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Networked media and information ocean literacy: a transformative approach for UN ocean decade

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The United Nations' Ocean Decade calls for co-designing transformative science, ocean networks, and learning strategies to address ocean health decline and deep-blue social divides in ocean governance. Yet the transformative capacity to advance ocean sustainability pathways shared by the UN Ocean Decade ecosystem of partners is still under-realized in the early stages of this global campaign. This paper explores the conceptual and institutional implications of the combined use of marine learning networks (MLNs) and media and information ocean literacy (MIOL) approaches to strengthen capacities for ocean governance systems' transformation (leadership, strategies, skills, and actions). We build upon an empirical case study of the self-organized, youth-led Brazilian Future Ocean Panel, applying a regional alternative to such a combined approach (namely Social-Environmental Educommunication) during a four-year transdisciplinary program. We reveal the synergistic benefits of MLNs and MIOL in empowering early-career ocean professionals and fostering their transformative capacity in ocean policymaking. Our findings emphasize the practical implications of these approaches for advancing ocean governance systems transformations in other regions. Insights are shared on MLNs and MIOL applications in the pursuit of transdisciplinary solutions, ocean governance transformation, capacity development, and effective responses to foundational challenges facing the UN Ocean Decade's global efforts toward sustainability.

INTRODUCTION

Facing deep-blue social-ecological divides

The ocean plays a vital role in advancing sustainable development, requiring the reconciliation of ecological, sociocultural, and economic imperatives amid rapid global change. Since the Rio+20 United Nations Conference on Sustainable Development in 2012, the UN and its agencies have embraced multifaceted strategies for ocean-related initiatives, encompassing environmental protection, cultural heritage, literacy, social welfare, and economic development[1–3]. However, the 2nd World Ocean Assessment (WOA) report reveals an ongoing decline in ocean health due to anthropogenic stressors[4]. Simultaneously, the rise of Blue Growth/Economy agendas has sparked concerns about their potential incompatibility with equity-based social struggles and just collective actions[5]. Deep social divides are evident in sentiments such as "Blue Fear"[6], which describes the growing anxiety among communities dependent on the ocean for their livelihoods and identities, e.g., "*For small-scale fishers, blue economy is blue fear. Blue economy says inclusive, we fear competitive exclusion*" (Dawda Saine, Secretary General of the African confederation of artisanal fishers' organizations; UN Ocean Conference, Lisbon, 2022)[7].

The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) (hereafter "Ocean Decade") is situated in this challenging context, aiming to strengthen the role of science, education, and communication in shaping societal relationships with the ocean. Led by UNESCO's Intergovernmental Oceanographic Commission, the Ocean Decade seeks to establish networks and mainstream co-design in marine science, education, and communication to enhance human-ocean interactions[8]. Despite the emphasis on engaging early career ocean professionals, their active involvement as leaders in sustainability science has yet to meet high expectations[9]. To address skepticism, frustration, and fear of failure in achieving its outcomes, the Ocean Decade's campaign partners need to confront imbalances in ocean science capacity and prioritize critical public engagement and governance transformation globally[10]. Societal actors, on the other hand, including non-governmental organizations, local communities, and marine conservationists, are often seeking greater influence in ocean decision-making processes.

The Ocean Decade is largely led by the marine science research community (e.g., mostly with a background in biophysical, and increasingly in social science and humanities) to foster transformative ocean science solutions for sustainable development, ultimately leading to a vision of "The science we need for the ocean we want"[11]. It is essential to clarify whom 'we' encompasses in this ambitious vision, ensuring that it represents a collective inclusive of both scientific and non-scientific actors, recognizing the diverse stakeholders in ocean knowledge and stewardship. This vision informs a global campaign following a series of intergovernmental dialogues between 2017 and 2020, with respective top-down steering mechanisms under initial implementation since 2021 by several nation-states. To be successful, the ambitious challenges posed by the Ocean Decade framework for societal engagement in marine science require high levels of mobilization of new ocean stewards and campaign buy-in from

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the bottom up to protect and promote ocean justice and sustainable development[10,12,13].

Progress, especially deepening and extending meaningful involvement of marginalized groups in decision-making, including youth leaders, Indigenous Peoples, and small-scale fishers, has proven challenging in past ocean development and conservation efforts[14,15]. Although various global environmental assessment platforms exist, inclusive and equitable coordinating mechanisms are not in place to integrate ocean knowledge systems and governance across levels or facilitate knowledge-sharing across ocean science-policy-practice divides[16].

Knowledge fragmentation, language and institutional disparities, and weak global ocean governability are exacerbated by power asymmetries and unequal knowledge accessibility among ocean users[17]. New frameworks and capacities are needed for inclusive and equitable ocean knowledge co-construction in the interfaces with decision-making[18]. Coastal stakeholders, particularly under-represented communities, women, young scientists, and activists, face daily challenges in comprehending and navigating the intricacies of ocean and coastal governance[19]. For example, in Brazil alone, national-level ocean governance involves over one hundred societal actors (public, private, civil society actors, and multi-stakeholder platforms or networks)[20], which highlights the immense challenge confronting managers, activists, and community leaders seeking greater influence in decision-making. Gaining competencies to have influence in these systems necessitates, for instance, knowledge of historical social and ecological baselines, which are often obscured by intergenerational gaps in knowledge transmission[21] and limited awareness of marine ecosystems' past, present, and future states and institutions' political mandates.

To effectively bridge the significant social and biophysical disparities during the Ocean Decade, the United Nations (UN) must foster strategies and competency development that empower ocean stewards at the interfaces with decision-making, especially those from historically marginalized groups at the crux of ocean knowledge and policymaking[18,22].

