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Ocean Literacy: The Foundation for the Success of the Ocean Decade, Volume II

Fostering Community, the Sustainable Blue Economy, and the Arts

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Teresa J. Kennedy
Editor

Ocean Literacy: The Foundation for the Success of the Ocean Decade, Volume II

Fostering Community, the Sustainable Blue Economy, and the Arts

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Editor's Note



2021 2030 United Nations Decade of Ocean Science for Sustainable Development

This book series is an officially Endorsed Activity of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030), submitted by the International Council of Associations for Science Education (ICASE), an NGO in Official Partnership with UNESCO, as the Lead Institution. Volume II extends this commitment by celebrating the creative and collective dimensions of Ocean Literacy, highlighting how communities, artists, and innovators are shaping a Sustainable Blue Economy and strengthening humanity's cultural connection with the Ocean.

Volume II opens with two forewords by esteemed global leaders whose careers have shaped international Ocean science and policy. Their voices highlight the broad relevance and profound significance of Ocean Literacy within the framework of the United Nations (UN) Decade of Ocean Science for Sustainable Development (2021–2030); referred to as the Ocean Decade (OD).

Foreword 1—Francesca Santoro, PhD

Senior Programme Officer for Ocean Literacy at the UNESCO Regional Bureau for Science and Culture in Europe (Venice, Italy), Dr. Francesca Santoro leads the IOC Project Office for Ocean Literacy and coordinates the global *Ocean Literacy With All* campaign, promoting inclusive, international engagement in the Ocean Decade. Her foreword calls for restoring humanity's relationship with the Ocean and highlights Ocean Literacy as the common language that connects science, society, and culture; linking education, community engagement, and innovation through inclusive and culturally grounded collaboration.

Foreword 2—Paula S. Bontempi, PhD

Professor of Oceanography and Dean of the Graduate School of Oceanography at the University of Rhode Island, Dr. Paula Bontempi previously served at NASA as a physical scientist, program manager for Ocean biology and biogeochemistry, and Acting Deputy Director of the Earth

Science Division in NASA's Science Mission Directorate. Her foreword underscores the scientific and societal urgency of understanding and protecting our dynamic Ocean planet, positioning Volume II as a reflection on how community engagement, cultural expression, and inclusive economic innovation can collectively foster an Ocean-literate society capable of addressing the grand challenges of our time.

In addition to these forewords, Volume II features reflections from leaders, educators, creative practitioners, and Early Career Ocean Professions (ECOP) who are advancing Ocean Literacy through community engagement, innovation, and the arts. Their perspectives capture the transformative power of collaboration and cultural expression in strengthening our shared connection with the Ocean. Together, these contributions highlight the diversity of voices and the collective imagination that drive this three-volume series forward.



International Council of Associations for Science Education

Foreword 1

To face the urgent challenges undermining the health of our Ocean—from climate change and biodiversity loss to pollution and unsustainable exploitation—we must first restore our relationship with it. The Ocean is not only vital to human survival, it is the beating heart of Earth's climate system, the cradle of life, and home to countless species whose futures are intertwined with the planet's. Its value exists beyond what it provides us—it has an intrinsic worth that demands respect and care. Rebuilding our connection to the Ocean is essential if we are to safeguard the balance of life it sustains.

Ocean Literacy: The Foundation for the Success of the Ocean Decade is born from this urgency. This three-volume series, officially endorsed as an Ocean Decade Activity by the United Nations Decade of Ocean Science for Sustainable Development, is not just a compilation of research and practice. It is a global conversation, a tapestry woven from the knowledge, stories, and experiences of more than 250 authors across 42 countries and regions.

Endorsement under the Ocean Decade is more than a seal of approval; it means this work is part of a coordinated, worldwide effort to achieve "the science we need for the Ocean we want."

Together, the three volumes take the reader on a journey—from the classrooms, laboratories, and field stations where the seeds of Ocean Literacy are planted, to the vibrant communities and creative spaces where it is nurtured, and finally to the global platforms, technological innovations, and cross-border collaborations where it is amplified. Along the way, we see how education can spark understanding, how communities can turn knowledge into stewardship, and how innovation can bridge the gap between vision and impact.

Ocean Literacy underpins every page of this work. It is the common language that allows scientists, educators, policymakers, and communities to exchange ideas, share solutions, and align efforts—transforming information into shared responsibility and action.

We are now halfway through the UN Ocean Decade, a decisive moment to reflect, refocus, and reaffirm our shared ambition. The next 5 years will be crucial to demonstrate that we can truly deliver on the vision we shaped together. Ocean Literacy is not just a pillar of this journey, it is the enabling factor that connects science to society, policy to people, and action to impact.

To succeed, we must deepen our collaboration with networks, experts, and communities across the different regions, ensuring our initiatives are not only

effective, but also meaningful and culturally grounded everywhere they are implemented. Ocean Literacy is our bridge—let's build it stronger, together.

Francesca Santoro, PhD
Senior Programme Officer for Ocean Literacy,
Intergovernmental Oceanographic
Commission of UNESCO Regional Bureau
for Science and Culture in Europe
Venice, Italy

Foreword 2

Our Earth is home to over eight billion people. The beauty of our Ocean planet is profound, and its importance to humanity, our health, and our economy is staggering. Earth's Ocean economy has an estimated turnover of between US$3 and $6 trillion per year, according to the United Nations. From jobs to food to recreation to regulating climate, the Ocean is vital to all life on Earth.

The explosive growth of human populations along coastal margins now places increasing pressure on dynamic Ocean ecosystems, modifying natural processes and, in many cases, putting life, health, and property at risk from hazards inherent to the Ocean. Despite this profound realization, the Ocean remains largely unexplored, and many discoveries await. The past has given us only a brief glimpse of a constantly changing Earth system, in which natural and human factors interplay. Advanced technologies and frequent, repeated global, field, and laboratory measurements of the Ocean are essential to our ability to observe and predict changes. Critical observations—from space to sub-seafloor—have revealed a diversity and complexity in Ocean ecosystems and resources that had not been appreciated decades earlier.

Our pathway will continue to evolve as improvements in our understanding of Ocean processes and our home planet unfold and lead to optimal strategies for supporting further scientific and technological advances. Our vision must fully uncover the mechanisms and interactions that sustain life on our Ocean planet, reaching new heights technologically, and revealing the unknown for the benefit of humankind.

Endless opportunities in Ocean science lie ahead for true experiential learning for pre-college to lifelong learners, and professional training in Ocean and Earth sciences, data science, and technology development. The timing is now, as we face urgent challenges related to food and national security, climate change, extreme events, and other scientific and technological grand challenges. Our planet and Ocean are restless, and we must answer the call to train the next generation of Ocean-literate leaders.

Volume II of *Ocean Literacy: The Foundation for the Success of the Ocean Decade* highlights how community engagement, cultural expression, and inclusive economic innovation can collectively foster an Ocean-literate society capable of rising to this call. By featuring diverse voices from around the world, it demonstrates the transformative power of creativity, collaboration, and local action in advancing Ocean sustainability and resilience.

Together, these contributions remind us that meaningful change begins at every level—with individuals, communities, and the shared commitment to protect and celebrate our Ocean planet. As we look ahead, let this volume serve not only as a reflection of what is possible, but as a catalyst for continued action, innovation, and hope for the Ocean we all call home.

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Reflections from the Ocean and Science Education Community

The voices featured here offer reflections from both Ocean and science education leaders whose work continues to shape the dialogue, reach, and impact of Ocean Literacy around the world.

"As the Lead Institution for this officially Endorsed Ocean Decade Activity, the International Council of Associations for Science Education (ICASE) is delighted to support this second volume, which brings a rich tapestry of voices together to explore Ocean Literacy in community life, cultural expression, and sustainable economic practices.

This volume exemplifies the Ocean Decade's call to action by centering grassroots leadership, artistic creativity, and the diverse ways communities connect with the Ocean. From musical theatre and youth-led initiatives to community-driven conservation and the creative economy, these chapters reflect the transformative power of Ocean Literacy when embedded within place-based traditions and inclusive participation.

By weaving together science, art, and social engagement, Volume II celebrates the many pathways through which Ocean Literacy fosters stewardship, justice, and sustainability. ICASE remains committed to supporting such interdisciplinary, cross-sectoral approaches to science education—approaches that acknowledge the lived experiences of Ocean-connected communities and recognize that sustainable futures depend on collaborative, culturally resonant action."

—Declan Kennedy, PhD, President, International Council of Associations for Science Education (ICASE), Cork, Ireland

"By showcasing how grassroots initiatives, sustainable economic models, and creative arts can drive Ocean engagement, this volume illustrates the diverse pathways through which communities can join forces to protect and conserve for future generations our shared blue heritage."

—Niccolò Bassan, Science Officer, Intergovernmental Oceanographic Commission (IOC) of UNESCO, Paris, France

"People are exploring ways to strengthen their connection with the Ocean through economic sustainability and artistic expression. Innovative approaches are emerging, such as the fusion of science and culture and the integration of education and economy. When combined with these approaches, Ocean Literacy opens new possibilities for understanding the Ocean. This series provides an invaluable resource for examining these intersections and inspiring educators, policymakers, and communities to strengthen their relationship with the Ocean."

—Mitsutaku Makino, PhD, Professor of the University of Tokyo and President of the Ocean Policy Research Institute of Sasakawa Peace Foundation, Japan

"Ocean health and human health are directly linked. As more Ocean injustices are revealed, proactive versus reactive solutions will be needed to solve these problems. InnerLight, alongside Indigenous-led organizations across the Ocean, are focused on creating systems change. Establishing the long-term infrastructure to protect our planet and its original stewards is vital moving forward. As more young people rise up for the Ocean, the power transfer and institutional capacity for long-term change is needed. Intergenerational collaboration is key. I strongly endorse this book series as a UN Ocean Decade, Challenge 10, Advisory Board Member. Empowering an Ocean-literate world is imperative to protecting our beautiful blue planet that is facing an onslaught of threats. Co-creating the future of our blue economy with principles based on Indigenous science, youth action, intergenerational collaboration, and Ocean equity is the pathway forward to restore Ocean health and human health."

—Bodhi Patil, Ocean Uprise, Parley for the Oceans, New York, USA

"At ECOP Canada, we see intergenerational collaboration as essential to advancing Ocean solutions, and this series is a testament to that. The volumes bring much-needed clarity, especially when the Ocean can feel out of reach for many, and digital overload and misinformation often overshadow important facts. We need work like this. Credible, well-informed, global perspectives that cut through apathy to spark the long-term thinking the Ocean Decade urgently calls for."

—Volita Yego, ECOP Canada Manager, SOI Foundation, Quebec, Canada



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1 Activating Ocean Literacy: Empowering Communities, Creativity, and Sustainable Futures

Teresa J. Kennedy

Abstract

The United Nations Decade of Ocean Science for Sustainable Development (2021–2030), the Ocean Decade, presents a transformative opportunity to reimagine how communities, cultures, and economies connect with the Ocean. Building on the foundational work established in Volume I, this introductory chapter to Volume II of the three-volume series, *Ocean Literacy: The Foundation for the Success of the Ocean Decade*, endorsed by UNESCO's Intergovernmental Oceanographic Commission (IOC) as an official Ocean Decade Activity, focuses on the role of community involvement, cultural expression, and the sustainable Blue Economy in strengthening Ocean Literacy. Volume II highlights the intersection of art, identity, equity, and locally driven innovation, showcasing diverse contributions from around the world that demonstrate how Ocean Literacy can take root in lived experiences and creative practices. This chapter explores the power of storytelling, youth empowerment, transdisciplinary collaboration, and place-based knowledge in fostering inclusive relationships with the Ocean. By surfacing multiple ways of knowing and advancing shared responsibility, Volume II illustrates how Ocean Literacy extends beyond education to become a dynamic societal practice, supporting more participatory, just, and sustainable relationships with the Ocean, and contributing directly to the goals of the Ocean Decade.

Keywords

United Nations Decade of Ocean Science for Sustainable Development · Ocean Decade (OD) · Ocean Decade Challenge 10 · UN Sustainable Development Goals (SDGs) · SDG 14 Life Below Water · Ocean Literacy (OL) · Community engagement · Sustainable Blue Economy · Arts-based marine education · Cultural expression · Equity · Transdisciplinary collaboration · Storytelling · Experiential learning · Traditional Ecological Knowledge (TEK) · Participatory approaches · Youth empowerment · Inclusive education · Science-society interface · Non-Governmental Organizations (NGOs) · NGO contributions to the Ocean Decade

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1.1 Introduction

The three-volume series, *Ocean Literacy: The Foundation for the Success of the Ocean Decade*, contributes to global priorities by showcasing diverse pathways through which Ocean Literacy supports societal transformation and more responsible decision-making about the Ocean's future. The series reflects a collaborative international effort, drawing on the knowledge and experiences of more than 250 authors from 42 countries and regions. These contributors bring forward diverse perspectives grounded in local realities, disciplinary expertise, and cultural knowledge. Represented nations span every continent and include Argentina, Australia, Bangladesh, Belgium, Bosnia and Herzegovina, Brazil, Canada, Cabo Verde, Chile, China, Croatia, Denmark, Ecuador, England, Finland, France, Germany, Greece, Hong Kong SAR, the Republic of Ireland, Italy, Japan, Kenya, Kuwait, Lebanon, Malta, Mexico, the Netherlands, Norway, Northern Ireland, Peru, Poland, Portugal, Romania, Scotland, South Africa, Spain, Sweden, Taiwan, Türkiye, the United States, and Wales (see Fig. 1.1 previously shared in Volume I). All 65 chapters included in the series underwent rigorous scholarly review conducted by more than 80 international peer reviewers who assessed the submissions through a double-blind review process, followed by final editorial review through Springer Nature. This collaborative and time-consuming process ensured that the work presented across the three volumes meets the highest academic standards while reflecting the lived realities and innovative practices of global Ocean Literacy efforts.

At the heart of this global effort is the understanding that Ocean Literacy must embrace not only scientific knowledge but also emotional connection, equity, cultural expression, and civic responsibility. The three-volume series was cre-

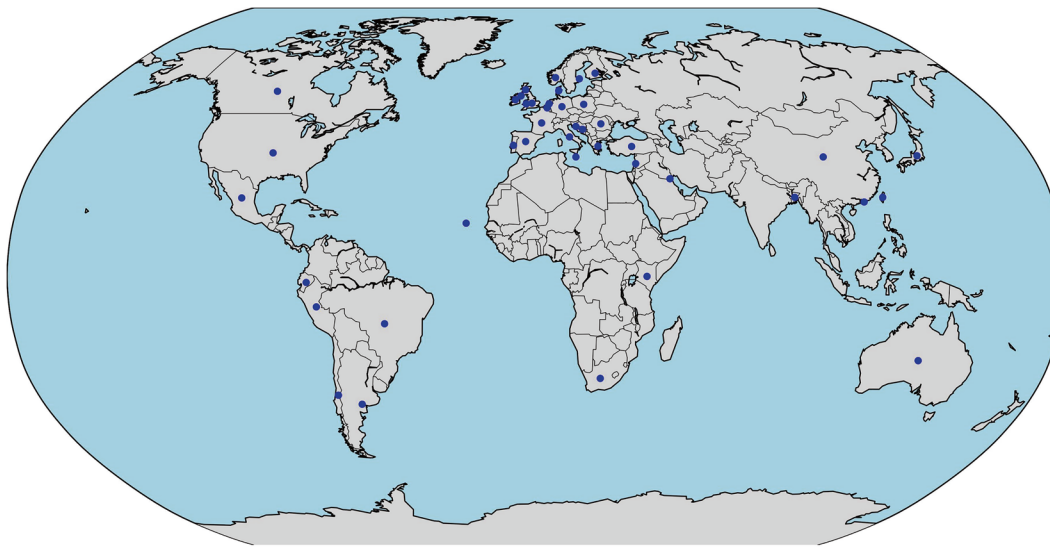


Fig. 1.1 Global Distribution of Author Affiliations Across the Ocean Literacy Book Series. *Note:* While this map presents authors' affiliations at the country level, additional regional detail reflects the depth of participation. For example, contributors from Canada are affiliated with institutions in four provinces—British Columbia, Nova Scotia, Ontario, and Quebec—while those from the United States represent 17 states and Washington, D.C., including Alabama, California, Florida, Georgia, Iowa, Maine, Massachusetts, Missouri, New Jersey, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Texas, Virginia, and Washington. This subnational diversity highlights the extensive geographic reach within North America—from the West Coast to East Coast—and further emphasizes the comprehensive, international spirit of this Ocean Literacy collaboration (Kennedy 2026b). Similar regional diversity is also reflected in many other participating countries, where contributors represent a range of institutions across multiple cities and provinces

ated to support this broader vision, highlighting how education, civic action, artistic expression, entrepreneurship, and inclusive communication contribute to advancing the goals of the Ocean Decade, especially Challenge 10: "Restore Society's Relationship with the Ocean," as described by Glithero et al. (2024). The essential role of governments, policymakers, and institutional leaders in co-designing and supporting initiatives that foster long-term climate resilience must also be recognized (Kennedy 2024). This combined perspective underscores the value of systems thinking, intersectoral collaboration, and equitable governance in ensuring that Ocean knowledge and values are translated into effective and equitable action. When Ocean Literacy is embedded across all sectors, from education and societal actors to policy and planning, it becomes a transformative tool for advancing sustainability at every level.

Building upon the foundational framing provided in Volume I, this chapter reintroduces key concepts while expanding the lens to explore new dimensions of Ocean Literacy. The first volume, *Transforming Education, Research, and Engagement* (Kennedy 2026a), laid the groundwork by examining Ocean education in formal and informal contexts, introducing innovative pedagogies, showcasing interdisciplinary research, and emphasizing the important role of global partnerships, access, and inclusion.

It also introduced the intentional capitalization of the word *Ocean* to reflect its singular, interconnected identity as a global system. This deliberate choice signals a conceptual shift: a recognition that there is one global Ocean, a vast, interconnected system that transcends national boundaries and supports all life on Earth. This framing aligns with broader Ocean Decade efforts that call for systems thinking, co-designed solutions, and cross-sector collaboration.

The Earth, often referred to as the "blue planet," holds 97 percent of its water within five interconnected Ocean basins—the Atlantic, Pacific, Indian, Arctic, and Southern (NOAA, 2024, p. 2), alongside numerous marginal Seas, such as the Caribbean, Mediterranean, Irish, Red, South China, Coral, Bering, Greenland, and Ross, among others (Kennedy 2026b). As our understanding of the Ocean's complexity and humanity's role in its transformation has deepened, so too has the need for a more expansive framework that acknowledges how changes in one region of the Ocean inevitably influence others through global Ocean circulation patterns, while also altering atmospheric dynamics, shifting climate systems, redistributing heat and nutrients, and impacting biodiversity, food security, and human societies worldwide.

This expanded view asserts that knowledge alone is insufficient; it must be accompanied by cultural relevance, emotional connection, civic responsibility, and social justice. Volume I positioned Ocean Literacy as a societal outcome, one that unites individuals and institutions with the Ocean Decade's objectives and inspires collective action for a more resilient and sustainable future.

Extending the foundation laid in Volume I, *Fostering Community, the Sustainable Blue Economy, and the Arts* (Volume II) continues the momentum of the Ocean Decade (2021–2030), an unprecedented international framework to realign scientific, cultural, and social relationships with the Ocean, including cultural traditions, everyday practices, emotional bonds, and civic forms of responsibility and action. The Sustainable Development Goals (SDGs) highlight the importance of inclusive participation, encouraging communities to engage, collaborate, and contribute to solutions that support a more equitable and sustainable world (Kennedy & Cherry, 2023). Within this context, Ocean Literacy has become a vital means of fostering public awareness, participation, and commitment. This volume expands Ocean Literacy beyond classrooms, laboratories, research initiatives, and short-term encounters with the Ocean by emphasizing the powerful contributions of community-led actions, sustainable economic practices that link environmental responsibility with human well-being, and the integration of the Arts into everyday life. It also recognizes that Ocean Literacy begins in the earliest years, as young children are natural scientists who eagerly observe, explore, and discover the world around

them, making play a powerful catalyst for their first understandings of the natural environment (Kennedy & Tunnicliffe, 2022). These play-based experiences can spark curiosity, strengthen early connections with the Ocean, and lay foundations for lifelong Ocean engagement. Ultimately, this volume underscores that our global challenges, ranging from climate change to food security, cannot be addressed without fundamentally reexamining how humanity interacts with and depends on the Ocean.

While continuing to highlight the essential contributions of civil society, including Indigenous Knowledge Holders and other community leaders, Volume II also explores the emerging roles of artists, creative organizations and NGOs, youth, and entrepreneurs. It also emphasizes the growing importance of the Sustainable Blue Economy, highlighting how 21st century learning, rooted in creativity, problem-solving, collaboration, and digital literacy (Kennedy & Sundberg, 2020, 2025), equips individuals and communities to engage meaningfully with the Ocean and participate in sustainable, innovation-driven Blue Economy pathways. Ocean Literacy depends on the active commitment of all stakeholders; through their involvement in education, advocacy, and local-to-global action, Ocean knowledge can translate into meaningful and lasting change (Kennedy et al. 2024; Kennedy & Mascarenhas, 2025). These contributors highlight that Ocean Literacy is not a static concept, but a dynamic and evolving practice. It is shaped by place-based experiences, local knowledge systems, emotional bonds, and diverse forms of expression, all working together to restore and reimagine society's relationship with the Ocean.

Volume II builds on key recommendations from recent global guidance, including the *Challenge 10 White Paper: Restoring Society's Relationship with the Ocean* (Glithero et al. 2024), which outlines the importance of strategic communication, education, and cultural connection in advancing a more inclusive human–Ocean relationship that strengthens civic engagement, fosters shared responsibility, and supports sustainable Ocean action across all sectors of society. According to the U.S. *National Academies of Sciences, Engineering, and Medicine* (2025), interdisciplinary collaboration and knowledge-sharing are essential for driving the cultural shift needed to unite science, education, and governance. Echoing this call, UNESCO-IOC's education policy brief *Promoting Ocean Literacy* (2025) urges the integration of Ocean Literacy not only into education systems but also into broader policy frameworks that promote equity, sustainability, and informed Ocean governance.

Through case studies and conceptual frameworks, Volume II explores how civil society actors, artists, innovators, scientists, and educators are collaboratively creating pathways to Ocean sustainability. Organized around themes of cultural connection, civic participation, and collective innovation, the chapters illustrate how Ocean Literacy is enacted in locally grounded and creative contexts around the world.

Ambassador Peter Thomson, United Nations Secretary-General's Special Envoy for the Ocean, eloquently captures this shift in perspective:

> Ocean Literacy is the compass guiding us toward a sustainable future. It empowers us to understand the stakes, connect the dots, and take meaningful action. This is not just a matter of environmental stewardship but one of intergenerational justice because every action we take to protect the Ocean directly impacts the future security of humankind (Thomson 2025, paras. 11–12).

This call for a deeper, more personal and responsible relationship with the Ocean resonates throughout Volume II, affirming that Ocean Literacy must be built upon both science and humanity, and that communities need tools to anticipate change, protect marine ecosystems, and build more participatory, just, and resilient futures. There is a growing consensus among Ocean Literacy scholars and practitioners that we need more than just knowledge. We need relationships with the Ocean that are reciprocal, equitable, and enduring.

1.2 Revisiting the Foundations of Ocean Literacy

Since its formalization in the early 2000s, Ocean Literacy has provided a foundation for advancing public understanding of how the Ocean influences human life, and how human actions, in turn, influence the Ocean. Developed initially by marine educators and scientists in the United States, the concept is anchored by the Seven Essential Principles of Ocean Literacy (NOAA 2024, p. 4) listed below:

1. Earth has one big Ocean with many features.
2. The Ocean and life in the Ocean shape the features of the Earth.
3. The Ocean is a major influence on weather and climate.
4. The Ocean makes Earth habitable.
5. The Ocean supports a great diversity of life and ecosystems.
6. The Ocean and humans are inextricably interconnected.
7. The Ocean is largely unexplored.

These principles helped build a shared language for Ocean science, catalyzing curricular innovation, outreach programs, and policy connections.

Volume I of this series offered a comprehensive overview of these foundational principles and documented their impact on Ocean education over nearly two decades. It underscored how these principles unite diverse networks of educators and researchers around a common purpose: to promote Ocean Literacy as a central element of environmental education.

But as our understanding has evolved, so has the framework. There is increasing recognition that transformative change requires more than knowledge. It requires active involvement, inclusive participation, and collective action. Today, Ocean Literacy is increasingly recognized as a societal outcome, one that is essential to climate resilience, human security, and intergenerational equity. This framing will be carried forward in the chapters of this volume.

Volume II embraces this evolution by highlighting individuals and communities who are bringing these expanded dimensions of Ocean Literacy to life. Rather than a destination, Ocean Literacy is presented as a shared and evolving journey grounded in sustainability, connection, and care. As these foundational principles continue to evolve, they serve not only as a guide, but also as a springboard for new, interdisciplinary, and community-based approaches, such as those explored throughout this volume.

1.3 The Evolution of Ocean Literacy

Ocean Literacy is in the midst of a profound transformation. Once viewed primarily as a tool for communicating Ocean science, it has become a movement that embraces the full complexity of human relationships with the Ocean, including cultural, emotional, spiritual, and political dimensions. As the Ocean Decade progresses, this evolution is increasingly reflected in how Ocean Literacy is practiced, interpreted, and advanced.

Building on early efforts in North America and Europe, recent scholarship and international collaboration have called for more holistic, inclusive, and equitable approaches to Ocean Literacy. These approaches recognize the importance of Indigenous knowledge systems, traditional ecological knowledge, and other culturally rooted ways of understanding the Ocean. They also shift the focus from simply transmitting information to creating opportunities for personal connection, empowerment, and action. Recent research on phenomenon-based learning (PhBL) in STEM shows that when instruction is anchored in real-world phenomena, learners demonstrate stronger engagement and a deeper grasp of complex ideas, an educational shift that parallels the movement toward more experiential, participatory forms of Ocean Literacy (Kennedy & Fields, 2023, 2024; Kennedy & Odell, 2024). The inherently interdisciplinary nature of Ocean sciences supports this expanded framework, offering many pathways for participation and collaboration.

One of the most important realizations in this shift is that information by itself rarely inspires sustainable behavior. What motivates change is

the cultivation of values, relationships, and lived experiences. Place-based education, artistic exploration, and civic participation (citizen and participatory-based science) are increasingly recognized as powerful pathways for this transformation. Local voices and community wisdom are critical to ensuring that Ocean Literacy efforts are meaningful and impactful.

Ocean Literacy is no longer just a subset of science education. It is now understood as a societal outcome grounded in education, informed decision-making, emotional connection, and shared responsibility. The joint position statement from the National Science Teaching Association (NSTA) and the National Marine Educators Association (NMEA) emphasizes that one cannot be scientifically or environmentally literate without also being Ocean literate (NSTA & NMEA 2025). This recognition aligns with expanding global goals, including climate resilience, sustainable development, intergenerational justice, and human well-being.

The ability of communities to make informed decisions about the Ocean depends not only on access to data, but also on cultural relevance, local context, and inclusive involvement. According to the High Level Panel's 2025 Ocean Finance Working Paper, effective and lasting Ocean governance must integrate local communities into decision-making, recognizing that their livelihoods, cultural identity, and resilience are inseparable from healthy marine ecosystems (Thiele et al. 2025). This evolving vision aligns with the core goals of the Ocean Decade, which calls for innovation, co-design, and collaboration across sectors. It reinforces that everyone, regardless of age, background, geography, or profession, has a role to play in building a more Ocean-literate and sustainable world.

The chapters in Volume II offer compelling examples of how this expanded understanding of Ocean Literacy is brought to life around the world. Building on these conceptual foundations, the next section frames Volume II and introduces the diverse contributions that illustrate its themes in practice. From youth-led storytelling and Indigenous-led restoration projects to creative activism, sustainable entrepreneurship, and participatory art projects—including murals, sculpture, quilting, crocheted marine organisms, musical theatre, interactive performances, games, and more—these stories show how Ocean Literacy is being reimagined and revitalized in real, tangible ways.

1.4 Framing Volume II: Ocean Literacy: Fostering Community, the Sustainable Blue Economy, and the Arts

Volume II brings together 58 authors from 20 countries, including Argentina, Australia, Bosnia and Herzegovina, Brazil, Canada (from Nova Scotia and Ontario), Chile, Ecuador, England, Germany, Hong Kong SAR, the Republic of Ireland, Italy, Kenya, the Netherlands, Peru, Portugal, South Africa, Spain, the United States, and Wales. U.S. contributors represent eight states across the country, from the West Coast to the East Coast, spanning California**,** Iowa, Missouri, North Carolina, New Jersey, New York, Texas, Virginia, and Washington. Together, these diverse voices offer a global perspective on Ocean Literacy, showcasing forward-thinking strategies in education, curriculum design, and research that support the Ocean Decade's vision and mission. The following overview introduces each chapter.

Chapter 2, *Situating the Evolving Role of Ocean Literacy Research in the Ocean Decade: Case Studies at a Glance*, explores how Ocean Literacy Research (OLR) is emerging as a critical field within the UN Ocean Decade, particularly in support of Challenge 10—Restore society's relationship with the Ocean. The chapter highlights the growing recognition of Ocean Literacy as a societal outcome and examines its potential to inform climate action, shape the sustainable blue economy, and influence global policy frameworks. Through illustrative case studies, the authors consider how interdisciplinary collaboration and inclusive research practices are helping to bridge scientific knowledge and societal involvement, offering new pathways toward a more Ocean-connected world.

Chapter 3, *Empowering Communities for Ocean Sustainability: ICoRSA's Perspective on the Importance of Community Engagement and Stakeholder Involvement in Marine Initiatives*, explores how inclusive, community-driven activities can strengthen efforts toward Ocean sustainability. Showcasing the MUSICA and PHAROS projects as models of participatory governance, the chapter demonstrates how integrating local knowledge and stakeholder voices enhances marine conservation. It highlights nature-based solutions, citizen science, and Living Labs as approaches that foster inclusive Ocean care and responsibility. Aligned with the UN Sustainable Development Goals and the Ocean Decade framework, the chapter offers timely insights for researchers, educators, and policymakers seeking to advance collaborative, community-led Ocean action.

Chapter 4, *Living Labs: A Catalyst for Ocean Literacy and Sustainable Innovation*, examines how Living Labs (LLs) serve as open-innovation ecosystems that integrate research, policy, and community involvement to advance Ocean Literacy and sustainable development. Drawing on the Living Science Salt Farm project in Portugal, the chapter illustrates how LLs bring together scientists, policymakers, local communities, and industry leaders to co-create solutions to environmental and socio-economic challenges. Emphasizing participatory approaches, behavioral change, and interdisciplinary collaboration, the authors highlight how LLs foster trust, enhance communication, and translate scientific knowledge into real-world impact, positioning them as powerful tools for achieving Ocean Decade outcomes and driving innovation in coastal and marine ecosystems.

Chapter 5, *Ocean Literacy Beyond Borders. Engaging the Private and the Public Sectors on Ocean Literacy Initiatives to Accelerate the 2030 Agenda: "The Leaders We Need for the Ocean We Want,"* highlights the importance of cross-sector collaboration in advancing sustainable Ocean action. Drawing from Brazil's national and international engagement efforts, the chapter explores how governments, businesses, and civil society are co-developing Ocean Literacy initiatives aligned with the UN Sustainable Development Goals. Emphasizing inclusive governance, policy integration, and transdisciplinary partnerships, the chapter demonstrates how mainstreaming Ocean knowledge across both private and public sectors can accelerate progress toward a more Ocean-literate and sustainable global society.

Chapter 6, *Promotion of Ocean Literacy by Marine Research Institutions: Challenges and Opportunities. A Mediterranean Case Study*, examines how marine research institutions can play a central role in advancing Ocean Literacy, particularly through partnerships, communication strategies, and long-term collaboration with schools and communities. Focusing on efforts during the COVID-19 lockdown, the chapter investigates strategies such as developing digital educational resources, conducting public seminars, and assessing researchers' commitment to outreach activities. Drawing on experiences from the Mediterranean region, it highlights both structural challenges and promising opportunities for institutional transformation. The chapter offers practical insights on how to make scientific knowledge more accessible, strengthen science-society connections, and promote a culture of shared Ocean responsibility through inclusive and sustained outreach.

Chapter 7, *Effectiveness of a Marine Education Program Applied in a Marine Protected Area Context and Designed with Science Education Strategies*, explores the role of educational programs in strengthening Ocean Literacy within Marine Protected Areas (MPAs). The chapter presents findings from a structured marine education program that used interactive, science-based approaches to foster both cognitive understanding and emotional connection with the marine environment. By engaging students in observation, experiential learning, and place-based activities, the program deepened participants' awareness of human–Ocean relationships and supported sustainable decision-making. The chapter offers compelling evidence that MPAs can serve as powerful platforms for advancing Ocean Literacy and promoting long-term community commitment in marine conservation.

Chapter 8, *Making Real a Lifetime Salty Journey: From Unaware Professional Development to Field Experiences, up to the "Sea-To-Shore Approach"*, explores the evolution of Ocean Literacy through immersive field experiences, citizen science, and professional development. The chapter follows a long-term personal and professional journey from the perspective of an Early Career Ocean Professional (ECOP), emphasizing how hands-on learning and participatory approaches can foster lasting shifts in perception and practice. Case studies include educational outreach in Marine Protected Areas (MPAs), collaborations with the diving and tourism sectors, and citizen science campaigns launched during the early years of the UN Ocean Decade. The author presents a replicable framework for connecting formal education with lived Ocean experiences and emphasizes the importance of lifelong learning in strengthening society's relationship with the Ocean.

Chapter 9, *From Waves to Wealth: Harnessing Ocean Literacy for Sustainable Finance*, explores the intersection of Ocean Literacy with the business world, emphasizing the need for collaboration between these fields to foster economic prosperity and environmental sustainability. The author examines how Ocean-dependent sectors, such as shipping, fisheries, tourism, and Ocean energy, face increasing financial risks due to declining Ocean health, highlighting innovative investment mechanisms, including blue bonds and blended finance, as critical tools to bridge funding gaps in marine conservation. By positioning Ocean Literacy as essential for informed financial decision-making, the author calls for the integration of ecological knowledge into economic policy, Environmental, Social, and Governance (ESG) frameworks, and long-term investment strategies to build a more resilient and sustainable Blue Economy.

Chapter 10, *Ocean Art as an Integral Part of Kenya's Blue Economy*, explores how coastal and marine artists contribute to Ocean Literacy and sustainable development through creative expression. The chapter examines how artworks, such as murals, sculpture, and storytelling, can foster emotional and cultural connections to the Ocean, while also addressing key challenges such as market-driven disinterest in marine subjects and the influence of religious and cultural preferences that limit participation in Ocean-themed art. Emphasizing opportunities for co-creation, curriculum development, and strategic partnerships, the authors describe how Ocean Art has inspired youth, informed national policy, and catalyzed inclusive and culturally grounded action across Kenya's Blue Economy.

Chapter 11, *Community Empowerment and Ocean Conservation through Education*, explores how grassroots initiatives can foster Ocean Literacy and community-driven conservation. The chapter showcases how sustained work with underserved coastal communities in Ecuador, through experiential learning, emotional connection, and collaborative action, has built a strong culture of Ocean care. The author explains how implementing the Explore, Sense, Reconnect, Act (ESRA) methodology can serve as a framework for connecting education to tangible conservation outcomes, highlighting how locally rooted, inclusive approaches can inspire sustainable practices and empower future Ocean stewards.

Chapter 12, *Perspectives for Ocean Justice: Imagining fishing communities as Ocean Literacy*, critically examines how Ocean Literacy initiatives framed within the Ocean Decade may reinforce existing power imbalances by privileging dominant scientific and policy frameworks. It deconstructs the assumptions underlying Challenge 10 and calls attention to the marginalization of Indigenous knowledge systems and lived experiences of small-scale fishing communities. Through analyses of Ocean-related communications and a visual narrative from the Azores, the author highlights the importance of embracing diverse epistemologies and approaches to Ocean Literacy, and advocates for more just and equitable ways of relating to the Ocean that center relational knowledge and local perspectives.

Chapter 13, *Three Hearts, Nine Brains, and Infinite Camouflage: How the Wizardly Octopus Casts Us Back to Our Oceanic Home*, examines the deep connections between humanity and the

Ocean, using these extraordinary creatures as a lens to explore Ocean Literacy and our shared oceanic origins. With their remarkable intelligence, adaptability, and transformative abilities, the author explains how octopuses symbolize the Ocean's creative power and interconnectedness. Blending science, history, mythology, and popular culture, the chapter challenges readers to rethink assumptions about consciousness, evolution, and the Ocean's role in shaping life on Earth. Through the octopus, we are invited to rediscover the Ocean not as a distant backdrop, but as a vital and formative presence in our existence.

Chapter 14, *Something Very Fishy: Musical Theatre Performance Enhances Gains in Ocean Literacy STEAM Program for Young Children*, explores the intersection of science, technology, engineering, art, and mathematics (STEAM) in Ocean Literacy education. Centered on an innovative program for children ages 5–10, the chapter examines how musical theatre, puppetry, and hands-on marine science exhibits are used to engage young learners in both live and virtual formats. Through storytelling, creative expression, and interactive performance, the authors describe how arts-based approaches may foster curiosity, emotional connection, and early engagement with Ocean science. This chapter contributes to growing efforts to integrate the arts into environmental and Ocean education.

Chapter 15, *Transdisciplinary Approaches to Ocean Literacy through Student Agency and the Performing Arts***,** explores how a school-based theater production by students in grades 3–5 in Peru became a powerful tool for advancing Ocean Literacy. The chapter highlights how transdisciplinary learning, student agency, and social responsibility were woven together to foster Ocean awareness across an entire school community. Through an inquiry-driven process, students engaged in research, scriptwriting, and artistic expression, integrating Ocean themes across science, humanities, language, music, and visual arts. This chapter examines how the creative process empowered students as active participants in sustainability efforts, showing how storytelling and performance can catalyze meaningful dialogue around Ocean issues.

Chapter 16, *WE ARE OCEAN_Wadden Sea: Ocean Literacy and Youth Empowerment through the Arts*, explores the role of interdisciplinary art-science projects in advancing Ocean Literacy. Through the WE ARE OCEAN Wadden Sea project, students in Germany, the Netherlands, and Denmark engaged in experiential learning that bridged scientific understanding with artistic expression. The chapter highlights how participatory performances, collaborative installations, and sensory-based fieldwork fostered both emotional and intellectual investment in Ocean topics. By encouraging personal reflection and creative collaboration, the project illustrates how arts-based education can empower youth and promote deeper connections to the Ocean across national and cultural boundaries.

Chapter 17, *From Shores to Shelves: Nonfiction Children's Books as Tools for Ocean Literacy***,** explores how nonfiction literature can foster Ocean Literacy in young readers. The chapter examines how well-researched content, vivid storytelling, and engaging illustrations help children grasp complex ecological concepts, develop critical thinking skills, and form emotional connections to the Ocean. It highlights the potential of nonfiction books to make scientific knowledge accessible, inspire curiosity, and address eco-anxiety by sharing stories of positive action. The author offers practical guidance for educators, librarians, and caregivers in selecting high-quality titles that support Ocean education and empower future Ocean stewards.

