospheric Administration, n.d.). This vast unknown underscores the need to respect, discover, and integrate knowledge of yet-unexplored species and ecosystems into OCCD "hundreds eye-seeing" knowledge systems.

3.4.9. Porosity Index

Drawing from Mentz's (2023a, 2023b) dictionary for blue humanities, OCCD incorporates fluxes, currents, and cycles as defining dimensions. Porosity serves as both a physical and metaphorical concept, reflecting the

fluid exchange of ideas, disciplines, and interactions between humans and ecosystems, in a transdisciplinary way. This concept aligns with Barad's (2007) use of physical phenomena as knowledge metaphors. In nature, water permeates and mixes across surfaces, creating liminal spaces and porous boundaries between entities such as river deltas where fresh and saltwater meet. At the micro-scale within a porous medium, water functions as a connector, forming a dynamic liquid mesh that links different spheres. Similarly, if we try to visualise the dimensions of OCCD as distinct spheres in a four-dimensional space (Figure 5a), OCCD dimensions are included in a cone of possible futures (Voros, 2003, 2020) extending to a blue future where
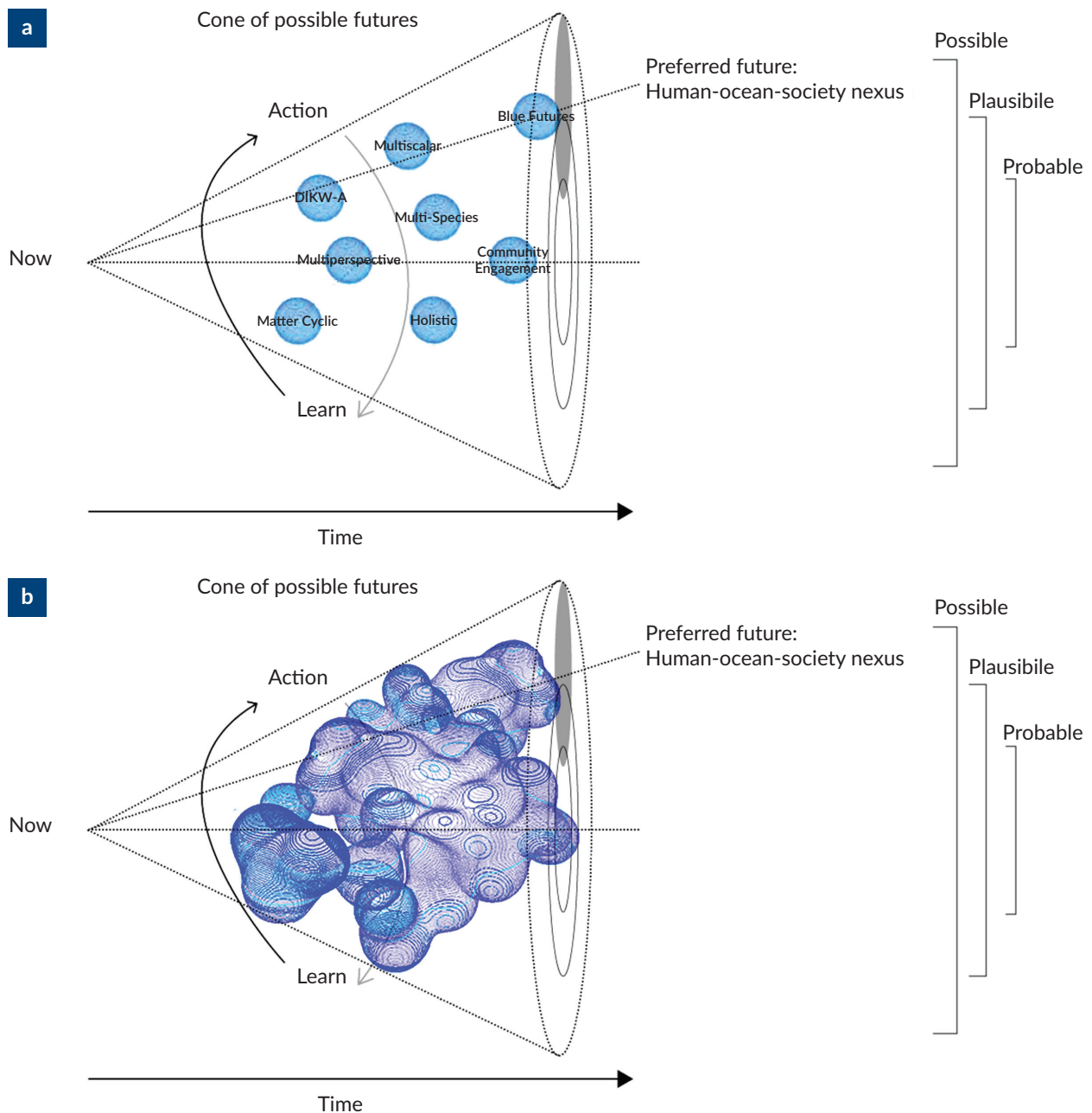