In this paper, we propose that the combination of Marine Learning Networks[19] with Media and Information Ocean Literacy strategies[23–25] can build transformative capacities[26] while forging connections across deep-blue social-ecological divides. This fusion contributes to the goals of the Ocean Decade of creating a transformational 'ecosystem of partners', and providing them with knowledge, solutions, and infrastructure to change humanity's relationship with the ocean.

We will first outline the challenges facing existing Ocean Literacy strategies within the framework of the Ocean Decade, highlighting its intersections with the co-design of transformational sustainability science, peer-to-peer learning, and networked engagement with ocean governance systems. A case study follows the evolution of a national-level marine learning network in Brazil to identify how its media and information ocean literacy approach is empowering early-career ocean professionals to contribute to transformations in ocean governance systems towards inclusive and ecosystem-based regimes.

Blue hope at the intersection of ocean education, communication and networking

In the goal-setting process in the framework of the Ocean Decade, and given concerns by members of the coordinating mechanism, the Intergovernmental Oceanographic Commission (IOC) acknowledged the importance of engaging with society. As a result, the IOC added a seventh objective, 'Ocean Literacy' (OL), to the Decade's guiding documents, aiming to enhance public engagement with ocean science and vice versa[10].

While OL has been around for over 20 years, in 2017 IOC's "Ocean Literacy for All" guidebook[27] inaugurated a series of

UNESCO's institutional recommendations describing the OL approach, with early applications in the USA and Europe, aiming to integrate ocean science into formal education curricula. More recently, the IOC (2022) launched another guidance document titled "Ocean Literacy With All"[25], expanding the conceptualization and application of OL to promote "...understanding [of] our influence on the ocean and its influence on us…"[25,28]. Historically, OL has been centered around marine education. However, recent works by McNeil et al. (2021)[29] and the Canadian Ocean Literacy Coalition[30], as well as McKinley et al. (2023)[13], emphasize the need for continued expansion of an initially recognized set of 10 dimensions of OL, including: knowledge, communication, behavior, awareness, attitudes, activism, emotional connection, access and experience, adaptive capacity, trust, and transparency.

An ocean-literate individual should comprehend essential principles and fundamental concepts about the ocean's functioning, communicate meaningfully about the ocean, and make informed and responsible decisions regarding the ocean and its resources[31]. Since the early days of OL, seven essential principles have been articulated including that the Ocean is a unified system with distinct subcomponents, possesses life- and Earth-shaping features, directly influences weather and climate, enables Earth's habitability, supports diverse species, habitats, and ecosystems, shares a deep, inextricable connection with humans, and yet remains largely unexplored[27]. This paper, along with other current research, is exploring ways to evolve these principles to better serve ocean sustainability goals and programs. This involves a more comprehensive consideration of the human and institutional aspects related to the Ocean.

The Ocean Decade strategy aims to promote OL principles and applications worldwide by setting ambitious objectives for 2025 and 2030[28]. The plan includes four key groups of actions: (1) integrating OL into education policies and training government representatives while increasing funding and monitoring policy implementation, (2) incorporating OL into formal education and ensuring at least 70% of educators and students receive training in ocean sustainability, (3) educating investors on OL to encourage ocean sustainability and the Blue Economy in corporate planning, investments, and reporting, and fostering partnerships among scientists, companies, and civil society organizations, and (4) developing collaborative local stakeholder networks to recognize and include local and Indigenous Knowledge in OL initiatives, integrate OL into community policies, and increase community involvement in ocean sustainability actions.

Commendable is the recent IOC-UNESCO stimulus for the advancement of 'critical' OL approaches[25] highlighting the importance of initiatives that explicitly incorporate five proposals, including (i) diverse and inclusive and pluriversal perspectives, (ii) promote active participation and dialogue, (iii) establish meaningful and lasting collaborations, (iv) engage under-represented groups, and (v) consider various forms of knowledge and values for a holistic vision of OL. Challenges for OL initiatives worldwide, therefore, include expanding their focus beyond the ocean's biophysical features, advancing towards critical literacy perspectives past one-way science-society communication, and fostering networked learning and collaboration between ocean stewards and governance systems[25,32]. Moreover, given the level of ambition this global and multi-level agenda advances, evaluating the Ocean Decade's strategy implementation is crucial to understanding its impact on knowledge democracy[33].

Santoro et al. (2017) propose a way forward for OL to foster civic relationships with the ocean and recognize the challenge of collaborating with current ocean governance systems to promote ocean sustainability. They assert: "*Addressing this challenge requires a form of governance which is made of formal and informal networks of governmental, nongovernmental, and international organizations using strategies that go far beyond conventional policy-making. Such forms of governance require and depend on the*
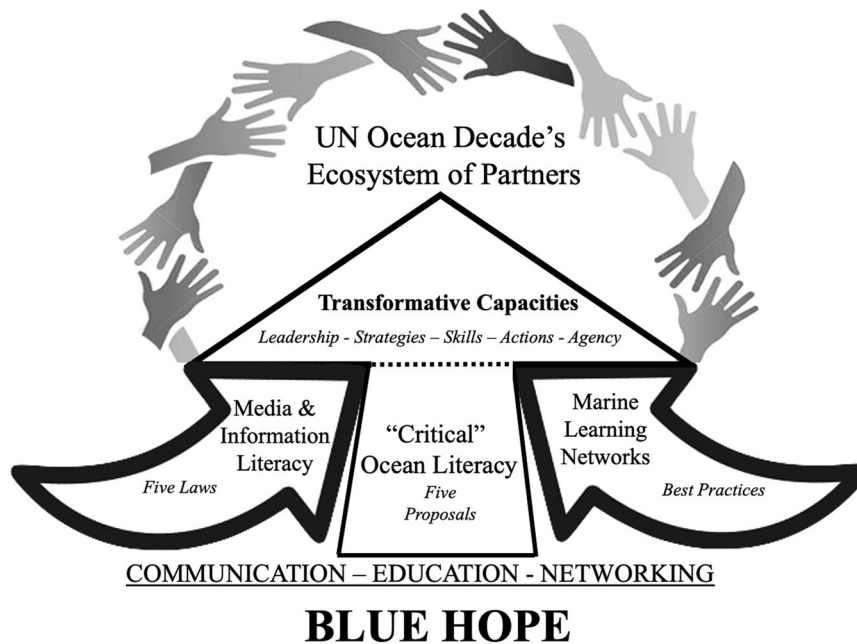
Fig. 1 **"Blue Hope" at the intersection of Ocean Education, Communication, and Networking.** The integration of IOC-UNESCO's 'critical' Ocean Literacy approach with Marine Learning Networks and Media and Information Literacy approaches may build up transformative leadership, strategies, skills, actions, and agency among partners of the Ocean Decade's ecosystem of partners (e.g., Global Stakeholder Forum and related communities of practice).