Chapter 18, *Creative Currents: Art as a Tool for Ocean Literacy***,** explores the transformative role of the creative arts in advancing Ocean Literacy and environmental advocacy among youth. Through Bow Seat Ocean Awareness Programs' decade-long initiative, the chapter highlights how interdisciplinary approaches combining Ocean science, storytelling, and artistic media foster deeper emotional connections with Ocean issues. It examines the global impact of the Ocean Awareness Contest, which has engaged over 38,000 students from more than 140 coun-

tries in expressing environmental concerns through visual arts, poetry, film, and more. By empowering young people to become Ocean advocates, the chapter illustrates how the arts can inspire education, empathy, and action on a global scale.

Chapter 19, *Expanding Ocean Literacy with Storytelling through Collaborative Quilts*, explores how quilting can serve as an innovative tool for science communication, education, and outreach. Through case studies, the chapter highlights how collaborative quilt-making projects have engaged scientists, students, and communities in sharing personal and scientific Ocean narratives. By integrating storytelling, creative expression, and community participation, these textile-based projects foster interdisciplinary learning, place-based reflection, and emotional connection to the Ocean. While acknowledging the challenges of assessing their educational effectiveness, the author emphasizes the power of quilts to make Ocean science more accessible and meaningful across diverse audiences.

Chapter 20, *"Tramares, Weaving Reefs": A Science–Art Mesophotic Project*, explores the intersection of art, science, and community partnership in advancing Ocean Literacy. Based in Chile, the authors detail a collaborative initiative in which women over 60 from coastal communities created more than 600 crocheted marine organisms to represent the biodiversity of mesophotic (twilight) reefs. Through workshops blending weaving, ecology, and geometry, participants formed deeper connections with the Ocean while contributing to an interactive traveling exhibition that has reached over 95,000 visitors. This science–art project demonstrates how locally led, creative approaches can foster intergenerational learning, deepen emotional connection, and inspire conservation through culturally meaningful expressions of Ocean knowledge.

Chapter 21, *Land or Sea: Diving into the Ocean from Land***,** introduces an innovative educational game designed to foster Ocean Literacy through analogy-based learning. Developed for use in landlocked communities, the game helps students draw meaningful connections between terrestrial and marine environments, strengthening conceptual understanding through interactive play. Focusing on the Ocean Connections Program in Puerto Rico and broader case studies in Europe, the chapter demonstrates how analogical thinking can bridge the gap between familiar land-based experiences and the less visible marine world. By sparking imagination, curiosity, and emotional engagement, the Land or Sea game nurtures personal and social connections to the Ocean, transforming abstract concepts into lived experiences. The authors describe how play-based and analogy-driven methods can overcome barriers of distance and access, expand perspectives on human–Ocean relationships, and encourage participants to see the Ocean with "different eyes." In doing so, it reinforces the volume's emphasis on creativity, inclusivity, and collective empowerment as powerful tools for Ocean Literacy and sustainable futures.

Chapter 22, *Seaweed, Science, and Society: A Collaborative Model for Ocean Literacy, Community Building, and Blue Innovation* highlights how an innovative school-based initiative connects classrooms with coastlines. The chapter explores how experiential learning, cross-generational partnerships, and creative integration of science with the arts can foster Ocean Literacy while linking education to real-world sustainability challenges. This contribution embodies the themes covered throughout Volume II by demonstrating how collective capacity-building, Blue Innovation, and artistic expression can converge to create lasting impact. The authors describe how small-scale, student-led projects can contribute meaningfully to ecosystem restoration while also serving as valuable research case studies, an inspiring reminder that education, culture, and innovation together are powerful drivers of change.

Volume II concludes with a reflective section that brings the chapters together, highlighting how they collectively illustrate the importance of community engagement, the Sustainable Blue Economy, and the arts in advancing Ocean Literacy. It reflects on shared themes across the volume, including the importance of cultural

connection, creative expression, and inclusive participation. The concluding section also situates these contributions within the broader aims of the Ocean Decade and underscores how the work presented contributes to ongoing efforts to strengthen society's relationship with the Ocean.

1.5 Conclusion

Volume II: Fostering Community, the Sustainable Blue Economy, and the Arts illustrates how Ocean Literacy is no longer confined to traditional science education but is being reimagined through creativity, emotion, and cultural context. From collaborative quilts and interdisciplinary theater to youth-led storytelling through poetry, puppetry, and public art, these initiatives affirm that Ocean Literacy is not a one-size-fits-all concept. It is a dynamic, living framework shaped by the people, places, and practices that bring it to life. This volume underscores that connection to the Ocean is not limited by geography but sustained through an enduring relationship that can be nurtured through imagination, inclusion, and innovation. Together, these contributions demonstrate the power of locally grounded, culturally resonant, and emotionally compelling approaches capable of advancing Ocean Literacy and sustainable futures.

Volume II opens space for new voices and cross-sector conversations, including perspectives from artists, performers, educators, and youth. It also highlights both inland and coastal communities whose lived experiences provide a rich array of examples and approaches that can inspire and be adapted elsewhere. It expands what is valued in the pursuit of Ocean knowledge and engagement, showing that creativity, cultural expression, and community identity are essential to understanding and protecting the Ocean.

The chapters in this volume model ways to embed Ocean Literacy within educational practices and community contexts, helping learners of all ages feel connected to the Ocean, even when they are not physically near it. Just as the arts offer a pathway for emotional connection, community-based economic models present tangible routes to structural change. These chapters illuminate how creative expression, storytelling, and local economic models can all contribute to restoring society's relationship with the Ocean. They show how Ocean Literacy efforts, when grounded in local relevance, can catalyze action and invite emotional and cultural resonance, expanding our understanding of what constitutes knowledge and who holds it.

Ultimately, the stories shared in this volume reveal the Ocean as a living presence within human culture, a source of inspiration, meaning, livelihood, and imagination, while remaining anchored in scientific knowledge that underpins our shared responsibility and action. Together, they invite us to co-create a future in which Ocean Literacy is inseparable from justice, equity, sustainability, and creative agency.

As you journey through the chapters of Volume II, we hope you find inspiration as well as practical ideas and meaningful connections that can be adapted and applied in your own contexts. The diverse voices represented here demonstrate that advancing Ocean Literacy is a collective endeavor, one that thrives on creativity, collaboration, and cultural relevance. Whether you're an educator, artist, policymaker, business leader, entrepreneur, or community advocate, may the stories and strategies within these pages encourage bold thinking, strengthen shared efforts, and reaffirm the vital role each of us plays in shaping a more Ocean-conscious and sustainable world. In this way, advancing Ocean Literacy contributes to the objectives of the Ocean Decade and also to the achievement of Sustainable Development Goal 14: Life Below Water.

1.5.1 Summary

Key concepts explored in this chapter include:

- Volume II builds upon Volume I by expanding Ocean Literacy into community contexts, cultural expression, and the Sustainable Blue Economy, reflecting its evolution from

classroom-centered education to a broader societal framework.
- The deliberate shift to capitalize "Ocean" as a proper noun reinforces its identity as one interconnected system, aligning with contemporary Ocean science thinking and Ocean Decade goals.
- The Ocean Decade is positioned as both a global mandate and local opportunity, calling for inclusive, emotional, and culturally relevant engagement with the Ocean.
- Ocean Literacy is presented as a societal outcome, not just an educational goal. It includes equity, emotion, civic responsibility, and justice, alongside scientific knowledge.
- Ocean Literacy is redefined as a living, dynamic practice that must reflect diverse cultures, creative agency, and community leadership.
- Emotional resonance, place-based learning, and inclusive storytelling are as crucial as data and formal education in fostering sustainable Ocean relationships, particularly when grounded in living marine ecosystems and species that reveal ecological interdependence, adaptation, and intelligence.
- Community-rooted initiatives such as collaborative quilting and crocheting, musical theatre, children's literature, and intergenerational art-science exhibitions illustrate the creative, participatory, and inclusive nature of Ocean Literacy.
- Finance, governance, and entrepreneurship are viable pathways to a more sustainable Blue Economy.
- Systems thinking, interdisciplinary collaboration, and co-designed solutions help to ensure meaningful, lasting change.
- Everyone has a role to play, regardless of geography or profession, in building a more Ocean-literate and sustainable world.

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[1]*Teresa Kennedy: Conceptualization; Writing—Original Draft, Review, and Editing; Book Project Administration—Supervision, Coordination of Chapter Submission, Oversight of the Double-Blind Peer Review Process, and Editing and Formatting.

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She played a key role in shaping the international science initiatives of the U.S. National Science Teaching Association (NSTA), serving five terms on its International Advisory Board from 2004 to 2024, and contributed as a member of the writing team for the joint NSTA and NMEA Ocean Literacy position paper (2024–2025). As former Deputy Director of NASA's GLOBE Program, she collaborated with science education leaders in over 100 countries, deepening her commitment to global collaboration and environmental education.

Dr. Kennedy has dedicated her career to enhancing global science education, promoting Ocean Literacy, and contributing to international STEM and sustainability initiatives. As the editor and driving force behind this project, she conceived the initiative and guided its development, ensuring a cohesive and impactful collection that unites diverse perspectives to advance Ocean Literacy.

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2 Situating the Evolving Role of Ocean Literacy Research in the Ocean Decade: Case Studies at a Glance

Jen McRuer, Emma McKinley, and Diz Glithero

Abstract

Ten core challenges frame the United Nations Decade of Ocean Science for Sustainable Development. *Restoring society's relationship with the Ocean (Challenge 10)* is foundational to bridging science and policy with society. Although an ever-pressing "challenge," it is also a once-in-a-generation opportunity to galvanize existing knowledge, resources, and practices toward a common goal: safeguarding the Ocean and all life that depends on it. This chapter discusses the importance of Ocean Literacy research as a driving force behind this transformative endeavour to foster an Ocean-connected society. Beginning with an overview of Ocean Literacy's growing recognition as a societal outcome indicative of greater understanding, value, and care for the Ocean, this chapter positions the concept's increasing uptake within Ocean research, governance, and communications discourse. Next, the chapter discusses the co-development of an Ocean Literacy research definition, a community of practice, and a research agenda resulting in four initial priorities: measuring Ocean Literacy and impact; the intersection of Ocean Literacy and climate action; linkages between Ocean Literacy and the blue economy; and promoting Ocean Literacy as a policy mechanism. Ensuring equitable, diverse, and inclusive paths forward is a cross-cutting theme for all. Case studies advancing these priority areas are shared, and ideas to further the priority areas through increased engagement and transdisciplinary collaboration across associated and complementary fields are discussed.

Keywords

Ocean Literacy (OL) · Ocean Literacy research (OLR) · Research Agenda · People-Ocean relationships · Co-development · Ocean Decade Challenge 10 alignment

2.1 Introduction

Launched in January 2021, the UN Decade of Ocean Science for Sustainable Development (2021–2030)–hereafter 'Ocean Decade'–is framed around ten key challenges. Challenge 10—Restoring society's relationship with the Ocean–is increasingly recognised as being foundational to all other aspects of the Ocean Decade.

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Originally framed as 'Changing humanity's relationship with the Ocean,' the revised framing herein draws on the Challenge 10 White Paper (Glithero et al. 2024), reflecting the many ways the Ocean, coasts, and seas are 'peopled' spaces (Bennett 2019). This positioning seeks to '*ensure that the multiple values and services of the Ocean for human wellbeing, 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).

Prior to the launch of the Ocean Decade, there had already been calls for improved inter- and transdisciplinary practice, and for better consideration of the human dimensions of the global Ocean (Claudet et al. 2020). Many concepts have evolved, including but not limited to: marine citizenship, which emphasizes the role of individuals as active participants in protecting the marine environment (Buchan et al. 2023); marine identity, or understanding how and why individual and community identities may be shaped by the Ocean (Buchan et al. 2024; Kelly et al. 2023); the concept of Ocean connectedness, or the sense of belonging to the marine environment that may influence day-to-day experiences, decisions, and values (Capaldi et al. 2014; Howell et al. 2011; Nuojua et al. 2022); and Ocean empathy or 'taking the perspective of, and feeling an emotional bond with, Ocean-dependent communities, marine organisms, and marine systems' (Blythe et al. 2021, p. 1285). These concepts reflect the complementary and transdisciplinary nature of broader social sciences research, drawing insights from traditional fields of, for example, anthropology, sociology, and human geography; as well as applied fields, such as behavioural sciences, political sciences, and environmental governance (McRuer et al. 2024; Spalding and McKinley, 2025). Each of these areas lends itself to (and indeed illustrates the continuing interest in) understanding the complex relationships between people and the Ocean. Importantly, to fully understand this complexity, there must also be intentional space created to exchange ideas and draw on insights arising between and across disciplines in natural and physical sciences, humanities and arts, business, and communications (Claudet et al. 2020, p. 36); and to be inclusive of multiple ways of knowing from local, place-based, and Indigenous perspectives.

In this chapter we focus on the concept of 'Ocean Literacy' which is gaining global attention for its potential to further unify and increase understanding of people-Ocean relationships. Arising from the field of marine education in the early 2000s to encourage understanding of 'our influence on the Ocean and its influence on us,' the concept is evolving beyond its original focus on Ocean science knowledge, communication, and decision-making (Cava et al. 2005). Discussed in more detail in other chapters, the current set of Ocean Literacy dimensions reflect several conceptual elements to position Ocean Literacy as multi-faceted and comprehensive, inclusive of knowledge, communication, behaviour, awareness, attitudes, activism, emotions (or 'emOceans'), access and experience, adaptive capacity, trust and transparency (Brennan et al., 2019; McKinley et al. 2020) as well as Ocean connectedness (Fauville et al. 2024). Each of these dimensions is informed by the many subfields in the marine social sciences, as well as traditional and applied fields of study (Fig. 2.1). Within and across these varying fields is wide recognition of the many ways people across geographies and cultures relate to the Ocean. With ongoing transdisciplinary insight, this conceptual model of Ocean Literacy dimensions will necessarily continue to expand to be even more inclusive of this diversity.

The concept of 'Ocean Literacy' has faced criticism, especially regarding its transferability outside of its formal education roots with predominant focus on Western science knowledge and English language context (MacNeil et al., 2021). It is also relatively new compared to established areas of marine social sciences. However, Ocean Literacy's growing presence in global Ocean discourse (as will be highlighted shortly) offers a

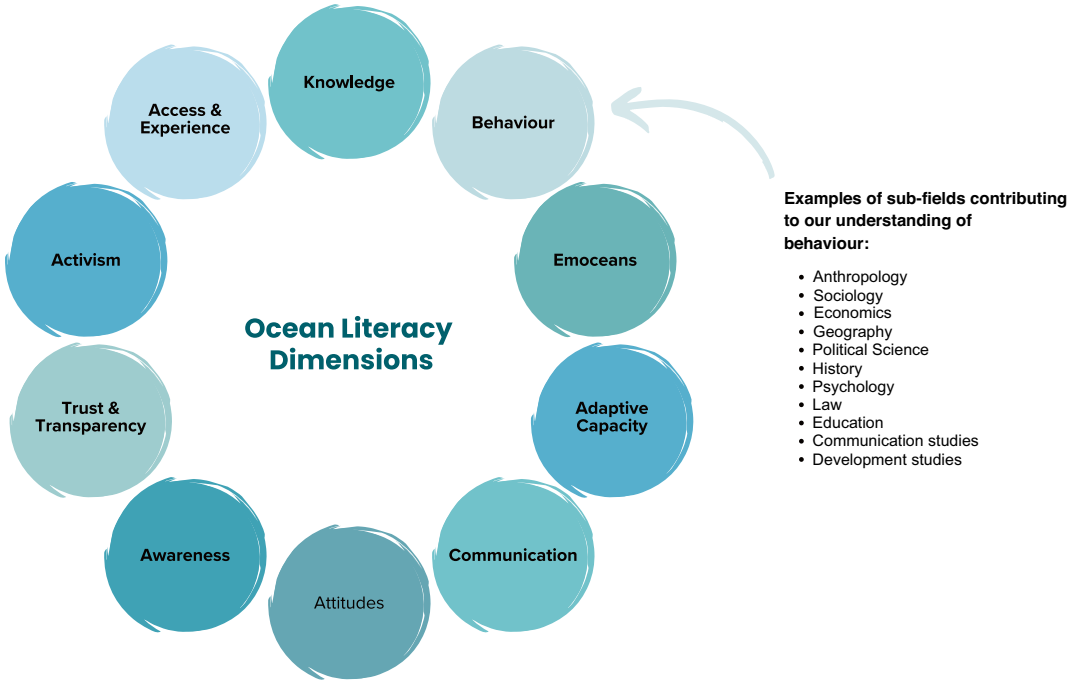


Fig. 2.1 Expanding dimensions of Ocean Literacy and showing examples of sub-fields that contribute to one dimension (adapted from McKinley et al. 2023).

valuable opportunity to unite diverse fields and perspectives to address shared goals and challenges. As the concept of Ocean Literacy rapidly and continuously evolves (Shellock et al. 2024), space must continue to be co-created to continue conversations on conceptual tensions, merits, uses, and impacts. This is especially needed given changing people-Ocean connections in light of increasing environmental and societal challenges, uncertainty, and complexity. That said, we need to be mindful to not lose momentum over a *term*, but to instead find a common framing that accommodates diverse dimensions and drivers of influence (McNeil et al., 2021). In this way, the concept and associated actions toward its realization can best support place-based relevance and uptake in decision-making.

Toward a common framing, Ocean Literacy has recently been positioned through the Challenge 10 White Paper as a *societal outcome,* reflective of a society that better understands, values, and cares for the Ocean (Glithero et al. 2024). This framing necessitates and encourages contributions across parallel and dovetailing fields of inquiry and consideration of diverse place-based contexts. Ocean Literacy as an outcome is dependent on collective efforts to not only change, but to *restore society's* relationship with the Ocean and all waterways that flow to it (Glithero et al. 2024). This positions the deteriorating state of the Ocean as a people problem, with people-driven solutions; helping to anchor not only Challenge 10, but all Decade Challenges in the importance of *societal* engagement as central to achieving success. This framing has gained traction in global Ocean discourse over recent years, evidenced, for example, in the Venice Declaration (IOC-UNESCO 2024), which has the positional aim to inform Ocean policy discussions and negotiations, such as the 2025 UN Ocean Conference (UNOC3) in Nice, France.

As the concept of Ocean Literacy, and indeed its position within broader Ocean discourse and scholarship advances, there has been a corresponding increase in attention to Ocean Literacy research, or the:

> transdisciplinary, cross-sector field of research which explores the diverse dimensions, drivers, influences, and impacts of initiatives aimed at strengthening people-Ocean relationships. It seeks to understand how these aspects may vary in different social, economic, cultural, political, and geographic contexts and is inclusive of diverse voices, actors and ways of engaging with the Ocean (McRuer et al. 2024, p. 11).

Particular attention has focused on the need to better account for and understand the many ways that Ocean Literacy research can help bring to the fore the interdependence of human society and the Ocean. Most recently, a call to advance Ocean Literacy research was included in the Barcelona Statement (May 2024), following the Ocean Decade Conference (IOC-UNESCO 2024). This testament emphasizes the fundamental role of multi-scale and multi-sector collaborations and Ocean Literacy research as key priorities within the Ocean research space. This focus affords more thorough investigation(s) into people-Ocean connections, behaviour change, and diverse cultural engagement across geographies; and aligns with the evolving conceptual underpinnings of Ocean Literacy already discussed.

While research on Ocean Literacy is not necessarily new, it remains relatively emergent. The pace and scale of Ocean Literacy research has begun to increase; take for example the increasing emphasis on public Ocean perceptions research (Glithero and Zandvliet 2021; Jefferson et al. 2021). Despite this traction, gaps in our understanding of the concept and how it can be meaningfully applied remain. For example, historically, Ocean Literacy research has placed emphasis on education and the dimensions of knowledge and awareness (Shellock et al. 2024), with limited recognition of other potential drivers of Ocean Literacy to date. To expand beyond this myopic tendency toward a more comprehensive outlook, the growing community of Ocean Literacy researchers must co-create opportunities for cross-disciplinary and cross-sector collaboration and communication. This approach is essential to deliver a progressive, inclusive, and impact-driven research agenda. Such an agenda must position the need for research that embraces and explores the multi-faceted nature of Ocean Literacy and seeks to understand the drivers and influencers of its many dimensions. Notably, the agenda must situate research directions within the broad scope of people-Ocean relationships; guided by the overarching question of how can we best affect wide societal change toward pro-Ocean behaviours and people-driven solutions?

2.2 Overview of Advances in Ocean Literacy Research: Community of Practice, Agenda, and Priorities

Opportunity to advance Ocean Literacy research traction arose in July 2021 during the first workshop of the UN Ocean Decade Laboratory series (Fig. 2.2). The first Laboratory invited satellite activities related to the Decade's Societal Outcome #7, 'An Inspiring and Engaging Ocean,' for which a proposal to bring together diverse Ocean Literacy researchers and practitioners across generations, geographies, and cultures was accepted. The proposal aimed to support the co-development of an Ocean Literacy Research Community and agenda for the Ocean Decade.

Between July 2021 and June 2022, a set of three workshops paired with collaborative crowdsourcing methods (i.e., surveys and community mapping through an interactive StoryMap website) were used to engage the growing Community in advancing Ocean Literacy research (see Table 2.1 below).

The participatory, co-development process to operationalize Ocean Literacy research exemplifies how disparate and parallel areas of research and practice can be brought together to co-articulate key pathways, leverage points, and impact opportunities. Additionally, the co-design process itself exemplified these shared building blocks. For example, interaction was fostered between global individuals interested in Ocean Literacy directions, regardless of degree of experience or area of focus. This inclusive and bottom-up approach also supported Community growth by inviting diverse ways of knowing and perspectives across cultures, regions, sectors, and scales typically neglected in Ocean science



Fig. 2.2 Graphic visualization of the first workshop at the UN Ocean Decade Laboratory series

(Meyer-Gutbrod et al. 2023). This helped to ensure that the aims determined through the research agenda were reflective of diverse interests, needs and experiences. This serves as an example of the collaborative efforts needed to strengthen collective and inclusive Ocean Literacy research trajectories to critically inform decision-making in ways that integrate research insights across Ocean-related policies.

Today, the growing Ocean Literacy research community is composed of over 180 individuals from 41 different countries. The members self-identify among a wide range of identities–geographic, gender, minority group, age, and sectors (e.g., researchers and practitioners from NGO, academia, industry, arts and culture, education, media, and government backgrounds). Crucially, what distinguishes the Ocean Literacy research community from other existing Ocean Literacy groups and initiatives (e.g., National Marine Educators Association, UNESCO's Ocean Literacy Group of Experts) is its emphasis on *facilitating and advancing research*. To support this Community, a lead coordinating organization (the Centre for Ocean Literacy Collaboration, formerly the Canadian Ocean Literacy Coalition) and eight collaborating partner organizations/institutions representing a range of global perspectives and experiences, have volunteered time and effort to guide the co-development process. The full list of partners can be found on the dedicated Community website designed to reflect ongoing growth and foster global collaboration and exchange of research (see the resources section). The website also serves to visualize a map of the Community by geographic area and professional expertise, current projects, and foundational cornerstones. Since these initial workshops and the formation of this Community, a working definition of our collective field of research has been co-crafted (see above) alongside a co-developed agenda, inclusive of four initial priority areas to address gaps and opportunities for alignment (visualized in Fig. 2.3 below):

- Measuring Ocean Literacy. There is a need to develop Ocean Literacy indicators and measures to better understand the efficacy of

Table 2.1 Importance of Operationalizing Ocean Literacy Research

Operationalizing Ocean Literacy Research
• **Co-identifying emergent needs and priorities:** Enabling Ocean Literacy research (OLR) allows for the co-identification of new and emergent needs, priorities, and opportunities. By being inclusive of transdisciplinary researchers, policymakers, educators, communicators, and local communities, initiatives are informed by diverse knowledge systems and perspectives across cultures, regions, sectors, and scales. This importantly includes the integration of local and Indigenous knowledge and the intentional inclusion of other underrepresented groups in the Ocean sciences (Meyer-Gutbrod, 2023). In recognizing multiple knowledge systems, it becomes possible to not only pinpoint critical areas that require immediate attention, but also learn from tried and tested approaches, augment previously siloed efforts by avoiding overlap, and build bridges between existing efforts. Collaborative approaches to enabling Ocean Literacy research ensure that research is responsive to current and future Ocean-related issues and relevant to those seeking to address them.
• **Informing existing and novel key initiatives: Ocean Literacy research** importantly provides the evidence base critically needed to support and enhance existing Ocean initiatives while also informing the development of new ones. For example, research focused on better understanding societal needs, attitudes, values, and perspectives can contribute to more effective and targeted Ocean conservation and communication strategies that are grounded in place-based contexts and are responsive to audience interests and needs. This helps to ensure that initiatives are relevant, appropriate, timely, and effective.
• **Measuring impact to better understand what is working and what is not:** Operationalizing Ocean Literacy research involves systematically measuring and evaluating the outcomes of Ocean Literacy initiatives. This process helps to identify successful strategies and areas needing improvement. By sharing existing measurement tools and understanding what works and what does not, approaches can be refined or new ones developed, resources allocated more efficiently, and positive impact of OLR maximized.
• **Leveraging and fostering transdisciplinary research partnerships:** Co-developing a shared understanding of how Ocean Literacy research can feed into effective practice requires the intentional co-creation of collaborative, transdisciplinary partnerships that can mobilize concerted efforts. For example, early alignment with professional communications strategists to shape research in ways that can meaningfully inform evidence-based and tailored messaging for public, policy, and funding audiences.

Ocean Literacy initiatives in fostering behaviour change across all societal sectors. In addition, Ocean Literacy research should be expanded to include monitoring of the multiple dimensions of Ocean Literacy over time, to assess how people-Ocean relationships are changing and what might be driving those changes.

- Ocean Literacy Research and Climate Change. Investigating the human dimensions of climate change, encompassing the social, cultural, economic, health, and governance aspects of the Ocean and its interconnected life-support systems, is needed. Future Ocean Literacy research must address the impacts of climate change on societal relationships with the Ocean and how these changes will affect Ocean Literacy across different communities. It is crucial that Ocean Literacy research incorporates elements of resilience and the dimension of adaptive capacity to better understand and respond to the challenges posed by a changing climate.
- Ocean Literacy Research and a Sustainable Blue Economy. Understanding how civil society and businesses connect to and value Ocean spaces is a notable priority. For example, to encourage the business community to better understand the importance of Ocean Literacy as a core component of their corporate strategy and social responsibility. In addition, efforts to raise knowledge and awareness of maritime career opportunities, improve recruitment to Ocean careers, and open possibilities for business diversification are also required.
- Ocean Literacy Research as a Policy Mechanism. Given the growing emphasis on the potential role of Ocean Literacy in Ocean decision-making and Ocean action, more research is needed to better understand the role of Ocean Literacy to support the integration of diverse values into the Ocean governance landscape. Furthermore, research to develop recommendations to support the use of Ocean Literacy as a practical policy tool to ensure impact is also urgently required.

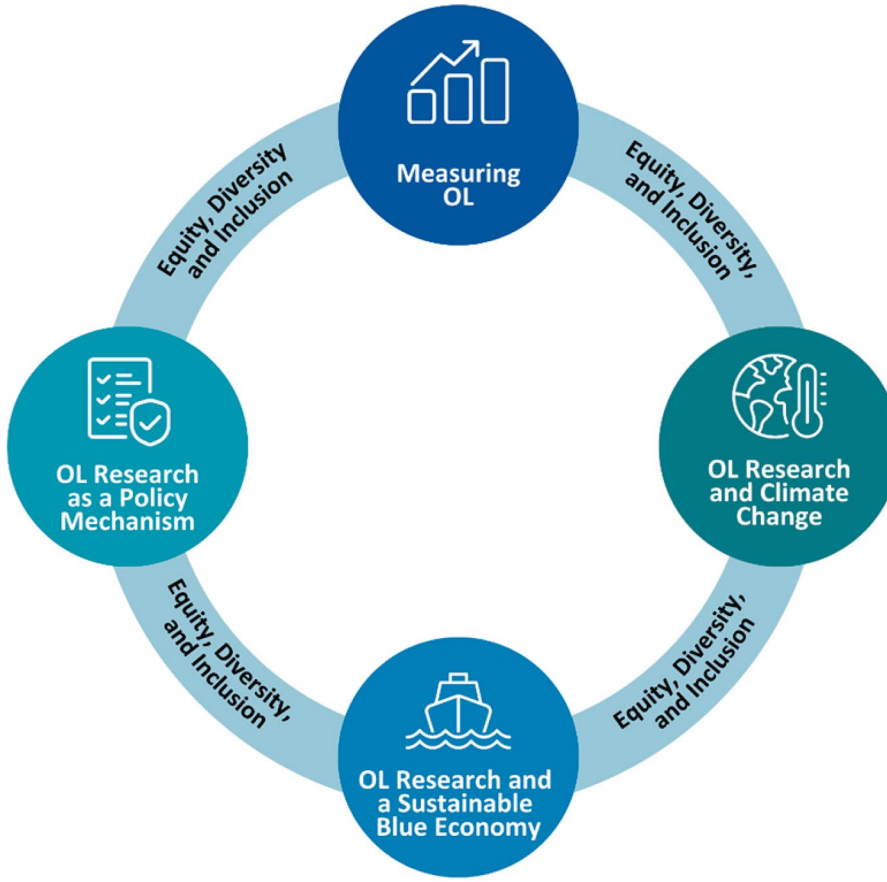


Fig. 2.3 Interconnected Ocean Literacy research priority areas, with the cross-cutting theme of equity, diversity, and inclusion (amended from McRuer et al. 2024).

Across all priority areas, the Ocean Literacy research community co-positioned the overarching theme of equity, diversity, and inclusion, with the caveat that too often this is given lip-service rather than being transparently actioned (McRuer et al. 2024). There are existing examples of Ocean Literacy research aligned with these co-identified themes being carried out by researchers around the world, for example community science research to inform policy, as seen in the Horizon 2020 Innovation Action project, 'Nautilos.' Paredes-Coral et al. (2021) have also identified areas of work aligning Ocean Literacy research and the blue economy, such as the Maritime Alliance for fostering the European Blue Economy through a Marine Technology Skilling Strategy (MATES), which seeks to enhance Ocean Literacy within the wider maritime sector. Research focused on the blue economy continues to be promoted as a key and emergent focal area, including, for example, seafood value chain research aiming to inform blockchain technology to aid consumer decision-making (e.g., Sea2See). Next, we summarize four case studies that align with the priorities set out by the Ocean Literacy research community. The first case study showcases three national studies undertaken to attain a baseline of Ocean Literacy; the second shares an initiative to co-design a shared global tool to assess Ocean Literacy and monitor change over time; the third presents a survey co-created by members of the Ocean Literacy research community to assess climate-related Ocean action and associated best practices; and the final case study shares a dedicated series for global exchange on Ocean Literacy topics, relating to all priority areas.

2.3 Case Studies at a Glance

The following case studies provide insights into various Ocean Literacy research initiatives related to current priority areas. Each case study highlights strategies and outcomes that contribute to a broader understanding of Ocean Literacy as a societal outcome. For further information, please refer to the resources section, where additional context and supporting materials are available.

2.3.1 Case Study #1: National Studies

Case Study #1 addresses the Priority Areas: *Measuring Ocean Literacy and Ocean Literacy Research as a Policy Mechanism.* This case study showcases examples of iterative, peer-reviewed national surveys aligning with the launch of the Ocean Decade, offering unique, yet complementary Ocean Literacy measurements in three different countries: Canada (2020)—place-based focus; United Kingdom (2021 and 2022)—Ocean Literacy dimensions focus; Brazil (2022)—communications focus. These surveys were recently selected for cross-analysis to inform a global Ocean & Society Survey tool to track public Ocean perceptions over time (see Case Study #2.3.2). We first elaborate on the intent and impact of each national study below.

2.3.1.1 Canada

The Canadian Ocean Literacy Survey (COLS) conducted by the Canadian Ocean Literacy Coalition (now the Centre for Ocean Literacy Collaboration) was an instrumental baseline of Ocean perceptions in Canada through a public lens (Glithero and Zandvliet 2021). This was one of the key pieces of research that informed a national Ocean Literacy strategy—the first in the world. Gaining better insight into the unique diversity and regional needs across Canada through the national survey directly informed key place-based priorities, actions, barriers, and gaps to be addressed, and pathways to both implement and measure progress over time. See more in Chapter 22 of *Ocean Literacy: The Foundation for the Success of the Ocean Decade Volume III: Accelerating Communication, Technology, and Global Initiatives.*

2.3.1.2 The United Kingdom

The England and Wales Ocean Literacy Survey was carried out in 2021 (England and Wales) and 2022 (all UK countries) (DEFRA 2022). The survey was commissioned as part of the project *Understanding Ocean Literacy and Ocean Climate-related Behaviour Change in the UK* led by Defra, in collaboration with the Ocean Conservation Trust, Natural Resources Wales, and Marine Scotland. The survey itself builds on research to better understand the concept of Ocean Literacy, its dimensions, and develop recommendations for UK-wide Ocean Literacy research.

2.3.1.3 Brazil

The Brazilian survey was carried out in 2022 (Fundação Grupo Boticário 2022) seeking to identify how people from all regions of the country perceive their connection with the Ocean. It aimed to be a baseline to track Brazilians' Ocean awareness, knowledge, and relationships to guide oceanic communication and literacy strategies and be an example for other countries to replicate. The survey succeeded in identifying the ways that Brazilian people are willing to adopt new habits and behaviors to support the health of marine environments, and with a communications-focus, the findings were shared widely to inform directions forward.

These nationally representative public assessments build upon preceding efforts to gauge Ocean Literacy among youth in educational settings (Fauville et al. 2019), widening our understanding of people-Ocean relationships across diverse geographical, social, and cultural contexts. For example, national surveys in the Republic of Ireland (Fair Seas, 2022), South Africa (Two Oceans Aquarium, Cardiff University, 2023), and Sweden (Swedish Institute for the Marine Environment, 2023) have since been administered

to capture unique place-based public Ocean perspectives. Moreover, Canada and Brazil have recently completed their second national survey administration (early 2025) to track Ocean Literacy progress over time. Assessments such as these complement and inform the increasing development of National Ocean Literacy Strategies, for example in Canada (2021), Wales (2025) and England (expected 2026).

2.3.2 Case Study #2: Ocean & Society Survey

Case Study #2 pertains to the Priority Area: *Measuring Ocean Literacy*. There is a need to position Ocean Literacy as a mechanism that can drive policy change across different sectors and levels of decision-making. To support this, evidence-based insights are needed. The Ocean & Society Survey is a global instrument collaboratively designed with 20 core partners, launched in 2025 to help fill this need (McRuer et al. 2025). Positioned within the evolving landscape of public Ocean perceptions research, and in alignment with the Ocean Decade Challenge 10, the Ocean & Society Survey strives to identify how public views of, and relationships with the Ocean may be changing over time.

Based on the comparative analysis of the above-mentioned national surveys (Case study #1), the questions included in the Ocean & Society Survey intentionally reflect the evolving concept of Ocean Literacy since its inception—in particular, how it has moved away from a knowledge or information deficit perspective, toward a more holistic approach that takes into account diverse knowledge systems, values, emotional connections, and ways of connecting with the Ocean, coastal, and freshwater environments. The Ocean & Society Survey includes a core set of 30 questions (inclusive of 10 demographic questions) chosen for their representation of Ocean Literacy themes and dimensions, cross-checked by metric measures to align with the goal of capturing diverse people-Ocean connections. Five Survey objectives were co-determined, including: to strengthen people-Ocean relationships by tracking how people understand, value, and engage with the Ocean; to guide pathways of engagement by identifying behavioural motivations, enablers, and barriers; to generate insights for targeted, audience-specific communications; to demonstrate the value of transdisciplinary partnerships; and to better understand what influences peoples' interests and concerns about the Ocean, alongside the willingness and capacity to take action and make informed decisions.

At the time of writing, the Ocean & Society Survey has been administered in 14 countries, with the aim to involve as many countries as possible by 2030. Comparative analysis over time and across regions aims to identify evidence-based insights to support opportunities for widespread public engagement in Ocean health solutions.

2.3.3 Case Study #3: Climate Change Survey

Case Study #3 reflects the Priority Area of *Ocean Literacy Research and Climate Change.* Members of the Ocean Literacy research community from Canada, Portugal, Spain, and Taiwan have worked to develop a survey to capture opinions on climate change messaging and action. Specifically, it looks to analyze what messaging works best, its efficacy, and what are the main drivers and motivations to carry out climate-related Ocean actions. The United Nations Development Programme has defined climate action as a stepped-up effort to reduce greenhouse gas emissions and strengthen resilience and adaptive capacity to climate-induced impacts, including mitigating climate change; adapting to the impacts of climate change; and, contributing to understanding climate change.

A climate-related Ocean action is, therefore, an action taken for the Ocean that addresses climate change. This is an action that falls under both Sustainable Development Goals 14 (Life below water) and 13 (Climate Action). The survey calls on the experience and suggestions of

those actively involved in research, study, and/or volunteering related to Ocean health, with a goal of better understanding our changing Ocean, its connection with climate, and how the global community can improve engagement for climate-related Ocean actions. The survey was translated into five languages, with the aim to achieve a better (and general) understanding of effective climate change messaging and to share this learning with the Ocean Literacy research community, helping to ensure that Ocean Literacy initiatives strengthen society's relationship with the Ocean in grounded and measurable ways.

2.3.4 Case Study #4: Ocean Literacy Dialogues

Case Study #4 addresses all Priority Areas. The Ocean Literacy Dialogues series is a global collaboration led by the *Ocean Literacy With All* community—an Ocean Decade-endorsed program coordinated by IOC-UNESCO. The aim of the Ocean Literacy Dialogues series is to co-organize public events that enable knowledge exchange across different geographical and socio-cultural contexts, and that catalyze action to achieve the overarching goal of the Ocean Decade.

The 1st Edition of the Ocean Literacy Dialogues series was jointly organized by IOC-UNESCO and the European Commission, specifically in the context of the EU4Ocean Coalition, in Lisbon, Portugal, during the 2022 UN Ocean Conference (June 28th-July 1st). The high-level event marked the beginning of a process to investigate the shared commitments that support Ocean Literacy across the globe.

Between October 10th to 14th, 2022, the 2nd Edition was held in Santos, Brazil, led by the Brazilian Ocean Literacy community with support from IOC-UNESCO. Drawing over 2,500 people from schools, private and governmental sectors, research, journalism, and civil society, the event facilitated discussions on Ocean engagement, featuring tailored events for various audience interests including formal education, research, media, urban development, culture, and sports.

During the Fifth International Marine Protected Areas Congress (IMPAC5) in Vancouver, Canada, the 3rd Edition took place between February 2nd and 9th, 2023. Led by the Canadian Ocean Literacy Coalition (now the Centre for Ocean Literacy Collaboration), with collaborating partners IOC-UNESCO, Cardiff University, Marine Social Sciences Network, University of Victoria, and the Department of Fisheries and Oceans Canada, this edition focused primarily on Ocean Literacy research, as well as Ocean art and storytelling, and Ocean education.

Tanzania, Africa, held the 4th Edition between November 4th and 5th, 2023, co-hosted by the African Union and Regional Seas with African parties, and in collaboration with IOC-UNESCO, the IOC Sub-Commission for Africa (IOC-AFRICA), as well as UNESCO's Dar es Salaam Field Office. The event focused on blue education and curriculum, with an emphasis on Ocean opportunities, decolonizing narratives, and ecological and traditional knowledge.