Figure 5. (a) Diagram of OCCD dimensions in a four-dimensional context of cones of possible futures; (b) representation of OCCD, as a four-dimensional connector of the different dimensions aiming to a preferred future where the human-ocean-society nexus is fully accomplished. Note: Figure 5a was adapted from Voros (2003, 2020).

the human-ocean-society nexus is balanced. Through cyclic processes of learn and action iterations, running between the different dimensions—ranging from individual to systemic scale—OCCD can be visualised as an evolving, amorphous mesh (Figure 5b). This fluid structure continuously adapts, integrating and interconnecting different OCCD dimensions, reinforcing its role as a unifying and dynamic framework.

OCCD fosters high porosity between disciplines, entities, and systems, allowing knowledge and processes to flow freely and enrich one another (Figure 5). In the chosen case studies, different degrees of exchange persist, emphasising the interconnected nature of all systems. The porosity index is evaluated, in this study, according to three levels of intensity: high, medium, and low.

4. OCCD: Case Studies

This section presents three case studies selected for their alignment with the dimensional assets of OCCD as defined by indicators in Section 3. These examples, drawn from the past decade, are intentionally diverse, representing various facets of OCCD. Each case study highlights the presence of certain dimensions and the absence of others within the OCCD framework, offering an opportunity to use these gaps as starting points for discussion, illustrating how integrating the absent dimensions could strengthen and enhance future OCCD approaches. The selected cases are examined through a critical yet forward-looking blue future perspective, viewing them not as finalised projects but as evolving, cyclic examples with significant potential for further development and deeper integration of OCCD principles.

They emphasise community engagement at multiple levels—from policymakers to local communities—and contribute to achieving Challenge 10's goal of restoring society's relationship with the ocean. The guiding principles for selection included:

1. Addressing transdisciplinary aspects (time, space, and matter) in an ocean cycle-centric approach.
2. Involvement of local communities in the decision-making process.
3. Consideration of the project's ecological and biome impacts using a multi-perspective and multi-species lens.
4. The introduction of DIKW-A society, leading to increased awareness to lead tangible behavioural changes.

4.1. SUPERFLEX: As Close as We Get

4.1.1. OCCD Indicators: Multispecies, DIKW-A, Multi-Scalar, Blue Futures, and Matter-Cyclic

The art-science installation As Close as We Get exemplifies the intersection of marine spatial planning, ecology, art-science, and material research. Created by SUPERFLEX with DTU Sustain and By & Havn, it features three "monoliths" in the Copenhagen Harbour. The project, part of the Super Rev programme, aims to restore reefs and promote marine biodiversity using sustainable, biocompatible materials.

The installation uses CO_2-absorbing concrete with a "sponge-effect," developed by DTU Sustain, to capture carbon and create marine habitats, aligning with the matter-cyclic ocean cycle centric indicator. This regenerative approach builds on projects like Vigo Port and ECOncrete technology.

The installation prioritises marine biodiversity, viewing harbours as spaces where human and non-human life interact. Materials, from ancient stone to modern fish-friendly bricks, embody a temporal continuum, reflecting the project's vision for a blue future. Underwater, the sculpture serves as a habitat, while above water, it engages the public, blending ecological function with artistic expression.