empowerment of communities and networks of business, universities, research centers, and civic groups to share the responsibility for addressing urgent threats"[27] (pg. 65). This quote from the UNESCO toolkit reveals threads for improving OL initiatives, which should prioritize approaches that empower stakeholders, reframe, and address conflicts in marine governance[34,35]. This paper explores how the networked learning approach, combined with a long-standing UNESCO strategic framework for education and communication—namely Media and Information Literacy—may bolster programs adopting critical approaches to OL programs capable of bridging deep-blue social divides. For UNESCO, *"…media and information literacy cover competencies that enable people to critically and effectively engage with information, other forms of content, the institutions that facilitate information and diverse types of content, and the discerning use of digital technologies*"[24].

As of 2021, the Ocean Decade also speaks of the 'co-design' of science to prioritize public engagement[36]. While this may appear as a novel approach in ocean science, social scientists have championed participatory action research since the 1940s[37] and transdisciplinarity since the 1970s[38]. Collaboration with marine social scientists can provide ocean biophysical scientists with valuable insights from decades of co-designed research experience[39–45]. While biophysical scientific knowledge is crucial, it is clearly not sufficient to address the mandate outlined above.

The Ocean Decade guidelines with recommendations and strategies for science co-design propose the creation of a facilitating **Global Stakeholder Forum**, a network "…*for convening Communities of Practice and co-design Decade Actions*"[36]. According to these guidelines, "*Communities of Practice can be perceived as networks or ecosystems of partners evolving in response to the needs of Decade partners*"[36] (pg. 14). The UN Development Program has long acknowledged the 21st century as "the network age", understanding that networks empower individuals by allowing them to access and contribute to the world's collective knowledge[46]. With the onset of the Ocean Decade and its focus on creating new networks across various governance levels, the 'Learning Networks' approach is gaining momentum[47–50].

Marine learning networks encompass various definitions and applications[19], displaying horizontal, hierarchical, or cross-scale dynamics in private and public sectors. In this context, a learning network can be described as a facilitated group sharing information and experiences, working to enhance capacity at the intersection of ocean knowledge and policy. Learning networks might unite individuals with similar professional roles (e.g., government or NGO employees) or those with complementary or even contrasting perspectives. To tackle the ambitious Ocean Decade challenges, scientists need to do more than just excel in science communication; they must develop transdisciplinary capacities and adopt best practices in networking with non-academic stakeholders in the co-production of knowledge[51]. This paper explores how this approach can potentially facilitate the continuous development and efficient operation of ocean-related communities of practice, particularly in the context of the Ocean Decade's Global Stakeholder Forum (Fig. 1).

In Brazil, a regional Media and Information Literacy perspective includes the development of learning networks within its theoretical framework, an approach referred to as Educommunication[23,52]. This concept has been advanced based on the experiences of Latin American educators and popular communicators[53], drawing inspiration from the ways of life of traditional and Indigenous Peoples. Indigenous Knowledge is now deemed essential for effective interventions in fostering cultural change, transitioning from an unsustainable culture to one of sustainability[54].

A significant feature of this regional media and information literacy paradigm, often referred to as the 'Southern epistemological perspective', is its focus on the dynamic interplay between education and communication[55,56]. This perspective, primarily developed in the Global South, emphasizes the importance of dialogic, relational, and networked approaches to learning, often drawing from traditional and Indigenous ways of knowledge sharing and co-learning. As such, this regional media and information literacy paradigm supports the creation and strengthening of 'educommunicative ecosystems', which may arise "…*when*

the conception of learning and communication is based on the idea of dialogicity and network action.[57] (p.74).

In the following section, we delve into the self-organization of a regional marine learning network in Brazil founded on the principles of Educommunication, to illustrate how such a combined networked Media and Information Ocean Literacy approach may play out in building capacities (networked strategies, skills, actions, and agency), with potential partners of the Ocean Decade ecosystem of partners, for transforming wide-reaching ocean governance systems.

RESULTS

Transformative 'Educommunicative' Brazilian ocean policy and action

Brazil's vast ocean area, known as the 'Blue Amazon' (Exclusive Economic Zone and Extended Continental Shelf, with a total area exceeding 5.7 million km^2), demands immense governance capacities. However, in recent decades, Brazil's ocean governance system has shown limited governability due to fragmented licensing, infrastructure, and coastal development projects, while few comprehensive or effectively implemented coastal and marine management plans exist at state and national levels[49,58,59]. This system, characterized by political instability, fragmentation, inadequate funding, and misaligned sectoral policies, performs poorly across jurisdictional scales and reinforces historical injustices towards less-powerful stakeholders such as small-scale fishers[49,60,61]. This situation is common in much of the global South and North[39].