The 5th Edition took place during the 2024 Ocean Decade Conference in Barcelona, Spain between April 8th and 9th, 2024. Led by IOC-UNESCO, this edition brought together a diverse community of Ocean Literacy researchers and practitioners. Sessions explored a range of topics, with a significant focus on blue education, as well as discussing OL innovation and trends, cultural connections, community engagement, and an emphasis on the importance of aligning Ocean Literacy research with strategic Ocean communications initiatives.

It is important to note that future editions of the series must continue to broaden beyond the educational lens that has traditionally situated Ocean Literacy, to be reflective and supportive of the evolving nature of the concept and associated research.

2.4 Discussion and Concluding Remarks

At the time of publication, we have entered the second half of the Ocean Decade, a pivotal moment to reflect on our progress across disciplines and sectors, learn from both successes and shortcomings, and leverage collective momentum. Advancing Ocean Literacy research over the remainder of the Decade will require a stronger focus on transdisciplinary collaboration and the integration of diverse knowledge systems and experiences. This is essential to develop innovative, people-driven solutions that can address both current and emerging challenges.

Too often, collaborative research endeavours are hindered by siloed approaches, limited funding leading to competition, unsuccessful proposals, and short-term contracts. By co-establishing a coordinated and dedicated agenda for the Ocean Decade, we can work together with streamlined messaging and targeted joint proposals to help leverage and secure long-term partners and sustained funding for collective initiatives. With the growing number of invested Ocean Literacy research community researchers and practitioners, and guiding Ocean Literacy research agenda priorities on hand, opportunity exists to connect ideas and projects. Using the interactive dashboard on the Community website, international colleagues can connect, learn from one another's work, and begin initiating dialogue and mobilizing initiatives across disciplines, sectors, and regions. Importantly, ongoing tracking and evaluation of Ocean Literacy initiatives is also needed to measure impact and to adapt and improve strategies to address interconnected challenges. Such feedback loops help to ensure continuous progress toward shared goals.

To collectively tackle the challenges facing the Ocean, Ocean Literacy research must be approached with greater urgency and ambition—delivered at the pace and scale necessary to generate real change. Despite growing interest in Ocean Literacy, its incorporation into Ocean policy remains limited. This requires a critical re-evaluation of business-as-usual models, identifying where transformation is needed, and fostering transitions that better serve both the Ocean and society. For example, while connections between Ocean Literacy research and Sustainable Blue Economy research are emerging, further integration is needed to ground understandings, practices, and policies in place-based perspectives, reflective of diverse cultural and societal contexts. At the same time, clear and actionable pathways for policy impact are paramount. Future Ocean Literacy research can support such efforts by pursuing approaches capable of co-identifying and -investigating emerging priority areas and Ocean Literacy dimensions, as well as strategically communicating and sharing evidence-based insights to support truly integrative and impactful research and practice.

2.4.1 Summary

Key concepts explored in this chapter include:

- The UN Decade of Ocean Science for Sustainable Development focuses on 10 core Challenges, with Challenge 10 centered on people-Ocean relationships.
- Ocean Literacy is being incorporated into research, governance, and communications, on account of its growing recognition as a societal outcome-one that better understands, values, and cares for the Ocean.
- Ocean Literacy research is positioned as a transdisciplinary, cross-sector field of research with the goal of fostering this shared societal outcome.
- The chapter introduces a community-informed Ocean Literacy research agenda for the Ocean Decade, and outlines co-identified priorities of measurement, climate change, the Sustainable Blue Economy, and policy mechanisms, with equity, diversity, and inclusion as a cross-cutting theme.
- The chapter calls for ongoing collaboration to strengthen Ocean Literacy research community efforts in ways that continue to enhance transdisciplinary practice, integrate diverse knowledge systems, and address emerging challenges with innovative, people-driven solutions.

2.4.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Centre for Ocean Literacy Collaboration (formerly Canadian Ocean Literacy Coalition) and collaborating partner organizations/institutions: https://centreforoceanliteracy.ca
- Barcelona statement: 'Inform knowledge drawn from transdisciplinary social science and Ocean Literacy research on people-Ocean connection, behavior change, and cultural engagement that can be integrated into Ocean Decade digital infrastructure and used to map and measure the impact of Ocean Literacy initiatives.'

Case Study #1:

- Canadian Ocean Literacy Survey Highlights Report https://centreforoceanliteracy.ca/wp-content/uploads/2020/06/COLSurvey-Highlights-Report-FINAL-1.pdf
- The Ocean Literacy in England and Wales Headlines Finding Report https://oceanconservationtrust.org/wp-content/uploads/15131_ME5239OceanLiteracyHeadlineReport_FINAL.pdf
- The Brazilian Survey: An Ocean Without Mysteries: Brazilians' Relationship with the Ocean https://fundacaogrupoboticario.org.br/wp-content/uploads/2025/02/An_ocean_without_mysteries.pdf
- Canadian Ocean Literacy Strategy (See also Chapter 22 in Volume 3) https://centreforoceanliteracy.ca/2022/wp-content/uploads/2022/01/Land-Water-Ocean-Us_-A-Canadian-Ocean-Literacy-Strategy_March-2021.pdf
- Wales National Ocean Literacy Strategy https://www.northwaleswildlifetrust.org.uk/sites/default/files/2025-01/Ocean%20Literacy%20Strategy_ENG.pdf

Case Study #2:

- Ocean & Society Survey https://oceanliteracyresearch.com/ocean-and-society-survey/

Case Study #3:

- Ocean Literacy and Climate Change Survey https://oceanliteracyresearch.com/current-olrc-initiatives/

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Emma McKinley, PhD, is a Senior Research Fellow at Cardiff University. Her research focuses on understanding the complex relationships between society and the sea, taking account of diverse perceptions, attitudes and values held by different communities and audiences, and considers how this insight can be used to support effective Ocean governance. Recent projects include the INTERREG Ireland-Wales funded project, Coastal Communities Adapting Together (CCAT – www.ccatproject.eu), which focuses on understanding public perceptions of climate change, building on models of Ocean Literacy and marine citizenship to explore the notion of climate citizenship; the GCRF Catalyst funded project Transforming Resilience across Food and Water Systems, including an assessment of social, economic and cultural impacts of algal blooms; and, the recently funded SMMR project, Integrating Diverse Values into UK Marine Management, leading work on Ocean Literacy. Emma is the founder of the Marine Social Science Network, a global, interdisciplinary community of marine social science researchers and practitioners, sits on the UK's National Decade Committee for the UN Ocean Decade, the International Science Advisory Group for MEOPAR and the IOC-UNESCO's Ocean Literacy Group of Experts.



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3 Empowering Communities for Ocean Sustainability: ICoRSA's Perspective on the Importance of Community Engagement and Stakeholder Involvement in Marine Initiatives

Giovanna Avellis, Gordon Dalton, Rosarii Griffin, Erna Karalija, Dannie O'Brien, and Silvia L. Vilches

Abstract

This chapter is presented by the International Consortium of Researcher Staff Associations (ICoRSA) and examines the interdependence between local communities and Ocean initiatives, emphasising the vital role of community engagement and stakeholder involvement in marine sustainability. The chapter explores the intersection of education, the UN Sustainable Development Goals (SDGs), and participatory research methods, stressing the necessity of involving local communities in sustainable Ocean stewardship. Beyond the MUSICA project, the PHAROS project is highlighted as an exemplary model of community-driven marine initiatives. By integrating 'Nature-Based Solutions', participatory governance, and citizen science, PHAROS demonstrates the impact of community empowerment on Ocean sustainability. Its 'Living Labs' and 'Educational Platforms' strongly align with the mission and vision of the Ocean Decade, reinforcing the need for collaboration across various initiatives to advance global marine conservation goals. Additionally, the chapter provides practical insights and recommendations for practitio-

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ners, policymakers, researchers, and educators on integrating community engagement strategies into sustainable governance. It ultimately advocates for a holistic and inclusive approach to addressing contemporary environmental challenges, underscoring the importance of shared responsibility and cooperative efforts in marine conservation.

Keywords

Ocean Literacy (OL) · Public engagement · Living lab (LL) · Quadruple helix (QH) · Community engagement · Stakeholders engagement · UN Sustainable Development Goals (SDGs) · Open access · Gender equality · Ethics/research integrity · Science education · Responsible research innovation (RRI)

3.1 Introduction

The International Consortium of Researcher Staff Association (ICoRSA) plays a pivotal role in advancing Ocean and energy sustainability through its partnership with local communities in the EU Project '*Multiple Use of Space for Clean Island Autonomy'* MUSICA (musica-project.eu) and EU Project '*Marine Biodiversity Restoration in the Atlantic and the Artic'* PHAROS (pharosproject.eu). The aim of MUSICA is to develop a replicable smart Multi-Use Platform (MUP) for the concurrent use of three types of renewable energy including wind, photovoltaic (PV), and wave, for use in small islands This initiative creates a one-stop decarbonising shop for the islands that includes on-site energy storage, modelling and forecasting, desalination, plus 'green services' to support aquaculture conservation (musica.org).

It will also address, in the context above, the issue of Public Engagement (Avellis 2022), which fosters 'research and innovation' (R&I) processes that are collaborative and multi actor: all societal actors work together during the whole process to align its outcomes to the values, needs and expectations of society. Through real-life examples and case studies, ICoRSA illustrates different models of successful community engagement in diverse oceanic initiatives. Our analysis demonstrates the positive outcomes of involving local stakeholders in the entire project lifecycle, from conceptualisation and planning to implementation and evaluation. From this approach, we can identify lessons learned and best practices that illustrate the interconnectedness between (a) socio-economic development, (b) environmental conservation, and (c) community well-being. Our analysis shows that successful coexistence and mutual dependence makes communities more resilient in the face of complex environmental challenges.

ICoRSA understands the transformative potential education has in fostering community engagement and stakeholder involvement to engender a meaningful co-existence in the face of complex environmental challenges. Building on the Ocean Decade's framework for stakeholder engagement, effective collaboration between NGOs, local communities, and decision makers can enhance Ocean Literacy efforts by fostering shared stewardship and knowledge exchange. The role of NGOs in co-designing solutions that integrate scientific research with community action, promoting sustainability and inclusive governance, is essential (Kennedy et al. 2024, pp. 26–28).

Hence, this chapter underscores the necessity of targeted educational programmes that equip local communities with the knowledge and skills necessary for informed decision-making, particularly in the realm of marine conservation With the success of such a project, a prototype could be developed that could potentially assist small islands and their communities to take optimal advantage of a full suite of solutions for 'Blue

Growth' that are not cost-prohibitive. This is one of the reasons why MUSICA is expected to be one of Europe's flagship projects of arising from the EU's Green Deal policy initiative. MUSICA also aligns with UNESCO's Vision 2030 White Paper '*Restoring Society's Relationship with the Ocean'*, Challenge 10 (Glithero et al. 2024). In addition to MUSICA, the PHAROS project tackles climate change and human impacts on marine biodiversity, which is a crucial part of EU's ambitious Ocean Mission (PHAROS Consortium 2024). It aims to achieve three key challenges: (a) restoring marine ecosystems and biodiversity; (b) eliminate Ocean pollution, and (c) create a sustainable blue economy. As such, PHAROS is set to bridge the development phase (ending in 2025) and the deployment phase (2026–2030). PHAROS approach strongly aligns with the vision of Ocean Decade. A fundamental aspect of the Ocean Decade is its "whole of society" approach, which strengthens connections between science, governments, private companies, NGOs, civil society, and all actors of sustainable development. This approach emphasizes collaborative co-design and coproduction of knowledge products and solutions (Kennedy et al. 2024).

3.2 The Role of ICoRSA in Empowering Communities in Ocean Sustainability Through Project MUSICA and PHAROS: The UN SDG's and Global Sustainable Development

Within the aforementioned context, ICoRSA developed a working framework to assist with stakeholder engagement with islanders through the project MUSICA and PHAROS which together aim to address key UN challenges in marine conservation and energy sustainable development, focusing particularly upon coastal communities' engagement with marine environments. For example:

- Research and Data Collection: ICoRSA coordinates research efforts under Project MUSICA to gather comprehensive data on various aspects of coastal ecosystems, marine biodiversity, and socio-economic factors affecting local communities.
- Community Engagement: ICoRSA facilitates community engagement initiatives within Project MUSICA, ensuring that local stakeholders were actively consulted in decision-making processes regarding marine resource management strategies.
- Capacity Building: Through workshops, training programs, and educational campaigns, ICoRSA enhances the capacity of local communities and stakeholders to implement sustainable practices and adapt to environmental changes.
- Policy Advocacy: ICoRSA advocates for policies that promote sustainable energy management, reduce marine pollution, and protect coastal habitats, aligning with international frameworks such as SDG-14.
- Monitoring and Evaluation: ICoRSA ensures the monitoring and evaluation of Project MUSICA's impact on marine ecosystems and community well-being, ensuring accountability and continuous engagement and communication.

3.3 The PHAROS Project

The PHAROS project is an EU flagship initiative is a comprehensive effort to restore marine ecosystems, eliminate Ocean pollution, and create a sustainable, circular blue economy. Running from 2024 to 2029 and funded with €9.5 million, PHAROS bridges the EU's Ocean Mission development and deployment phases, ensuring continuity in addressing critical marine challenges. PHAROS's innovative approach integrates Nature-Based Solutions (NBS), participatory governance, and cutting-edge technologies to address the degradation of marine ecosystems,

promote biodiversity, and tackle unsustainable exploitation. Central to its methodology is the empowerment of local communities, a principle that resonates with ICoRSA's focus on community engagement and stakeholder involvement.

3.3.1 Key PHAROS Initiatives and their Alignment with ICoRSA Goals

PHAROS's work revolves around three interconnected pillars: (a) restoring ecosystems; (b) reducing pollution, and (c) fostering sustainable exploitation—all implemented through innovative demonstrations in the Atlantic and Arctic basins. These initiatives provide tangible examples of how large-scale projects can successfully engage communities while achieving measurable impacts on Ocean sustainability.

3.3.1.1 Nature-Based Solutions for Ecosystem Restoration

PHAROS demonstrates the application of the NBS across various marine settings to address biodiversity loss and restore ecosystems. These efforts, described below, align closely with ICoRSA's emphasis on leveraging local knowledge and participatory research to achieve sustainable outcomes.

The first included integrated Multi-Trophic Aquaculture (IMTA) and Artificial Reef Restoration in Gran Canaria. PHAROS has implemented an IMTA system combining sea cucumbers, macroalgae, and aquaculture fish farms to restore nutrient-rich ecosystems while fostering high-value aquaculture production. These storm-proof installations serve as replicable models for biodiversity restoration. In addition, using advanced parametric designs, PHAROS creates Artificial Reefs (SER®) that optimize interactions with Ocean currents, improve biodiversity, and stabilize coastlines. These structures are actively recolonised through human-guided gardening initiatives, involving local communities as active participants.

The second involved creating Marine Forests. A combination of polyculture macroalgae and artificial reefs creates habitats for marine life, improves water quality, and captures carbon dioxide, mitigating Ocean acidification. These efforts directly support SDG-14 (Life Below Water) and SDG-13 (Climate Action).

3.3.1.2 Reducing Ocean Pollution Through Citizen-Driven Initiatives

PHAROS empowers communities to actively combat Ocean pollution through innovative programs that transform citizens into stakeholders in sustainability efforts, echoing ICoRSA's vision of public engagement. Two programs were initiated.

The Fisher Guardian's Programme was designed to turn fisheries into stewards of the Ocean, this program trains fishers in best practices, rewards environmentally friendly behaviours, and provides infrastructure to reduce abandoned fishing gear. Over ten demo sites actively engage fishers in pollution reduction, fostering shared ownership of marine conservation.

In addition, Citizen Litter Entrepreneurs were trained to collect, process, and repurpose marine litter into valuable products, PHAROS promotes a zero-waste circular economy while creating economic opportunities for coastal communities. These efforts align with ICoRSA's goals of community empowerment and socio-economic development.

3.3.1.3 Living Labs and Participatory Governance

Central to PHAROS's strategy is the establishment of *Living Labs*, which serve as hubs for participatory governance and collaborative problem-solving. These labs empower local actors to co-design and manage restoration initiatives, fostering a sense of ownership and long-term commitment.

The MINKA Platform is a digital citizen science platform enabling communities to contribute to biodiversity monitoring and environmental data collection. MINKA integrates seamlessly with EU-wide initiatives, such as the Blue School

Network, creating a long-term foundation for local capacity building.

Educational Initiatives such as open-schooling projects connect families, students, and stakeholders to address local marine challenges collaboratively. These efforts align with ICoRSA's focus on education and Ocean Literacy as a means of empowering communities.

3.3.1.4 Invasive Species and Unsustainable Exploitation

PHAROS addresses invasive species with advanced monitoring technologies and demonstrates sustainable practices to reduce the ecological impact of aquaculture and Ocean exploitation. For example, one program engaged in eDNA Monitoring for Invasive Species in Iceland. PHAROS uses advanced eDNA technology to detect and monitor invasive pink salmon, minimizing its impact on biodiversity. This method, which is cost-effective and scalable, serves as a model for managing invasive species in marine ecosystems.

Sustainable Aquaculture Practices, such as trials in Ireland integrate macroalgae with salmon farming to enhance biodiversity, sequester carbon, and improve water quality. These innovative approaches demonstrate how marine resources can be used sustainably while restoring ecosystem balance.

In undertaking the 'Ocean' MUSICA and PHAROS Projects, ICoRSA targets the following UN Sustainable Development Goals (SGDs) in relation to targeting UN agreed 17 SDG's established in 2015 (for more information about the SDGs, see Kennedy 2024 and Kennedy and Cherry, 2023). The following seven UN goals are relevant to Ocean sustainability, community life, education and community engagement with science in respect of the MUSICA and the PHAROS 'Oceans' Project: UN SDG-4: Quality Education; SDG-5: Gender Equality; SDG-11: Sustainable Cities and Communities; SDG-13: Climate Action; SDG-14: Life Below Water and SDG-15: Life on Land**.**

These UN SDGs collectively emphasise the interconnectedness between Ocean sustainability, energy conservation, community well-being, education, and scientific engagement. They also highlight the need for integrated approaches to achieve sustainable development while preserving marine and clean energy resources, fresh water, and promoting inclusive and equitable societies. This is partly what ICoRSA aims to achieve though its community engagement (Quadruple-Helix) theoretical framework, using participatory research methodologies to enhance gender equality, community participation and engagement.

3.4 Empowering Small Islands for Ocean Sustainability

As established above, ICoRSA believes empowering communities for Ocean sustainability is crucial in achieving the UN SDGs, particularly those related to environmental sustainability and community well-being. ICoRSA emphasises the significance of community engagement and stakeholder involvement in marine initiatives as essential components of sustainable development. This perspective aligns especially with SDG-14 (Life Below Water), which aims to conserve and sustainably use the Ocean, seas, and marine resources. By actively involving local communities in marine conservation efforts, ICoRSA promotes SDG-14's targets of reducing marine pollution, protecting marine ecosystems, providing clean energy and water, and enhance marine biodiversity.

ICoRSA's approach also resonates with SDG-11 (Sustainable Cities and Communities) by fostering community resilience and inclusivity in coastal areas. Engaging communities in marine initiatives not only supports sustainable resource management but also contributes to SDG-1 (No Poverty) and SDG-2 (Zero Hunger) through enhancing food security through sustainable fisheries management. The involvement of stakeholders, including local communities, local/Indigenous groups, and non-governmental organisations, ensures that marine conservation efforts are socially inclusive and economically viable, thereby addressing SDG-10 (Reduced Inequalities).

ICoRSA's emphasis on community empowerment and participatory stakeholder involvement (though its research methodologies) in marine initiatives underscores ICoRSA's and MUSICA's commitment to achieving the UN SDGs, particularly SDG-14. By integrating community perspectives and local knowledge into marine conservation strategies, ICoRSA contributes significantly to global efforts toward sustainable development, gender equality, and community engagement in marine resource conservation. It also supports the goals and aspirations of *changing humanity's relationship with the Ocean,* as outlined in the *Vision 2030 Challenge 10 White Paper* (Glithero et al. 2024).

3.5 ICoRSA's Holistic 'Living Labs' Approach to Community Engagement

ICoRSA realises taking a holistic approach to community engagement requires the need for a paradigm shift, where global aspirations are translated into meaningful actions at the grassroots level and are driven by local concerns. Two of the key aspects regarding sustainability of marine environments are community engagement and stakeholder engagement which involve a range of activities and strategies specifically designed to bring together different groups with interested in use and health of the seas. The importance of the community engagement and stakeholder involvement can be reflected through adherence to the following principles:

- Inclusive decision-making: By engaging local communities and stakeholders, we can ensure that the decision process is inclusive and considers diverse perspectives that lead to more effective and rewarding outcomes.
- Enhanced legitimacy: With the development of policies and measures through broad participation of stakeholders it is more likely that these will be accepted and supported by the community, thus enhancing their legitimacy and likelihood of successful implementation.
- Local knowledge: If we do not involve local communities, valuable traditional and experiential knowledge about marine ecosystems can be neglected that could be otherwise used for practices and policies.
- Empowerment and ownership: Empowering communities through their participation in decision-making processes fosters a sense of ownership and responsibility toward marine/seas.

PHAROS employs **Living Labs** as participatory governance tools to empower local actors, including citizens, schools, and industry stakeholders, to co-develop and manage its initiatives. These Living Labs ensure ownership and long-term commitment to the project's outcomes, echoing ICoRSA's emphasis on inclusive governance and local knowledge.

Key examples of PHAROS initiatives include:

- Integrated Multi-Trophic Aquaculture (IMTA) systems in Gran Canaria, restoring nutrient-rich ecosystems while fostering high-value aquaculture.
- Artificial Reef Restoration in the Atlantic basin, combining marine forest and reef arrangements to promote biodiversity.
- Citizen Litter Entrepreneurs Programs, training local stakeholders to collect, repurpose, and valorise marine litter into sustainable business opportunities.
- Fisher Guardians Programs, transforming fisheries from polluters to Ocean stewards by adopting best practices and implementing environmentally friendly solutions.

Each of these initiatives reflects the shared values of ICoRSA and PHAROS: empowering communities, fostering education, and driving sustainable development through innovative practices.

3.6 Identification of Key Stakeholders Involved in Community Marine and Ocean Sustainability

The marine and maritime stakeholders were grouped into different categories. Most often, categorisation followed the Quadruple-Helix model into Academia, Industry, Policy, and the Public. These groups we were subdivided into the following stakeholder groups:

- Local communities: These include local residents living near the coastal areas that depend on marine resources in context of their living and well-being.
- Fisheries and aquaculture sectors: Under this category, we included industries that directly depend on marine resources, including small-scale and commercial fishers.
- Environmental NGOs: All organisations (non-governmental) dedicated to marine conservation and advocacy.
- Government agencies: Include national and local government bodies that are responsible for the creation and implementation of marine policies and regulations.
- Scientific communities: Scientists and researchers that study marine ecosystems and provide evidence-based recommendations pertinent to the sea
- Tourism industry: All businesses and entities that are involved in marine-related tourism activities.
- Indigenous communities: Groups with historical and cultural ties to marine environments.

3.6.1 ICoRSA's Approach to Engaging with Stakeholders and Communities

ICoRSA adapted its engagement strategies based on the stakeholder group to maximize involvement. General approaches included:

- Public Consultations: Organising meetings, workshops, and forums where stakeholders can voice their concerns, share ideas, and provide inputs.
- Collaborative Management: Implementing co-management approaches where local communities and stakeholders share responsibility and decision-making authority with government agencies.
- Educational Programs: Raising awareness and building capacity through education and outreach initiatives focused on marine conservation and sustainable practices.
- Citizen Science: Involving local communities in scientific research and monitoring efforts to gather data and contribute to knowledge about marine environments.
- Stakeholder Advisory Committees: Establishing committees comprising representatives from various stakeholder groups to advise on policy development and implementation.

3.6.1.1 Concerns and Challenges when Engaging Communities and Stakeholders

When engaging with stakeholders/communities, one of the challenges is to ensure that diverse needs of different stakeholder groups are considered and balanced. Stakeholder engagement often requires resource allocation and limited financial or human resources can hinder its effectiveness. When combining different stakeholder groups—especially NGOs and government entities—conflicts may arise. Resolving such conflicts is crucial for successful engagement and collaboration. One of the biggest challenges is creation of long-term commitment throughout the project and beyond, and this can be achieved with ongoing participation of stakeholders in the project itself.

3.7 Stakeholder Engagement Framework (SEF) Based on the MUSICA Project

The Stakeholder Engagement Framework (SEF) was developed as a guide for project partners to adopt stakeholder engagement protocols, ensuring stakeholder reach is meaningful within the MUSICA project.

This SEF promoted stakeholder interaction at every stage of the project, from design and implementation to completion. The MUSICA project had a profound impact on the local community and ensured that residents, businesses, industry, and government were actively involved during every step.

The purpose of this framework outlined the model of engagement, key actions, and approach in accordance with our strategic priorities:

- Bring communities and government together for better collaboration.
- Enable small islands to become independent from the mainland in terms of electricity and fresh water.
- Bring new job posts.
- Support local fisheries.
- Support local tourism.

ICoRSA's strategic approach towards creating more meaningful engagement included:

- Producing a guide to the engagement approach.
- Implementing a five-step model for conducting engagement activities
- Utilizing tools and strategies ensuring fit-for-purpose
- Listing challenges to consider
- Recording Lessons learned

The SEF includes guidance, tools and templates for stakeholder management and support for partners undertaking stakeholder engagement activities.

3.7.1 Stakeholders Involved in the Quadruple-Helix (QH) Framework for Engagement

ICoRSA realised that stakeholder engagement is a highly complex activity and is an ongoing process that builds relationships between parties enabling information exchange. This process allows stakeholder affected by decisions of organisation in question to contribute to the decision-making process. ICoRSA understood that the process of stakeholder engagement is also voluntary, open and involves active dialogue that identifies current position of all parties included, outlines objectives and outcomes, and identifies how to achieve them. Parties that are included in the engagement can change but the process of engagement is continuous. The process of stakeholder engagement is multi-faceted process including:

- Providing information.
- Capacity building to equip communities and stakeholders to effectively engage.
- Listening and responding to community and stakeholder concerns.
- Including communities and stakeholders in relevant decision-making processes.
- Developing goodwill and an understanding of objectives and priorities which will lead to confidence in decisions.
- Establishing a realistic understanding of potential outcomes, and
- Building an understanding of the decision-making process.

For stakeholder engagement to be effective there are some requirements: willingness and motivation of stakeholders to participate (Gunton et al. 2010); inclusivity of all possible interests (Reed, 2008); equal access to information and knowledge (Gunton et al. 2010; Gopnik et al. 2012). Some barriers in the process of engagement can be identified as well such as: participation can be tokenistic (cosmetic) rather than active (Pomeroy

and Douvere 2008; Gopnik et al. 2012; Flannery et al. 2018); unfamiliarity with the processes and activities of the organisation in question; public can have deeply rooted value and belief system (e.g., local fisherman) affecting the trust level in organisation in question (Jentoft and Knol 2014).

The main value of engagement with stakeholders lies in understanding of dialogue dynamics and enabled participation (Luoma-Aho 2015). Generally, engagement is referred as interaction between stakeholders and organisation where interaction influences stakeholder thoughts, actions and emotions toward organisation. The benefits of Quadruple-Helix stakeholder engagement by development of collaborative network are evident through access to knowledge, development of scientific competence, obtaining competitive advantage through acceleration of ideas, but significant challenges still remain how to manage such relationships.

3.8 Principles for Engagement

At ICoRSA, we aspire to build consistent, open and respectful working relationship with our stakeholders through five key principles of engagement. The proposed principles are consistent with current stakeholder engagement standards and practices. Engagement must be: a) purposeful; b) inclusive; c) timely; d) transparent and e) respectful.

3.8.1 Process of Engagement

The process of engagement with stakeholders can be seen as a six-step process (Fig. 3.1). Such structure of engagement process is supported by planning, preparation, action and evaluation of every engagement activity. The process itself is a dynamic, ongoing cycle and can be improved

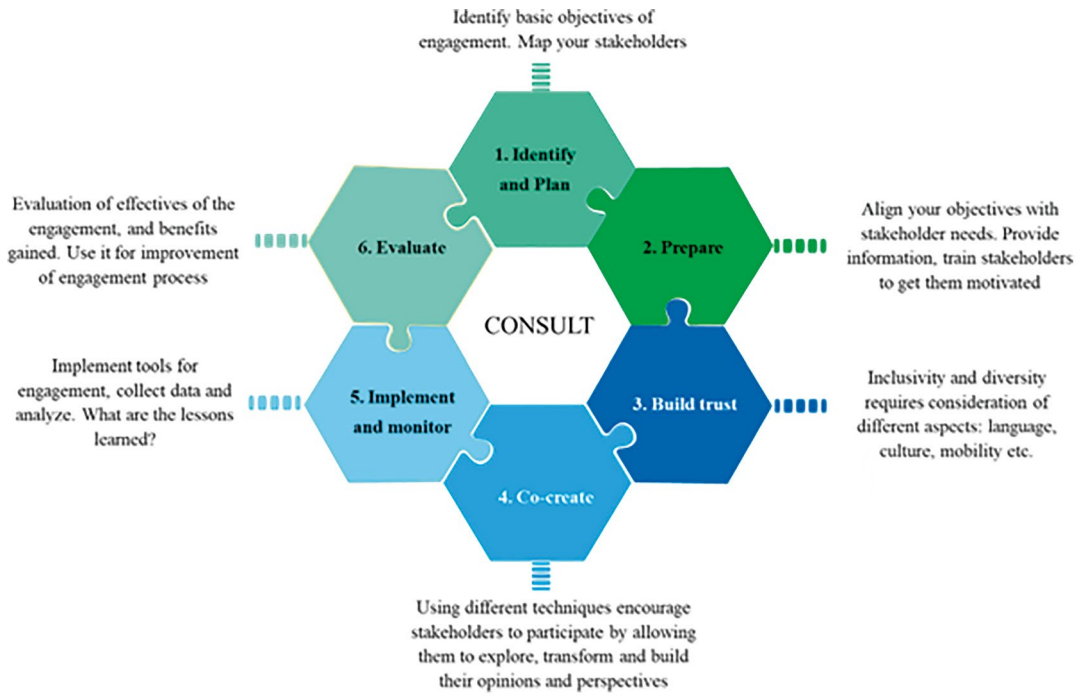


Fig. 3.1 Five-step process of stakeholder engagement (Akhmouch and Clavreul 2016)

over time depending on the needs of stakeholders and objectives of the engagement itself.

3.8.1.1 Inclusive Engagement

Inclusion is one of the core Stakeholder Engagement Principles that guide our engagement; we are committed to work with stakeholders who may be harder to reach for reasons such as language, culture, age, or mobility. Some of the priority stakeholders for inclusion are:

- *Small Islands:* A key success factor will be to expand the capability of all staff to effectively engage island local communities to take account of their opinions and positions during the development of projects outputs. It is essential to possess a strong cultural awareness and appreciation, along with strong engagement skills for developing policies and implementing programs that meet cultural needs. Also, social disadvantages (electricity shortages, water shortages, immigration, lack of jobs etc.) which face local communities are important to understand before closing the gap.
- *Culturally and linguistically diverse communities*: There may be a need to develop an engagement strategy for communicating with these communities to bridge the gap of Indigenous language and other cultural differences. In the engagement process, different stakeholders are included—government, industry, civil society and local people. Cultural aspect will be a strong influencing parameter in the engagement. Methodology on how to bridge these should be considered. ICoRSA actively supports individuals with disabilities, maximizing their involvement and ensuring their full participation as equal citizens in society.

3.8.1.2 Levels of Engagement

There is no one right stakeholder engagement method and one may choose a number of methods at different stages of the process. Thinking about and selecting the most appropriate method of stakeholder engagement and the relevant tools and techniques to facilitate the engagement process can vary according to the situation, time, skills and resources. All engagement methods have their benefits and limitations, and it is important to select the right one and review to ensure the method best fits the particular environment. Table 3.1, adapted from the International Association for Public Participation (IAP2) Spectrum (2007), provides guidance on the various levels of engagement, and our commitment to stakeholders.

Table 3.2 provides an outline of suggested ways in which one can engage stakeholders according to each level of engagement. Our activities across the department are diverse, so it would be expected that engagement will occur at all levels.

At lower levels, it may be determined that engagement simply means ensuring stakeholders are well-informed about our processes and outcomes. At higher levels, this approach shows that for some issues we may seek more direct stakeholder input. The level of approach applied will be determined by the purpose of the engagement, our role and responsibilities, and the issue or issues being considered. Three additional levels of engagement also exist, including Remain Passive, Monitor, and Transact as shown below in Table 3.3. While these can be viewed as not valid engagement; however, they can often be the first steps in a building a relationship with stakeholders that can lead to more interactive and effective engagement.

3.9 Identification of Barriers to Meaningful Engagement

Effective stakeholder engagement requires careful planning to ensure meaningful participation and collaboration. However, various challenges

Table 3.1 Levels of Engagement

Inform	Consult	Involve	Collaborate	Empower
To inform or educate stakeholders in one-way communication, there is no invitation to respond.	To gain information and feedback from stakeholders to inform decisions made internally. Limited two-way communication - ask questions, stakeholder provides answers.	To work directly with stakeholders throughout the process to ensure that issues and concerns are understood and considered. Two-way or multi-way communication where learning takes place on both sides.	To partner with stakeholder and/or stakeholder groups for the development of mutually agreed solutions and joint plan of action. Two-way/multi-way communication where learning, negotiation and decision making occurs on both sides. Stakeholders work together to take action.	To delegate decision-making in the hands of the stakeholders on a particular issue. Stakeholders are enabled and/or equipped to actively contribute to the achievement of outcomes.
We will keep one informed.	We will keep one informed, listen to your concerns, consider your insights, and provide feedback on our decisions.	We will work to ensure that your concerns and issues are directly reflected in alternatives developed and provide feedback on how input influenced the outcome.	We will work together to agree on what we will implement and incorporate your advice and re-commendations into the outcomes to the maximum extent possible.	We will implement what one decides, and we will support and complement your actions.

Table 3.2 Methods of Engagement

	Inform	Consult	Involve	Collaborate	Empower
Methods of engagement	• Fact sheets and websites	• Surveys	• Multi-stakeholder forums	• Reference groups	• Integration of stakeholders into governance structure (e.g. as members or shareholders on particular committees
	• Bulletins and letters	• Focus groups	• Advisory panels	• Joint projects	
	• Corporate documents (annual reports)	• One-on-one meetings	• Consultative committees	• Multi-stakeholder initiatives	
	• Speeches, conference and public presentations	• Public meetings and workshops	• Participatory decision making processes	• Partnerships	
	• Media releases and advertising	• On-line feedback and discussion	• Workshops		

Table 3.3 Methods of Building Stakeholder Relationships

Remain Passive	Monitor	Inform	Transact
There is no goal and no engagement at this level of participation. There is no active communication and there is no relationship. An example of this level could include the stakeholder expressed concern through protest, letters, media, websites etc. or pressure via advocacy efforts	There is one-way communication to monitor the views of stakeholders. There is no relationship. An example of this level could include media and internet tracking or monitoring or a dependency on second hand reports from other stakeholders		To work together in a contractual relationship where one partner directs the objectives and provides funding. There is limited two-way communication – setting and monitoring performance according to the terms of the contract.
			We will provide the resources to enable you to do what we agreed

Table 3.4 Engagement Mitigation Strategies

Potential Issue	Method for Mitigation
Unclear purpose	If the purpose of the engagement is poorly defined, all the activities that follow will be affected, including the identification of stakeholders, determining the methods to be used, and managing stakeholder expectations. One may need to involve stakeholders in defining the purpose of the engagement.
Differing capacity of stakeholders	Stakeholders can sometimes have different levels of skills and experience of engaging with government. This can affect their ability to fully participate in an initiative, as well as the quality of the information they provide. One may need to work with some stakeholders to build their capacity to contribute or offer modified or different models of engagement.
Insufficient skills in the team	Effective stakeholder engagement requires a specific skill set. The absence of the right skills can hinder collaboration across organisational boundaries and make it hard to identify issues and opportunities. This can result in damaged relationships between government and stakeholders, and poor-quality advice and information. During the planning stages, identify skills available and skills required at subsequent stages. Explore options to develop skills and/or engage external expertise.
Unfocused dialogue	Stakeholder engagement can cover a range of issues that are important to stakeholders but may be less so to the initiative. If this happens, it can distract from obtaining relevant input. The engagement plan should be clear on what issues are relevant and how to manage and respond to any ad hoc issues that are raised. Responding to ad hoc issues thoughtfully is important. For example, there may be another area in the department where those issues could be considered further.
Failure to review and evaluate	Without robust review and evaluation, it is difficult to know if the approach is working and whether changes are needed. Failure to review and evaluate also reduces the ability to learn from and improve engagement. The engagement plan should include review points throughout the policy design and implementation, with flexibility to adjust the approach if needed.

can arise that may impede the process. Table 3.4 identifies key barriers to effective engagement and provides strategies for addressing them.

3.10 Public Engagement

ICoRSA addresses the five Pillars, or 'keys' for successful Responsible Research Innovation (RRI) strategies. These include:

- Open Access,
- Gender Equality,
- Ethics/Research Integrity,
- Public Engagement, and
- Science Education.

While each of these 'pillars' must be addressed on its own terms, each element has overlaps and interlinks with the others. Gender is a cross-cutting element that must be integrated into and embedded in the development and implementation of the other pillars. Entrenching gender in Responsible Research and Innovation (RRI) enhances both research processes and outcomes, as well as the research and innovation arena in the widest sense. The twenty-first century has seen an evolution in RRI, often strongly linked to broader societal challenges such as the United Nations Sustainable Development Goals and the European Commission's (EC) Seven Grand Challenges, alongside developments within the research and innovation (R&I) arena itself. The EC has been at the forefront of shaping RRI as a concept, defining it as "an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation." In this evolving landscape, the MUSICA project adopts the EC's five 'pillars' as a framework for RRI while acknowledging that national, institutional, and policy contexts vary widely. As a result, the application of these pillars will inevitably differ across contexts, and certain settings may have pressing RRI needs that are not fully addressed by the existing framework. The five RRI policy keys, as outlined in the *Expert Group Report on RRI* (2015), include core principles: (1) Public Engagement, (2) Science Education, (3) Open Access, (4) Gender Equality, and (5) Ethics/Research Integrity.

ICoRSA designed a Self-Assessment Tool (SAT) (Avellis 2020) for the MUSICA EU projects [https://musica-project.eu/] where the MUSICA partners will pay attention to any potential Responsible Research and Innovation (RRI) issues in MUSICA teams and activities, hence encouraging team-lead reflection and action. It is intended to aid reflexivity, to provide support, and to help each team reflect on and plan for the integration of the RRI dimensions into their team and research. It will also assist in documenting some basic data and documenting how partners are approaching the issue of integrating RRI over the course of the project.