As Close as We Get demonstrates the DIKW-A chain by turning material research into an actionable prototype, raising awareness and enhancing public understanding of marine ecosystems. The project also reimagines urbanism within the Hydrocene, where water dominates global ecosystems and coastlines are a shifting and changeling boundary, offering a model for future harbour policies and multi-species urban design. This pioneering project merges ecological regeneration, material science, and public engagement, serving as a blueprint for sustainable urban–marine symbiosis.

4.2. Whanganui River

4.2.1. OCCD Indicators: Holistic and Systemic, Community Engagement, Multiperspective, DIKW-A, Blue Futures, and Multi-Species

In March 2017, the Whanganui River in Aotearoa, New Zealand, became the first river globally to be granted legal personhood. This recognition stems from viewing the river as a living entity and spiritual ancestor of the Whanganui Iwi, a Māori tribe (Kramm, 2020). The case is a significant advancement in legal pluralism, redefining humanity's relationship with non-human entities like water bodies (Charpleix, 2017).

The Whanganui River case is inherently holistic, considering the river's vast geographical extent of 290 km across Aotearoa New Zealand. This spatial reach has played a crucial role in uniting the riverine communities that have inhabited its waterways for centuries. The Whanganui Iwi ontologically conceive and understand the river as an indivisible, living entity, and as the spiritual ancestor of the Māori people residing along its shores. For generations, Māori settlements have been established along the river's course, with Whanganui—meaning "big harbour" in Māori—regarded not only as a vital source of food and healing but, more significantly, as the embodiment of the Iwi's ancestors (Kramm, 2020).

In this context, the river as a spiritual and living entity serves as a tangible example of a multi-perspective and multi-species approach, aligning with Giaccardi's conceptualisation of an extended network of non-human actors. Beyond its fundamental role in human survival—as a food source, a waterway for transport, and an essential ecological system—the river is deeply embedded in the Iwi's language, beliefs, and social structures, acting as a source of food, single highway and spiritual mentor (Charpleix, 2017). Recognised as a less anthropocentric approach, the Whanganui River case is particularly significant in the discourse of environmental management, especially in relation to water governance (Charpleix, 2017).

The Whanganui River represents a co-design experience (as co-design is intended in Zhang et al., 2024), understood as a system of collaborative processes that engage diverse communities and contribute to the advancement of water body policies on a global scale. The relationship between the Whanganui River and its community illustrates how Indigenous knowledge, cultivated through centuries of symbiotic coexistence and aligning with the DIKW framework at the wisdom level, ultimately leads to action in policymaking and large-scale community engagement.

The legal personhood of the river, established through the Te Awa Tupua Act, was achieved following a century-long struggle between the Whanganui Iwi (a Māori tribe) and the New Zealand Government. The Whanganui Māori have been advocating for their rights over the river since the colonisation of the 1840s (Charpleix, 2017). Kramm (2020) provides a detailed examination of the bureaucratic structures and processes—comprising guardians, a strategy group, and an advisory group—that facilitated the recognition of the river's legal personhood and its practical implementation. This legal status enables the river to be represented in court, with two appointed guardians acting on its behalf.

4.3. Explore the Ocean

4.3.1. OCCD Indicators: Community Engagement, Multiperspective, DIKW-A, and Blue Futures

The design process employed by the Science Communication Lab, as outlined by Landis and Duscher (2022), is notable for its interdisciplinary approach. Scientists and designers collaborated iteratively to transform research into a visually cohesive language tailored for specific audiences. This process involved testing and revisions with the target audience to refine the product (Landis & Duscher, 2022).

Explore the Ocean's process is innovative compared to other spatial representations, even official ones. For instance, national geoportals for maritime spatial planning often lack participatory features, restricting co-design opportunities (Davret et al., 2023) in spite of official requirements for engagement (Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning, 2014). To foster inclusivity, testing user-friendly interfaces and incorporating public engagement during planning stages are essential (Barbanti et al., 2023).

This approach effectively communicates complex scientific concepts by connecting with audiences on visual and emotional levels. The interactive poster introduces scientific topics engagingly, demonstrating design-driven science communication through interactive storytelling. It covers aspects of the ocean system, including geodynamics, the biosphere, climate, and observing systems, and addresses challenges like plastic pollution and overfishing. This mirrors the DIKW-A chain (data to action), a key framework in this study.