In Brazil, the Interministerial Commission for Sea Resources hierarchically leads the country's executive mandate of the ocean governance system, hosting high-level representatives from 16 ministries concerned with ocean affairs. The commission's mandate encompasses numerous subcommissions, technical groups, and programs, with very restricted participation of civil society organizations. This system starkly differs from civil society organizations' expectations for more inclusive ocean governance and equitable, sustainable blue economy models[62]. Traditionally, civil society organizations in Brazil have had limited capacity and opportunities to maintain effective ocean advocacy campaigns in the capital, Brasilia, which is geographically distant from the ocean[49]. This prompted the establishment of the Brazilian Future Ocean Panel (PainelMar) in 2015, an inter-institutional network composed of over 100 marine scientists and practitioners with the primary goal of enhancing knowledge exchange and networking to address existing ocean governance challenges in Brazil (www.painelmar.com.br).

This case study draws from a series of applications of the "Theory of Transformative Agency in Linked Social-Ecological Systems" (TTA)[63], between 2015 and 2022, by PainelMar members (authors of this paper included) who assessed the opportunity context outlined above to identify leadership models and develop strategies, skills, and actions for transforming the Brazilian ocean governance system[49]. Herein we will engage with these insights to evaluate in which ways PainelMar's adopted networked media and information OL approach may have contributed to building transformative capacity while weaving ocean knowledge in the interface with decision-making at the federal ocean governance level.

Despite encountering an "Opaque Opportunity Context" – i.e., stable in a fragmented and sectoral ocean governance regime –[63] PainelMar members found out pockets of innovation were emerging in late 2018 within the Federal Government, pointing to the possibility of experimenting with more inclusive governance architectures. However, the ultra-conservative government that took office in 2019 resulted in severe environmental policy setbacks and democratic erosion[62]. Consequently, most

environmental governance structures were dissolved in 2019 by then-President Jair Bolsonaro. The country's marine spatial planning agenda is still gaining traction ten years after its inception in 2014, while deep-blue divides have continuously expanded, for instance after the recent rise in speculation around offshore wind energy production's being promoted in customary artisanal fishing territories[20,60,64]. Irrespective of the political leanings of Brazil's new (more progressive) presidential administration that took office in January 2023, marine spatial planning, which is strongly seen as a tool for allocating offshore wind energy production zones, may continue to rely on technocratic methods if the ocean governance system is not transformed into an inclusive regime. Civil society therefore remains watchful to determine if free, prior, and informed consent for small-scale and Indigenous fishers, for instance, will be maintained in the face of emerging blue economy agents, such as the allocation of marine areas for offshore wind turbine installations in northern Brazil[61,65,66].

Even though the opportunity context for transformations has changed in the period 2019-2021 following democratic backlashes, all applications of TTA consistently hypothesized that in order to gain transformative capacity, PainelMar's constituents should challenge the dominant ocean governance regime by promoting collective action and mobilizing resources across networks[62]. These studies also identified (2018)[49] and confirmed (2021, 2022)[20,62] the institutional entrepreneurship strategies, skills, actions, and types of social agency needed for PainelMar members to become more transformative.

Between 2018 and 2019, PainelMar's plenary of members successfully raised funds for a four-year program called "Brazilian Ocean Horizon" with an opportunity to experiment with the theoretical insights gained with the TTA application. The primary objective of this program was to build capacity for ocean governance system change. The executive team, consisting of mid-career researcher mentors, early-career ocean professionals, consultants, and undergraduate students from public universities nationwide, supervised the voluntary involvement of over 200 early-, mid-, and senior-career members from research and advocacy marine networks and institutions across Brazil. The program aimed to promote the leadership of early career ocean professionals at the intersection of ocean knowledge and policy.

The Brazilian Ocean Horizon's program's main question was whether its participants could act as a catalyst and accelerate the transition to inclusive and ecosystem-based ocean governance. The program adopted Educommunication (a regional approach to media and information literacy) as a cross-cutting methodology to enable co-design, implementation, and evaluation with participants. The strategic insights on the opportunity context for ocean governance transformation gained with the application of the TTA was a key component of the knowledge base shared to inform the co-design of a four-year program by PainelMar (first co-design seminar held in Brasilia, April 2019).

From 2019 to 2022, the program featured three annual inter-network seminars, where participants collaboratively formed eight action-research teams (Fig. 2); each co-designed plans for the co-production of knowledge action and products in the following year. These plans addressed various urgent ocean policy issues focusing on cross-cutting action-research teams on Educommunication and Collective Civil Society Mandate at federal policy-making, as well as focal action-research teams on Justice, Fisheries, Ecosystems, Marine Spatial Planning, International Affairs, and Learning Networks. In each cycle, the appointed co-leads of each action-research team have jointly engaged with participatory network mapping workshops to inform tailored strategies, a process that involves engaging stakeholders in creating visual representations of relationships and interactions within a network. A Real World Laboratory evaluative framework was also used to steer the teams through the three cycles of co-design,
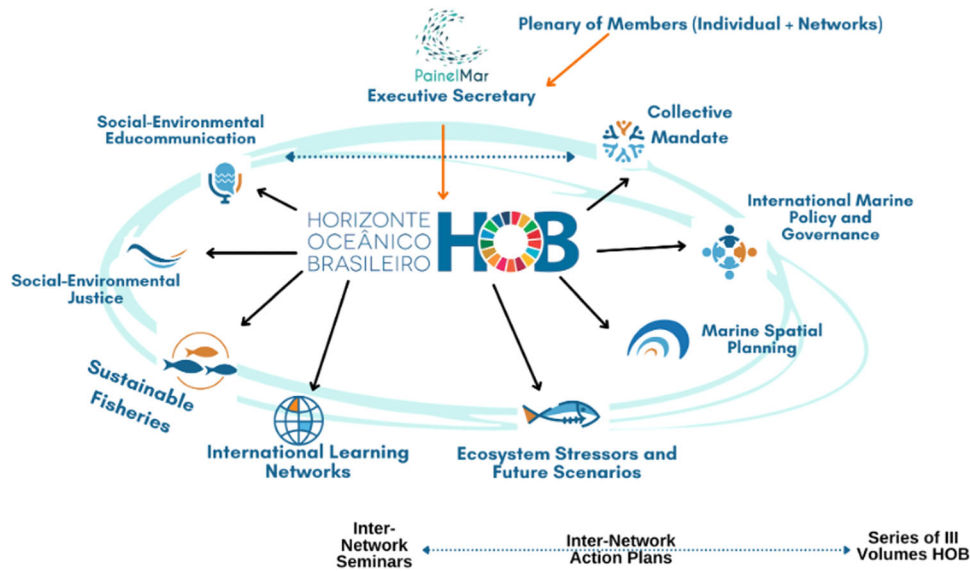
Fig. 2 Networked Media and Information Ocean Literacy in Brazil. Representation of the multiple ocean sustainability issues addressed by action-research teams during the Brazilian Ocean Horizon 4-year program (2019-2022), using a networked media and information Ocean Literacy approach.