There is a considerable level of RRI expertise within the MUSICA consortium, especially in the partners participating in RRING [rring.eu] and GRRIP [grrip.eu] projects on RRI in ICoRSA. However, given the variety of consortium members and institutional contexts, and the broad expanse of research interests, not all research teams will have members with RRI expertise or training, and not all working environments will be as conducive to integrating RRI across both people and processes as others. The SAT aims to capture the level of RRI expertise that is present within each Work Package team.

The Self-Assessment Tool (SAT) is to be completed by each MUSICA Work Package (WP) Leader and submitted at the end of the first year of the project and every 12 months thereafter. We strongly encouraged them to share and discuss the SAT with all their team members so that it become a tool for discussion, reflection and self-assessment on progressing RRI within their own team rather than simply being paperwork to fill out.

A member of the ICoRSA team provided feedback to each WP Leader on their SAT within an agreed mentoring timeframe. A tutorial in form of a workshop has been implemented and attended by all the WP leaders. One SAT is completed every 12 months by each Work Package Leader of MUSICA project in collaboration with the partners in each Work Package. Subcontracting partners in each Work Package should also collaborate to complete it with the Work Package Leader. The SAT and Protocol are designed with the goal of structuring a process of reflection, self-assessment, learning and planning. Therefore, it is needed to allow adequate time to complete it, including time for finding some information, and related resources, for thinking/reflecting and for the Work Package Leaders to consult with each partner in the Work Package.

Each completed SAT is retained by the WP Leader and made available to all members of the WP team (Avellis 2022).

3.10.1 Findings: Strategies for Success

The following are some strategies that ICoRSA identified to ensure that the stakeholder engagement process was successful in its aims, aspirations and outcomes (Barrett et al. 2016). These are presented in brief:

- Commit to action
- Manage time and resources
- Map stakeholders and get the right stakeholders to the table
- Agree on the rules of engagement
- Plan the engagement and manage expectations
- Ensure a coherent approach across the department
- Use a mixed or fit-for-purpose approach
- Use consistent and appropriate messages
- Act with transparency and accountability
- Learn from others
- Use the information one collects
- Be focussed and flexible
- Listen and be respectful
- Maintain the right to disagree
- And remember, change does not happen overnight!

3.11 PHAROS: A Lighthouse for Ocean Sustainability

A description of the extension of the ICoRSA Stakeholder Engagement Framework (SEF) in the PHAROS Project, '*Bridging Innovation and Community Engagement for Ocean Sustainability*' best describes the impact of this project.

ICoRSA extended and refined its SEF through the PHAROS project, a flagship initiative under the European Union's Ocean Mission to restore marine ecosystems, eliminate Ocean pollution, and create a sustainable, circular blue economy (CORDIS 2022). From 2024–2029, PHAROS aims to bridge the EU's Ocean Mission development and deployment phases, ensuring continuity in addressing critical marine challenges while promoting societal transformation and positive societal impact. The PHAROS project specifically addresses critical challenges in marine conservation, including biodiversity loss, pollution, and the need for sustainable blue economy practices through technical innovations including nature-based solutions, integrated multi-trophic aquaculture, artificial reefs, e-DNA, and innovative technologies to manage marine pollution and develop blue economy resources. PHAROS's objectives align directly with key UN SDGs (United Nations 2015) particularly targeting the following UN SDGs: SDG-14 (Life Below Water); SDG-13 (Climate Action); and SDG-4 (Quality Education).

PHAROS has built an exciting consortium of leaders from highly relevant, innovative and replicable projects and will have high-level collaboration with many Mission Ocean initiatives to leverage lessons learned, tools developed, and networks fostered under the Mission Ocean goals. A key feature for success of the PHAROS stakeholder engagement activities will be its ability to integrate, refine and deploy key stakeholder engagement tools and methodologies.

A key feature for success of the PHAROS stakeholder engagement activities will be its ability to integrate, refine and deploy key stakeholder engagement tools developed under synergistic projects. These approaches are being unified into the PHAROS working methods and activities, based around the four technical Demonstration and five Replication sites in the Atlantic and Artic region. Such initiatives provide tangible examples of how large-scale projects can successfully engage communities while achieving measurable impacts on Ocean sustainability, particularly when in collaboration. The Minka citizen science platform, for example, enables citizen science communities to contribute to biodiversity monitoring and environmental data collection.

Through integration with the EU-wide 'Blue School Network' (ProBleu Project) with PHAROS, its reach will be extended to new students, parents, and educators. This provides previously untapped opportunities for synergistic use and creates a long-term foundation for local capacity building in Ocean Literacy centred around the school community. These efforts resonate with ICoRSA's focus on education as a means of building capacity in marine communities. ICoRSA's stakeholder engagement in PHAROS will centre the empowerment of local communities through applying the SEF developed in MUSICA and advancing its extension, the adapted Living Labs methodology (Robles et al. 2015).

3.11.1 Living Labs and Participatory Governance

Living Labs (LL) are at the core of PHAROS, operating as real-world environments for testing and refining solutions. PHAROS'LLs, will serve as hubs for participatory governance and collaborative problem-solving at each Demonstration and Replication location. These LLs empower local actors to co-design and manage restoration initiatives, fostering a sense of ownership and long-term commitment (Robles et al. 2015), crossing the 'involve', 'collaborate', and 'empower' levels of the Stakeholder Engagement Framework in a transactional relationship between PHAROS researchers, technical actors, and the local communities. The LLs will have full deliberative engagement at all project stages. The LLs will provide practical and grounded experimentation environments for open innovation, co-created by the communities in the regions of operation. These communities will consist of stakeholders under the Quadruple Helix (QH) Model namely: Citizens, Government, Industry, and Academia. Early and committed involvement of all QH groups will ensure stakeholder ownership and long-term commitment to the project's outcomes, echoing ICoRSA's emphasis on inclusive governance and local knowledge.

3.12 Conclusion

ICoRSA believes that stakeholder engagement in the marine and maritime sector, as defined by Akhmouch and Clavreul (2016), is a crucial part of every Ocean Sustainability project with a direct or indirect impact on the local community and a key factor for project success. ICoRSA has learnt through its project MUSICA and now PHAROS. ICoRSA believes that for stakeholder engagement to be effective, it requires preparing a stakeholder engagement strategy and a continuous process of capacity building, with designed and adapted levels of engagement according to the cultural aspects, harnessing existing experience and the key values of the given society we are engaging with. In the context of engaging with the marine and maritime community sector, ICoRSA is of the firm view that it is crucial to include local communities, recreational fishers, traditional owners, non-governmental organisations (as part of non-commercial stakeholders), commercial fishers, tourism, shipping and port operations, military (related to marine), aquaculture and renewable energy sectors (commercial stakeholders), and academia and industry covering all four levels of the aforementioned Quadruple-Helix and now Living Lab (LL) model of stakeholder engagement. In our collective experience, it is only by empowering local communities for Ocean sustainability that the UN SDGs will be met. Within this framework, sustainability projects will be successful, since all stakeholders are encouraged to be engaged in a meaningful, dialectical way, where they also benefit economically and socially from the project. Our Quadruple Helix model, together with the LL model of stakeholder engagement, create a viable framework that can be applied anywhere to achieve potentially similar positive results.

3.12.1 Summary

This chapter highlights key ideas, including:

- Ocean Literacy Strengthens Conservation Efforts. Raising awareness and understanding

of Ocean processes fosters greater stewardship and participation in marine sustainability initiatives.
- Community Engagement is Essential for Marine Sustainability. Local communities and stakeholders play a crucial role in effective Ocean conservation and long-term sustainability.
- Marine Sustainability Aligns with UN SDGs. Addressing Ocean conservation supports multiple Sustainable Development Goals (SDGs), particularly those related to climate action, education, and responsible resource use.
- Community-Driven Initiatives Lead to Impactful Change. Projects like PHAROS and MUSICA demonstrate how citizen engagement, nature-based solutions, and collaborative governance enhance marine sustainability.
- Living Labs and Educational Platforms Enhance Innovation. These frameworks provide practical solutions by integrating local knowledge, scientific research, and policy implementation.
- Strong Policies Require Stakeholder Collaboration. Effective governance for marine sustainability depends on inclusive and participatory decision-making processes.
- A Holistic and Inclusive Approach is key to Sustainability. Addressing environmental challenges requires shared responsibility, cooperative efforts, and inclusive decision-making.
- Responsible Research Innovation (RRI) Enhances Sustainability. ICoRSA's RRI framework, addressing the five Pillars ('keys') in the SAT Assessment Tool, provides a model for ethical, inclusive, and impactful sustainability efforts.

3.12.2 Recommended Resources

The following resources provide further insights and support on this topic:

- MUSICA Project: https://musica-project.eu/
- ICoRSA: https://ICoRSA.org/
- Transforming our World: The 2030 Agenda for Sustainable Development https://sdgs.un.org/2030agenda
- The 17 Sustainable Development Goals: https://sdgs.un.org/goals
- The Global Goals, Goal 14: Life below Water: https://www.globalgoals.org/goals/14-life-below-water/
- United Nations Sustainable Development Goal 14, Conserve and sustainably use the Ocean[s], seas and marine resources for sustainable development: https://www.un.org/sustainabledevelopment/oceans/
- UNESCO Challenge 8 White Paper—Create a digital representation of the Ocean: https://unesdoc.unesco.org/ark:/48223/pf0000390123/

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4 Living Labs: A Catalyst for Ocean Literacy and Sustainable Innovation

Cátia Marques, Ana Cunha, and Zara Teixeira

Abstract

Living Labs (LL) are open-innovation ecosystems that integrate research and innovation processes bringing together multiple knowledge types. This chapter builds on the *Living Science Salt Farm* project, implemented in Central Portugal, to argue that LLs can be powerful Ocean Literacy (OL) enablers. They promote behaviour change towards environmentally sustainable innovations, supporting Ocean Decade outcomes. The project used a participatory process to assess stakeholders' motivation to establish a LL focused on the sustainable exploitation of solar saltwork ecosystems. Stakeholders generally expressed motivation, viewing LLs to improve communication and foster trust through transparent processes. However, this indicates a limited awareness of LLs' full potential. Implementing a LL favouring sustainable saltwork products and services, which collaboratively creates and tests solutions in real-life environments, could be a game changer. From an innovation perspective, it would enhance contributions to various Ocean Decade outcomes. From an OL perspective, it would drive attitude shifts towards management, by promoting actions that effectively bring about policy, institutional and societal changes; and contribute to several dimensions of OL.

Keywords

Ocean Literacy (OL) · Living Labs (LLs) · Collaborative networks · Motivation assessment · Ecosystem services · Participatory approach · Behaviour change · Saltwork systems

4.1 Introduction

Marine and coastal ecosystems are facing unprecedented pressures from human activities, leading to significant degradation and loss of biodiversity

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and ecosystem services, including carbon sequestration potential, coastal protection capability, and recreational opportunities. Addressing these challenges requires solutions that not only restore and protect these ecosystems but also consider the common-goods problem inherent in their management (Muradian 2013). The common-goods problem arises when resources that are accessible to all (common goods) are overexploited and degraded because individuals act in their own self-interest rather than considering the collective good. Managing marine and coastal ecosystems is thus a collective action challenge in which individuals are interconnected in a way that pursuing individual interests in the short term leads to suboptimal outcomes for the group. This requires coordination across social groups, even when their interests diverge and require alignment across various scales and decision centres (Lubell et al. 2021). In this context, sustainable socio-economic development should be conceived through incentives for collective action rather than through market solutions for the resolution of environmental externalities (Muradian 2013).

Coordination across social groups has been addressed through non-hierarchical processes, such as participatory decision-making and co-governance. One advantage of these approaches is the possibility of engaging communities with strong cultural connections to the Ocean, such as coastal communities. Cultural connections to the Ocean refer to the knowledge, actions and relationships that people have with the Ocean space. Engaging these communities fosters intrinsic motivation and leads to more persistent behaviour, as solutions are driven by internal goals and outcomes (Albarracín et al. 2024). Other advantages of coordinated decisions are the opportunities created for co-design, co-development and co-production of knowledge. Bringing together a multitude of interested parties, from science to decision-making, to local communities, increases the potential for innovation guided by pro-Ocean behaviour.

Innovation is key to addressing the challenges facing marine and coastal ecosystems and overcoming the common-goods problem. By developing innovative restoration techniques, implementing effective policy frameworks, and creating economic incentives, we can promote the sustainable management of these vital ecosystems. Innovation driven by collaborative processes, such as those intrinsic to Living Labs (LLs), has a higher probability of success in delivering effective sustainable solutions. LLs are open innovation networks based on voluntary collaboration, where each participant holds a similar role and relevance. They serve as creative social spaces for designing and experiencing the communities (Borda et al. 2024).

This chapter explores the role of Living Labs as catalysts for action and pro-Ocean behaviour change, positioning them as potential Ocean Literacy (OL) tools within the blue economy. It begins by examining the characteristics of Living Labs and their potential for Ocean sustainability. The chapter then presents a case study of the *Living Science Salt Farm* project in Central Portugal. This initiative assessed the motivation of a wide diversity of stakeholders to establish a Living Lab capable of promoting the development of sustainable innovations in solar saltwork ecosystems. Building on the project's results, the chapter concludes by discussing the potential of Living Labs as OL Tools.

4.2 Living Labs as a Framework for Ocean Sustainability

4.2.1 Understanding Living Labs

A Living Lab (LL) is a user-oriented, open-innovation ecosystem where academia, industry, government and civil society collaborate to develop concepts, design, produce, and test new products and services. LLs are expected to better address citizens' needs and wants and promote the co-creation of value to benefit the

economy, society and the environment (Compagnucci et al. 2021). An open-innovation environment means that LLs provide facilities for users and developers to innovate, co-design, and create solutions for real problems, whether they are specific contexts or broad challenges, with an open research direction. LLs adhere to a co-creation philosophy that fosters user participation in all stages of the development lifecycle, promoting collaboration among users and providing a meeting place for actors with complementary knowledge assets. This means that LLs are deeply interoperable, allowing one system to communicate with other parts. Another characteristic of LLs is that they evaluate solutions as close as possible to real environments, although a mix of controlled technology lab and everyday life situations can occur. Lastly, LLs assume that all stakeholders are important and that a trust relationship and a shared vision between stakeholders must be maintained to ensure that everyone understands the scope of the projects, their respective roles, and activities (Vale et al. 2018). Due to these characteristics, LLs are one of the most promising approaches to tackle the three dimensions of sustainability: social, economic and environmental.

LLs face several challenges, including governance and management, economic sustainability, context-related issues (geographic, sectorial and institutional), approaches for collaborative work, and role of research, among others (Bouwma et al. 2022; Compagnucci et al. 2021). Given the complexity of having multiple stakeholders with different (and sometimes opposing) agendas and interests, managing the expectation-implementation gap, motivation, and sustaining collaborations are among the biggest challenges (Nguyen and Marques 2022). To address these challenges, it is essential to find the best approach to involve stakeholders in each phase. Six main levels of engagement can be fostered: No engagement, symbolic engagement, engagement by advice, engagement by weak control, engagement by doing and engagement by strong control (Andhini 2017). From an Ocean Literacy perspective, engagement by strong control, when stakeholders have decision-making power over the solution development process and the outcome, is the level of engagement that might make the most difference. This level holds the highest probability of behaviour change as a result of social-structural determinants of behaviour, such as trustworthiness and injunctive norms (Albarracín et al. 2024). For the same reason, it may have the greatest potential to harness stakeholders' motivation for participating in a Living Lab.

4.2.2 Living Labs for Sustainable Innovations

A sustainable lifestyle means understanding how our choices impact the world around us and finding ways for everyone to live better and lighter. This includes considering how innovations can be better harnessed for sustainability, which is crucial for supporting the implementation of the Sustainable Development Goals (Compagnucci et al. 2021). LLs provide a flexible and inclusive framework for addressing the need for sustainable practices and stakeholders' coordination. Several characteristics of LLs support this endeavour.

- LLs test and validate new technologies and practices under actual conditions, ensuring that solutions are theoretically sound, practical and effective in real-world settings. This approach allows for scaling impact on human wellbeing (Borda et al. 2024). For example, LL can aid decision-making in the face of climate uncertainty and address climate adaptation barriers (Tiwari et al. 2022).
- LLs facilitate continuous monitoring and adaptive management of conservation initiatives, allowing for timely adjustments based on real-time data and feedback. This dynamic approach is crucial for addressing the complex and evolving challenges of coastal conservation (Shirk et al. 2023).
- LLs provide a meeting space for the co-development of innovative sustainable solutions that balance economic growth with

environmental protection (Bouwma et al. 2022). For example, LLs can support the management of coastal areas by integrating data from decision-makers and stakeholders, promoting a shared vision of growth and innovation at the community level (Anton et al. 2022).

- LLs leverage the diverse expertise of stakeholders, foster knowledge exchange and capacity building, and promote the dissemination of best practices, enhancing the creativity and effectiveness of the solutions developed. This collaborative learning process is essential for scaling up successful initiatives and achieving broader sustainability goals (Compagnucci et al. 2021).
- LLs actively engage local communities and provide a platform for integrating traditional knowledge with scientific research, creating all-inclusive and context-specific conservation strategies. Engagement fosters a sense of ownership and responsibility among community members, leading to more effective and sustainable conservation outcomes (Bouwma et al. 2022). For example, within a LL, local knowledge integration can help reduce local vulnerabilities to natural disasters (Wamsler et al. 2020) and ensure that knowledge gathered through nature-based scientific research remains a part of community-developed Indigenous knowledge systems (Porri et al. 2023).
- LLs create a neutral space where stakeholders can build trust and establish partnerships based on mutual interests and shared goals. This trustworthy collaborative environment allows stakeholders to share their knowledge and resources more freely, enhancing communication and the pooling of resources (Mackenzie et al. 2019).
- LLs facilitate dialogue among stakeholders from different sectors and disciplines, promoting understanding of the challenges and opportunities in Ocean services and coastal conservation. This approach is essential for developing comprehensive and integrated solutions, and scaling up to interdisciplinary, multidisciplinary and transdisciplinary solutions (Rölfer et al. 2021).
- Living Labs hold significant potential in supporting sustainable practices related to Ocean services and coastal conservation. By fostering sustainable practices, engaging local communities, and promoting collaborative networks, LLs can enhance understanding of the Human-Ocean relationship and drive positive change. As we continue to face the challenges of environmental degradation and climate change, LLs offer a promising path forward.

4.3 Case Study: *Living Science Salt Farm*

4.3.1 The Living Science Salt Farm Project and Participatory Process

The *Living Science Salt Farm - Cooperation, safeguarding and innovation* was a project active between 2020 and May 2024, led by the Municipality of Figueira da Foz, in Central Portugal. One of its main purposes was to determine whether local, regional and national stakeholders were willing to join a Living Lab aimed at fostering innovations focused on the exploitation of solar saltwork ecosystems, while preventing their degradation, and promoting their conservation or restoration.

Solar saltwork systems are specialized facilities, in use for centuries, designed to produce salt by evaporating seawater using solar and wind energy. Although being an anthropogenic biome, they are in equilibrium with coastal environments providing a great diversity of Ecosystem Services, such as water purification, flood and erosion control and recreative areas. In Portugal, after the peak of salt production, in the 60s and 70s, this artisanal activity was gradually abandoned putting at risk the ecosystem services they provide, as well as its cultural and historic heritage. Currently, it is mostly a familiar activity, with an aged workforce, low awareness of salt added-value products, and in constant conflict with aquaculture farmers, which have taken up some of the abandoned saltworks. To counteract the abandonment trends, it is crucial to support the

community towards sustainable innovation, as a means to increase income and attractiveness to new investors and visitors, while protecting its surrounding natural environment. This can only be done by involving a wide diversity of stakeholders, including decision-makers, salt producers, aquaculture farmers, tourism entrepreneurs and researchers.

To support this endeavour, the project first interviewed 60 stakeholders from all artisanal solar salt production systems in Portugal. The semi-structured interviews allowed us to gain their trust and have a first glimpse on their relationship with the ecosystem and the degree of collaborations within and among types of stakeholders. From this group, 25 stakeholders were selected and involved in a participatory process to further explore stakeholders' cultural connections, perceptions of human-ecosystem interactions, and motivations to create a LL. The participatory approach combined pre- and post-surveys with a focus group workshop, following these five steps:

1. Selection of stakeholders based on their knowledge and experience, ensuring representation of relevant social groups: salt producers (6), aquaculture farmers (5), halophyte producers (2), local and national administration (6), tourism entrepreneurs (3), academia (3), and geographic areas (5 out of 6 solar artisanal salt-production areas).
2. First round of anonymous survey to assess stakeholders' motivation to participate in a LL and their understanding of LL.
3. Workshop with stakeholder groups, divided into three phases:
   (a) Individual reflection about "what I most like about saltwork environments"
   (b) Presentations followed by discussion about:
      (i) international trends in the development of coastal and marine innovations focused on the conservation of the natural world. It included information from a previously held systematic review (Marques and Teixeira 2021). Examples of types of innovations presented: biotechnology to tackle pollution, governance for inclusive growth, aquaculture to tackle biodiversity loss, and fisheries to tackle food shortages.
      (ii) involvement of national stakeholders in the implementation of sustainable innovations in Portuguese solar saltwork systems (information retrieved from semi-structured interviews);
      (iii) ecosystem services provided by solar saltwork systems, their current state, future trends, relationship with human activities, and potential for economic development (information from semi-structured interviews and Caro et al. (2020);
   (c) Definition and characterisation of LLs.
4. Second round of anonymous survey to assess stakeholders' motivation to participate in a LL and their understanding of LL pre- and post-surveys allow evaluating the immediate impact of the workshop on participants.
5. Compilation of survey responses and focus group discussions, highlighting stakeholders' perceptions and motivation.

Surveys followed the Intrinsic Motivation Inventory (IMI) approach, rooted in the Self-Determination Theory (Albarracín et al. 2024), for which a 5-point unipolar Likert scale was used. The survey included twenty-four statements divided by four main questions:

1. "To me, a Living Lab can be useful to…"
2. "How international projects can influence me?"
3. "How national projects can influence me?"
4. "How can the interaction with the natural world influence me?"

Using the IMI approach relies on the assumption that information may diffuse through society (Young 2009), and motivate new approaches. Information about international trends should act as a contagion model, through which people tend to adopt procedures that have already been adopted. Information about stakeholders'

involvement in the implementation of innovations in Portuguese solar saltwork systems should act as a social influence model, through which people tend to adopt procedures which have already been adopted by a large enough group. Information about ecosystem services (interaction with the natural world) should act as a social learning diffusion model, through which people tend to adopt procedures for which they have seen enough empirical evidence to convince them that the procedure is worth adopting (Young 2009).

Data analysis of survey results comprised a non-parametric Wilcoxon Signed Rank Test, suitable for small samples, using R software (package rstatix). We tested for the null hypothesis (H_0) that "There is no difference between the pre- and post-surveys", considering a p-value = 0.05. Stakeholders' discussions during the workshop supported the interpretation of survey results.

4.3.2 Understanding Stakeholders' Perceptions

Stakeholders demonstrate an awareness of the value of saltwork environments, indicating a cultural connection with these ecosystems. When asked, "What do I like most about these saltwork environments" their knowledge and relationship with these ecosystems are revealed through six categories: *natural environment*, *cultural environment*, *products & services*, *uniqueness*, *interconnectedness*, and *feelings* (Fig. 4.1).

The *natural environment* category had the most word items, with mentions from 15 out of 25 stakeholders. Highlighted by expressions such as "biodiversity" and "nature", it indicates that the intrinsic natural value of these systems is recognised. This perception is confirmed by the high levels of agreement ("Totally Agree"), in both pre- and post-surveys, concerning the statement "It is important to me to know that my activity contributes to [environmental] sustainability" (Fig. 4.2).

Notice however that the statements 2 and 3 from Fig. 4.2—"It is important to me to know that my activity contributes to sustainability and "It is important to know if my activity has negative impacts on the ecosystem so that I can improve my activity and/or functions"—have lower levels of agreement (less stakeholders "Totally Agree") after the intervention (Fig. 4.2). Although not statistically significant (p-value>0.005), these results appear somewhat contradictory, as increased awareness of impacts should, in principle, contribute to identifying solutions that minimise the impacts of their activity. Given the small sample size, future work could delve deeper into possible explanations.

Despite this apparent contradiction, the second category with the most word items was *products&services*, with expressions related to all three main types of ecosystem services: provisioning (e.g., "associated products"), regulating (e.g., "protection from climate change"), and cultural (e.g., "well-being"), associating them with benefits to humans such as "economy" and "opportunity" (Fig. 4.1.). This shows that stakeholders are aware that humans retrieve benefits from these natural environments, and thus that they are somewhat aware of this binomial relationship.

Additionally, stakeholders associated expressions related to *cultural environment*, *feelings* and *interconnectedness* with what they most like about saltwork environments (Fig. 4.1.). The *cultural environment* category demonstrates that stakeholders recognise the relevant social role of these man-made ecosystems (e.g. "Tradition", "History"). The *feelings* category reveals they have an emotional connection with saltwork environments (e.g. "brilliance", "Salty Passion"). The *Interconnectedness* category demonstrates that stakeholders recognise the strength of these ecosystems arises from balanced relationships among the social, economic, cultural, and environmental dimensions (e.g. "Complementarity", "Coexistence"). This was confirmed by workshop discussions, during which stakeholders recognised several of the environmental challenges presented by the workshop facilitators and showed a somewhat deep understanding of the interrelationships between their activities and the positive or negative impacts on the environment



Fig. 4.1 Word cloud following the question "What do I like most about these saltwork environments". Colours reveal the six main categories found after content analysis: dark green—natural environment, orange—cultural environment, purple—products & services, light green—uniqueness, yellow—interconnectedness, and pink—feelings. Word size represents the word frequency mentioned by workshop participants

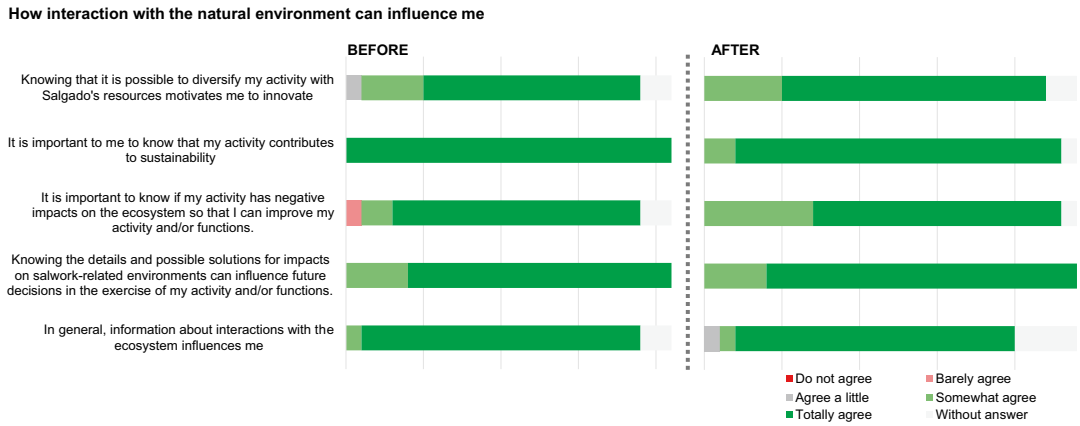


Fig. 4.2 Pre- (before the workshop) and post-survey (after) results to statements within the group "How interaction with the natural environment can influence me"

and the feedback on the social, cultural and economic dimensions.

These findings help understand how stakeholders approach the broad sustainability of these ecosystems and is a valuable starting point to understand whether stakeholders place business performance in the centre of their goals (category *Ecosystem Services*) or if they are willing to value stakeholders' relationships and cooperation (category "Interconnectedness") for business success. In other words, it helps us understand whether we are dealing more with barriers or

motivators to pro-Ocean behaviour change. It also serves as a starting point to determine if they recognise the social and environmental responsibilities (categories *cultural* and *natural environments*) of their professional activities in addition to economic value creation (category *Ecosystem Services*) (Tapaninaho and Kujala 2019).

The above information guides us in assessing the potential success of the proposed LL. We believe it will be successful, given the already evident cultural connection. However, are stakeholders genuinely motivated to create one, considering the many challenges involved? When directly asked "I feel motivated to join a Living Lab", stakeholders showed positive motivation even before participating in the workshop and receiving detailed information about the characteristics of Living Labs. The answers ranged from "Agree a little" to "Totally agree" (Fig. 4.3).

Although a slight increase in motivation was seen in post-surveys—the "Agree a little" answers disappear" (Fig. 4.3) -, generally, the opinions remained the same, with non-significant (p-value>0.05) differences between pre- and post-surveys. Equivalent trends occur for all survey statements, with overall opinions hardly changing in all four groups of statements. We cannot conclude that the population median differs from the hypothetical median (p-value>0.05; 3 statements out of 21 have median = 4 |"Somewhat agree" in the pre-survey, and median = 5|"Totally agree" in the post-survey. The remaining show median = 5|"Totally agree" both in the pre- and post-survey) (Fig. 4.4).

These results were unexpected, but stakeholders' feedback during the workshop provided valuable insights. Producers and entrepreneurs from saltwork environments feel neglected by local and national administrations and unanimously claim that effective communication channels are essential to facilitate inter-institutional relations and support the socio-economic development of these ecosystems. Consequently, even before the workshop they believed that an approach fostering dialogue among stakeholders from different groups, such as the LL, was most necessary. This perspective might explain the high levels of agreement ("Totally agree") for the statements 7 and 8 from Fig. 4.3—"A Living Lab can be useful to… create a community with which I can communicate more easily" and "A Living Lab can be useful to… act as a community to solve problems" -, both before and after the workshop (Fig. 4.3).

When confronted with the statement "A Living Lab can be useful to… learn from key players in other sectors of activity", agreement levels increased after the workshop (statement 1 from Fig. 4.3). However, this trend was not observed when asked about "How international projects influence their activity" (Fig. 4.5).

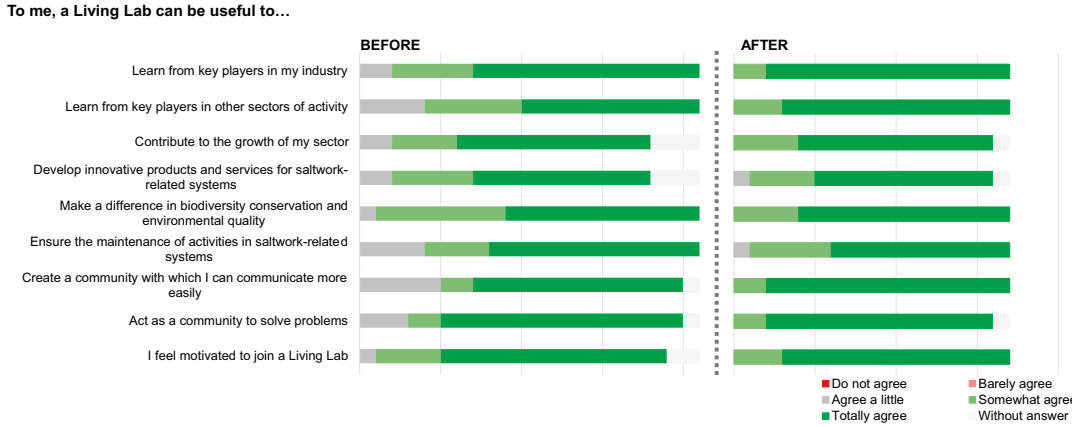


Fig. 4.3 Pre- (before) and post-survey (after) results to statements within the group "To me, a Living Lab can be useful to"

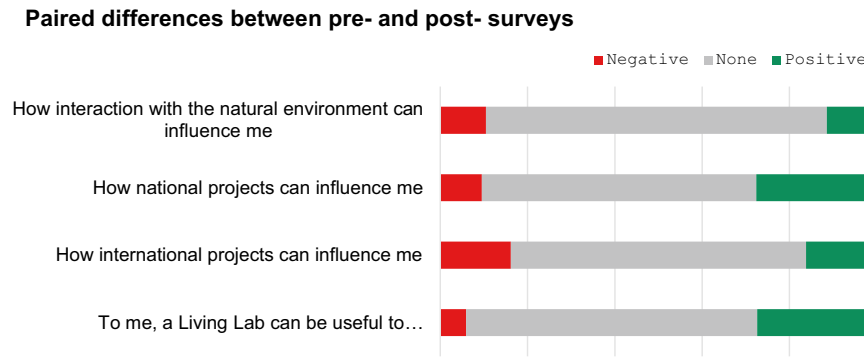


Fig. 4.4 Paired differences between pre- and post-survey results within all four groups of statements: "To me, a Living Lab can be useful to...", "How international projects can influence me", "How national projects can influence me" and "How interaction with the natural environment can influence me". Negative differences correspond to the percentage of statements to which the level of agreement decreased after the workshop. Positive differences correspond to the percentage of statements to which the level of agreement increased after the workshop. None corresponds to the percentage of statements to which there were no differences between the level of agreement before and after the workshop

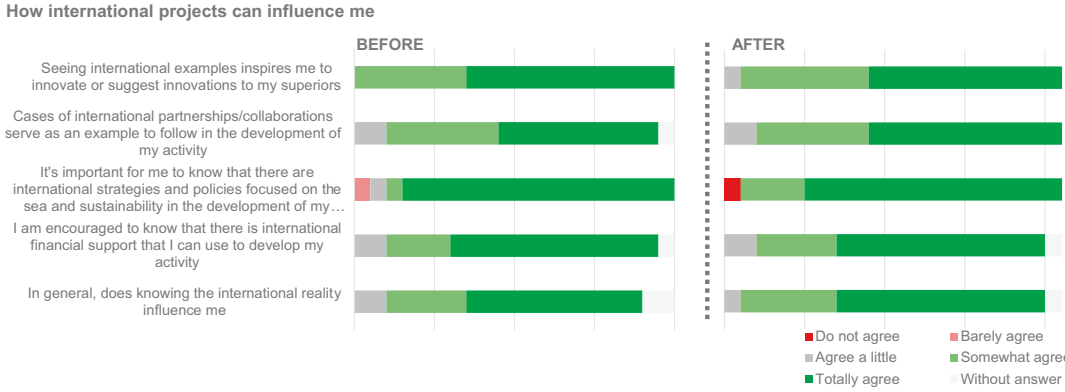


Fig. 4.5 Pre- (before) and post-survey (after) results to statements within the group "How international projects can influence me"

During the workshop, most international examples exposed were from sectors of activity unrelated to saltwork systems, despite being in coastal areas. Examples of international innovations presented include: bio-based ropes for mussel production; co-management processes; global network of algae producers; sea cucumber production. Stakeholders provided oral feedback indicating that the information provided was not very helpful. The exception was the statement regarding the impact of international strategies and policies on their activity, which received the highest level of "Totally agree" responses (statement 3 from Fig. 4.5). The reaction of stakeholders to examples from other sectors of activity may suggest that they are focused on solving their own problems without considering the value of interdisciplinarity and potential co-design. This is despite showing excitement about several innovation examples during presentations and discussions. Because one of the strengths of Living Labs is their ability to leverage the diverse expertise of stakeholders and promote a holistic understanding of the challenges and opportunities in Ocean services and coastal conservation through dialogue, in the future, more attention

should be paid to how stakeholders can learn from each other and collaborate to effectively innovate and address environmental challenges.

Conversely, the level of agreement with the statement "A Living Lab can be useful to… learn from key players in my industry" (statement 2 from Fig. 4.3) aligns with the levels of agreement for the statements within the group "How national projects can influence me" (Fig. 4.6). In both cases, the levels of agreement increased, which might be related to the fact that during the workshop, the national examples provided were saltwork environment activities. Workshop discussions support this conclusion, as stakeholders showed high interest in learning from others. This aligns with the earlier observation that stakeholders are primarily focused on the specific challenges of activities in saltwork systems. While this focus is expected and relevant, it can be a limiting factor for innovation and co-design if stakeholders refrain from engaging in true collaborative actions built upon interdisciplinary knowledge.

The answers to the groups' statements "How international / national projects can influence me" are relevant because they guide us on what stakeholders would value more once a LL is established. Understanding strategies, policies and collaborations among national stakeholders are top priorities. Discussions around these issues were very active during the workshop. Private entities raised concerns about misalignment between their activity and current decision-making processes and management rules, while public administration attempted to justify some and acknowledged the misfit of others. These discussions also highlight that much work remains to clearly demonstrate the true value and ultimate goal of a LL, which is to collaboratively create, innovate and test in real-life environments. And in the case of a LL in the scope of the *Living Science Salt Farm* project, to demonstrate the true value in delivering collaborative, sustainable and innovative products and services for the effective socio-economic development of solar saltwork ecosystems.

4.4 Living Labs as Ocean Literacy Tools

4.4.1 Living Labs as Enablers of Ocean Literacy

In the *Living Science Salt Farm* case study, stakeholders from saltwork ecosystems appear to possess deep knowledge and a strong connection with these ecosystems. From an Ocean Literacy perspective, where behaviour change is the ultimate goal, one of the main advantages of a LL favouring sustainable saltwork products and services may lie in its collaborative network that can potentially induce policy and institutional changes in favour of Ocean conservation. The effectiveness of the LL as an enabler of OL will depend on its ability to manage these collaborative networks in the following areas: community engagement, providing real-world and hands-on



Fig. 4.6 Pre- (before) and post-survey (after) results to statements within the group "How national projects can influence me"

experiences, integrating interdisciplinary approaches, leveraging knowledge sharing and communication, and bridging the gap between science, policy, and education.

Community engagement is essential for promoting pro-Ocean behaviour, as it empowers individuals to take ownership of their local marine environments. Studies have demonstrated that community-based conservation initiatives can lead to significant improvements in environmental outcomes and increase community members' willingness to engage in pro-environmental behaviours (Stoll-Kleemann 2019). Our research has shown that there is already an emotional connection with saltwork environments, as in many other coastal communities. A LL would have the ability to strengthen, or promote, a connection of local communities to the Ocean, by aligning a community-based approach with existing cultural values and norms. For example, involving local leaders in conservation initiatives can help normalise sustainable practices within the community.

Experiencing the direct impact of human actions on marine and coastal ecosystems enhances our understanding of the inextricable connection between the Ocean and humans (OL Principle 6). LLs foster participation in real-world challenges, reinforcing the importance of sustainable practices (Compagnucci et al. 2021) and the understanding of our influence on the Ocean. Our research has shown that stakeholders in saltwork environments, despite understanding the relationship between activity and natural ecosystems, have yet to fully understand their role in mitigating these impacts and the effects on, and of, their own business fields. LL could provide a means to achieve this understanding and contribute to Ocean Decade outcomes such as *a clean Ocean*, *a healthy and resilient Ocean*, *a productive Ocean*, and *a predicted Ocean*. This could be accomplished by exploring innovative approaches based on financial incentives and access to resources, such as payment for ecosystem services, reputation-based incentives and eco-certification programs. By demonstrating the economic benefits of sustainable practices, LLs can motivate individuals and businesses to adopt environmentally friendly behaviours.

Additionally, initiatives implemented in the context of LL often involve hands-on activities, providing an experiential learning approach crucial for fostering a deep understanding of oceanic processes and the importance of marine conservation. Research has shown that hands-on learning can significantly enhance environmental awareness and promote pro-environmental behaviours (Stoll-Kleemann 2019). By involving participants in activities such as monitoring water quality, restoring habitats, and studying marine biodiversity, LLs help individuals develop a personal connection to the Ocean, which is a key driver of behaviour change (Stoll-Kleemann 2019).