Explore the Ocean is an example of the DIKW-A framework, by bridging the DIKW-A at various levels. On one hand, it underlines the importance of knowledge sharing and raising awareness through storytelling methods (double diamond processes) in supporting the behavioural shifts that are essential for sustainable ocean management.

The concept of "revision loops" aligns with circular design principles, such as the double diamond framework, reinforcing co-constructed knowledge with society. Audience feedback was crucial in refining the product, creating a dynamic loop between science and the public. The focus on emotional resonance supports ocean literacy goals, enhancing engagement with marine systems.

The Explore the Ocean poster is an effective tool for public interaction with marine science, ensuring transparency and credibility (Duscher et al., 2017). The use of innovative 3D visualisation creates an immersive experience, demonstrating how design, communication, and scientific research converge to make marine science more accessible and relevant, advancing OCCD principles.

5. Results: Comparison of Case Studies on Ocean Cycle-Centric Indicators

Table 4. Comparison of OCCD indicators in case studies, porosity ranking level (low-medium-high).

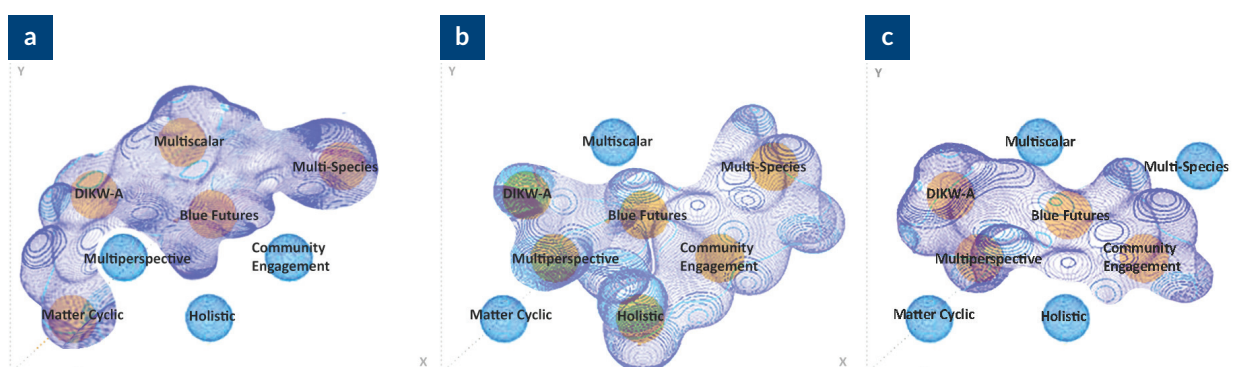|	3.5.1. Multi-scalar	3.5.2. Dikw-A	3.5.3. Blue futures	3.5.4. Holistic and inter-connected	3.5.5. Uncertainty and multi-perspective	3.5.6. Matter-cyclic	3.5.7. Community engagement	3.5.8. Multi-species	Porosity index
(a) As Close as We Get	X	X	X	—	—	X	—	X	Medium
(b) Whanganui River	—	X	X	X	X	—	X	X	High
(c) Explore the Ocean	—	X	X	—	X	—	X	—	Low

Figure 6. Diagram representing the OCCD approach, in a four-dimensional, fluid form. Note: The variations depend on the active OCCD dimensions and their interconnectedness for the selected case studies (a, b, and c) as named in Table 4.

In Figure 6, we present the active indicators within each case study (a, b, and c), illustrating how OCCD, depicted as a four-dimensional mesh, shifts in shape and density around the different indicators (1, 2, and 3). This visualisation aims to emphasise the fluid and evolving nature of OCCD, highlighting its capacity to adapt over time. Additionally, it underscores how the missing indicators in each case study can be integrated through future developments and iterations, allowing for continuous evolution and refinement of the OCCD framework.