co-production, and co-evaluation of knowledge products and advocacy actions[67–69]. Participants produced a sequence of three thematic volumes (compilations) of informational materials focused on "Inclusive Ocean Governance" (2020)[70]; "Networked Educommunication" (2021)[71]; and "2030 Impact Horizons of Brazilian Ocean Literacy through Networked Educommunicative Action" (2022)[72]. The co-production process generated numerous policy briefs and social media strategies using podcasts, videos, webinars, original research articles, online courses, and in-person guided knowledge action visits in Brasilia city.

The program concluded in December 2022 with a final seminar in Brasilia, following the federal elections. There was optimism for a new government that could create opportunities for ocean governance regime transformation in 2023. The program's closing seminar focused on the long-term sustainability of PainelMar's inter-institutional network and a capacity-building program for early career ocean professionals on Educommunication. In 2022 PainelMar was invited to serve as the Executive Secretary of an Oceans Working Group within the Environmental Parliamentary Front in the National Congress. With the dissolution of almost all democratic environmental governance structures in 2019, marine-related civil society organizations lacked a political forum for critical deliberation on federal ocean governance[62]. The Oceans Working Group now provides Brazilian ocean networks with more transparent access to monitor federal ocean affairs in Brasilia. PainelMar leaders were also invited to join the Federal Government transition team in late 2022, enabling early-career ocean professionals to contribute to the country's re-democratization process and the official 2023-2026 mandate on fisheries, environment, tourism, international relations, and regional development, among other topics. In summary, while these efforts have not yet generated deep systemic changes in the ocean governance system, they have significantly built transformative capacities that improved national policymaking within a major democracy. Research in the transformation of wide-ranging ocean governance systems suggests that PainelMar's efforts may be advancing a 'shadow network'[73], one with ideas and practices that will be valuable to steer transformational change when a window of opportunity arises.

The recommendations provided by the TTA have been aligned with substantial institutional entrepreneurship strategies, skills,

actions, and salient agencies in the self-organization of PainelMar's Brazilian Ocean Horizons program (Fig. 3). Networked Social-Environmental Educommunication approaches have attempted to empower more critical and competent early-career ocean professionals, better positioning them to mobilize resources and peers' knowledge for cross-network activities that challenge centralized and technocratic decision-making while advocating for inclusive and ecosystem-based ocean management approaches.

Three cycles of co-production facilitated interactive learning and the development of new knowledge, skills, and attitudes that support transformative change. The program enhanced inter-generational dialogues fostering new bonds between scientists and policy practitioners concerned with social equity and environmental sustainability. It provided space for imagining innovative pathways for ocean sustainability and exploring new models of inter-institutional partnerships in ocean governance systems. The program's connection to real policymaking during Brazil's re-democratization process offered early career ocean professionals opportunities to contribute their share of the efforts aiming for more inclusive ocean governance, and to advance Brazil's Ocean Decade ecosystem of partners during the onset of the IOC-UNESCO global campaign in the country[74].

DISCUSSION

"Critical" Pathways: Gaining Transformative Capacities with Networked Media and Information (Ocean) Literacy