Interdisciplinary approaches help participants appreciate the interconnectedness of Ocean systems and human activities. Understanding these connections is essential for developing sustainable Ocean management strategies. For example, integrating social science research into LLs can provide insights into the social and cultural factors that influence behaviour, enabling the development of more effective strategies for promoting sustainable practices (Stoll-Kleemann 2019). LLs can significantly contribute to increase transdisciplinary collaborative practices, enabling effective co-design, co-development, and co-production of knowledge for pro-Ocean behaviour change (Glithero et al. 2024).

The synergy among scientists, policymakers, educators, and the public ensures that scientific knowledge is translated into actionable policies, management strategies and educational programs. In a collaborative environment, LLs may set the scene for knowledge exchange and for open and equitable access to data, information and technology, aligning with the Ocean Decade outcome *An accessible Ocean*. Making scientific data and processes more accessible and understandable to the public can demystify scientific processes and encourage public interest in marine science and Ocean stewardship.

Additionally, LLs can adopt a vision of data collection and sharing, through technologies and citizen science platforms, contributing to the

increase of knowledge and open data, and ensuring Ocean observing systems deliver information to all. Synergies among stakeholders also provide a platform for raising awareness and educating about the importance of Ocean conservation and sustainable practices. They also serve as a platform to document and share success stories, inspiring others to adopt similar approaches. These stories are powerful tools for advocacy and knowledge dissemination.

Our approach provided a glimpse on how through workshops, seminars, and public outreach activities, LLs can foster a deeper appreciation of the Ocean's value and the need for its protection, creating a supportive environment for pro-Ocean behaviour. Additionally, collaboration with policymakers and institutions can help create an enabling environment for pro-Ocean behaviour change at the political and institutional levels. LLs can advocate for policies that promote marine conservation and sustainable practices, ensuring that individual actions are supported by broader systemic changes.

The features above demonstrate the multifaceted approach of LLs that addresses both internal and external factors. Internal factors include emotional connections, knowledge and awareness, while external factors encompass sociocultural, economic, and political contexts.

4.4.2 The Power of Living Labs as OL Tools

When established to harness the potential of Ocean products and services, LLs can serve as a robust platform to better understand the Human-Ocean relationship, share local knowledge and co-develop innovative sustainable solutions with positive effects on aquatic ecosystems. By doing so, LLs become enablers to action and pro-behaviour change, supporting the achievement of Ocean Decade challenges and outcomes, in particular Ocean Decade Challenge 10 (Glithero et al. 2024). Additionally, the power of LLs as OL tools comes from their ability to contribute to the evolution and better understanding of the OL concept (McKinley et al. 2023). In particular, LLs have the ability to:

- Address multiple knowledge types: by including local and Indigenous knowledge.
- Increase awareness: by engaging participants in real-world settings, allowing awareness of solutions and actions to be taken.
- Drive attitude shifts: by adapting the design, delivery and implementation of initiatives.
- Encourage behaviour change: encouraging institutional and systemic change.
- Foster activism: by offering opportunities and capacity to participate in Ocean activism.
- Improve communication: by supporting the use of trustable sources of information about Ocean issues; by improving personal and institutional communication; and by using meaningful communication that resonates with LLs participants.
- Strengthen emotional connections: by sharing stories and providing immersive experiences.
- Diversify access and experience: by providing new and innovative experiences that do not rely on direct access to marine and coastal ecosystems.
- Enhance adaptive capacity: by equipping participants with the skills and knowledge needed to respond to changing environmental conditions.
- Increase trust and transparency: by involving participants in the research process, sharing data openly, and demonstrating the impact of their actions on marine ecosystems.

4.5 Conclusion

Living Labs (LLs) provide a practical framework for addressing the challenges of sustainable development in marine and coastal ecosystems. By bringing together diverse stakeholders and promoting collaboration, LLs enable the creation of innovative solutions that respond to real-world environmental, social, and economic needs. Using the Living Science Salt Farm project as an example, this chapter has shown LLs, through participatory processes and interdisciplinary approaches, can support Ocean Literacy and drive pro-Ocean behaviour change. LLs have the capacity to foster sustainable practices, influence policy, and bridge the gap between cultural values

and ecological conservation, offering a promising path for socio-economic development aligned with Ocean conservation goals.

4.5.1 Summary

Key concepts explored in this chapter include:

- Living Labs (LL) are collaborative open-innovation ecosystems.
- Portuguese stakeholders' express motivation to establish a LL to foster innovations focused on the sustainable exploitation of solar saltwork ecosystems.
- Stakeholders aren't yet fully aware of an LLs' potential, mainly valuing communication improvements and increased trust.
- An LL focused on solar saltwork ecosystems would drive an attitude shift, bringing about policy, institutional and societal changes.
- Effectiveness of LLs as enablers of OL stems from their ability to engage communities, provide real-world and hands-on experiences, integrate interdisciplinary approaches, leverage knowledge sharing and communication, and bridge the gap between science, policy, and education.
- LLs can be powerful OL tools by promoting behaviour change in favour of environmentally sustainable innovations, supporting Ocean Decade outcomes.

4.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

- European Network of Living Labs. https://enoll.org/
- Research Topic at Frontiers in Public Health: https://www.frontiersin.org/research-topics/20968/living-labs-and-open-innovation-approaches-to-scale-impact-for-human-wellbeing/magazine

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Cátia Marques is an Environmental Engineer with deep knowledge of artisanal saltworks ecosystems. She contributed to the official spatial registry of aquaculture and saltpan establishments in the Centre Region of Portugal, as well as to the application of the Salt of Figueira da Foz for inclusion in the UNESCO Intangible Cultural Heritage. As a researcher at MARE, she supported the development of strategic guidelines for ecotourism based on the Ecosystem Services approach. She is currently a PhD Student focusing on the potential of the Ecosystem Services concept to inform the creation of Living Labs for sustainable coastal development.



Ana Cunha is a graduate of Marine Sciences who brings her expertise to stakeholder engagement and Ocean Literacy initiatives. As a researcher at MARE, affiliated with the University of Coimbra, she actively collaborates on Ocean Literacy research projects. Her work involves defining programs and implementing them, with a focus on engaging young students and families. Ana was a key contributor to the Living Science Salt Farm project, where she took responsibility for planning and implementing participatory activities within the initiative. In parallel, she is a PhD student in Geology focusing on the effects of climate change and human actions on wetlands.



Zara Teixeira, PhD, is a multidisciplinary researcher whose work focuses on Environmental Geography and Stewardship with extensive experience as an Ocean Literacy (OL) practitioner and researcher. She has (co-) coordinated OL research projects and facilitated a variety of OL initiatives, including training and mentoring school projects, while actively engaging with stakeholders, mainly from educational communities and coastal local businesses. She has played an active role in the Portuguese Ocean Literacy and Science Communication communities, serving on working groups, scientific committees, and overseeing dissemination and communication actions as a Board member of MARE – Marine and Environmental Sciences Centre and ARNET – Aquatic Research Network.

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5 Ocean Literacy Beyond Borders. Engaging the Private and the Public Sectors on Ocean Literacy Initiatives to Accelerate the 2030 Agenda: "The Leaders We Need for the Ocean We Want"

Patricia Furtado de Mendonça

Abstract

This chapter explores a largely untapped opportunity for Ocean Literacy (OL) professionals: engaging public and private sector leaders—particularly decision-makers—to integrate Ocean knowledge into sustainability and ESG strategies. Recognizing the Ocean's pivotal role in climate regulation, energy transition, biodiversity regeneration, food security, and economic stability is essential for advancing a sustainable, resilient, and safe future. While OL has traditionally focused on education and youth engagement, its scope must expand to influence corporate leadership, policymakers, and industry stakeholders, embedding Ocean sustainability into business operations and public governance. By integrating Ocean science and addressing Ocean-related risks and opportunities, OL can inform decision-making to drive and scale systemic change across sectors. Achieving this transformation requires the co-design of innovative initiatives between OL professionals and stakeholders from both sectors. Only through the development of tailored content can OL be effectively integrated into corporate strategies and public policies, aligning with the UN Ocean Decade challenges and the 2030 Agenda to foster a long-term, cross-sectoral commitment to Ocean stewardship. As a perspective piece, this chapter offers insights, critical reflections, and strategic recommendations to stimulate dialogue and inspire further research in this evolving field.

Keywords

Private sector · Public sector · Decision-makers · Ocean economy · Ocean Literacy (OL) · Climate · Sustainability

5.1 Introduction

In December 2019, two pivotal workshops occurred in Venice, Italy, led by IOC-UNESCO as part of the Ocean Literacy (OL) initiatives under the UN Decade of Ocean Science for Sustainable Development (Ocean Decade). These workshops—"OL in the Context of the UN Decade" and "OL Professional Development for the Private Sector"—brought together diverse

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international participants to explore how OL could advance the Ocean Decade's goals. I had the privilege of participating in both workshops.

A key takeaway was that although OL has traditionally focused on educating future leaders by mainly working with children and youth, its potential to shape today's decision-makers in both private and public sectors is equally significant. OL has often been defined as "an understanding of your influence on the Ocean and the Ocean's influence on you." However, for decision-makers, it can be reframed as "an understanding of how the Ocean impacts your business (or policies) and how your business (or policies) impacts the Ocean." This reimagined perspective highlights the potential for integrating OL into the private sector and beyond. Accordingly, Acqua Mater is developing an international survey to assess companies' Ocean-related knowledge. At a later stage, the initiative may be expanded to include public-sector policies.

The health of the Ocean is essential to achieving the entire 2030 Agenda for Sustainable Development, as it underpins many of its goals and targets. Its interconnected role in regulating climate, supporting biodiversity, providing food security and sustaining economies cannot be overstated. Yet, many leaders remain unaware of these links or the Blue Economy's potential to address global challenges while fostering regeneration and sustainability. Even within Ocean-centric industries and policy-making bodies, significant Ocean knowledge gaps persist. As the Ocean continues to face mounting threats—warming, acidification, deoxygenation, biodiversity loss, and the increasing frequency of climate-induced disasters—engaging leaders across all sectors becomes urgent. Educators, scientists, and entrepreneurs must seize this opportunity and explore new areas of action by creating innovative OL initiatives to meet these challenges and achieve the Ocean Decade's goals.

This chapter explores the growing momentum to engage new audiences through OL. It also raises critical questions for decision-makers in both private and public sectors, such as:

- What are the direct and indirect impacts of my company's activities on the Ocean, regardless of its sector?
- What is the direct and indirect impact of the Ocean on my company's business and operations, regardless of its sector or location?
- How do the public policies of my department (or ministry) directly and indirectly impact the Ocean?
- How does the Ocean directly and indirectly impact the public policies of my department (or ministry)?

By addressing these questions, we can deepen our understanding of the Ocean's critical role in global sustainability, positioning it not only as an end goal but as a vital means to achieve broader objectives.

OL plays a crucial role in bridging knowledge gaps, highlighting vital connections, driving behavioral change, and catalyzing meaningful actions to ensure a sustainable future for both the planet and its people. Awareness of the need for innovative action often precedes the readiness to implement it. This phase is not one of inaction but of preparation—a time to mature ideas, refine strategies, and secure the necessary resources to bring a vision to life. That time has arrived, making these reflections and proposed initiatives both timely and essential for our OL community.

5.2 Ocean Literacy Beyond Traditional Education Settings

For about 20 years, OL has been applied in educational settings, with the aim of integrating Ocean sciences into school curricula and providing educators with guidelines and key principles. Nevertheless, in parallel with formal education efforts, numerous non-formal and informal educational initiatives emerged to reach children, youth, and families outside of schools – effectively aiming to engage society as a whole.

In formal education, schools may adopt "Blue Curricula" and "Blue Schools" programs that

incorporate Ocean science into subjects like geography or biology. For example, UNESCO's *Ocean Literacy for All – a toolkit,* published in 2018, provides lesson plans and resources to teachers.

Non-formal education includes structured community projects that occur outside formal educational institutions, as citizen science programs, where volunteers monitor local beaches for pollution. On the other hand, informal education is often unstructured and refers to learning through daily activities or experiences. It can take place through artistic and public engagement initiatives, such as Ocean-themed exhibitions, murals, or art and education festivals. It can also include beach cleanups, ecological coastal walks or other sport events, such as sailing competitions, that blend informal learning with active participation.

These OL initiatives raise awareness and foster experiential learning through direct interaction with the environment, helping participants develop hands-on knowledge about marine ecosystems and sustainability practices. On the other hand, OL lectures, workshops, and webinars are effective tools for engaging both professionals and the general public, providing knowledge in accessible formats.

Nowadays, OL initiatives can reach each individual of society, regardless of age, ethnicity, religion, nationality, sociocultural background, or hierarchical position within diverse public or private organizations.

As Challenge 10 suggests, we need to restore society's relationship with the Ocean, considering every human being, across all sectors of society, and helping them make decisions, act, and behave in ways that ensure a healthy Ocean (Glithero et al. 2024).

5.3 Ocean Literacy within the UN Ocean Decade, Focusing on the Private and Public Sectors

Three key Ocean Decade publications highlight these sectors as essential partners. This section will briefly explore how they are addressed in these publications to better understand the expectations placed upon them and the role of OL within their respective contexts.

5.3.1 Ocean Decade Implementation Plan

This text was published in 2021, around the same time as the previously mentioned *Ocean Literacy Framework* (Intergovernmental Oceanographic Commission (IOC) of UNESCO 2021a). Both documents were developed concurrently by separate UNESCO teams. To ensure consistency in their conceptual messaging regarding OL and the Ocean Decade, the teams maintained close communication from the beginning. As a result, certain sections of the texts are nearly identical, differing only in the way specific messages are articulated.

The term *Ocean Literacy* is mentioned 26 times within the 56 pages of the *Ocean Decade Implementation Plan*, emphasizing its relevance in this context. On page 25, under Objective 3 (Increase the use of Ocean knowledge and understanding, and develop capacity to contribute to sustainable development solutions), it states the need to "broadly communicate and promote the role of Ocean science for sustainable development across diverse stakeholder groups, including through formal and informal education and an expansion of OL approaches across stakeholder groups".

Additionally, on page 32, the text aligns closely with the *"OL Framework"*, further reinforcing the role of OL in this effort, as follows:

> OL as a concept and approach is rapidly evolving from being an instrument applied in formal education and training contexts to a tool and an approach for society as a whole. A broad range of stakeholders can learn and benefit from OL. (…) Throughout the Decade, OL will play a key role in promoting sound public marine policy, fostering more responsible behaviors, encouraging more Ocean-aware corporate practices and stimulating young people to start a career in the sustainable Ocean economy, Ocean science, marine policy or Ocean conservation and management. (…) OL efforts during the Ocean Decade will also support governments and other stakeholders to develop the skills and tools needed to effectively implement activities that are the most relevant in their particular context.

In the 20-page Summary of the *Implementation Plan*, there is also a dedicated chapter on OL that highlights the same four key priority areas present in the "OL Framework": policy formulation; formal education; corporate action; community engagement.

5.3.2 Ocean Literacy Framework for Action

This publication aims to support the Ocean Decade by inspiring global OL practitioners to take action by engaging various stakeholders, fostering inclusive dialogues, and collectively generating new knowledge to support Ocean sustainability (Intergovernmental Oceanographic Commission (IOC) of UNESCO 2021b).

It was collaboratively developed by experts from various international organizations, enriched by stakeholder consultations, and informed by the multi-stakeholder workshops held in Venice in December 2019.

The publication also highlights how the public and private sectors play crucial roles in advancing the Ocean Decade goals and challenges. Tables 5.1 and 5.2 outline the specific actions and contributions expected from both sectors as part of the broader effort to drive sustainable progress during the Ocean Decade.

Through Table 5.1, we conclude that the private sector plays a pivotal role in advancing Ocean sustainability by integrating OL into corporate operations. Companies are expected to incorporate sustainability practices in their planning, operations, and strategic investments, while partnerships between businesses and nonprofit organizations will further strengthen the sustainability of marine ecosystems. These actions will help enhance global awareness, innovation, and accountability, positioning Ocean sustainability at the core of the business agenda.

The outlined targets and actions provide a roadmap for integrating OL into governance structures, emphasizing education, training, and investment to cultivate Ocean-conscious leaders capable of tackling sustainability challenges. OL training for government officials is essential to coordinate strategies, increase financial resources, and embed OL into sustainable policies that safeguard marine ecosystems while fostering a thriving blue economy.

Table 5.1 Mobilizing corporate action

Targets	Potential actions
By 2025, private sector employees and investors worldwide receive training in Ocean Literacy to understand the connection of their operations with the Ocean.	• Training programs for employees and/or customers and suppliers on Ocean sustainability and Blue Economy.
By 2030, Ocean sustainability is strongly incorporated into business planning and operations, including strategic planning and environmental practices and policies.	• Investments in incubators focused on Ocean innovation, technology, sustainability and social enterprise.
By 2030, companies around the world enhance and incorporate actions for Ocean sustainability and Blue Economy opportunities within their operations, including R&D, products and services, investments and reporting.	• Development of programs that empower women and girls in Ocean science and conservation.
By 2025, partnerships are developed and enhanced among companies and/or companies and non-profit organizations to strengthen Ocean sustainability.	• Development of school-based programs that empower capacity building and developing the next generation of Ocean professionals. • Introduction of certification schemes for Ocean-literate companies demonstrating commitment to Ocean conservation/ sustainability.

5.3.3 Ocean Decade Vision 2030 White Paper: Challenge 10

This document emphasizes the importance of fostering OL, raising awareness, and engaging diverse stakeholders to make informed decisions

Table 5.2 Mainstreaming Ocean Literacy in Education Policy Formulation

Targets	Potential actions
By 2025, 70% of Member States have a National Ocean Literacy Strategy and integrate Ocean Literacy into the curriculum and education policies of formal education systems.	• Establish a National Ocean Literacy Strategy and Ocean Literacy coordination mechanism and designate a National Focal Point for Ocean Literacy.
By 2025, governmental representatives and officials possess the knowledge capacity, skills and commitment to incorporate Ocean sustainability into local, national and regional policies.	• Include Ocean Literacy in National Curriculum Standards in order to embed Ocean education in primary and secondary schools.
By 2028, Ocean Literacy policies are adequately monitored and measured.	• Offer/organize training programs for government officials on Ocean sustainability and/or Blue Economy opportunities.
By 2025, Member States increase annual spend on Ocean Literacy.	• Boost investments in Ocean Literacy schools and/or Ocean Literacy programs.

Table 5.3 Goals and Needs for Industries and Businesses

End Goals By 2030	Needs By 2030
Industry and business understand and make decisions that value Ocean health.	• Scientific framework to understand what "good Ocean action" looks like from business/industry perspectives.
Industry and business understand that consumers value a healthy Ocean and engage in and publicize their "blue" behavior in the same way they do as "green."	• Identify and engage with leaders whose businesses use / abuse the Ocean.
Industry and business engage their consumer base in Ocean positive action/campaigns, etc.	• Government regulates for the people, not against the people, by ensuring industries and businesses do not benefit from activities (or lack thereof) that harm our Ocean, waterways, and climate and the humanitarian issues that arise therefrom. Government should provide incentives to truly protect and operate sustainably.
Industry leaders realize the financial impact of overexploitation of marine resources and other human impacts on Ocean health.	
Encourage shareholders to take collective action against businesses abusing the Ocean.	
Adopt a new and different definition of success, moving away from short-term profit focus at all costs—including exploitation and destruction–toward a long-term plan involving less exploitation and sustainable development.	

that support Ocean sustainability, highlighting the critical role of public engagement, cross-sector collaboration, and inclusive policymaking in protecting marine ecosystems (Santoro et al. 2017). By improving the understanding of Ocean-related issues, Challenge 10 seeks to inspire a global shift in behavior, industrial practices, and governance frameworks, contributing to the overall goals of the Ocean Decade.

It indicates corporate leaders and policymakers as two key sectors that should support pro-Ocean behavior. To help shape the underpinnings of Challenge 10, the report highlights "imaginative sketches" interrelating strategic ambitions and frameworks while outlining the priority users of this material, along with their goals and needs. Table 5.3 covers industry and business, and Table 5.4 addresses policymakers.

It's evident that industries and businesses need to take a more proactive stance in recognizing the importance of Ocean health. The overarching objectives show that companies must understand the value consumers place on sustainability and actively participate in promoting Ocean-positive actions. This involves not only adopting sustainable practices but also aligning their business models with long-term environmental goals. Businesses should engage in responsible resource

Table 5.4 Goals and Needs for Policymakers

End Goals By 2030	Needs By 2030
Policymakers make decisions that take into consideration the vital role of Ocean health across a broad spectrum of initiatives.	• Policymakers have access to the science they require on how Ocean health relates to their specific policy issue (e.g., briefing docs).
Policymakers make Ocean-positive decisions in response to demonstrative public support for actions that protect the Ocean and appeal to the public to garner support.	• Up-to-date nationally representative studies demonstrating high levels of support for Ocean positive decisions, that can be used as internal advocating data.
Strength of human connection to the Ocean is such that policymakers use Ocean action as a campaigning platform at key political moments.	• Designated "Ocean consultants" who can work with governments to "translate Ocean science" to show salience of Ocean health across a variety of ministries, departments etc.
Policymakers understand and value the role of the Ocean in human life and recognize the impact of their decisions on the functioning of the Ocean.	• More effective communication between scientists and policymakers.
Understanding of the role of our one-water system–that connects to our everyday lives, as well as issues of intersectionality involving human rights.	• Compulsory Ocean Literacy training for all decision makers in governments around the world. • Ample time "in the field" with youth, scientists, and native/ Indigenous peoples. Ample time listening to educators who have successfully applied project-based/ progressive education.

use and move away from focusing solely on short-term profits.

Policymakers must be equipped with the knowledge and tools to integrate Ocean health into their decision-making processes. This requires access to Ocean-related science, training to understand the Ocean's complex role in human life and fostering a strong human-Ocean connection. Additionally, they need public support, reliable data, and effective communication with scientists. Engaging with youth, Indigenous peoples, scientists and educators is essential to deepen understanding of the Ocean's significance and promote informed, Ocean-positive decisions and policies.

5.4 Engaging the Private and Public Sectors in OL Initiatives. Challenges and Opportunities

Engaging the private and public sectors in OL initiatives involves diverse approaches, each with unique challenges and opportunities for educators and their audiences. This section explores four key approaches.

The first one positions organizations as enablers, facilitating projects aimed at external audiences. In contrast, the remaining three focus on initiatives targeting employees directly as the primary audience. Importantly, this section addresses initiatives within professional contexts, distinguishing them from voluntary, community-based OL activities.

5.4.1 Support of OL Initiatives Directed at Society

Companies are often approached to sponsor OL initiatives that promote Ocean conservation or education through formal, non-formal, or informal learning activities. Depending on the company's size and structure, OL educators and institutions may engage departments such as Corporate Social Responsibility (CSR), Sustainability, Marketing, or Communications. Governments are also key partners, not only providing financial support but also helping to establish "Blue Curricula" or "Blue Schools" in their regions, often through public policies that ensure program quality and longevity (Table 5.5).

Table 5.5 Opportunities and Challenges: Initiatives Directed at Society

Opportunities for	Companies	• Improve the company's image with society and ESG-focused investors.
		• Gain recognition through awards or titles for contributions to Ocean conservation and sustainability.
		• Build stronger community relations, enhance brand reputation, and show leadership in corporate social responsibility.
	Governments	• Equip future generations with knowledge for sustainable Ocean stewardship and Blue Economy development.
		• Lead in global environmental education, improving international standing on sustainability.
		• Foster public engagement in conservation, and support for marine policies, contributing to SDG goals.
	Educators	• Gaining visibility and access to broader audiences.
		• Develop innovative teaching strategies to align OL content with the specific needs of sponsors/supporters.
		• Strengthen connections within other environmental networks, opening doors for more collaborative projects.
		• Contribute to long-term societal change by raising awareness and enhancing Ocean stewardship.
Challenges for	Companies	• Aligning sponsorships with long-term CSR or sustainability goals.
		• Balancing commercial objectives with genuine educational or conservation initiatives, without appearing self-serving.
		• Difficulty in demonstrating a clear return on investment, complicating long-term corporate support.
		• Maintaining the authenticity of sponsorship without excessive commercialization.
	Governments	**Formal OL Initiatives:**
		• Integrating "Blue Curricula" into school systems, especially in regions where environmental education is not prioritized.
		• Limited funding for environmental education and lack of trained educators.
		• Stakeholder resistance due to unfamiliarity with Ocean conservation's urgency.
		• Competing educational priorities and mandates delaying implementation.
		• Difficulty in measuring effectiveness and sustaining political and financial support.
		Non-formal and Informal OL Initiatives:
		• Securing consistent funding and sponsorship to maintain and grow these activities.
		• Engaging diverse audiences in non-traditional educational settings.
		• Tracking the effectiveness and behavior changes resulting from these initiatives.
	Educators	• Balancing educational goals with sponsors' expectations and priorities, according to their core business and priorities for branding or CSR benefits.
		• Securing sustained funding for long-term projects.
		• Demonstrating measurable impact to justify continued investment from sponsors.

5.4.2 Participate in OL Initiatives Held On-site and Offered by Their Organizations

Employees from both the private and public sectors can engage in on-site OL activities offered by their organizations. These initiatives may be part of volunteer programs within their companies or agencies. Activities include beach clean-ups, where participants learn about Ocean pollution while removing litter, recycling workshops that raise awareness about plastic use, eco-friendly coastal walks educating on marine ecosystems, boat tours focused on biodiversity, and natural cosmetics workshops promoting alternatives to harmful chemicals. These programs not only foster environmental awareness but also enhance team-building efforts and a sense of shared responsibility. Human Resources departments may organize such initiatives as part of corporate sustainability or employee engagement strategies (Table 5.6).

5.4.3 Receive Basic Training on the Core Principles of OL and its Connection to Sustainability and Climate

This type of training involves a foundational understanding of the 7 OL Principles, which covers the Ocean's role in Earth systems, the interconnectivity of the Ocean and humans, and the importance of sustainable interaction with marine ecosystems. This training can connect OL principles to broader issues like sustainability challenges and climate change, highlighting how the Ocean influences global climate systems, biodiversity, and general socio-economic factors (Table 5.7).

5.4.4 Receive Tailored OL Training Connecting Ocean Science with Their Businesses or Governmental Sector

Training aligns Ocean science with their core activities. OL workshops and trainings must be promoted for all industry and governmental sectors, not limiting them to Ocean economy industries or public sectors directly related to the Ocean and to the environment. All activities and policies are connected, directly or indirectly, to the Ocean. Decision-Makers from both sectors must learn about these connections and the positive and negative impacts they can generate on the Ocean, and vice-versa. OL can be integrated into corporate strategies and to regional and national policies, designing sustainable initiatives, and contributing more effectively to climate resilience and Ocean stewardship plans (Table 5.8).

5.5 Reflections and Initiatives Underway on This Direction

5.5.1 Ocean Stewardship: Political and Economic Agendas

Those working in OL recognize the Ocean as the planet's life support system, crucial for maintaining ecosystem balance and regulating climate. Its full connection to both economic and political agendas is undeniable.

5.5.1.1 The Ocean Political Agenda

The Ocean shapes political decisions and public policies globally, influencing national security, trade, and economic stability, especially in coastal and island nations. Its health impacts climate change, biodiversity, and resource management policies.

Engaging only education or environment departments is insufficient; partnerships must also include sectors such as Health, Energy, Security, Economy, Finance, Tourism, and Social Services. These connections become evident when considering the multifaceted ways the Ocean intersects with human systems: Ocean health impacts human health, as highlighted by the One Health concept; renewable energy production occurs offshore and in coastal areas; extreme weather events and alternative fuels pose security risks in urban ports; the Ocean economy drives economic growth and ESG-driven investments; employment opportunities

Table 5.6 Opportunities and Challenges: Participation in OL Initiatives

Opportunities for	Companies	• Enhancing corporate reputation by aligning with sustainability goals and improving ESG performance.
		• Boosting employee engagement, morale, and team-building through hands-on environmental activities.
		• Encouraging innovation in sustainable practices, such as recycling or eco-friendly products.
		• Gaining positive public relations and visibility within the community and media.
	Governments	• Leading in environmental policy and stewardship by engaging their employees.
		• Raising marine conservation awareness among their employees.
		• Strengthening global influence by aligning with international sustainability goals.
		• Creating long-term impact through an Ocean-conscious workforce.
	Educators	• Engaging employees in OL hands-on experiences can lead to major awareness and more impactful learning.
		• Strengthening relationships with corporate and governmental partners for long-term collaboration.
		• Showcasing best practices to be recognized as a leading OL organization.
Challenges for	Companies	• Ensuring sustained engagement from their employees.
		• Balancing employee time dedicated to these activities with business functions.
		• Demonstrating measurable benefits for employee engagement or ESG indicators.
	Governments	• Overcoming logistical, budgetary, and regulatory barriers.
		• Aligning employee participation in OL initiatives with operational priorities.
		• Proving the long-term value of these programs to maintain political and financial support.
	Educators	• Aligning activities with the company's or government's operational schedules.
		• Securing funding and resources for on-site activities.
		• Measuring the effectiveness of OL initiatives for long-term behavior change.
		• Balancing the educational goals with the corporate or governmental objectives.

in coastal tourism, which, in turn, affect marine ecosystems – particularly in developing countries and SIDS (Small Island Developing States); social services also face challenges like climate refugees or migrants risking their lives at sea to escape hunger, conflict, or war. The connections extend far beyond this list.

International cooperation is also crucial for managing shared Ocean spaces, positioning the Ocean at the heart of geopolitical negotiations and global frameworks like the United Nations Convention on the Law of the Sea (UNCLOS). Marine Protected Areas (MPAs), Marine Spatial Planning (MSP), and the BBNJ (Biodiversity Beyond National Jurisdiction) treaty highlight the necessity of collaborative stewardship. These initiatives ensure the sustainable use of marine resources, protect biodiversity, and emphasize that Ocean governance transcends borders, fostering a collective responsibility for the planet's most vital ecosystems.

For these reasons, it is essential to introduce OL activities to public officials in these departments, as they often address such issues without adequate

Table 5.7 Opportunities & Challenges: Basic Training

Opportunities for	Companies	• Equipping employees with OL knowledge helps companies select effective OL initiatives to sponsor, aligning with sustainability goals and enhancing ESG performance.
		• Encourages employees to connect their work with OL principles, Ocean sustainability, and climate action.
		• Strengthens HR goals on training, boosting engagement and morale.
		• Companies can be recognized with "best practices" or case "study awards", gaining positive visibility.
	Governments	• Aligns public sector initiatives with national and international climate goals.
		• Helps government employees make informed policy decisions.
		• Encourages employee awareness of sustainability, improving public sector efficiency in tackling environmental issues.
		• Governments may receive recognition for environmental leadership through awards or "best practices" titles.
	Educators	• Developing educational content that resonates across various industries and government bodies, creating broader awareness and understanding of Ocean sustainability and climate issues.
		• Strengthening partnerships with governments and companies, leading to long-term collaborations and expanding outreach efforts.
		• Gaining recognition for delivering effective and award-winning OL initiatives, enhancing professional reputation and influence.
Challenges for	Companies	• Ensuring that the training content aligns with the company's sustainability goals, making it relevant for employees across departments.
		• Allocating sufficient budget to fund these OL training programs while balancing other corporate priorities.
		• Engaging employees effectively and maintaining their motivation throughout the training, especially if it's not directly tied to their daily work.
		• Demonstrating the impact of the training, particularly in terms of improving the company's ESG performance or sustainability reputation.
	Governments	• Securing necessary funding for comprehensive OL training across different governmental departments and ensuring its availability.
		• Incorporating OL training into existing employee education frameworks, especially when current programs may not focus on environmental topics.
		• Finding the time for employees to attend these training sessions within their often-packed schedules.
		• Ensuring the OL training is relevant and engaging for government employees working in sectors not directly connected to Ocean or environmental issues.
	Educators	• Aligning content with different organizational priorities.
		• Maintaining sustained engagement in the training process.
		• Securing funding to continue training initiatives.
		• Measuring the effectiveness of training programs in real-world applications.

Table 5.8 Opportunities and Challenges: Tailored Training

Opportunities for	Companies	• Boosting ESG performance, positioning the company as a leader in sustainability by integrating OL practices across operations.
		• Unlocking emerging business opportunities by exploring innovative technologies, products, and services that are part of the growing blue economy.
		• Advancing sustainability finance, gaining access to green investments, such as the blue bonds, climate-related funds, and sustainable business incentives.
		• Strengthening innovation and competitiveness, adopting case studies from global markets to advance sustainable practices and profitability.
	Governments	• Enhancing alignment with the 2030 Agenda, progressing not only SDG 14 but also SDG 13 (Climate Action), SDG 7 (Affordable Energy), and SDG 12 (Responsible Consumption).
		• Access to sustainability finance, leveraging OL to support green bonds, public funding, and climate investments.
		• Developing new policies through OL insights, improving sectors like infrastructure, resource management, and public health.
		• Strengthening international collaboration, using OL to foster knowledge exchange with other cultures and nations.
	Educators	• Expand their knowledge by learning about sectors outside of education, environment and science, such as corporate operations and government policies.
		• Gain valuable insights through exchanges with individuals who think differently, encouraging out-of-the-box problem-solving.
		• Discover new areas for collaboration, leading to broader, impactful, creative and innovative projects.
		• Experience satisfaction from seeing their solutions scaled up through company or government decisions, creating larger, real-world impacts on the Blue Economy, Ocean Conservation, Sustainability, Energy Transition, etc.
Challenges for	Companies	• Ensuring OL training connects meaningfully with the company's core business values and long-term goals.
		• Balancing the cost of organizing OL workshops while justifying the potential return on investment.
		• Engaging employees in OL training and embedding its contents into corporate culture without affecting productivity.
		• Maintaining long-term engagement with OL contents, ensuring their continuous relevance after initial training sessions.
	Governments	• Allocating resources for OL training can be difficult, especially when there are competing budgetary priorities.
		• Ensuring that OL contents are effectively integrated into various governmental sectors not directly linked to the environment, such as Energy and Health.
		• Reaching remote or underserved regions for consistent training implementation can pose logistical challenges.
		• Convincing departments not directly involved in marine policy of the importance and relevance of OL training.

(continued)

Table 5.8 (continued)

	Educators	• Learn about corporate and governmental environments, including their operational logic, financial, or political objectives, and organizational culture.
		• For sector-specific initiatives, study the context in-depth:
		(a) Private sector: technologies used, products marketed, socio-environmental impacts, and industry or company-specific culture.
		(b) Government: their regulatory frameworks, main policies, and socio-political agendas.
		• Be adaptable in co-design innovative contents with the private/public sector, aligning Ocean science with the company's core business or government priorities, even if it requires stepping outside your comfort zone.
		• Avoid seeing the company as "the polluting enemy"; explore mutual gains for Ocean protection and profit. Similarly, avoid accusing governments for insufficient policies, focusing instead on solutions to drive impactful Ocean stewardship.

access to reliable scientific information. This requires engaging decision-makers at all levels within governmental agencies and institutions.

5.5.1.2 The Ocean Economic Agenda

The Ocean is a major pillar of the global economy. According to the *Reviving the Ocean Economy* report (WWF, 2015), its value is estimated at approximately $24 trillion, contributing between 3% and 5% of global GDP. The Ocean economy encompasses diverse sectors directly supporting 55–65 million jobs and indirectly benefiting 8% of the world's population through secondary and subsistence activities.

According to the International Maritime Organization (IMO), around 90% of global trade is conducted through shipping, highlighting the Ocean's fundamental role in ensuring economic stability and interconnectivity. Shipping not only moves essential goods across continents but also drives global commerce, supporting various industries and sectors.

Aquaculture is another key growth area, representing the fastest-growing sector in food production due to an increasing global population and demand for seafood. Sustainable aquaculture is crucial to feeding billions while protecting marine biodiversity.

The renewable energy potential of the Ocean, including offshore wind, wave, and tidal energy, contributes substantially to energy transitions needed to meet global climate targets. The International Renewable Energy Agency (IRENA) projects that offshore wind could supply over 10% of the world's electricity by 2050. This creates opportunities for sustainable energy development while providing new jobs and technological advancements.

In biotechnology, the Ocean is a source of unique compounds and organisms that are contributing to medical breakthroughs, pharmaceutical advancements, and innovative materials. Marine biotechnology plays an increasingly important role in sectors ranging from healthcare to agriculture, providing bio-based alternatives that are more sustainable.

Tourism linked to coastal and marine environments is also a key contributor, generating over $390 billion annually, providing jobs, and fostering cross-cultural exchange. However, ensuring sustainability in tourism is crucial to preserving marine habitats and the natural beauty that drives this industry.

Many industries contribute to the Ocean Economy. To qualify as part of the Blue Economy, these industries must utilize marine resources in a sustainable manner. OL initiatives can play a pivotal role in supporting this transition. Key industries within this sector include:

- Fisheries and Aquaculture
- Shipping and Ports

- Marine Biotechnology
- Offshore Oil and Gas
- Renewable Energy
- Tourism and Recreation
- Shipbuilding and Repair
- Desalination
- Marine Construction
- Maritime Safety and Security
- Marine Research and Education

Nevertheless, OL initiatives should extend beyond industries within the Ocean economy. According to the report *From Source to Sea – The Untold Story of Marine Litter*, "marine litter is defined as all human-made solid items that end up in the coastal or marine environment (European Environment Agency 2023). Land-based sources account for 80% of marine litter, and approximately 85% of it is plastic." These estimates exclude other forms of pollution, such as biological, chemical, thermal, or sediment pollution.

Several land-based industries are particularly harmful to marine ecosystems, degrading habitats and impacting biodiversity and ecosystem services, as highlighted in the report *From Pollution to Solution: A Global Assessment of Marine Litter and Plastic Pollution* (United Nations Environment Programme 2021).

Engaging broader economic sectors through OL is therefore essential for mitigating their impacts on marine environments. Below are some of the key land-based sectors that have the greatest negative impact on marine ecosystems, along with explanations of how these impacts occur.

- Agriculture: Runoff from pesticides and fertilizers leads to nutrient pollution, causing algal blooms and dead zones, leading to eutrophication;
- Textile and Fashion: Discharge of untreated dyes, chemicals, and microplastics into waterways, which often flow into the Ocean, contributing to significant marine pollution;
- Mining: Leads to heavy metal runoff and erosion, releasing metal pollutants into rivers and Oceans, which negatively impact marine biodiversity;
- Manufacturing: Industrial wastewater often contains toxins that harm marine life;
- Forestry: Deforestation increases sediment runoff, harming coral reefs and seagrass beds;
- Urban Development: Runoff from construction sites and impermeable surfaces increases pollution in coastal waters, while urban expansion also leads to greater sedimentation, negatively impacting marine ecosystems;
- Plastic Production: High volumes of plastic waste end up in Oceans, affecting marine animals through ingestion or entanglement;
- Chemical Industry: Releases hazardous substances that persist in the marine environment and accumulate in the food chain;
- Livestock Farming: Manure runoff is rich in nutrients and contributes to coastal eutrophication;
- Oil Refineries: Risk of spills and leakage contaminates marine environments and severely affects marine life.