The results are organised in Table 4. As it shows, each case study can be related to numerous indicators. As Close as We Get exemplifies a matter-cyclic approach, emphasising how human structures within harbours can prioritise biodiversity and the marine biome. Through its design, the project seeks to transcend anthropocentric life cycles by incorporating the hydrological cycle and the complexity of ecosystems in a more-than-human approach. It offers a vision of a blue future, addressing the preservation and regeneration of harbours and endangered coastal ecosystems and habitats.

Rooted in transdisciplinarity, the project bridges art-science, research, engineering, and ecosystem-based management. It reflects a collaborative process between disciplines that includes innovations in material science and public art to reimagine human interactions with marine environments. Community engagement in this initiative has been a bottom-up process, driven by Copenhagen's municipal strategies and projects

such as Living Ports. However, the project's primary objective is fostering citizen's curiosity and awareness through its sculptural and ecological design, focused on increasing a multi-species perspective and interaction of harbour's ecosystem health.

This study acknowledges the absence of a co-design approach in this case, a highly relevant aspect of the Ocean Decade's success, as indicated by Zhang et al. (2024). However, it must be said that it is a contemporary challenge to shift from a "design for" to a "design with" methodology, as well as to involve all relevant stakeholders (Zhang et al., 2024). This transition reflects the complexity of integrating participatory design practices and active civic engagement, which require significant changes in both mindset and process. That is why the Whanganui River case study is particularly meaningful, as it demonstrates a multi-scalar community engagement in the co-design of the river's legal personhood, highlighting how collective action can shape and redefine governance models.

The Whanganui River exemplifies a holistic perspective, spanning its geographical extent and integrating scales from local communities to national recognition in Aotearoa, New Zealand. Historically, the river has been a vital connector, facilitating Indigenous knowledge transfer and providing a foundation for DIKW-A processes. This was realised through community-led advocacy, culminating in legislative change via the Te Awa Tupua Act, which granted the river legal personhood.

The interconnectedness of the human–ocean nexus is deeply embedded in this example, with the porosity between the river's life and the communities living alongside it extending to a multi-species perspective. This perspective was instrumental in achieving the river's legal personhood, demonstrating how cultural and ecological Indigenous wisdom can influence and design contemporary policymaking.

A critical factor in this case is the duration of the Iwi community's efforts—over 60 years of sustained advocacy to recognise the Whanganui River as a legal entity. This long-term commitment reflects a blue futures perspective, wherein the interplay of intergenerational wisdom and persistence offers a model for other ecosystems seeking similar legal recognition. However, it also highlights the challenges such processes entail, requiring considerable time, resilience, and community solidarity.

The Explore the Ocean initiative engages fewer OCCD indicators compared to the previous examples but holds value as a dissemination-focused project. Its integration of DIKW-A is evident in how raw marine data is transformed into information, knowledge, and narratives. While it did not directly contribute to policymaking or tangible actions, its approach offers inspiration for potential future initiatives that might connect awareness-building efforts with actionable change.

The project's strength lies in its transdisciplinary and porous methodology, uniting marine science, graphic design, and interactive technology to create a compelling ocean literacy output. By providing an immersive, data-rich exploration of ocean systems, it demonstrates the potential of storytelling to expand public understanding. The initiative emphasises porosity across disciplines, encouraging a blend of scientific rigour with creative communication to engage diverse audiences.

Moreover, Explore the Ocean supports a blue futures outlook by fostering public engagement and imagination through its interactive storytelling. While the initiative primarily enhances the visitor experience on cruises,

its accessible and visually captivating design promotes an understanding of ocean dynamics and potential human impacts. Such projects can inspire innovative educational tools to bridge the gap between scientific knowledge and public awareness, offering new avenues to envision sustainable marine futures.

These three cases collectively underscore the importance of integrating OCCD principles into diverse domains. As Close as We Get highlights how harbour infrastructure can embody biodiversity and regenerative practices using innovative materials and art-science integration. The Whanganui River demonstrates how community engagement and Indigenous wisdom can lead to transformative legal and policy changes over time, advocating for a holistic and multi-species approach. Explore the Ocean offers a model for connecting scientific knowledge with public engagement, emphasising immersive and interdisciplinary storytelling as a pathway to inspire action.