The Ocean Decade's Global Stakeholder Forum should be regarded as more than yet another on-line forum to subscribe to, but a complex sociopolitical construct at the interface of ocean knowledge with decision-making, thus requiring multi-pronged transformative strategies. The Ocean Decade's ecosystem of partners[36] needs to evolve in turbulent political landscapes marked by historical social conflicts and struggles experienced by disadvantaged ocean users, revealing deep-rooted social-ecological divides. As novel ideas, practical solutions, and socio-political arenas are globally conceived and implemented top-down (e.g., blue economy and growth facilitated by technocratic marine spatial planning), the significance of Networked Media and Information Ocean Literacy initiatives grows. These methods' built-in co-design capabilities can leverage established
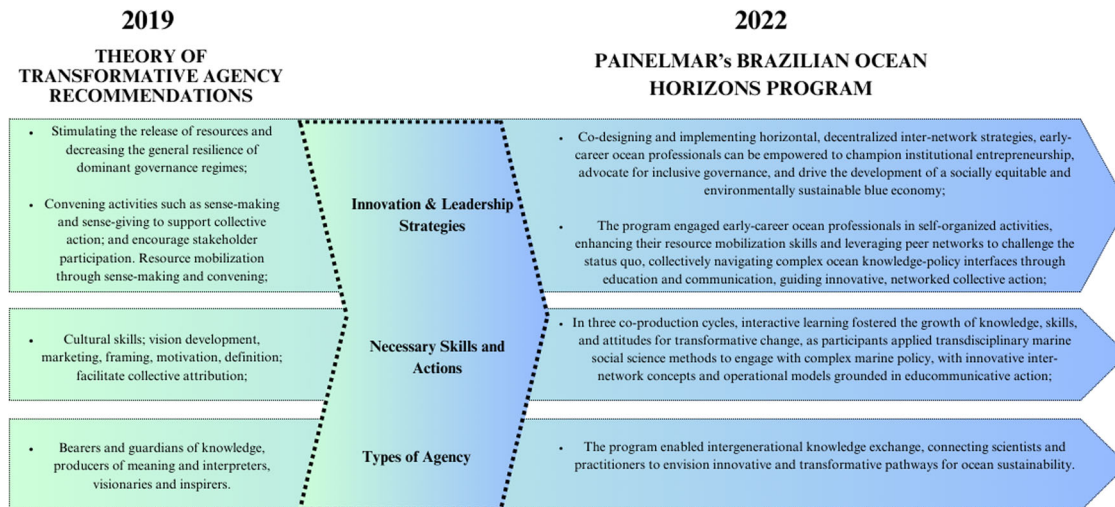
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Fig. 3 PainelMar's case-study application of recommendations from the Theory of Transformative Agency. Correlations between a set of recommendations (hypothesis) derived from applying the Theory of Transformative Agency (TTA)[20,49,62,63] to analyze the opportunity context for transforming the Brazilian ocean governance system (left - 2019) and key Media and Information Ocean Literacy (or Educommunicative) leadership models, strategies, skills, and actions implemented by the Brazilian Ocean Horizons program, hosted by PainelMar (right - 2022).

frameworks and initiatives in global marine social science and policy, integrating long-standing bottom-up strategies with critical perspectives on learning, education, networking, and communication. These are fundamental aspects to foster the evolution of the Ocean Decade ecosystem of partners.

Pursuing critical OL approaches is indispensable to overcome the risk that education and communication programs be imposed on local communities by top-tier international Ocean Science institutions[13,32,75]. Such critical approaches may ensure transformative science-society dialogues when weaving local and Indigenous ocean knowledge systems and collective action[33,55]. To achieve the UN Decade's inclusivity goals, broader participation from the Global South is essential.

UNESCO-IOC's recent consultation with member states on ways to improve Indigenous and Local Knowledge's contribution to Ocean Science programs (UNESCO-IOC 2022; IOC-UNESCO 2023) indicates a potential opportunity for this inclusivity. Critical OL approaches impel Ocean Decade campaign adopters to move beyond a narrow view of OL as the communication of science to society. Critical OL favors weaving knowledge across biophysical and social sciences, and traditional or Indigenous Knowledge – and could benefit from strategies building transformative capacities between academic and non-academic partners. Adoption of critical approaches to OL by partners in the Ocean Decade ecosystem may avoid overlooking crucial aspects for inclusive and equitable co-construction of knowledge for decision-making, such as ocean dependency, cultural ocean relations, the balance of profit and basic needs, and the sectoral and regional asymmetries in ocean expertise, levels of influence, transformational competencies, and strategies.

Media and Information Literacy provides a strong foundation for UNESCO to apply critical OL strategies globally. Drawing on Aufderheide and Firestone's (1993) definition of media literacy[76], the Information for All Programme (IFAP) established by UNESCO in 2001 has consistently advocated global media and information literacy across different contexts[77]. Developing these competencies should form a central component of critical OL projects involving various stakeholders, including policymakers, educators, information and media professionals, youth organizations, and marginalized or underrepresented populations such as Indigenous coastal communities and small-scale fishers.

Advancing critical OL should emphasize not just understanding of the ocean's influence on us and our influence on the ocean, but also the critical role of informed and engaged citizens in sustainable ocean governance. Integrating the Five Laws of Media and Information Literacy[24] into OL programs can specifically contribute to that end. Firstly, by emphasizing that sources of ocean information, like media and technology, are tools for civic participation. Secondly, empowering every individual as both a consumer and creator of ocean-related information fosters a sense of responsibility and stewardship in communicating ocean-related matters. Thirdly, acknowledging that ocean information can carry biases encourages a more discerning and critical engagement of ocean knowledge. Fourthly, tapping into the inherent human desire to understand and share information can drive better-informed discussions about the ocean's health and our role in it. Lastly, understanding that OL, like media and information literacy, is an ongoing process for acquiring competencies ensures that our knowledge, skills, and attitudes evolve with the changing dynamics of marine social-ecological systems, leading to more adaptive, resilient, and transformative ocean sustainability pathways.

The dynamic interplay between individuals and groups fosters collective learning and novel perspectives, making knowledge and social relations (networks) critical in promoting engagement in ocean governance system transformation and facilitating the communication of ideas, experiences, and learning[49]. At the individual level, the proficiency of "learning to learn"[78,79] is perhaps the cornerstone skill that critical OL should help advance, cultivating synergy between building knowledge and the weaving of social relations (networked knowledge) to facilitate effective engagement in ocean governance system transformation. This vital competency enables individuals to navigate intricate issues, collaborate within networks, foster democracy, and combat inequalities through education, hence facilitating a more inclusive approach to ocean governance[80,81].