In this context, the report *Business for Ocean Sustainability*: *Early responses of Ocean governance in the private sector*, coordinated by Rafael Sardá and published in 2022, highlights that "according to the expert's independent assessment, all industries directly or indirectly interacting with the Ocean/seas potentially exercise negative pressures on most of the 11 Good Environmental Status Descriptors" (GES) (Sardá et al. 2022). These descriptors, introduced by the EU Marine Strategy Framework Directive, outline key components of healthy marine ecosystems, whose preservation and good status is paramount for a fully functional Ocean. These descriptors are organized under 3 Ocean domains: marine biological integrity & diversity; marine water contamination and chemical conditions integrity; seawater and/or seabed physical conditions integrity.

Given the critical importance of the Ocean for both national and international policies, as well as for businesses – directly or indirectly – connected to the sea, it is essential to engage current decision-makers from the corporate and government sectors in OL initiatives. By doing so, they can acquire the necessary scientific knowledge to

make informed decisions that ensure the sustainable use and protection of marine resources, ultimately supporting both Ocean health and economic growth.

5.6 Acqua Mater's Steps in This Direction

The primary focus of Acqua Mater is to explore the fourth approach mentioned in Sect. 5.4. (5.4.4), engaging diverse industrial and governmental in OL initiatives, placing the Ocean at their sustainability strategies.

5.6.1 Towards Innovative and Co-Designed OL Initiatives

To develop these new workshops and training sessions, it will be necessary to collaboratively create new content tailored to the specific governmental sectors or industries being targeted. These materials should be co-designed with input from stakeholders, addressing their challenges and opportunities while aligning with the goals of the 2030 Agenda.

Undergraduate programs that train marine educators should incorporate these themes into their courses to ensure that future educators are equipped to explore this emerging area. This area may remain unexplored because OL educators have not yet identified these opportunities or are unsure how to approach them. Achieving these goals requires stepping out of one's comfort zone, entering new environments, learning new (mental) languages and organizational cultures, and finding ways to connect Ocean science with public policy or entrepreneurship.

During the months and years of the COVID pandemic, Acqua Mater focused on developing potential content tailored for the business world. This involved designing training structures, curating content relevant to various industrial sectors, identifying case studies, selecting scientists and executives for interviews, and experimenting with adapting the 7 OL principles to the corporate context.

However, it became clear that this approach needed to be rethought. Offering predetermined content based solely on assumptions about what companies should "learn" risked being both presumptuous and ineffective. Acqua Mater recognized that the development of meaningful content required first understanding what companies already know about the Ocean, the mutual impacts between their operations and marine ecosystems, and the potential business opportunities tied to Ocean sustainability

To address this, Acqua Mater began developing a survey aimed at assessing, from multiple perspectives, how "Ocean literate" companies from various sectors are. This survey, designed to be answered by the companies themselves, connects the Ocean to their specific business operations. Unlike surveys typically led by scientists or academics and focused on schools or society in general, this initiative has a distinct objective: to identify what OL professionals can offer to the private sector. The pilot for this project is expected to be launched in 2025.

5.6.2 Acqua Mater's Ocean Dialogue within the G20

In 2024, Acqua Mater was invited by the UN Global Compact to consult on structuring and coordinating the Ocean Dialogues of the Ocean Engagement Group of the G20 (O20). The G20 addresses pressing global challenges, including trade, financial stability, climate change, and sustainable development. Engagement Groups like the O20 integrate diverse stakeholders to provide critical policy recommendations to G20 leaders.

In this context, Acqua Mater host an Ocean Dialogue under the same title as this chapter (Acqua Mater 2024a). Organized in partnership with IOC-UNESCO, the event brought together panelists from all continents and sectors, ensuring a truly global and multidisciplinary perspective on

OL, Ocean sustainability and Ocean stewardship. It included 3 panels, besides the Opening and the Closing Remarks:

- Panel 1: Ocean Literacy in Formal, Informal and Non-Formal Education: Engaging Schools and Society to Regenerate our Ocean
- Panel 2: Empowering Public Sector Leaders: Ocean Literacy for Sustainable and Blue Policymaking
- Panel 3: Driving Corporate Sustainability: Ocean Literacy as a Catalyst for Change in Business Practices

The discussions emphasized the global importance of integrating science-based Ocean knowledge into decision-making processes across industries and governments through collaborative and co-designed OL initiatives. They also addressed the relevance of OL for land-based industries, highlighting its potential to bridge gaps between these sectors and broader sustainability efforts on a global scale. Main outcomes from the discussions are:

5.6.2.1 Valuing the Ocean Through Inclusive OL

Foster a holistic approach to OL by integrating diverse knowledge systems and perspectives. Focus on engaging underrepresented groups and decision-makers to promote informed and inclusive actions. Align OL initiatives with scientific insights, behavioral change strategies, and the interconnected goals of SDG14 and the broader 2030 Agenda, ensuring that decisions actively contribute to Ocean sustainability.

5.6.2.2 OL Beyond Formal Education

Advance OL by integrating a Blue Curriculum into national education policies and supporting the establishment of Blue Schools. Foster multi-sector collaboration to embed OL into industries, particularly through Corporate Social Responsibility (CSR) initiatives that promote Ocean stewardship. Extend OL beyond formal education by creating public engagement opportunities such as marine walks, beach cleanups, and marine exhibitions, ensuring it becomes an accessible part of daily life

5.6.2.3 OL Initiatives Addressed to Public Sector Employees/ Decision-Makers

Encourage G20 leaders and governments to invest in capacity building for policymakers by identifying needs and fostering international collaborations to share OL best practices. Promote disaster prevention and coastal resilience training, establish dedicated OL expert roles, and enhance communication tools, such as creative apps, to effectively engage policymakers and stakeholders on Ocean-related issues.

5.6.2.4 OL Initiatives Addressed to Private Sector Employees/ Decision-Makers

Promote public-private partnerships that integrate OL into addressing global challenges like climate change, biodiversity loss, and water scarcity, while balancing Ocean protection and sustainable use. Foster collaboration between governments, the private sector, and Ocean stakeholders, including Indigenous communities, to co-design informed management strategies. Encourage businesses across sectors to integrate Ocean knowledge into decision-making, emphasizing the critical connection between Ocean health and long-term success.

5.6.2.5 Urgent Actions for Ocean's Health

Prioritize significant investments in OL initiatives and science-based solutions to address urgent Ocean challenges, including climate stabilization, biodiversity conservation, and microplastic removal. Recognize the critical need for immediate action to reverse Ocean degradation and secure its health and sustainability for future generations.

Many recommendations from this Ocean Dialogue were integrated into the O20 Communiqué, which highlights OL as a key priority for G20 leaders. It advocates science-based

educational programs to enhance Ocean knowledge and inform decision-making in public and private sectors. It also calls for capacity-building initiatives to support inclusive policies, innovative Ocean stewardship, and the transition to a sustainable and equitable Ocean economy. Additionally, it stresses funding OL initiatives through public-private partnerships to drive conservation and broad-based community participation.

The full transcript are published on the Acqua Mater website, and the video recording is available on the IOC-UNESCO YouTube page (Acqua Mater 2024b).

5.6.3 Acqua Mater Recommendations for OL Educators

In the context of the Ocean Decade, various publications encourage the development of OL initiatives targeting both the public and private sectors. However, few initiatives currently involve employees from these sectors in OL lectures, workshops, or trainings to address OL principles, sustainability, and climate change. Moreover, such efforts are typically directed at companies or government sectors already linked to the Ocean economy or environmental policies.

Although various publications in the context of the Ocean Decade encourage engaging the private and public sectors in OL initiatives, few activities specifically target their employees. When such efforts occur, they are typically directed at companies or government sectors already involved in the Ocean economy or environmental policies. Nevertheless, tailored OL initiatives that connect Ocean science to the core businesses or policies of these audiences remain largely unexplored.

Developing and implementing such initiatives could help integrate the Ocean into the sustainability strategies of companies and governments, fostering mechanisms to protect aquatic ecosystems, advancing the blue economy, generating business opportunities, and shaping blue public policies. Indeed, this represents an emerging field that OL professionals have yet to fully explore.

5.6.3.1 Engaging the private sector

Businesses can greatly benefit from Ocean science knowledge, just as OL educators can gain from collaborating with the private sector. Business decision-makers have the potential to drive meaningful change while generating profits for their companies. Meanwhile, OL educators can expand their professional scope, gain access to diverse knowledge systems and scientific data, and amplify their positive impact on the Ocean. This creates a win-win situation, where both sides must step out of their comfort zones while co-designing contents, ambitions and solutions. Suggestions for engaging with the private sector include:

- Promote training programs that help businesses align their operations with long-term environmental goals, emphasizing the benefits of Ocean sustainability for innovation and accountability.
- Develop tailored OL initiatives that engage stakeholders across the value chain, including investors, to create an Ocean-aware workforce that drives new business opportunities.
- Incorporate modules on sustainable resource management, highlighting practices that protect marine ecosystems and enhance ESG performance and reputation.
- Include case studies in training to showcase the value of cross-sector partnerships in advancing Ocean sustainability, supported by government incentives that benefit ecosystems and business goals.
- Equip private sector participants with an understanding of the Ocean's role in sustainability and the economy, emphasizing the profitability and resilience of sustainable practices.

5.6.3.2 Engaging the public sector

Much of what is written above also applies here, with necessary adaptations for the public sector. Policymakers and the public sector play a critical

role in shaping sustainable development and safeguarding Ocean health. However, to effectively integrate Ocean considerations into their policies, they must first become Ocean literate. Suggestions for engaging with the public sector include:

- Equip policymakers with Ocean science knowledge to enable the enforcement of policies that protect marine ecosystems, safeguard coastal communities, combat climate change, and promote the blue economy.
- Provide public sector leaders with access to Ocean-related science data and resources that highlight the Ocean's multifaceted role in human life, the economy, and its implications for national and regional governance.
- Encourage policymakers to adopt inclusive approaches by collaborating with vulnerable groups, such as Indigenous and traditional communities, while also giving space for youth and educators to enrich perspectives and foster informed, equitable, and Ocean-positive decision-making;
- Develop initiatives that integrate OL into public governance structures, ensuring the Ocean is embedded as a key consideration in sustainability-focused decision-making processes
- Build partnerships and networks to support long-term sustainability and the effectiveness of Ocean-focused policies, including promoting the Blue Curriculum and Blue Schools for broader societal engagement.

5.7 Conclusion

Given the critical importance of the Ocean for both national and international policies, as well as for global businesses directly or indirectly connected to the sea, it is essential to engage current decision-makers from the corporate and government sectors in OL initiatives. By doing so, they can acquire the necessary scientific knowledge to make informed decisions that ensure the sustainable use and protection of marine resources, ultimately supporting both Ocean health and economic growth.

For the conclusion of this chapter, the following thoughts from Vladimir Ryabinin, Former Executive Secretary of IOC-UNESCO, are particularly relevant. A visionary advocate for Ocean Literacy (OL), he played a pivotal role in advancing its development both within and beyond UNESCO, recognizing its potential to engage diverse audiences. His insights, shared during the O20 Ocean Dialogue mentioned above, hold particular significance as the event was intentionally designed to align with the themes explored in this chapter. It provided a unique opportunity to present and refine these ideas with global Ocean experts, incorporating their perspectives to strengthen the discussion.

At the Ocean Dialogue, Ryabinin emphasized the transformative power of OL in supporting the transition of traditional marine economies toward a sustainable blue economy. He underscored the urgency of expanding OL beyond its conventional focus on education and youth engagement, advocating for its integration into corporate and governmental decision-making. By embedding Ocean knowledge into business strategies, industry practices, and public policies, OL can drive sustainability and foster informed choices across sectors.

Reflecting on the evolution of the UN Ocean Decade, Ryabinin noted how its mission expanded from a purely technocratic vision to an inspiring and engaging global movement. This shift, he explained, broadened OL's impact, making it more accessible and relevant to businesses, governments, and other key stakeholders. He stressed many times the importance of co-designing OL initiatives with educators, scientists, policymakers, and industry leaders to ensure their effectiveness and applicability.

"The precise, holistic understanding of the role of the Ocean is crucial. This involves considering the future of the Ocean and its impacts. This is definitely a challenge for OL and represents a new approach. We need to develop new approaches if the demands are different, and

these approaches should be distinct from previous ones. The approach to embracing the Ocean economy and Ocean management needs to be different because it must focus on other aspects," Ryabinin stated.

Looking ahead, he called for embedding Ocean economy concepts into broader consumption patterns and business models, emphasizing that Ocean sustainability must become an integral part of economic systems. OL professionals have a crucial role to play in bridging knowledge gaps, fostering cross-sector collaboration, and ensuring that decision-makers integrate Ocean sustainability into all their strategies and policies.

5.7.1 Summary

Key concepts explored in this chapter include:

- OL has traditionally focused on educating children, youth and society in general, but is now recognized as essential for decision-makers in the private and public sectors.
- The Ocean plays a critical role in climate regulation, energy transition, biodiversity loss, human health, food security, trade and economic growth, yet many business leaders and policymakers lack sufficient knowledge about these connections.
- Broadening the scope of OL beyond traditional educational and public awareness initiatives is essential to ensuring that corporate and governmental leaders integrate Ocean considerations into their decision-making processes.
- Three key Ocean Decade publications—the Implementation Plan, the OL Framework for Action, and Vision 2030—emphasize the importance of OL in corporate sustainability strategies and public policymaking.
- OL should be integrated into corporate sustainability and ESG strategies, ensuring businesses recognize their impact on the Ocean and incorporate Ocean stewardship into decision-making, responsible investments, and sustainable supply chains.
- Governments need to integrate OL into public sector training and policies to ensure informed decision-making regarding environmental regulations, marine resource management, and more.
- OL professionals must collaborate with businesses and policymakers to co-design innovative strategies that promote sustainable Ocean management and economic transformation.
- Acqua Mater's Ocean Dialogue at the 2024 G20 Ocean Engagement Group underscored OL's critical role in corporate and governmental decision-making, gathering experts from diverse sectors who validated its importance in shaping sustainability strategies.
- Acqua Mater is developing an international survey to assess companies' knowledge of Ocean-related issues, with potential expansion to public policy assessments.

5.7.2 Recommended Resources

The following resources provide further insights and support on this topic:

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- Intergovernmental Oceanographic Commission (IOC) of UNESCO. (2021). *Ocean Literacy framework for the UN Decade of Ocean*

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6 Promotion of Ocean Literacy by Marine Research Institutions: Challenges and Opportunities. A Mediterranean Case Study

Janire Salazar, María Vicioso, Begoña Vendrell-Simón, Carine Simon, Josep-Maria Gili, and Sílvia Gómez

Abstract

Traditionally, marine knowledge has been confined to specific sectors of society, such as marine research, fisheries, or maritime industries, resulting in a lack of integration into broader societal discourse. To reverse this trend, various education and outreach initiatives have been developed by multiple stakeholders, with marine research institutions playing a paramount role. This chapter presents a case study of a successful initiative developed by the Institut de Ciències del Mar (ICM-CSIC) in Barcelona, Spain. The main objective of this initiative was to bring Ocean ecosystems "into homes" by addressing the seven Ocean Literacy (OL) principles, aligning with the Sustainable Development Goals. Through a collaborative effort involving over thirty marine researchers, the initiative developed fifteen educational capsules and four seminars, creating a digital repository to engage the public in OL. This study examines the development and impact of this initiative, providing a potential model for similar institutions. Additionally, it introduces a survey, designed for the staff of marine research institutions, to identify the factors that influence their involvement in OL activities. A pilot test confirmed the tool's reliability and validity. The study emphasizes the vital role of marine research institutions in educational and outreach initiatives, marking a significant step toward fostering a globally Ocean-literate society and promoting sustainability.

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Keywords

Ocean Literacy (OL) · Capacity building · SDG 14: Life Below Water · Virtual repositories · Scientific education · Marine Research Center · Education & Outreach · Non-formal education

6.1 Introduction: The Role of Marine Research Performing Organizations in the Context of the United Nations Ocean Decade of Ocean Science for Sustainable Development

As Ocean ecosystems face increasing threats derived from human activities, such as climate change, pollution and overexploitation of natural resources (Pörtner et al. 2021), promoting Ocean Literacy (OL) becomes crucial for their preservation. OL encompasses a comprehensive understanding of the Ocean's influence on us and our influence on the Ocean. In response, the United Nations has declared 2021–2030 as the Decade of Ocean Science for Sustainable Development, commonly referred to as "the Ocean Decade". This initiative aims to support global efforts and stakeholders under the guiding motto "the science we need for the Ocean we want". Among its many objectives, the UN Ocean Decade emphasizes the necessity of a rigorous OL program of activities to enhance social awareness and knowledge, thereby fostering sustainable attitudes and behaviors, and informed policymaking (UN 2018).

Traditionally, marine knowledge has been generated and concentrated within specific sectors of society, including marine research, fisheries, and maritime industries. Consequently, this knowledge has often remained siloed, leading to a lack of integration into broader societal understanding and discourse, a phenomenon highlighted by several assessments conducted globally (Cavas et al. 2023).

To counteract these trends, a variety of education and outreach (E&O) initiatives have been launched by diverse stakeholders, including educational professionals in both formal and non-formal settings, policymakers, and the scientific community. Although OL is still considered an emerging field of study, research efforts have already begun to illuminate critical areas, such as establishing baseline OL levels among individuals from diverse communities and documenting traditional knowledge systems within these groups (Cavas et al. 2023). However, significant gaps remain, particularly regarding the development of OL capacity within marine research institutions, which are among the primary sources of marine knowledge (Salazar et al. 2022).

To date, studies focusing on marine research centers have been limited, mainly on aspects like OL promotion through social media (Fauville et al. 2015; Kopke et al. 2019), often with little or no direct engagement of broader audiences in local settings. Previous studies on tropical marine knowledge production (Partelow et al. 2020) and the challenges and opportunities identified for deep-sea research capacity-building in South Africa (Sink et al. 2021), have highlighted the risks of conducting science without inclusive strategies that ensure the involvement of local communities. These studies also revealed significant disparities influenced by the Global North, where tropical inhabitants often become research objects rather than the active participants in the change on their own land.

Capacity-building assessments should be accompanied by further plans that identify barriers, challenges, enabling factors, and opportunities to redress the current situation, alongside a follow-up process.

Marine research centers are adept at maintaining effective knowledge organization systems, primarily designed to preserve and safeguard scientific data and its conclusions in rigorous formats that align with the standards of the scientific community. The technical nature of these formats often necessitates the adaptation and development of various tools and materials

to make the information accessible to broader audiences. While the production of scientific content is clearly the responsibility of scientists and is supported by various open access strategies (Pampel 2023), the question of who should be responsible for adapting this content for different audiences remains a topic of debate. This uncertainty frequently hampers the development of effective E&O strategies within marine research centers.

The allocation of sufficient resources and the clear assignment of responsibilities have proven to be powerful strategies for overcoming complex global challenges, exemplified by the pivotal role that ministries play in the fight against climate change (Limberg et al. 2024). Nevertheless, it is equally important to recognize that social awareness, grounded in a thorough understanding of Ocean issues, is vital for compelling policymakers to address these challenges (Schubel and Schubel 2008). Therefore, bridging the gap between science and society should become a priority on political agendas, and this necessitates the participation of scientists. The environmental commitment of society is one of the central points of the manifesto from the Barcelona conference on the UN Ocean Decade, in which OL plays a key role. Advancing societal engagement is a political necessity and requires OL.

With this in mind, the main objective of this chapter is to integrate marine research centers into the broader OL research conversation and address several associated challenges. Firstly, it presents a case study on the development of a comprehensive virtual repository, created through a participatory approach involving several marine researchers working towards a common goal. Additionally, a survey is introduced as a new tool to identify facilitating and limiting factors, detecting needs, and gathering diverse perspectives on OL from individuals working in a marine research center. Finally, the chapter concludes with reflections on the future role of marine research centers in developing effective OL strategies.

6.2 "L'Oceà a Casa" (Ocean at Home): A Virtual Repository to Bring Ocean Ecosystems "Into Homes"

During the COVID-19 lockdown in Spain, the severity of the situation led to the enforcement of strict measures across society. Among the most impactful ones was the mandate that required everyone, regardless of age or other conditions, to remain at home for several weeks, with only limited opportunities to go outdoors. This period highlighted the critical importance of open spaces for our well-being, emphasizing the vital role that direct contact with nature plays in people's lives (Gismero-González et al. 2020). This was particularly significant for children, who were not allowed to go outdoors at all, as natural spaces serve as essential playgrounds and learning environments, crucial for their development (McCormick 2017).

In response to these circumstances, three marine scientists from the Institut de Ciències del Mar (ICM-CSIC, Barcelona, Spain) launched an initiative with the support of the ICM-CSIC's directorate, the cooperation of a local naturalist and scientific illustrator, and the direct involvement of over thirty marine researchers and collaborators. The entire participatory process is illustrated in Fig. 6.1. Recognizing the challenges of going outdoors and the diverse situations in different households, the team decided that creating an open access virtual space with a variety of educational resources would be a strategic approach. This decision was also informed by the understanding that most students, particularly children, are often considered "digital residents", and numerous innovative virtual educational tools have proven to be effective for this population (McCauley et al. 2021).

The result was the creation of a virtual repository containing fifteen learning capsules and four virtual seminars. The design and content of the initiative are summarized in Fig. 6.2. The initiative encompassed all the OL principles (Schoedinger et al. 2010) and aligned with the

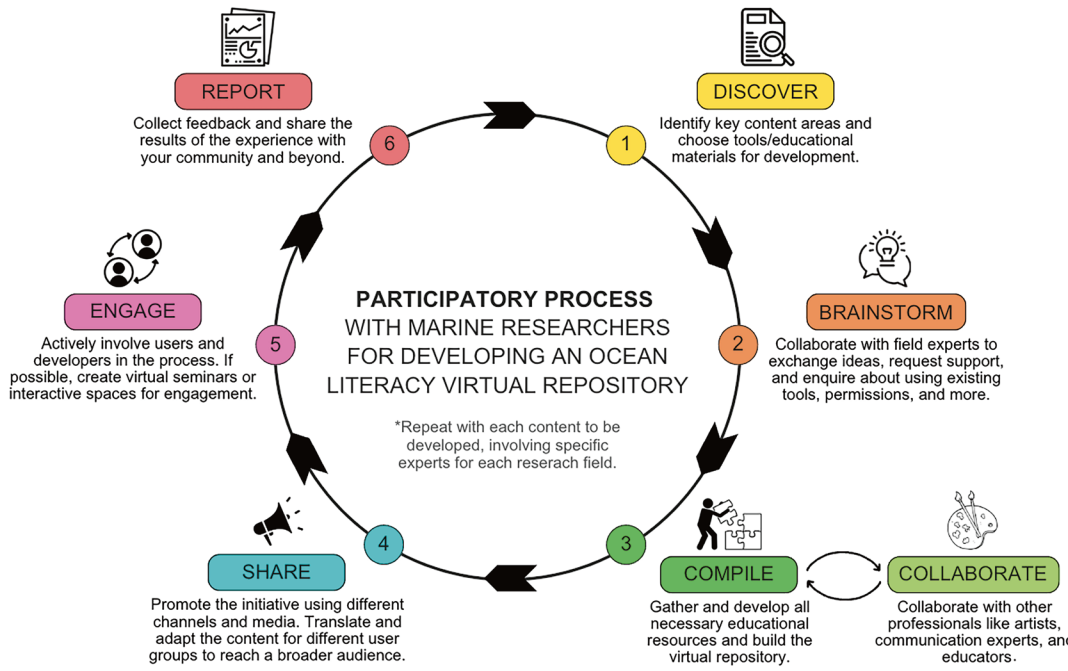


Fig. 6.1 The participative process followed to develop the virtual repository "L'Oceà a Casa" (Ocean at Home). *Note:* The participative process included the 6 steps indicated above

Sustainable Development Goals (SDG's) and the UN Ocean Decade Challenges and Outcomes (UN 2018). For instance, one module focused on marine pollution and plastics in the Ocean (Challenge 1: Understand and beat marine pollution), while another addressed the Ocean-climate nexus (Challenge 5: Unlock Ocean-based solutions to climate change). Each capsule included different formats and levels of content (Challenge 9: Skills, knowledge and technology for all). Additionally, the final post was dedicated to reflecting on the necessary shift in humanity's relationship with the Ocean (Challenge 10).

Regarding Ocean Decade outcomes, the initiative aimed to contribute to all of them, with particular emphasis on: "A clean Ocean", "A healthy and resilient Ocean", "An accessible Ocean" and "An inspiring and engaging Ocean". The entire initiative, along with all the educational content developed, is available in open access on the website in both Catalan and Spanish, as these are the mother tongues of the ICM-CSIC's target audience located in Catalonia (see Resources Section for link).

Although the program was initially designed for primary school children (equivalent to K-6: Kindergarten through 6th grade, ages 5–12), it reached a much broader audience. There was a very high level of staff involvement and commitment, and overwhelming positive feedback was received. This section presents the effort and entire process followed, including the identified limiting and facilitating factors. Feedback collected from participants is also discussed.

At least eleven different stakeholders from various sectors, including policy, education, and media, shared the initiative. In just one month, over 11,000 visits were recorded, as tracked by Google Analytics. The initiative also offered participants the opportunity to register for daily updates on new entries. A survey with open-ended and 5-point Likert scale questions was developed and shared with registered participants to gather their perspectives. This questionnaire

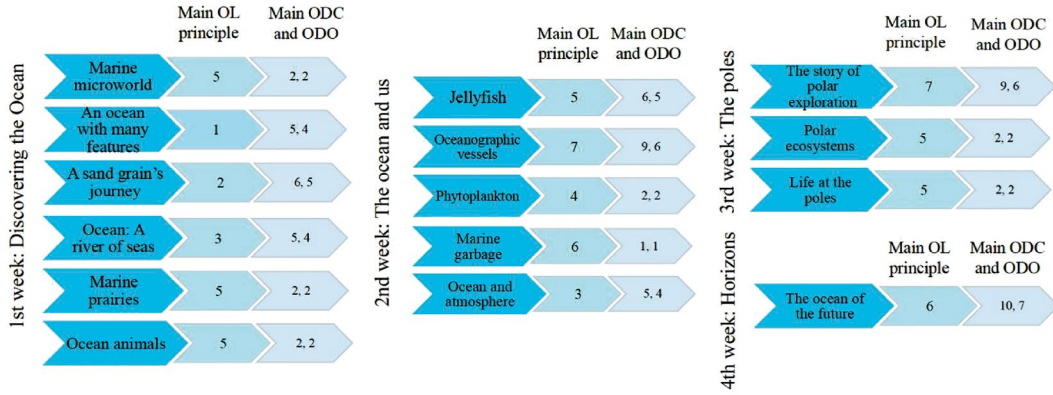


Fig. 6.2 Educational content scheme of "L'Oceà a Casa" (Ocean at home) initiative. *Note:* Links to the content of main OL principles and the main Ocean Decade Challenge (ODC) and Ocean Decade Outcome (ODO) covered. Each week, a cross-cutting theme was covered with different posts. Contents were not published on public holidays, so some weeks had fewer educational materials than others

has remained available on the website for future users.

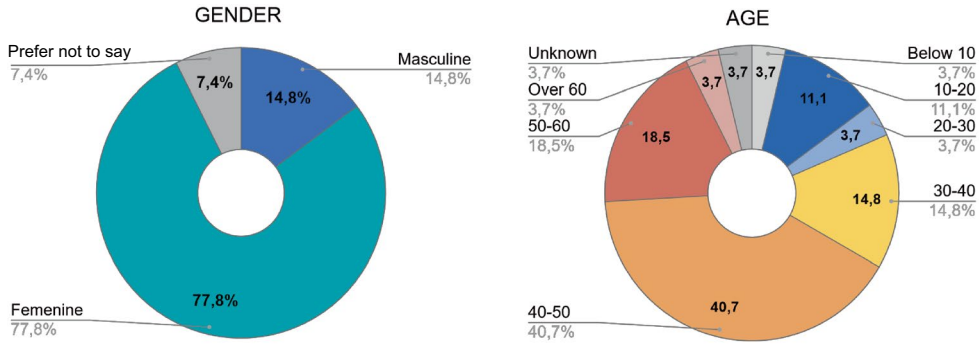
The final feedback provided by participants is displayed in Fig. 6.3. A total of 27 participants responded to the questionnaire assessing their level of satisfaction and follow-up regarding the initiative. Of these, 4 were men, 21 were women and 2 preferred not to disclose their gender. Four participants were children (aged 9, 12, 13, and 13), while the remaining participants' ages ranged from 32 to 63 years old. Most respondents were teachers, but the group also included a physiotherapist, a gardener and parents of students. The majority of participants held higher education degrees. Twenty-two participants lived in coastal towns or villages, while five resided inland (more than 50 km from the coast). There was a variety of frequencies in visits to coastal ecosystems, but all participants reported visiting at least once a year. Most participants, however, did not venture below the sea surface, only a few had experiences with snorkeling or diving. The initiative was primarily discovered through official WhatsApp messages, social media, or recommendations from friends or relatives. Participants generally did not follow the entries daily but checked them periodically over several days, and not all entries were viewed by everyone. Those who participated in the online seminars expressed strong appreciation for them and recommended the initiative to friends and relatives.

Participants commended both the quality and relevance of the content, and they positively evaluated the initiative duration. They reported learning new, otherwise inaccessible, information. Some of the most surprising aspects they learned included the Ocean-climate relationship, the prevalence of microorganisms in the Ocean, and the fact that the Ocean remains largely unexplored. Some participants were previously unaware of multidisciplinary and collaborative approaches used in marine research. Overall, participants rated the initiative high and recommended it. Additionally, they suggested expanding the access to more marine educational resources.

When asked to compare this initiative to other educational programs during the COVID-19 lockdown, most participants awarded it the highest possible rating, resulting in an overall score of 4.64 out of 5. They also conveyed their sincere gratitude, noting that learning about the Ocean helped to alleviate some of the anxiety experienced during the lockdown.

This experience serves as further evidence, adding to numerous existing reports, of the crucial yet often overlooked role the Ocean plays in

A)



B)

Concept	*Score (over 5)*	*Scale 1 to 5*
Boring	1.44	1 not boring, 5 very boring
Repetitive	1.68	1 not repetitive, 5 very repetitive
Length	3.66	1 very short, 5 very long
Surprising	3.68	1 no surprising, 5 very surprising
Narrative	3.68	1 haven't liked them, 5 I've liked them very much
Linked resources	3.76	1 haven't liked them, 5 I've liked them very much
"I've learnt new things"	3.88	1 nothing, 5 a lot
"I would recommend it"	4.16	1 nothing, 5 very much
FINAL OVERALL MARK GIVEN	**4.64**	1 very bad, 5 very good

Fig. 6.3 Questionnaire of the initiative "L'Oceà a Casa" (Ocean at Home). *Note:* (**a**) The profile of participants who answered the questionnaire of the initiative "L'Oceà a Casa" (Ocean at Home). (**b**) The value given, from 1 to 5 to the different aspects of the initiative

human wellbeing (Fleming et al. 2024). It would be interesting to explore the potential and limitations of this kind of virtual actions in enhancing safe learning spaces and promoting health benefits, such as overcoming fears and trauma or fostering collective empowerment, as other studies have already reported with *in situ* actions (e.g., Burtscher and Britton 2022). Additionally, further opportunities for engagement should be explored to reach a wider audience, by adapting the materials to other languages and broader contexts. Increasing dissemination efforts through the institution's channels and activities is also crucial, especially to reach non-marine populations. Such efforts will be explored further in the future.

6.3 The Importance of Capacity Building in Marine Research Institutions: A Test to Boost OL

Marine research centers, as primary sources of Ocean-related knowledge, play a crucial role in advancing OL. However, knowledge generated within these centers often remained siloed.

Internally, knowledge is often compartmentalized across different research groups. This fragmentation is further exacerbated by common challenges such as time constraints and limited internal communication, often driven by the inherently competitive nature of academic environments. As a result, it becomes difficult for the staff to interact and share their perspectives on OL.

Given the increasing importance of comprehensive OL strategies (Salazar et al. 2024), and drawing inspiration from Madden et al. (2023), a survey was designed at the ICM-CSIC to gather insights from researchers on OL. It was also intended to be useful for other national and international marine research centers, with minor adaptations needed. The structure of the questionnaire is outlined in Table 6.1, and includes the following sections:

- Survey purpose and data usage: An explanation of the survey's purpose, along with a section on data treatment, where participants could choose to accept or decline the use of their data for research purposes.
- Participant's personal data: Six single-choice questions collected data, including gender, age, role, center, research field, and years of experience.
- Viewpoints on E&O, including: (a) Institutional OL structures: An open-ended question asked whether participants were aware of any specific structures promoting OL within their institutions (e.g., committees, task forces, representation in a directorate team), (b) Capacity to contribute to OL: A series of five 5-point Likert scale questions assessed participant's self-perceived ability to contribute to OL efforts, (c) Institutional feelings about OL: A single-choice question gauged participant's perceptions of OL efforts within their own centers, (d) Personal experience in E&O: Multiple-choice questions explored participants' experiences with E&O activities and the reasons for their level of engagement, (e) In-person E&O activities: Multiple-choice questions investigated participants' experiences with and barriers to participating in in-person E&O activities, (f) Role of different agents in promoting OL: Five 5-point Likert scale questions evaluated the perceived roles

Table 6.1 Structure of the questionnaire for OL capacity building in marine research centers

1st	**Survey purpose and data usage**	Explanation of the study framework + Consent to participate: 1 single-Choice question (Yes/No)
2nd	**Participant's personal data**	6 single-choice questions
		• gender
		• age
		• professional category
		• marine research center
		• research field
		• years of experience generating marine knowledge
3rd	**Views on Education and Outreach**	7 open-ended questions
		• institutional OL structures
		• in-person E&O activities
		• additional OL enablers
		• ranking of agents
		• additional needs
		24 5-point Likert scale questions
		• capacity to contribute to OL
		• motivations for E&O
		• role of different agents in promoting OL
		2 single-choice questions
		• institutional feelings about OL
		• frequency of E&O participation
		5 multiple-choice questions
		• personal experience in E&O
		• in-person E&O activities
		• factors influencing E&O engagement
		• best OL resources
		• ideal OL strategy
		• final comments

Note: Structure, content and kind of questions of the OL capacity-building questionnaire

of various agents in promoting OL, (g) Additional OL enablers: Open-ended questions sought participants' views on other potential relevant facilitators in OL promotion, (h) Ranking of agents: An open-ended question asked participants to rank agents from most to least important in promoting OL within marine research-performing organizations (RPO's), (i) Frequency of E&O Participation: A single-choice question inquired about the frequency of participant's involvement in E&O activities, (j) Motivations for E&O: Five 5-point Likert scale questions explored participants' motivations for engaging in E&O, (k) Factors influencing E&O engagement: A multiple-choice question examined what factors might encourage participants to engage more in E&O, (l) Additional needs: An open-ended question invited participants to identify other needs related to E&O, (m) Best OL resource: Participants were asked to provide an example of the best OL resource they knew, (n) Ideal OL strategy: An open-ended question asked participants to describe an ideal strategy for improving OL, (o) Final comments: A concluding open-ended question provided participants the opportunity to add any additional comments.

The survey provided insights into OL status within marine research institutions and capacity-building needs.

The questionnaire was developed after thorough documentation, discussions and several rounds of improvements conducted over two years by a transdisciplinary group of six experienced researchers with backgrounds in physical oceanography, marine biology and ecology, marine social sciences, marine education, and communication. It was distributed via email to ICM-CSIC's staff, including a summary of the study's main goal and ethical considerations, in accordance with the recommendations and after the approval of the Spanish National Research Council (Consejo Superior de Investigaciones Científicas, CSIC) Ethics Committee. The survey was distributed during the summer, a period chosen to provide more flexibility and ample time for respondents to complete it. The profile of respondents can be seen in Fig. 6.4.

Out of approximately 300 staff members, 20 participated in the survey (14 women and six men, a common percentage in voluntary surveys), representing various age ranges and professional roles. Fields of work included Biology, followed by Marine Resources, Central Services, Geosciences, Biogeochemistry, Physics, and Marine Social Sciences.

The relatively low number of participants is probably due to the voluntary character, its length and/or the choice of summer for conducting the study. This participation could potentially be increased with the collaboration of the centers' directorate, for example by explaining the importance of the study for developing effective strategies during internal meetings with high staff attendance. Answers to the survey are summarized in Table 6.2.

Regarding their experience in generating marine knowledge, participants showed diverse experience levels: Six had less than three years of experience, three had 3–5 years, one had 6–9 years, one had 10–12 years, and 9 had more than 15 years of experience. All participants were aware of a group dedicated to OL in their research institute. Although three respondents admitted they were unsure of the group's exact name or purpose, most were familiar with it.

Participants rated their institution's capacity to contribute to OL positively, particularly when collaborating with other entities. However, they rated their own contributions to OL less favorably. This result is not unusual; in a marine research center, where there are often individuals who are more aware and committed to OL than others. Consequently, perceptions of the center's contributions are often rated higher than individual contributions.

Participants expressed a willingness to improve their involvement and performance in OL, with 16 feeling they had enough opportunities within their center and four feeling they did not. 13 respondents believed they were already sufficiently promoting OL, while seven felt they should do more. This highlights the importance

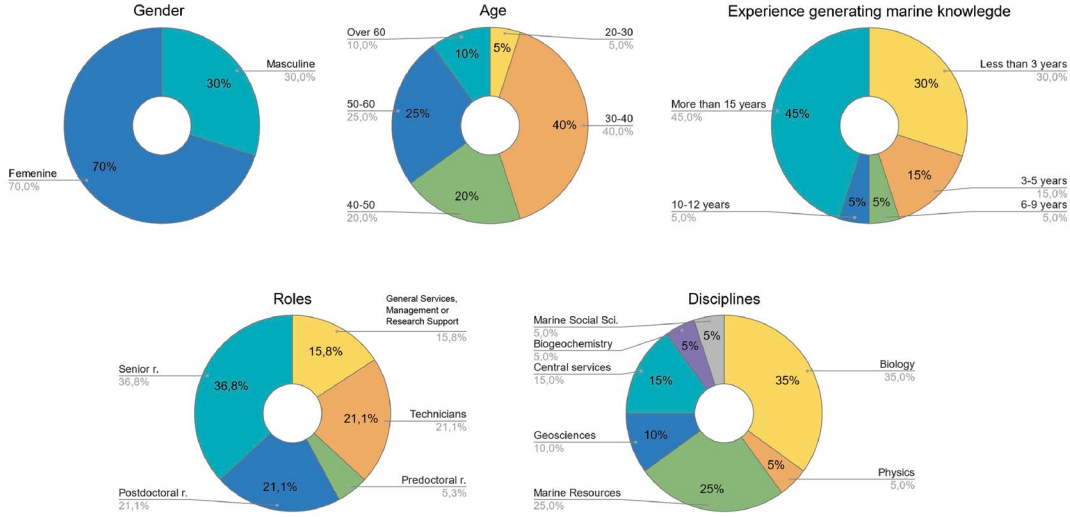


Fig. 6.4 Profile of the respondents of the OL capacity-building survey. *Note:* Gender, age, role, discipline and experience generating marine knowledge of each respondent of the OL capacity-building survey is shown

of not taking for granted the existing training opportunities and resources for OL development available to staff.

In terms of participation in E&O activities, only one respondent had not participated in any activities. Most participants had engaged in activities organized by their research center, primarily targeting children or young people. Additionally, some participated in events for the general public and specialized audiences organized by their research center and by other institutions. The most limiting factor was lack of time, followed by the belief that they were already dedicating enough time to these activities and lack of awareness of available opportunities. three participants expressed a desire to engage more in E&O. Two respondents felt that E&O was not their responsibility. 1 participant mentioned that these activities were not adequately recognized in their scientific career.