Together, these examples reflect a spectrum of approaches to fostering interconnectedness between human and non-human marine systems, offering a blueprint for future strategies rooted in sustainability, collaboration, and long-term impact. The exercise shows that it is possible to evaluate actions and their design processes according to the indicators and the proposed framework.

6. Conclusions

Inspired by the *Venice Declaration for Ocean Literacy in Action* (IOC, 2024), we sought to analyse the concept of "ocean-centric design" and explore its application in real-world scenarios. Through examining established sources on ocean literacy and design, we developed a framework called "OCCD," aiming to support innovative solutions that strengthen the human-ocean nexus. This framework builds on systemic thinking, civic design, and hydrocenic epistemologies, addressing the multifaceted relationships between individuals, societies, and the ocean.

Drawing from Brennan et al. (2019), ocean literacy involves understanding the ocean's influence on individuals and humanity, as well as their influence on the ocean. An ocean-literate person not only grasps the importance of the ocean but also communicates its significance effectively and makes informed, responsible decisions about its resources. However, translating these decisions into actions requires design approaches that integrate perspectives, scales, disciplines, and communities, fostering sustainable relationships with the aquatic environment. In terms of research questions, we can now define OCCD as a transdisciplinary, systems-based approach that integrates human and non-human perspectives to address interconnected marine and environmental challenges. It emphasizes holistic, multi-scalar, and anticipatory thinking, considering humans as part of the marine biome while fostering circular innovation, radical scenario planning, and ocean citizenship. OCCD promotes civic engagement, inclusive policymaking, and participatory design, leveraging local, Indigenous, and scientific knowledge to create sustainable, context-specific solutions that benefit both local ecosystems and the global ocean cycle. It aligns design with ecological impact, embraces uncertainty, and operates across disciplines to generate adaptive, future-oriented strategies for marine preservation and human-ocean interactions.

Thanks to the indicators we identified, we have shown that there are already examples that align, at least partially, with the principles of OCCD because they explored the interconnection of humans and the marine environment while being concerned for the future and having a holistic approach. However, the limits in terms

of community engagement, multilevel governance, and porosity, prove that there is still room for improvement to achieve a full OCCD.

Our study demonstrates the feasibility of bridging ocean literacy dimensions (McKinley et al., 2023) with design frameworks, highlighting overlaps between civic design and ocean literacy. Notably, a shift in jargon and language is critical to influencing behaviours and maritime oceanic mindsets. The overlaps showed that ocean literacy and design thinking share a systems-oriented, participatory, and experiential approach to fostering engagement, knowledge, and action. The assessed dimensions highlight transdisciplinary, action-driven, and inclusive methodologies that connect the two disciplines for a more systemic impact.

By exploring society's various relationships with the ocean, we devised a conceptual framework merging ocean literacy and design, identifying and testing a set of indicators through three significant case studies. This analysis revealed that designers and citizens can foster a more holistic interaction with the ocean by embracing multiperspective approaches and embedding socio-environmental considerations.

The envisioned success for Challenge 10 includes cultural and behavioural shifts towards a healthier ocean and more effective communication of ocean science across societal layers. Building on this, we propose evolving the definition of an "ocean-literate" individual into an active "ocean cycle-centric designer and citizen."

An "ocean cycle-centric designer and citizen" recognises the interconnectedness between their life and the ocean's health, acting as a Hydrocene epoch citizen who creates, acts, and improves systems while considering their socio-environmental impacts in a multiperspective and multiscalar manner. This approach accounts for the hydrological cycle's temporal dimensions, extending beyond human lifetimes to include multispecies and transgenerational impacts. It also expands the physical scale of actions from local to global, reflecting water's role as the unifying element of the Hydrocene epoch, connecting aquatic ecosystems and human communities on a planetary scale.

In addition to fostering informed decision-making, this perspective emphasises exploring potential, data-supported futures beyond traditional political agendas. Such exploration is essential for evaluating solutions to extreme situations and advancing sustainability, ensuring that both ocean literacy and design contribute meaningfully to societal and environmental resilience to navigate the future's *ignotae aquae*.

Acknowledgments

Conflict of Interests

The authors declare no conflict of interests.

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