While the transformative capacities of marine learning networks is increasingly recognized, their full potential remains unexplored[82–84]. Many marine research and policy initiatives involve partnerships with diverse knowledge backgrounds, but these collaborations often lack dedicated resources and co-design strategies, resulting in suboptimal impacts. Recent research has shown that effective marine learning networks pursue four

essential attributes[19] (best practices) to enhance their impact and functionality. Initially, a clear definition of scope ensures focused objectives and activities from the development stage onward. Trust and commitment to longevity are also pivotal, establishing a stable and collaborative environment through transparent actions and a dedication to long-term goals. Additionally, the promotion of equitable participation and open knowledge-sharing fosters an inclusive and collaborative learning atmosphere. Lastly, maintaining responsible and sustained leadership and coordination ensures the network navigates challenges effectively and consistently steers towards its objectives. Pursuing best practices based on the four crucial attributes can assist ocean stewards globally, especially partners of the Global Stakeholder Forum, in maximizing the utility and cost-effectiveness of their communities of practice. This involves enhancing participation and leadership, overseeing and assessing progress, fine-tuning learning via methods suited to the context, and adeptly navigating external influences[19].

The approaches combined in the Networked Media and Information Ocean Literacy framework (Fig. 1) and empirical case study (Figs. 2–3) outlined herein share a deeply rooted commitment to the emancipation of individuals in learning through education, communication, and civic engagement programs concerning environmental matters[85]. For instance, Media and Information Literacy (e.g., Social-Environmental Educommunication), along with other environmental education and communication concepts and applications, may be closely linked to these ideas and supported by well-established networks worldwide[85]. Therefore, we believe one of the greatest challenges for Ocean Literacy initiatives and research is to fundamentally reconceptualize it within the tailored contexts of such existing regional critical educational and communicational paradigms and the institutional frameworks that steer their implementation. To ensure blue justice in ocean sustainability dialogues, OL strategies must include Southern epistemologies by building upon synergies with country-specific terminologies, and educational and communicational practices.

For instance, equating OL as "Ocean Culture" in all Portuguese-speaking countries or simply regarding it as a synonym of Educommunication or Environmental Education as is often the case in Brazil[86] does not pay due respect to their histories, differences, and synergistic potentials. Moreover, it can lead to misrepresentation of the term's origins and meanings, potentially downplaying power dynamics resulting from technical terminologies and solutions enforced by OL-related campaigns. OL campaigns must, therefore, cater to the unique collective action needs of historically marginalized populations, such as Indigenous Peoples and small-scale fishers. It is not an issue of accepting or rejecting OL, but acknowledging it poses an invitation to difficult conversations[29]. Adopting the "staying beside" approach to OL as advocated by MacNeil and collaborators[29] offers a richer, more inclusive, and pluriversal perspective as suggested by IOC-UNESCO's recent OL guidelines[25]. "Pluriversal" refers to the acknowledgment and existence of multiple, diverse realities and knowledges, emphasizing a world where many different worlds and perspectives coexist and are all considered valid. It's often discussed in the context of decolonial theory and as a critique of universalism[87,88]. Rather than asserting dominance over a concept or seeking a linear understanding, staying beside emphasizes coexistence and open engagement. It avoids the temptation to oversimplify or pigeonhole, instead valuing the myriad interpretations that can emerge about how to educate and communicate about ocean-human relationships. By positioning ourselves "beside" the concept of OL, we may create a space where diverse perspectives can flourish, fostering a dialogue that captures the nuances and complexities of human-ocean relationships.

Ocean Literacy campaigns specifically catering to the needs of historically marginalized populations are still scarce. This is a field awaiting much necessary experimentation and debate. In fact, some of these groups may feel that ocean literacy is not a concept or term that they need, want, or that they are already 'ocean literate'. Our case study, in turn, builds upon Social-Environmental Educommunication, a regional approach to Media and Information Literacy with a track record at the intersection of education and communication practices with fisherfolk in Brazil[89,90]. Social-Environmental Educommunication has also been recognized as a communication policy for environmental education by the Brazilian Ministry of Environment since 2005[91–93]. It aims to empower individuals to use their voice for local change while understanding global connections and implications.

As an alternative Southern epistemology[55,94], Educommunication has a rich history of theoretical progress and practical application in public health, primary education projects with coastal communities, and graduate and post-graduate programs within Brazilian public higher education institutions[53,95]. In the 2020 Global Media and Information Literacy Awards, UNESCO recognized Brazilian policies for Educommunication in basic education as one of the top three media and information literacy strategies worldwide[96]. While the legacy experience of both OL and Educommunication approaches with basic education may offer a potent avenue for synergies in formal school education settings, the vision for OL within the scope of the Ocean Decade is to move beyond, building educational and communicational competencies with stakeholders at the interfaces of ocean science, policy and practice at all levels.

Our case study exemplifies how Brazilian civil society organizations may have increased their transformative capacity when adopting the combined media and information OL approach, particularly through the regional marine learning network, PainelMar. This suggests that regional marine learning networks established for global Ocean Decade programmatic implementation could profit from a culturally sensitive, decolonizing, media and information literacy approach to transform ocean governance systems. By integrating ocean science diplomacy[10,97] with a networked media and information ocean literacy approach, dynamic global ocean stewardship networks can be cultivated. For instance, emerging global ocean networks like the Ocean Knowledge Action Network[50] and the International Panel for Ocean Sustainability[16] aim to enhance connections between the Global South and North to promote ocean sustainability.

The path forward therefore necessitates the re-conceptualization of OL strategies for implementation 'beside' the context of existing regional educational and communicational paradigms, as well as the institutional frameworks (both formal and informal) that guide their implementation. By adopting a combined networked media and information ocean literacy approach, the Ocean Decade can foster knowledge-building, problem-solving, and decision-making, bridging the gap between campaigners and diverse ocean partners enrolling in the Global Stakeholder Forum. This requires implementing an incentive structure that adequately supports learning networks and encourages participation from the bottom-up, of individuals with asymmetric levels of media and information literacy competencies and focuses on developing tailored capacities that may trigger transformative shifts in ocean governance when opportunities arise.