The responses indicated a commitment among staff to promote OL across different sectors of society, with no neglected sectors detected. The issue of lack of time is likely difficult to address due to the nature of the academic system in which marine research centers operate. A potential solution could involve compensating staff for the time and effort spent on OL tasks. Possible measures might include providing certificates and genuine promotion opportunities, allocating budgets for OL activities, offering financial compensation, or even granting additional leave to staff.

Regarding non-in-person activities, 2 participants had not engaged in any, while the rest had experience on virtual environments (13), social media (11), creating materials for specialized audiences (9), creating books or comics for the general public (7) and for children or young people (8), designing educational games (3), and developing educational support materials (10).

Respondents contributed with different formats in the development of OL resources and OL promotion. The lack of awareness of opportunities could be reverted by strengthening internal communication channels and embedding OL activities in institutional communication plans.

Interestingly, none of the participants selected the lack of direct personal economic incentives as a reason for limited involvement. When asked who they believed was most important in promoting OL, the most frequently mentioned stakeholders were journalists, professionals in marine science communication and university professors of marine science-related fields. However, one participant downplayed the role of journalists, giving more importance to teachers. Influencers and social media content creators received fewer votes compared to others.

Table 6.2 Main results of the pilot OL capacity-building test

Topic	Results	Comments
Involvement in OL	• 80% stated they had enough opportunities for engaging in OL activities within their centers • 65% believed they were already sufficiently promoting OL • Only 5% had never participated in E&O activities • 10% engaged in OL activities almost every week, • 15% at least twice a month, • 20% at least once a month, • 40% at least twice a year, • 15% at least once a year • 65% of respondents had experience in E&O virtual environments • 55% had promoted OL via social media • 50% had developed educational support materials • 45% had created materials for specialized audiences • 40% had created books or comics for children or young people • 35% had created books or comics for the general public • 15% had experience designing educational games	Due to the voluntary character of the survey, probably most respondents were people committed to OL promotion. Main reason to be involved in OL: • Desire to improve societal understanding of the Ocean and foster a better relationship between society and the Ocean. • Expression of a sense of responsibility, viewed as part of their duties as researchers. • The least valued incentive was the potential recognition in future promotions or hiring processes.
Facilitating factors	Factors encouraging greater engagement in OL: • 60% indicated budget allocation • 60% noted a new culture among the staff that views knowledge transfer as a tool for societal change • 55% emphasized the need for dedicated personnel to develop E&O content • 45% identified recognition of OL efforts as effective work, rather than voluntary extra tasks • 40% noted recognition of OL efforts in hiring and promotion processes • 35% indicated more training opportunities • 30% pointed out additional funding for facilitators • 20% identified guides or support material	Best OL tools identified: educational games and resources developed at the research institute, along with documentaries. 1 participant suggested the importance of making a diverse array of high-quality resources available. Among the most effective OL strategies identified were allowing researchers more time to engage for OL engagement and properly recognizing and professionalizing roles focused on OL enhancement.
Limiting factors	• 15% expressed a desire to engage more in E&O but were unaware of available opportunities • 10% felt that E&O was not their responsibility • 5% stated that these activities are not adequately recognized in scientific careers Reasons for limited engagement in non-in-person OL activities: • 30% cited lack of time • 20% mentioned lack of awareness about these activities • 30% believed that are already sufficiently involved • 5% felt OL efforts lack recognition in scientific career paths • 0% mentioned a lack of direct personal economic incentives	The most frequently cited barriers for greater involvement were lack of time followed by the belief that they were already dedicating enough time to these activities. Interestingly, none of the participants selected a lack of direct personal economic incentives as a reason for limited involvement.

(continued)

Table 6.2 (continued)

Topic	Results	Comments
Responsibility for OL promotion	• 65% fully identified marine research center staff as responsible for OL promotion • 15% identified marine research staff partially responsible for OL promotion Additional key players in OL promotion identified by marine researchers: • policymakers • government personnel • Marine Protected Areas managers • members of environmental education organizations Difficulties in identifying the main responsible for OL promotion in marine research centers, diversity of opinions (PhD students, senior researchers, technicians, the Marine Science Literacy Committee…)	There was no clear consensus on who is responsible for promoting OL: diversity of opinions, a shared responsibility among various stakeholders, led by specialists. Journalists, professionals in marine science communication and university professors in related fields were seen as primary OL promoters. Influencers and social media content creators received less attention. Consensus: Marine researchers agreed that OL promotion should involve collaboration among various stakeholders across sectors.

Note: Summary of the involvement in OL, facilitating factors, limiting factors and responsibility for OL promotion

Notably, 13 participants rated the responsibility of marine research centers' staff as 5/5, although 3 rated it below 3/5, indicating a diversity of opinions on this issue. Some participants suggested other key players in promoting OL, including policymakers, government personnel, managers of Marine Protected Areas (MPA's) and members of environmental education organizations. There is no clear consensus on who should be responsible for promoting OL. Rather, it seems that marine research staff views this as a shared responsibility among various stakeholders.

To enhance collaboration, it is essential to create spaces where these different agents can meet, align their commitments, and build strong partnerships. Adequate political support will be necessary to ensure that these collaborative spaces are established and scaled from local to national and international contexts.

When asked who should oversee OL within marine research centers, most respondents identified OL Committees as the primary coordinators. Others pointed to marine social scientists, while many responses involved various staff members, including senior researchers, students, and technicians. Interestingly, one participant suggested that marine researchers should not be involved in OL activities, arguing that these responsibilities should be handled by specialized personnel. These answers indicate a general perception of shared responsibility. More importantly, there is a clear difficulty in identifying who should take on these roles, which represents a challenge that needs to be addressed.

Regarding frequency, 2 participants engaged in OL activities almost every week, 3 at least twice a month, 4 at least once a month, 8 at least twice a year, and 3 at least once a year. Most participants indicated their motivation to contribute to OL stemmed from a desire to improve societal understanding of OL and enhance society's relationship with the Ocean. They expressed a sense of responsibility, viewing it as part of their duties as researchers. The least valued incentive was the potential recognition in future promotions or hiring processes. When asked what factors would encourage greater engagement in E&O activities, 12 participants identified the need for a budget dedicated to these initiatives. Another 12 emphasized the importance of fostering a new culture within the staff that views knowledge transfer as a tool for societal change. Additionally, 11 respondents highlighted the necessity for specialized personnel to develop E&O content. 9 participants expressed the desire for these activities to be recognized as effective work rather than as voluntary extra tasks that add to their existing responsibilities. Furthermore, 8 indicated a wish for greater recognition of these activities in hiring and promotion processes, while 6 wanted funding for the facilitators of these activities. Seven participants

requested more training, and 4 sought additional guides or support materials. Some also expressed a desire for more opportunities to connect with other stakeholders.

Among the best OL tools identified were educational games and resources developed at the center, along with documentaries. One participant suggested that a diverse array of high-quality resources should be made available. The most effective strategies identified included providing researchers with more time to engage in OL efforts and properly recognizing and professionalizing the role of those who enhance OL.

6.4 Key Findings and Analysis of the Preliminary Evaluation

After analyzing the two initiatives described above, several key conclusions can be drawn:

- Effectiveness of OL virtual repositories: The virtual repositories developed by facilitators from marine research centers have proven to be an effective strategy for compiling diverse knowledge from their research groups and creating new educational resources for both formal and informal OL purposes. Although this initiative arose under extraordinary circumstances, the questionnaire results suggest that similar outcomes could be achieved under different conditions, provided that adequate human resources are allocated. Importantly, it is essential to recognize and compensate staff commitment, ensuring that their involvement is viewed as part of their duties rather than as voluntary extra tasks.
- Value of the initiative: Participants in the virtual initiative assessed the project positively, highlighting their previous lack of access to OL and scientific marine knowledge. This emphasizes the need for continued development of educational materials in various formats, as well as strengthening networking and collaboration with other sectors to enhance resource availability. Participants identified unfamiliar concepts, such as the Ocean-climate nexus and microorganisms in the Ocean, which underscores the necessity for robust strategies centered on OL and ongoing knowledge transfer from marine research centers to broader societal contexts.
- Participation motivations: The impressive participation of over thirty scientists in a month-long project can be attributed to unique circumstances, such as the pandemic. This situation motivated scientists who do not typically engage in OL projects to participate, resulting in a rapid positive response. Initiatives like "L'Oceà a Casa" (Ocean at Home) illustrate that scientists may require specific encouragement to engage in OL projects, and these initiatives can serve as a crucial first step in involving previously disengaged individuals.
- OL capacity-building assessment: The assessment for OL capacity-building in marine research centers is an effective tool for identifying both limiting and facilitating factors in promoting OL. While the response rate was relatively low—potentially due to the timing and length of the survey—results provide valuable insights into the topic. Future efforts should focus on gathering a more comprehensive view of the research institute's perspectives. Emphasizing the importance of completing the survey, conducting targeted interviews, or discussing OL as a focal point in internal meetings could enhance participation.
- Commitment and resource allocation: The findings indicate that there is a committed group of marine researchers engaged in OL activities. However, reliance on voluntary participation poses a potential risk. To maintain the involvement of marine researchers in promoting OL, it is crucial to allocate additional resources for this purpose. Most respondents believe that the responsibility for mobilizing marine knowledge to society should be professionalized, advocating for dedicated staff positions focused on OL to facilitate the collection and dissemination of marine knowl-

edge to wider audiences. Notably, while some participants expressed interest in financial compensation for their efforts, the majority prioritized having time allocated during work hours for OL activities, along with the recognition of this time as effective work. There was also a general agreement on the need for budget allocations for these activities.

- Strategies for enhancing OL: Although these are preliminary results that should be interpreted with caution, the study highlights several strategies supported by the staff that could be implemented in marine research centers to enhance OL opportunities: (a) Designate professional roles specifically for OL tasks and professionalize these positions within the institute. (b) Allocate budgets for each research group to pursue their own OL initiatives. (c) Create and facilitate OL opportunities for marine research staff. (d) Improve access to existing institutional networks to promote synergies. (e) Foster an institutional culture where OL is integrated into research performance, contributing to desired social change and adequately recognizing staff involvement in OL activities.
- Ongoing staff engagement: Given the unstable conditions of marine scientific careers, staff turnover at marine research centers is frequent. It is essential to periodically gather staff perspectives to ensure that they are comfortable with the adopted modus operandi and to identify new facilitating and limiting factors.
- Recognizing and compensating OL efforts: There is a strong commitment among marine research staff toward OL. However, to build effective strategies and develop robust institutions, it is crucial to care for marine researchers by recognizing and compensating their efforts adequately. Rather than providing direct supplementary stipends, it may be more beneficial to allocate a specific budget for OL initiatives. This would enable researchers to access training, expert support, and necessary resources. Additionally, it is vital to recognize these efforts as effective work, equivalent to laboratory or other typical marine research tasks.

6.5 Conclusion: Next Steps and Final Remarks

This study has provided experiences and resources created in a marine research center, highlighting the importance of these spaces as primary sources of marine knowledge. This work wanted to show some difficulties faced but also opportunities from these spaces and wanted to provide tools for other marine research centers for facilitating their integration into the global OL movement. This is a first step in a long way and should be viewed as such.

Effective strategies should be developed in the short but also in the long run to achieve goals and consolidate the changes pursued. Also, as the global OL movement itself has been demonstrating, collaboration and action of like-minded individuals has made the change, and it is essential to continue like this in the future. All OL networks are encouraged to work together pursuing three P's: People, Products and Partnerships (Marrero et al. 2019).

The tools presented in this study have proven effective in promoting OL within a marine research center and in gathering crucial information for developing effective strategies. However, OL-directed measures for each marine research center should be tailored to the specific opportunities and needs of each institution, based on a thorough analysis of their contexts. The tools discussed may not yield the same results in different environments and should be tested beforehand. It is advisable to evaluate these methods prior to implementation, complement them with other methodologies as suggested, and, if necessary, consider alternative approaches.

Implementing a shared assessment methodology across centers could open new avenues for identifying common patterns and differences, thus enhancing our understanding of the role of marine research centers in the OL movement. However, applying general methodologies that do not align with a center's unique circumstances may yield unexpected results. This study does not intend to provide a one-size-fits-all toolkit but rather encourages centers to contribute with their feedback and perspectives to the broader discus-

sion, utilizing either the proposed methodologies or their own.

To sum up, the importance of incorporating marine research center staff's perspectives into the development of OL strategies has been highlighted, to achieve the goals and challenges of the UN Ocean Decade and beyond.

6.5.1 Summary

Key concepts explored in this chapter include:

- During the COVID-19 lockdown, "L'Oceà a Casa" initiative developed a virtual repository that brought marine knowledge into homes, reaching a wide audience beyond its primary target of children. Through resources like educational capsules and seminars, over 30 researchers engaged to create materials aligned with the Ocean Decade and SDGs.
- Respondents involved in the "L'Oceà a Casa" initiative provided very positive feedback, highlighting the value of learning about marine ecosystems, climate-Ocean interactions, and Ocean microorganisms—topics often inaccessible to the public. They noted the initiative's relevance in alleviating anxiety during lockdown, with over 11,000 visits in one month indicating significant interest in virtual OL resources.
- A survey by ICM-CSIC researchers revealed barriers to developing and conducting OL initiatives, such as limited time and insufficient academic acknowledgment for OL activities. Respondents expressed a desire for more institutional support, including budget allocations, clearer role definitions, and professional recognition of OL efforts. The findings suggest that formal support could sustain and enhance researcher engagement in OL.
- ICM-CSIC researchers face typical challenges within academic institutions, including fragmented knowledge sharing and individual priorities overshadowing collective goals. To address these challenges, the study suggests adopting an institutional approach by designating specific personnel for OL and integrating OL as a core institutional goal. Recognizing OL efforts as essential rather than voluntary could encourage more significant results in marine knowledge transfer.
- The study proposes several strategies to enhance OL in marine research centers: professionalizing OL roles and allocating resources for these activities; fostering an institutional culture around OL to promote broader societal engagement; and regularly surveying staff to adapt OL initiatives to evolving needs, ensuring alignment with institutional priorities.
- The study suggests that these approaches could enhance OL engagement and marine knowledge transfer in other research centers. It also advocates for collaboration across institutions to develop common methodologies and resources sharing, facilitating cross-institutional understanding and cooperation toward global OL goals.

6.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

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7 Effectiveness of a Marine Education Program Applied in a Marine Protected Area Context and Designed with Science Education Strategies

Yolanda Sánchez Álvarez, Adrián Villaseñor, Gonzalo Bravo, and David Santibáñez

Abstract

The study examines the effectiveness of a marine education program in a Chilean marine protected area (MPA), designed using science education strategies to promote Ocean Literacy and sustainable decision-making. It involved 240 participants who engaged in activities illustrating ecosystem services, human impacts, and marine conservation, emphasizing interactive learning and practical application. A Teaching and Learning Sequence (TLS) was employed during a sustainable fishing game to connect theoretical knowledge with daily life decisions. The program significantly improved participants' understanding of the human-Ocean connection, reflected in an average 9% increase in correct responses on post-activity surveys. Notable gains included awareness of ecosystem services and the impact of human activities, such as overfishing. Six to twelve months later, 44% of surveyed participants reported applying their learnings in sustainable consumption practices and sharing knowledge with others.

This approach highlights the potential of TLS and experiential education to enhance Ocean Literacy and foster long-term behavioural change, which is critical for the success of MPAs and marine conservation efforts. Future research should explore broader applications of such educational strategies to create a more Ocean-literate society.

Keywords

Ocean Literacy (OL) · Marine conservation · Science education · Marine protected area · Learning-teaching sequence · Community engagement

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7.1 Introduction: Education for Marine Conservation

The Ocean is essential for life on our planet and provides us with numerous benefits known as Ecosystem Services (ES). However, many fail to recognise that the Ocean is vulnerable to degradation and its resources are not limitless. Human activities are affecting Oceans worldwide (Österblom et al. 2017), creating a considerable challenge for marine conservation and the management of those ES. In this context, we must also address one of the Ocean's most significant threats: the lack of information that promotes responsible decision-making (Pendleton et al. 2020).

One of the primary mechanisms for addressing the environmental risks currently impacting global coasts is the establishment of Marine Protected Areas (MPAs). MPAs are not solely created to protect marine habitats and shield endangered marine species but are also implemented to benefit local communities by supporting better fisheries management or boosting other economic activities, like tourism (Ban et al. 2019). Research shows that key stakeholders in protected areas are more likely to accept MPA rules when they are informed because they understand the rationale behind these conservation tools, and recognize their benefits, contributing to the long-term success of the MPA (Gall and Rodwell 2016).

Marine education is crucial for the long-term sustainable management of the coast and seas, motivating public involvement in governance (Katikiro 2016). During UNESCO's "Ocean Decade", Challenge 10 was proposed to restore society's relationship with the Ocean. One of its key Priority Outcomes is to use formal education in schools, colleges, universities, and nonformal experiential learning (e.g., citizen science, museums, aquariums, multimedia, etc.) to build connection (physical and emotional), deepen Ocean understanding, and motivate individual and community action (Glithero et al. 2024).

To increase knowledge, awareness and connection with the Ocean and MPAs, it is required that conservation incorporate Ocean Literacy (OL) methodologies to increase knowledge and raise awareness through education as key strategies for the success of MPAs (Bennett and Dearden 2014). Increasing evidence links sustainable behaviour to improvements in marine ecosystems (Ruckelshaus et al. 2013), with studies showing that such behaviour is often associated with participation in environmental education programs. Effective implementation of education and outreach programs, clear communication of rules and regulations, and activities to build confidence and resolve conflicts will enhance participation and integrate local values and knowledge into conservation planning (Bennett and Dearden 2014).

Despite efforts to enhance OL and promote responsible decision-making, considerable uncertainty remains about the best effective approaches to achieve these goals. Research emphasizes the need for more rigorous evaluations of educational tools used in these programs to validate their effectiveness and impact on marine conservation outcomes (Watson et al. 2014). Evaluations highlight the potential of education strategies to empower communities and contribute solutions. They also provide a means to measure success and offer valuable evidence for future projects (Veiga et al. 2016).

7.2 Science Education for Ocean Literacy (OL)

Marine education should prepare citizens to make responsible decisions regarding environmental issues. The challenge for marine educators is to link information with daily decisions which involves developing knowledge and attitudes at an individual level (McKinley and Fletcher 2012). Science education research suggests that a constructivist approach is a coherent strategy for marine education and sustainable

development (Walsh and McGowan 2017). This approach fosters higher-order thinking skills, enabling students to apply their knowledge to make responsible decisions (Robottom 2004). Current scientific education gives relevance to the use of meaningful contexts, the centrality of alternative ideas, and the participation of students in learning scenarios in which direct contact with the phenomenon under study, data collection and evidence analysis is possible (Vosniadou 2019).

In recent years, the purpose of scientific literacy has shifted from a contextual science approach to a critical scientific literacy aimed at societal transformation (Sjöström and Eilks 2018). This approach emphasizes that understanding science should empower responsible citizenship by tackling real socio-scientific issues. Consequently, marine education strategies need to address students' existing ideas and attitudes about specific issues (Hawkins and Stark 2016, while also considering social and cultural factors. Students develop ideas and understandings of their interactions and experiments with topics such as the Ocean (Marrero 2009), and meaningful learning occurs when their alternative views, often inconsistent with formal science, are acknowledged and addressed (Vosniadou 2019). In biology science learning, both children and adults face similar challenges in modifying their alternative ideas, as the differences lie not in the underlying conceptual structures but in the relevance and application of these structures in different contexts (Inagaki and Hatano 2013). Instructional planning should focus on activities encouraging students to question and refine their ideas (Robottom 2004). The teaching and learning sequences (TLS), which gained prominence in the early 2000s, offer a comprehensive framework for planning educational activities by detailing what, how, and why to teach. The learning cycle proposed by Sanmartí (2000) exemplifies TLS by considering context, prior knowledge, and student interests, facilitating the didactic transposition needed for effective learning. Additionally, TLS adopts a socio-constructivist perspective, positioning the educator as a mediator and fostering cognitive conflicts and peer learning opportunities (Leach and Scott 2002).

This study aimed to evaluate the impact of a TLS as a tool for promoting knowledge increase in marine conservation and the long-term application of learnings expected as a strategy to promote Ocean conservation.

7.3 Methodology

7.3.1 Educational Visits

Chile es Mar is a marine education program created in 2012 to share scientific information and promote marine conservation in Chile. The program was primarily developed in the *Estación Costera de Investigaciones Marinas* (a marine research and teaching laboratory of the Pontificia Universidad Católica de Chile), located in Las Cruces (Valparaíso). The research station was based there due to the creation of a marine and coastal protected area in 1982. The program aimed to increase knowledge and understanding of ecosystem services (ES), human impacts (HI), and marine conservation strategies (MC) through the lens of the OL sixth principle that "humans and the Ocean are inextricably connected." The program featured a variety of activities, but the most notable one was the visit to the research station. Initially, these visits were designed for schools, aligning some concepts with the national curriculum. However, due to high demand, family visits were introduced, typically held on weekends and during holidays. The visits were tailored to all age groups, attracting participants from diverse locations, ranging from nearby communities to visitors from Santiago, a city located 100 kilometers from the coast.

Family visits were performed for guided groups of 20 participants. All Guides participated in in-person training covering the educational methodology behind the activities and the activities themselves. Sessions lasted 2.5 h and were structured into four stages, each set in a different environment to enhance learning through varied experiences. The stages were as follows:

1. Stage 1—MPA Visit: Understanding MPA Values and Benefits
   The first stage took place within the MPA, where participants explored the ecological and social benefits of these protected areas. The marine coastal landscape is visibly divided between protected and non-protected zones, with a fence restricting community access to the protected area. This demarcation highlights the contrast between accessible and restricted coastal sites. From an elevated vantage point at the Research Center, visitors observed and compared the biological richness of both zones, even quantifying visible differences in biodiversity. Extending their perspective beyond directly observable, allowed participants to grasp the broader impact and critical importance of protecting marine ecosystems. This activity emphasized how MPAs play a pivotal role in preserving biodiversity and supporting the sustainability of human communities.
2. Stage 2—Aquarium: Learning About Biodiversity
   In the second stage, participants visited an aquarium room featuring a touch pool. The activity began with educators emphasizing the importance of respecting and caring for the animals involved, guiding the group throughout the experience. This setting provided a unique opportunity to introduce new marine species, many of which were unfamiliar to the visitors, showcasing the richness of Chilean coastal biodiversity and its vulnerabilities. Participants learned about various organisms inhabiting the region, with a focus on how human activities, such as habitat destruction and overfishing, can threaten these species and disrupt marine ecosystem balance. This stage fostered meaningful connections between visitors and marine biodiversity. For some, the close observation of the animals and their movements sparked curiosity and surprise, while for others, emotional bonds emerged as they engaged with the marine life during the activity.
3. Stage 3—Open Air: Interactive Game About Responsible Fishing
   The third stage took place outdoors and featured an interactive game focused on responsible fishing (Fig. 7.1a). This stage fully implemented the TLS approach, making it a cornerstone of the educational program. The activity was designed to enhance participants' understanding of overexploitation in Chilean fisheries and to promote informed, responsible decisions about marine resource consumption. To achieve these goals, the activity was divided into four phases:
   (i) Exploration Phase: Participants were asked key questions (Table 7.1) to challenge their existing ideas and misconceptions about marine resources, overfishing, and the concept of fish reproduction sizes. This discussion helped to establish a baseline understanding in preparation for the following stages. The end of this activity includes the interaction with cards (Fig. 7.1b) that show the primary marine resources used in Chile (on this coast) and their reproduction sizes.
   (ii) New Knowledge Introduction Phase: Participants were introduced to conservation strategies, including closed seasons (no-fishing seasons) and the importance of reproductive sizes for sustainable fishing. They learned how choosing fish based on their size could support marine conservation.
   (iii) New Knowledge Structuring Phase: Participants took on the role of fishermen in this phase. Having a pool of mock-up fish as options to fish, they had to decide what to catch or not, using the information they had about reproduction sizes, closed seasons, and overexploited species. They used tape measures (Fig. 7.1c) and species information cards (Fig. 7.1b) to make informed decisions, applying the knowledge gained in the previous phase.
   (iv) New Knowledge Application Phase: Participants reflected on their decisions after the game and discussed whether they were sustainable. They were given

tape measures as a takeaway (Fig. 7.1c) to use in real-life markets, encouraging them to apply what they learned daily by verifying fish sizes before purchasing.

4. Stage 4—Lab: Conclusions. The final stage occurred in the conference room, where participants reflected on the day's activities. This was an opportunity to synthesise the knowledge gained across all stages while self-evaluation and explicit learning occurred. The discussion focused on the importance of responsible consumption, conservation strategies, and how participants could contribute to marine sustainability in their daily lives. Educators facilitated this conversation through questions but avoided sharing information to encourage participants to lead the reflections, allowing them to connect personally with their learnings and the broader marine conservation goals.

7.3.2 Survey Design, Validation and Application

This study utilized both qualitative and quantitative analyses to assess participants' knowledge and perceptions before and after their educational visits. From 40 family groups who participated during the summer, 12 groups were randomly selected to complete in situ tests before and after the activity (Table 7.2). This resulted in 240 of the 790 in-person participants being included in the pre-post-test. Among these, 90 participants consented to share their contact information for follow-up, and they were subsequently invited to participate in an online survey conducted 6–12 months later. Of these, 44% responded, representing 17% of the initial 790 participants.

Table 7.1 Questions used for the exploration phase during stage 3 (Interactive game about responsible fishing)

Questions
Are marine resources limited?
Do you know any strategies for marine conservation?
How do we contribute to marine conservation at the same time that we eat marine resources?
Do Chilean people eat a lot or a few amounts of fish? Has this consumption had an impact on the marine ecosystem?
Have you eaten young or old fish? Can we know that information?
What is your favourite fish? What fish is eaten most in your family?
Is a fish's size connected to its reproduction?
What size would you say that a fish must be to be reproductive?
Can some fish reproduce even if they are tiny?
How old is a reproductive fish?
Have you observed any differences in sizes at fish markets?

While the study was limited by the self-selecting nature of the follow-up participants and the relatively small sample size for long-term evaluation, efforts were made to mitigate potential biases and enhance validity. These efforts included random selection of groups for initial testing, the use of validated survey instruments, and pre-testing of the questionnaires to ensure clarity and consistency. Additionally, the multi-phase design—combining immediate pre-post assessments with long-term follow-ups—allowed for a more comprehensive evaluation of knowledge retention and application, strengthening the reliability of the findings despite the study's constraints.

7.3.2.1 Survey A: Before and After the Activity (Appendix 1)

Survey A, conducted in situ, consisted of a 5-page questionnaire that gathered socio-demographic data, including 2 open-ended questions, and 14 multiple-choice questions. The open-ended questions were categorized based on three key topics outlined in the introduction: Ecosystem Services (ES), Human Impact (HI), and Marine Conservation (MC). To ensure consistency and reliability, two researchers independently categorized responses, achieving 82% agreement in Survey A and 85% in Survey B. Each response could represent one or more categories.

The multiple-choice questions were analyzed to identify correct and incorrect answers, both before and after the activity. Responses were evaluated independently and grouped according to the themes from OL Principle 6. To determine whether there were significant differences between pre- and post-activity correct answers,

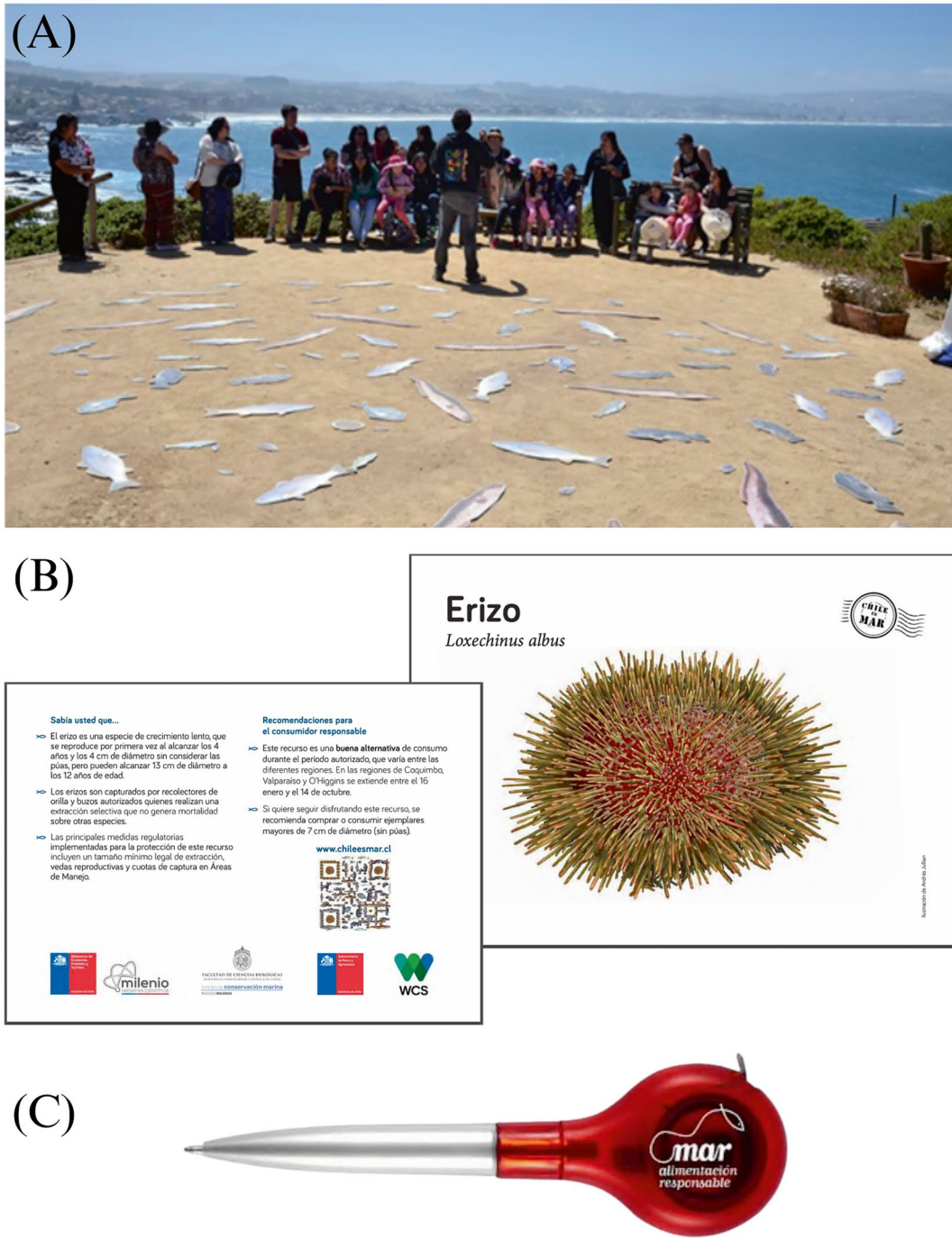


Fig. 7.1 (**a**) Interactive game taking place close to the MPA. (**b**) Educative cards of species and (**c**) Pen with measure tape was provided to the visitors as a takeaway

Table 7.2 Summary of surveys conducted before, after, and 6–12 months post-visit to assess participant misconceptions, experiences, and application of knowledge from the educational program

Stage	Survey	Description	Objectives	Design	Application
1	A (Appendix 1)	Before the visit, a 5-page survey with socio-demographic data, 2 open-ended questions, and 14 multiple-choice questions.	Identify misconceptions reiterative in the participants and compare it with other studies.	Studies on various aspects of marine education were adapted to inform the survey questions, while new questions were developed to address previously identified misconceptions.	Socio-demographic and open questions first and retired.
	After the visit, a 5-page survey with socio-demographic data, 2 open-ended questions, and 14 multiple-choice questions.	Diagnostic OL initial level from principle 6.	Additional questions were designed by the author, drawing on her experience in marine education programs.		Multiple choice test later, to avoid possible influence on the first stage test.
3	B (Appendix 2)	Between 6 and 12 months after the visit. Compounded by short answer questions.	Open questions were designed to reflect about her/his experience during the visit, thinking about what activity is more remembered and what information has been used during their daily life.	Open questions were designed based on main goals from the program.	Implemented online. Link for the questionnaire was sent to 90 participants from Survey A and B (those who shared with us their email address to be contacted). Answers were received from 6 to 12 months after the visit.

statistical tests include the "t-student" ($p < 0{,}001$) and Wilcoxon test ($p < 0{,}001$).

7.3.2.2 Survey B: 6–12 Months After the Activity (Appendix 2)

Survey B was administered online 6–12 months after the visit. It focused on short-answer questions to reflect participants' long-term recollections of the visit, including which activities were most memorable and how the information influenced their daily lives. The questions in this survey were directly aligned with the program's primary objectives.

A panel of two marine education experts, two marine biologists, and two science education teachers reviewed and validated both Survey A and Survey B. Their recommendations were incorporated into the final design. The instruments were pre-tested on an initial group of 20 participants to evaluate internal consistency, eliminating one poorly worded question.

7.3.3 Results

Among the 240 visitors, we found a similar proportion of men and women. The most frequent age groups were children between 8 and 12 years old, and adults between 35 and 45, although participants ranged from 7 to 85 years old. 68% of the visitors came from inland areas, while only 32% were residents who live year-round in the coastal area. The occupation and educational level of each visitor were also recorded. However,

no significant differences were found in any of the previously described parameters, with very similar results both in initial knowledge and in the increase after the visit when comparing place of residence, age, gender, education, and occupation.

7.3.3.1 Ocean-Human Relationship According to Open-Ended Questions

Survey A included open-ended questions about people's influence on the Ocean and, in turn, the influence people identify the Ocean has on their lives. These responses were classified according to the same three main groups from Principle 6: ecosystem services, human impact, and marine conservation. This classification encompasses all Ocean-human relationships (the types of benefits received from the sea, the types of impact caused by extraction and use, and the measures in place to minimize these impacts). The same questions were applied pre and post activity. Figure 7.2 presents pie charts of the most common responses at entry (left) and exit (right). At entry, nearly 70% of visitors recognized that their influence on the Ocean is related to pollution. In comparison, approximately 12% mentioned the consumption of marine resources, and another group stated they do not influence the Ocean in any way. When comparing the pre-and post-activity responses, the most significant result was, first, the reduction from 12.5% to less than 4% in the responses, indicating that individual actions 'do not influence' the Ocean at all. Secondly, it is essential to mention that the 'Food' category, which included all responses related to understanding that humans extract marine resources and that this has an environmental impact, increased from only 30 mentions at the beginning (12.9% of responses) to 128 mentions (more than 44% of responses). This was linked to Stage 3 of the visit, where we implemented the sustainable fishing game using the teaching and learning cycle. As previously defined, this activity goes through the stages of the TSL so that participants can understand their role as consumers of marine resources and their individual responsibilities. Interestingly, the reduction in the percentage of pollution-related responses is likely due to participants diversifying their answers about their influence on the Ocean.

Figure 7.3 shows the results regarding the question: 'How does the Ocean influence you?' Before the educational activities (left pie chart), respondents identified Food (30.9%) and Tourism (22.8%) as the two primary sources of the Ocean's influence on their lives. After the intervention, participants identified climate regulation as the second significant influence of the Ocean in their lives, giving greater importance to oxygen (O_2) production (14%). This again suggests greater diversification in participants' responses, indicating increased knowledge of the ecosystem services they benefit from.

7.3.3.2 Ocean-Human Relationship According to Closed-End Questions

We observed that, on average, participants in the educational activities provided nearly 10% more correct answers to the closed-ended questions of Survey A after the visit (Table 7.3). Regarding topics associated with ecosystem services, all responses improved at the exit. Notably, understanding the oxygen contribution from algae increased from 18% correct answers to 50%, which is significant as it indicates the presence of a prior misconception and its possible conceptual change. Another prior understanding that improved was the Ocean's importance in the water cycle, with correct responses increasing from 58% to 79% at the exit.

Regarding questions related to understanding human impact on the Ocean, the most notable change in this category was the increased understanding of the connection between pollution in Santiago (an inland city) and the Ocean. The misconception that Santiago's waste is unrelated to the Ocean decreased from 47% to 34%. Another change observed was the improvement in correct responses (from 24% to 37%) regarding the understanding that most of the population lives near the coast, as well as the longevity of plastics (from 55% to 62%) and the state of fisheries in Chile (from 61% to 71%). Another significant improvement was seen in the awareness of

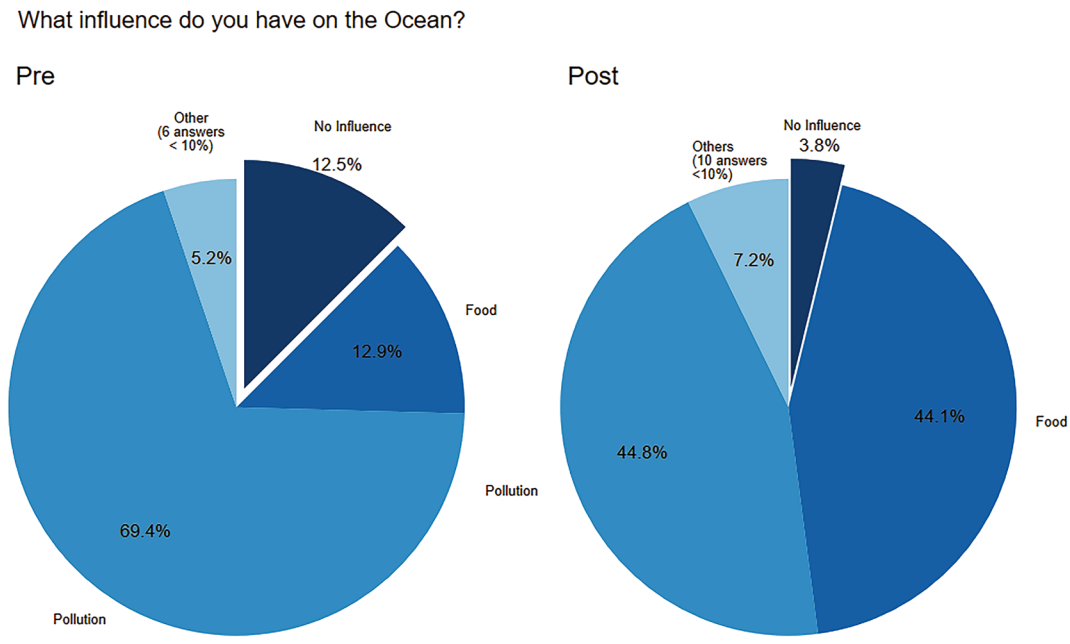


Fig. 7.2 Pie plot with percentage (%) of answers for the question: What influence do you have on the Ocean? *Note:* Total N = 240

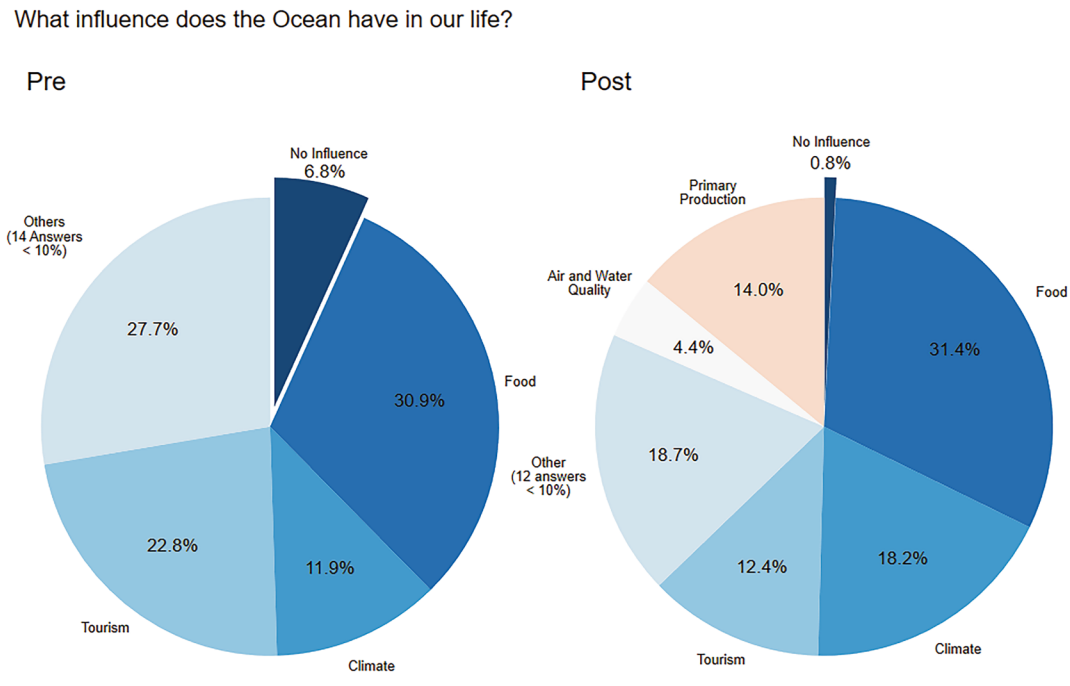


Fig. 7.3 Pie plot with percentage (%) of answers for the question: What influence does the Ocean have in our life? *Note:* Total *N* = 240

Table 7.3 Comparison of correct answers in pre-and post-tests using t-test and Wilcoxon test

	%Correct answers		Mean difference tests (t-test)			Wilcoxon test	
Questions	Pre	Post	Difference	Est. t	P-Value	Est. Z	P-Value
Overall	56.7%	65.9%	9.2%	−5.40	0.001	8.64	0.001
Ecosystem Services	62.3%	72.1%	11.1%	−6.7	0.001	6.68	0.001
Human Impact	46.6%	54.8%	8.3%	−5.3	0.001	5.05	0.001
Conservation	61.5%	71.1%	7.1%	−5.8	0.001	5.03	0.001

marine resource overexploitation in Chile, with correct responses increasing from 61% to 71%. However, there was a 2% decrease in correct responses related to the extent of resource consumption.