This approach may foster synergies in science-policy-society interactions, enabling the integration of local and Indigenous ocean knowledge systems and collective action into broader strategies[33,55]. By focusing on a comprehensive understanding of ocean functioning, critical engagement with information and technology, and the capacity to participate in diverse, transdisciplinary networks for co-producing and disseminating knowledge

in decision-making interfaces, we can address the pressing challenges of ocean sustainability transformations in a holistic and inclusive manner.

CONCLUSIONS

The paper argues that the networked media and information ocean literacy approach, which integrates critical thinking, diverse knowledge sources, and collaborative strategies, is capable of empowering the participants of the Ocean Decade's broader ecosystem of partners (e.g., Global Stakeholder Forum and constituent communities of practice) to gain transformative agency hence allowing them to more effectively navigate the entire spectrum of pressing ocean sustainability-related issues. The approach therefore addresses all three key groups of challenges the global campaign is set to achieve (knowledge, infrastructure, and foundational challenges)[11].

'Knowledge and Solutions' (Group 1 Challenges) center on research priorities that cover not only scientific but also social, economic, and political fields, along with Indigenous and Local Knowledge. A networked media and information OL approach may contribute to any project and program fostering a clean, healthy, resilient, productive, and climate-safe ocean for people and nature. By potentially lining up with comprehensive, plural valuations of risk and ocean benefits to people, or climate mitigation, adaptation, and resilience-building strategies, it may offer essential opportunities to support ocean sustainability transformations needed in, but not restricted to, for instance, food systems and in the pathways toward environmentally sustainable and socially equitable ocean economy development.

Secondly, 'Essential Infrastructure' (Group 2 Challenges) is directed at the vital infrastructure required to support the goals of the Ocean Decade. Networked media and information OL approaches can be instrumental in facilitating the co-design of digital ocean knowledge systems with users (science, industry, citizens), and ensuring they follow ethical integration for social well-being and human rights. By also potentially facilitating strategies for generating, sharing, and learning about data, gaining knowledge, technology skills, and attitudes for better application, they can help the Ocean Decade's communities of practice to better engage with the complexities of social-ecological systems, ensuring we advance towards a more predictable and accessible ocean. Crucially, they may facilitate co-design processes of future ocean sustainability pathways and scenarios, enhancing inclusivity in the making of the Global Ocean Observing System and its Digital Representation.

Lastly, 'Foundational' (Group 3 Challenges) points to crucial, overarching components that create a conducive environment for the Ocean Decade. Networked media and information OL strategies are poised to enable ocean stewards' ability to learn, unlearn, and relearn about human interactions with marine ecosystems and their governance. Importantly, the application of these approaches may contribute to raising awareness of cultural diversity, equity, and social justice, and ultimately enhancing community resilience and transformative capacity, particularly for historically marginalized small-scale fish workers and other marginalized coastal communities.

The case study of Brazilian civil society organizations exemplifies the value of Southern epistemologies and associated critical and decolonial literacy approaches (Educommunication) to the implementation of the Ocean Decade. We believe these findings hold significant implications for the broader programmatic implementation and should inform the aspired transformational research and practice. In conclusion, given the ubiquitous presence of social networks, literacy, media, information, education, and communication in our lives, marine learning networks represent a powerful tool to engage ocean citizens from all backgrounds in co-designing ocean sustainability pathways. This,

we propose, is a critical step toward creating the Decade We Need for the Ocean We Want.

METHODS

The paper's Introduction starts by reviewing the high-level guidance documents generated UNESCO on the context of the Ocean Decade, focusing on the potential synergies between Marine Learning Networks (MLNs), Media and Information Literacy, and Ocean Literacy – perspectives that can be combined into a proposed "Networked Media and Information Ocean Literacy" (NMIOL) approach. The case study research approach in this paper involves an in-depth, contextually rich examination of the Brazilian Future Ocean Panel (PainelMar) and its "Brazilian Ocean Horizon" program. We aim to uncover nuanced insights into the 'critical' and 'transformative' aspects of the NMIOL's regional approach (Social-Environmental Educommunication) adopted by PainelMar. It does so by taking stock and evaluating the strategies, actions, main skills, and types of agency developed during the self-organization of PainelMar, using mostly published information and data, as well as the co-authors direct experiences and observations. This approach enables the exploration of complex phenomena within real-world laboratory context, providing a comprehensive understanding of the transformative capacities developed in the Brazilian ocean governance arena. To ensure rigor and validity, the study triangulates data from various sources, including published outcomes of participatory workshops and activities, program internal documentation, and produced materials, while applying a established analytical framework titled "Theory of Transformative Agency in Linked Social-Ecological Systems" to evaluate the case-study's adequacy to hypothesis set in previous past research by LCG, DFH, and BG in Brazil. Additional details about the specific methods used to steer knowledge co-construction in the case-study can be accessed in each of the provided references.

DATA AVAILABILITY

All relevant data supporting the findings of this study are available in the public domain. Details about the case study, including activities conducted by the Brazilian Ocean Horizon program hosted by the Brazilian Future Ocean Panel, are accessible on the organization's website (www.painelmar.com.br). Additional data, including technical reports and policy briefs, are also available on the aforementioned website. Furthermore, multimedia content related to our research, including audiovisual outputs and social media communication, can be found on the organization's Instagram page (https://www.instagram.com/painel_mar/) and YouTube channel (https://www.youtube.com/@PainelMar). These platforms provide open and unrestricted access to all data used in our study, supporting our commitment to transparency and reproducibility in research. For any further inquiries regarding the data, please contact the corresponding author or the Brazilian Future Ocean Panel directly.

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L.C.G. and P.C. originated the paper's initial idea and framework, which was subsequently substantially developed with contributions from all authors. L.C.G. wrote the first draft, and all authors reviewed the paper. L.C.G., D.F.H., R.G.M., and I.S. developed the study case.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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