Finally, in analysing responses related to marine conservation, understanding the benefits of marine conservation is one of the objectives of this education program. At entry, 40% of participants correctly answered the question about the benefits of marine conservation. In contrast, at the exit, 62% identified that protected areas benefit not only the ecosystem but also fishermen and consumers. The most notable change in this section was the increase from 72% to 90% responding correctly regarding individual responsibility in marine resource consumption. However, we observed a 4% decrease in correct responses related to the description of marine conservation.

We found that the increase in the percentage of correct responses in the post-test occurred predominantly overall (Table 7.3 and Fig. 7.4a) and within each of the question categories: Ecosystem Services, Human Impact, and Conservation (Table 7.3 and Fig. 7.4b). For the overall count, there was an increase of more than 9% in correctly answered questions at the exit compared to the knowledge at the entry. When the questions were analyzed by group, the largest change was observed in the 'Ecosystem Services' group (questions 2, 3, 4, 5, and 8), where only about 64% of the questions were answered correctly at the entry, compared to 75% at the exit. Additionally, the groups of questions on 'Human Impact' and 'Conservation' also showed positive changes (greater knowledge), from 47% to 55% and from 58% to 65%, respectively.

There was a statistically significant increase in correct responses overall and also within each group of questions (Table 7.3). The p-values for all statistical tests are less than 0.05, indicating that we can reject the null hypothesis of equal means with a 95% confidence level.

7.3.3.3 Learning Persistence and Application

As highlighted throughout the theoretical framework, this type of marine education program's main objective is to convey information to participants and promote future decision-making using the information provided. To evaluate this, participants were contacted several months after the activity and asked about their experience (Table 7.2). The most prominent question was about the key learning they remembered from the activity (Fig. 7.5a). A total of 40 visitors responded to the survey, indicating a 44% participation rate from the total number of participants who received the questionnaire. Almost 50% of the survey responses referred to Stage 3 of the activity, which was associated with sustainable consumption fishing. This was followed by 40% of respondents who mentioned that their most significant learning experience was linked to the biodiversity activity (aquarium visit). Less than 15% of respondents referenced MPA, the importance of learning about these topics, and other general marine conservation themes.

Despite knowing that the aquarium visit was always the most anticipated and emotional part for participants, the fishing game was the most frequently remembered activity (Fig. 7.5b). Activities such as talks and debates were the least mentioned in these results. Of the 40 participants who voluntarily responded, only one indicated that they could not apply anything they learned during the visit. As for the rest, all applied what they had learned in one way or another. The most repeated responses (60% of respondents,

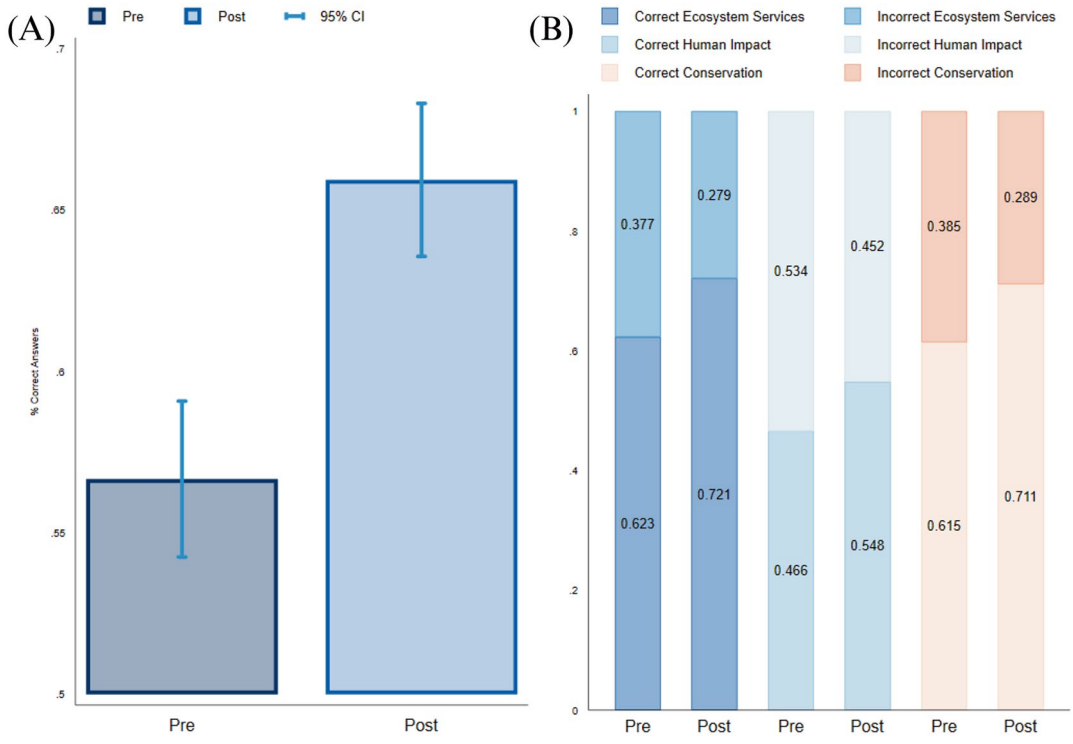


Fig. 7.4 Bar plots with percentage (%) of correct answers before (pre) and after (post) for the overall (**a**) and within each of the categories (**b**)

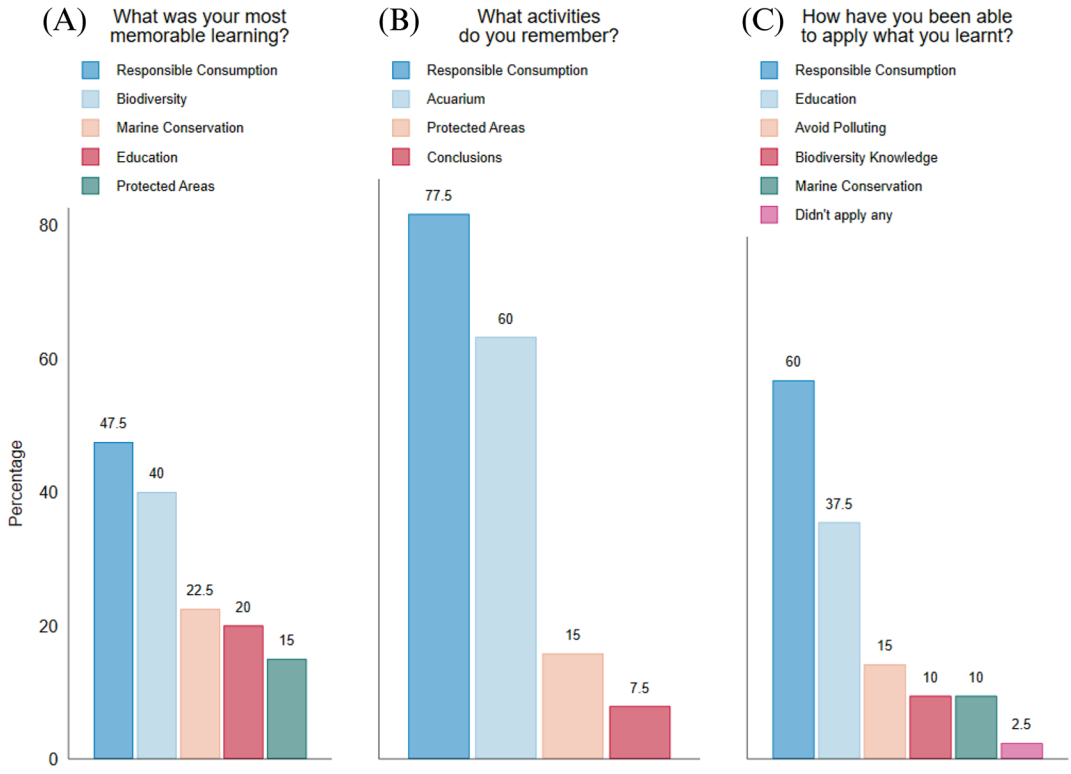


Fig. 7.5 Bar plots with percentage (%) of different types of answer to 3 questions: (**a**) What was your most memorable learning? (**b**) What activities do you remember? and (**c**) How have you been able to apply what you learnt?

Fig. 7.5c) were related to making decisions for responsible consumption of resources (respecting fishing bans, ensuring resources are above their first reproduction size, avoiding consumption of overexploited resources, etc.). In second place (37%), participants indicated they used the information acquired to share it with their immediate environment and encourage behaviours aligned with marine conservation. Finally, a smaller number of responses were related to marine pollution.

7.4 Discussion

Our results demonstrate a significant improvement in Ocean Literacy, particularly in questions related to Principle 6, with a marked increase in correct answers after participation in the activity. This aligns with the challenges identified in the literature, where students' understanding of the Ocean has often been described as limited and inconsistent, even when interest is present (Ballantyne 2004). These findings further support previous evidence that non-formal marine educational activities can enhance knowledge effectively (Joyce et al. 2019).

Only two questions showed a decrease in correct answers after the visit. The first was related to the concept of marine conservation, with correct responses declining by 4%. This decrease may be attributed to visitors potentially conflating the definition of conservation with the institution's name, *Marine Conservation Station*, leading to confusion between the general concept and a specific location. The second decrease, by 2%, was observed in a question regarding marine resource consumption and the size at first reproduction. This could reflect a misunderstanding; while the activity emphasized the importance of respecting the first reproduction size, participants might have been influenced by additional discussions about the greater reproductive capacity of larger specimens, leading to conflicting interpretations. Nonetheless, in both cases, the t-test results indicated that these differences were not statistically significant.

Despite these results, the program achieved significant success by improving participants' ability to identify a broader range of ecosystem services, illustrating their connections to the Ocean even from distant locations, and deepening their understanding of the benefits of marine conservation. To effect a change in decision-making, it is necessary to introduce participants to new content that helps them understand the Ocean's functioning, natural phenomena, and the science behind it (Ballantyne 2004). In this sense, having more knowledge after the activity demonstrates that in just 2 h and 30 min, it is possible to convey relevant information about the connection between humans and the Ocean.

While our results suggest a significant increase in Ocean Literacy following the educational activities, the study lacked sufficient data to establish a definitive causal relationship. Nevertheless, we analysed whether those activities with a stronger didactic focus might have been related to long-term changes. Considering the activity design, it is essential to highlight that while didactic strategies are incorporated throughout the entire visit, a complete TLS is fully implemented only during the sustainable fishing activity. Implementing this TLS aims to provide visitors with the tools needed to apply the new content in their daily lives. During this activity, participants engaged in debates about different strategies for sustainably consuming marine resources and the responsibilities of all actors involved in extracting, legislating, and consuming these resources. Up to this point, the activity is similar to other visit stages, even incorporating additional information from the guide. However, after the debate, each participant is assigned a fisherman's role and asked to decide which resources they would fish from a wide range of options. By engaging in the activity this way and being required to make decisions, participants need to use the newly acquired information and the ability to apply it. As previously mentioned, this stage was designed based on a teaching and learning cycle, with the final step being the application of new content in different contexts. This is what differentiates it from the design of other stages. At the end of the activity, participants realised that the

same decisions they made as fishermen can be applied as consumers when selecting marine resources at the market. This becomes a new, accessible tool in their daily lives to contribute to Ocean and resource conservation.

Although information related to individual conservation tools (such as not littering beaches, avoiding the extraction of marine animals from rocks in summer, respecting MPA, etc.) is provided throughout the visit, in the open responses collected online months after the activity, nearly 80% of the responses mentioned the tools for responsible consumption, which were covered during the TLS of Stage 3, despite the opportunity to mention other learnings from the visit. This suggests that integrating the TLS positively impacted visitors, as applying the new content in their contexts when consuming marine resources was the most frequently mentioned response. This fulfils the program's objective of providing information to the community and promoting using that information for responsible decision-making.

7.5 Conclusions

The marine educational activities designed with specific didactic strategies promote the incorporation of new content related to the relationship between humans and the Ocean, increasing levels of OL knowledge component. This highlights the effectiveness of these strategies in enhancing participants' understanding of the human-Ocean connection.

The results suggest that the TLS facilitate participants' ability to apply the acquired information to their daily decision-making processes. This indicates that educational interventions can impact how individuals use knowledge practically and meaningfully.

The participants in this study voluntarily attended the marine education activities, demonstrating a prior interest in learning about the Ocean. However, despite their interest, many participants shared their need for more information about basic OL concepts. This suggests that more than interest alone is required to have the necessary information to make responsible decisions regarding the Ocean.

There is a need to encourage, develop, and support research in this area of marine education to create programs that foster an Ocean-literate community capable of protecting the Ocean and its resources. It is crucial to test if the educational activities design proved effective in improving understanding of ecosystem services, human impacts, and conservation strategies, as the individual use of this knowledge to make responsible decisions which are critical for the success of MPA. It is not sufficient to simply continue implementing marine education programs; we must demonstrate their effectiveness in fostering the Ocean-human connection necessary to cultivate individual leadership in Ocean conservation.

7.5.1 Summary

Key concepts explored in this chapter include:

- The study demonstrates that integrating Teaching and Learning Sequences (TLS) into marine education significantly improves Ocean Literacy by linking scientific knowledge to real-life decision-making in a Marine Protected Area (MPA) context.
- Participants showed a measurable increase in understanding of ecosystem services, human impacts, and marine conservation.
- Stage 3 of the program, which involved a participatory fishing game based on TLS, was most effective in promoting conceptual change and fostering long-term behavioral shifts toward sustainable seafood consumption.
- Six to twelve months after participation, surveyed individuals reported applying their

learning in everyday life, primarily by making more sustainable consumer choices and sharing knowledge within their communities.
- The findings underscore the importance of evaluating educational interventions not only in terms of knowledge gain but also for their capacity to encourage persistent, actionable change that supports the objectives of MPAs and marine conservation efforts.

7.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

- *Chile es Mar*: https://chileesmar.cl
- Red de Educación Latinoamericana para el Océano (RELATO) www.relatoceano.org

Acknowledgements from Lead Author

I would like to begin by expressing my heartfelt gratitude to all the individuals who enthusiastically participated in the activities, demonstrated a willingness to learn and share knowledge, and generously agreed to complete the questionnaires, even while on vacation.

I am deeply thankful to the Estación Costera de Investigaciones Marinas and Centro de Conservación Marina of the Pontificia Universidad Católica de Chile, located in Las Cruces, Chile, as well as to all the dedicated individuals who worked as part of the Chile es Mar team during the visits.

I also extend my gratitude to the master's program in Science Education Methodologies at the Pontificia Universidad Católica de Chile for providing me with the opportunity to merge Ocean studies with science education methodologies.

Special thanks go to the marine education networks that have inspired this type of work, including the National Marine Educators Association (NMEA), the European Marine Science Educators Association (EMSEA), and, of course, the Latin American Ocean Education Network (RELATO).

Finally, I want to recognize and salute everyone who strives to bring visibility and validation to marine education through research while working tirelessly to bring the Ocean closer to more and more people.

Appendix 1

Questionnaire 1: Entry and Exit

Name: _____

Age: _____ ID Number: _____

Email: _____

Address: _____ Commune: _____ Region: _____

Level of education completed: (circle all that apply)

Primary Secondary Technical and professional University None

Occupation: _____

How often do you visit the sea? (circle one)

Once or twice a year Very frequently I live by the sea.

What kind of activities do you like to do related to the sea?

Fishing, sports, vacations, artistic inspiration, others _____

Have you done this visit before? No__ Yes__

When? _____

Mark the following options where you learned about the sea:

- In class
- In aquariums
- In museums
- At science camps
- During personal experiences (e.g., visiting the beach)
- Through conversations with friends and family
- Watching television, movies, documentaries, etc.
- Through the internet
- Reading magazines, newspapers, and books
- Others: _____

_____

Write examples of how the Ocean influences your daily life. If you believe it doesn't, please indicate so.

_____

Write examples of how your daily life and decisions might affect the Ocean. If you believe they don't, please indicate so.

_____

Can you name a Marine Protected Area in Chile? Indicate where it is located.

_____

Tell us what you expect from this visit.

_____

_____

1. Which of the following definitions of marine conservation do you think is most accurate?
   a. Marine conservation refers to protecting the marine environment above all else, avoiding the use of the sea and its resources to prevent human damage.
   b. Marine conservation is about caring for the marine environment while including human use and understanding interactions, requiring collaboration between scientists, fishers, institutions, communities, etc.
   c. Marine conservation solely depends on marine scientists, who manage areas to cultivate marine flora and fauna and ensure their survival over time.
   d. Marine conservation solely depends on the navy, which must constantly ensure the protection of marine resources.

2. Imagine our planet without Oceans. What would the global temperature be like?
   a. Temperature changes would be more extreme (warmer summers, colder winters).
   b. Seasonal changes would be less extreme, with no difference between seasons.
   c. The Ocean does not affect the planet's temperature.
   d. The Ocean only affects coastal areas, and the absence of Oceans would not change the planet's temperature.

3. What benefits do humans obtain from the Ocean?
   a. The Ocean is a source of energy and transportation.
   b. The Ocean is essential to national security.
   c. The Ocean is a source of inspiration for artists, rejuvenation, and recreation.
   d. All of the above.

4. Most rainfall on land comes from:
   a. Freshwater rivers.
   b. Saltwater Oceans.
   c. Lakes, ponds, and glaciers.
   d. Ice from snowy mountain ranges.

5. We've always been taught that trees provide the oxygen we breathe, but in the sea, algae also produce oxygen. What percentage of the oxygen we breathe comes from algae?
   a. Only about 5%.
   b. Approximately 25%.
   c. Nearly 50%.
   d. More than 75%.

6. If you were a fisher wanting to fish responsibly to help conserve resources:
   a. You would fish older resources because they can no longer reproduce, minimizing ecosystem impact.
   b. It's best to leave older fish as they are key reproducers and fish those that haven't reproduced yet, as their removal causes less damage.
   c. The best decision is to wait until they reproduce at least once before fishing them.
   d. Responsible fishing is impossible; to be responsible, we must stop fishing.

7. Which statement is FALSE regarding marine pollution:
   a. Most beach trash consists of plastics left behind by tourists.
   b. Chile's most plastic-polluted beach is on Easter Island.
   c. Trash discarded in Santiago does not affect the sea.
   d. One of the most abundant wastes on Chilean beaches is cigarette butts.

8. How is humanity connected to the sea?
   a. Through freshwater and the oxygen we breathe.
   b. Through the food and medicine we use.
   c. Through the planet's temperature.
   d. All of the above.

9. Globally, most people live:
   a. Far from the sea, as it is risky due to tsunamis, hurricanes, etc.
   b. Close to the sea, due to its resources and water availability, modifying beaches and coastal areas.
   c. Indifferently; populations are equally distributed near and far from coasts.
   d. Far from the sea for economic and job-related reasons.

10. You're enjoying a summer day at the beach, and without realizing it, the wind carries your plastic bag into the sea. How long do you think plastic remains in the Ocean?
    a. Thousands of years.
    b. Between 20 and 30 years.
    c. Less than 5 years.
    d. Between 100 and 150 years.

11. Chile is one of the most productive countries in terms of marine resources:
    a. Therefore, there are no fishing quotas limiting resource extraction.
    b. Despite its productivity, nearly 50% of fisheries are in critical overexploitation.
    c. Resources like loco or hake are overexploited but represent less than 10% of fisheries; most remain abundant.
    d. Resource overexploitation has reached such extremes that we must import all fish we consume from other countries.

12. Regarding the benefits of Marine Protected Areas (MPAs) where fishing is prohibited:
    a. MPAs solely benefit the marine ecosystem and its conservation.
    b. Fishers are only negatively impacted because they cannot fish in those areas, losing opportunities.
    c. Fishers benefit from MPAs as they lead to increased available resources.
    d. The Ocean is so vast that MPAs have no impact on fishers (positive or negative).

13. In recent years, many documentaries about the sea and seabed have been made. What percentage of the Ocean does humanity know about?
    a. Only about 5%.
    b. Approximately 25%.
    c. About 50%.
    d. More than 75%.

14. As consumers of marine resources:
    a. By the time we reach the market, resources have already been extracted, so it's not our responsibility.
    b. We are responsible for protecting the resources we consume and can contribute individually when purchasing marine resources.
    c. Marine resources are not our responsibility; only fishers and the government determine what is extracted and regulated.
    d. Our individual consumption is so small it doesn't impact conservation; it's the responsibility of large supermarkets.

Appendix 2

Questionnaire 2

1. What was the most significant learning experience for you during this visit?
2. Do you remember any of the activities?

   Which ones do you recall?

3. Have you been able to apply anything in your daily life over the past few months from what you learned during your visit to *Chile es Mar*?

   In what way have you been able to apply it? Please share your experience with us.

4. In your opinion, which aspect of the *Chile es Mar* program is more successful: teaching about the Ocean or changing attitudes toward the Ocean?

   Why?

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8 Making Real a Lifetime Salty Journey: From Unaware Professional Development to Field Experiences, up to the "Sea-To-Shore Approach"

Martina Gaglioti

Abstract

In the face of ongoing social and environmental crises, there is an urgent need to adapt our daily behaviors, educational approaches, and resource management strategies in response to a rapidly changing planet. The global efforts of the UN Decade of Ocean Science for Sustainable Development (Ocean Decade) have been defined as a pivotal collective action paving the way toward a transformative change. A diverse range of professionals and stakeholders are actively contributing to this mission, with several initiatives already evolving into long-term success stories. However, many regions and sectors still require significant progress to meet the Sustainable Development Goals (SDGs). This chapter highlights key contributions to the Ocean Literacy movement developed since the early stages of the Ocean Decade. It presents a selection of effective field-based experiences, and offers practical insights to support future Ocean Literacy initiatives. These examples aim to help individuals and organizations align their efforts with identified gaps and objectives, strengthening coherence and impact in the ongoing global endeavor to restore humanity's relationship with the Ocean.

Keywords

Ocean Literacy (OL) · Adaptive measurements · Blue education · Participative approaches · Marine professional engagement · Life-long learning · SDGs achievement · Marine conservation

8.1 Introduction

In a historical time of ethical and environmental crises, the Ocean Literacy mission is a global duty, calling everyone with expertise in salty matters to take concrete actions against misinformation or unawareness about Ocean-related topics. But what happens when you begin this work long before it becomes a formally defined career, and perhaps fitting into the hyper-simplification of seven sentences may feel too limiting to fully encompass the complexity of the mission? Perhaps, you try to shape practical sessions that go beyond academic frameworks, engaging people beyond the experts' world, and providing a

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personal interpretation, relying also on your multidecadal practical experience.

This has been my own path—shaped by 24 years of experience in both recreational and professional diving, followed by a smooth transition into marine science and education through formal academic training. The hardest part of this journey continues to be turning a childhood passion into a proper job commitment, since passion is inextricably connected to professional duty and being accepted and making my voice heard and respected as a young female professional is an ongoing challenge.

From this perspective, over the last ten years of active engagement, I have had the opportunity to develop several initiatives intercepting different contexts and audiences to share my expertise and field experience with many people (both young and adults), even interacting with public bodies, NGOs, and private enterprises. This chapter highlights several successful contributions developed within the Ocean Literacy mission and shares field-based insights to support more coherent and effective future implementation, addressing existing gaps identified to date.

8.2 Projects and Contributions

The Ocean Literacy mission requires, more than ever, active engagement in the field. This section summarizes some initiatives I developed and led over the past six years, many of which are replicable. Additional information for each project is included in the recommended resources section.

8.2.1 MBioKids

MBioKids is a small self-funded project developed in 2020, during the pandemic period, for primary school children and their parents, engaging them in games and field experiences to learn about Mediterranean Sea life. This initiative was developed in a rural area and involved 20 children, not directly linked to the coastal zones, but very eager to learn more about marine life and the fascinating underwater world. At first, the activities were performed remotely, due to constraints related to the COVID-19 pandemic. Subsequent field activities engaged the children in daily expeditions and a snorkeling session, performed also under the supervision of their parents. The MBioKids Project final report of activities contains descriptions of the activities (see the Resources section for more information).

8.2.2 Fins into the Water—Ocean Literacy into Practice

Fins into the water—Ocean Literacy into practice was the reply to the theoretical approach of the seven Ocean Literacy Principles. This project was initially proposed and developed in a diving center located in the Tavolara Marine Protected Area, in collaboration with the field staff and customers of the diving center. Tavolara Marine Protected Area is recognized as a Specially Protected Area of Mediterranean Interest. Although some safety issues occurred that prevented the proper finalization of the original idea, the project did result in the creation of the Tavolara Marine Protected Area Outreach Manual, made possible by the financial and logistical support of the local diving center that shared the vision behind the project proposal. The Outreach Manual was subsequently recognized at the EU level by DG MARE as a good practice and was mentioned in the Ocean Sustainability through Education and Sport (OSES) Handbook (Wojcieszek et al. 2024).

This project, along with its sister project, was subsequently developed by additional individuals joining the original team and involves the private sector to expand the potential soundness of the Ocean Literacy mission. The project aims to define Mediterranean Sea Literacy by building on the seven principles highlighted in the Med Sea Literacy brochure and through engagement of all

the stakeholders and visitors of the Mediterranean region that actively contribute the field work.

Interacting with the private sector means working with an enterprise who primarily needs to receive profits from the paradigm shift, and it is not easy at all to deliver this process in a respectful and smooth way, especially if you are an ECOP working with adults not so ready to make some adjustments to their current enterprise model. In addition, some contexts are historically more accustomed to interacting with scientists and naturally inclined to environmental protection while other businesses are more focused on the economic profit and leisure aspects of the Blue Economy and may be not so interested in this kind of paradigm shift. Additionally, a significant gap must be addressed, as unethical behavior by some representatives of the research community has led to the perception that the private sector, particularly in this segment of the Blue Economy, exists merely to serve science, rather than being recognized as a vital partner whose activities must align with environmental protection priorities through collaborative partnerships. Even if sometimes it is not so obvious to see entrepreneurs changing their habits in the short term, once they understand the importance of conservation goals and establish a respectful relationship aimed at working toward common objectives, even the more resisting contexts can turn their daily routine into something new.

In the past, environmental protection was considered just a segment of the daily routine of the diving sector. Today almost all the businesses in this sector include some scientific figures on their staff responsible for dissemination, field education and research duties.

8.2.3 Advanced Citizen Science Campaigns—Progetto Mediterraneo 2023

This initiative was conducted onboard "Mediterranea" along the 2023 route developed across three different EU neighboring countries: Montenegro, Albania and Greece. It is a program developed onboard to engage adults in laboratories and theoretical sessions during their summer break period to discover more about Mediterranean life and how to sustainably interact with it. Beside some outreach sessions, the crew and the passengers onboard were engaged in some demonstrative sampling activities including samples collection aimed at water quality assessment, macrobenthic species observation, water sampling for monk seal monitoring program, floating litter monitoring protocol and macrofauna samples identification. During the "science talks" onboard, we also spoke a bit about the restoration disciplines, the citizen science initiatives and the UN Ocean Decade latest advancements. The most rewarding aspect of this experience was the fascinating reaction of the crew and people onboard while discovering new things about marine life.

8.2.4 Freedivers and Volunteers Training within Cleanup Sessions

In addition to formal education programs during the first four years of the UN Ocean Decade, I contributed to the development of volunteer training, both in formal and informal education contexts. With the engagement of some free divers, we also finalized some underwater and onshore clean up sessions in the Circeo Biosphere Reserve and in its nearby in 2023 and 2024 (see the resources section for video footage of the training). Water Literacy is also something we can develop in different aquatic ecosystems, for this reason in a source-to sea perspective, I developed some initiatives engaging the Civil Protection volunteers during the "Lago Sicuro" operation within the SCI IT6030038 "Albano Lake" in August 2024 and some volunteers from Birdlife actively engaged in spring 2023 within the wetland area "Pantanello", a Regional Park and Natural Monument within Latium region. Additionally, interacting with dozens of volunteers from Plasticfree NGO, I had the opportunity to share some knowledge on environmental sciences and support some public engagement

initiatives. Some data obtained through the field engagement of volunteers was shared with EU Projects such as the REMEDIES Project or stored in European databases such as the *European Atlas of the Seas* to integrating some extant datasets.

8.2.5 Contribution to the advancement of the "Asinara Camp"

The "Asinara Camp" project is a long-standing initiative launched by two local divers with years of experience in the scientific diving sector. Together, we developed the next steps to help ensure the project's long-term viability. The greatest value of this initiative lies in the founders' commitment to training a new generation of young divers—those who are environmentally aware, able to observe underwater life with a critical eye, and mindful of the safety aspects of diving.

Launched in 2011, the camp was a pioneering effort to create diving experiences "on kids measure" within one of Italy's Marine Protected Areas (the Asinara National Park). After a period of disruption caused by the COVID-19 pandemic, the project entered a phase of renewal. The program takes a holistic approach to diving education, incorporating health awareness, physical activity, and safety into its training for young divers.

Participants trained at the camp often go on to support other Marine Protected Areas by contributing to citizen science and monitoring programs. They become reliable volunteers, much like adult divers. Educational, social, and environmental values form the foundation of the project. Today, the camp remains a nationally recognized model, having welcomed hundreds of young divers who, with the continuous support of the field staff, have taken their first steps toward promising diving careers.

8.2.6 Green & Blue Literacy @ School

Green & Blue Literacy @ School is the first EU Blue School program, developed in 2023 in collaboration with a high school located in a rural area of Latina Province, Italy. This project was initially conceived to engage a community not directly linked to the sea into marine-focused educational sessions. The journey started with freshwater ecosystems and concluded with the introduction of coastal ecosystems and marine biodiversity.

This initiative, which integrated theoretical and laboratory activities with outdoor education sessions, enabled students to interact with volunteer associations, institutions, museums, and local authorities. Through these interactions, students gained a deeper understanding of their local environment and learned how to engage responsibly with natural resources—even those near their schools and homes.

Students also participated in citizen science initiatives and cleanup activities, including the Plastic Pirates Campaign and the REMEDIES Project. In 2024, the project was renewed for a second edition, with a program more specifically focused on marine and Mediterranean Sea ecosystems (Fig. 8.1).

8.2.7 Le Lezioni del MAREdì

Le Lezioni del MAREdì is the first Blue School program entirely developed within the first designated UNESCO Biosphere Reserve of the global network and one of the oldest national parks in Italy. It was aimed at 67 high school students from a scientific high school, engaging them in both classroom and field sessions. We covered ecological topics, focusing mainly on the coastal and marine environment, but also referring to transitional and inland ecosystems included within the protected area itself. The students worked in different groups throughout the project, and subsequently, a representative from each



Fig. 8.1 Activities carried out with the high school students within the "Green and Blue Literacy @ School project"



Fig. 8.2 Final presentation of "Le Lezioni del MAREdì" project

group was awarded a prize, giving him or her the opportunity to have an underwater experience in an Italian Marine Protected Area, where they could learn basic diving skills and interact with representatives from both the conservation field and the diving sector. To better understand the complexity of ecosystems formally protected within the Biosphere Reserve—and to broaden their perspective while developing a critical mindset about the ecosystem mosaic of their home territory—they also had the opportunity to interact with visiting environmental representatives from another Biosphere Reserve and make connections with other ongoing initiatives at transboundary level (Gaglioti and Oyugi 2024, Fig. 8.2).

8.2.8 Trash Talk in Action

Trash Talk in Action is a transboundary initiative developed through a partnership between

Italy and Kenya and officially endorsed under the United Nations Decade of Ocean Science for Sustainable Development. It has been active since May 2023, in collaboration with a local Ocean advocate, to engage children from a marginalized community in Kenya (Mombasa County) in meaningful Ocean Literacy sessions. We worked with them to launch an Ocean Club, providing local youth with a meeting point to carry out their weekly Ocean-related activities.

The project has been developed as a cross-border collaboration, allowing some Italian students enrolled in the EU Blue School program to interact with the Kenyan participants, learn about the initiative, and develop parallel activities in both Italy and Kenya on similar topics. Among the most rewarding activities carried out were the following sessions, where we stimulated the children's creativity as much as possible:

- Marine Origami Session or the "Coral Reef Lab: Turn marine litter into art" session focused on key ecosystems for their local communities, such as coral reefs or mangroves (Fig. 8.3).
- The Letters to the Sea activity, where the kids, through their letters, made their voices loudly heard, delivering their messages also to high-level representatives and policymakers. This is a way to make a project developed through a gamification approach useful also from a long-term perspective. See the resources section for a video showing the Letters to the Sea displayed at UNOC3 on board R/V Meteor (Fig. 8.4).
- Deep sea tales from the Ocean friends is a session focused on the open Ocean's deep-sea biodiversity to share with kids the outcomes of a deep-sea expedition performed in collaboration



Fig. 8.3 Creative labs and art sessions performed at the Ocean Club within the "TRASH TALK IN ACTION" initiative



Fig. 8.4 Letters to the sea activities performed within the "TRASH TALK IN ACTION" initiative



Fig. 8.5 A cartoon version of the deep-sea exploration experience performed in collaboration with E/V Nautilus during the 2023 field session

with Ocean Exploration Trust and the National Oceanic and Atmospheric Administration (NOAA). Turning the scientific contents into a cartoon story, more easily understandable for children of their age, shared also within the Deep Ocean Stewardship Initiative (DOSI) official newsletter. In this way the Kenyan youth had the opportunity to see the outcome of the research field work, useful to better understand the Ocean life (Fig. 8.5).

This transboundary initiative addressing such a hot topic as waste management (Cornacchia et al., 2024) led to the development of a larger-scale effort—the 'Baus Taka Project'—which expanded local engagement and focused on improving waste management systems. Following the principle of co-design of UN Decade initiatives, it was developed under the leadership a local woman from Mombasa County. This upscaling action was recognized also at the United Nations level giving the local community the opportunity to be recognized for their active engagement toward environmental sustainability even beyond the national boundaries of Kenya.

8.2.9 E/V Nautilus 2023–2024: Field Expedition & Scientist Ashore Program

The Nautilus Exploration Program aims to seek out new discoveries in the fields of geology, biology, maritime history, archeology, and chemistry while pushing the boundaries of education, outreach, and technological innovation. The E/V Nautilus expeditions focus on scientific exploration of the seafloor, collaborating with the broader research community to identify priority regions and phenomena, and sharing field experiences with explorers around the world via live telepresence technologies (Ballard 2019). This innovative approach has allowed us to share insights into deep-sea life and remotely unexplored areas also beyond National Jurisdiction boundaries. The Scientist Ashore Program has gathered dozens of scientists and experts from all over the world so far, contributing to fill the existing gaps in the Ocean knowledge according to the seventh Ocean Literacy Principle, "The Ocean is still largely unexplored" (UNESCO n.d.). Also, it has been an opportunity to actively engage people based elsewhere or culturally too far from the scientific world, otherwise unable to directly take part in field exploration experiences.

I personally tested this approach by engaging my 93-year-old grandmother in a telepresence session of deep-sea exploration off the American Samoa Archipelago. To me, it was an unconventional yet meaningful opportunity to engage someone from a frequently overlooked group in our society—our cherished elders. Considering that most efforts of the Decade are addressed to younger people, it may be such a nice innovative approach to deliver the Ocean Literacy messages even to an unusual target audience, fostering the so-aimed intergenerational dialogue in an alternative way. Some recent research on the "blue

gym effect" (White et al. 2016) highlighted the importance of blue space environments in our daily life, since it might be positively related to human health and well-being. Whilst the wider initiative considers all blue spaces, including inland bodies of water (e.g., lakes, rivers and canals as well as the Ocean and its coasts), Ocean Literacy can align with this concept for aspects more strictly related to the marine environments (Fig. 8.6).

The scientific value of these expeditions can be considered at multiple levels: expanding current scientific knowledge on marine biodiversity, ecosystem functioning and geology; providing updated information useful in the decision support processes and contributing to the technology transfer process by interacting with stakeholders beyond the research world.

Whilst the expedition is ongoing, we face daily mysteries of life below the surface. When the science team comes through an unknown invertebrate or an unclear sponge species coming under the ROV light, the team of observers onshore and the experts operating remotely joined their efforts and shared knowledge to come to an identification solution. Also, sometimes the dive plan can require collecting some rock samples for further analysis ashore (Gaglioti 2024). The sustainability of the project lies also in the possibility to collect samples and holotypes for potential new species that may be discovered during the cruise and all the sampled material is at the disposal of the scientific community once collected to be analyzed and further investigated afterward (MarineBio 2024) (Fig. 8.7).

Another fascinating aspect of joining an E/V Nautilus cruise is that, according to scientific understanding and progress, the existing conservation measures can be adapted, Protected Areas boundaries revised, and new ecological paradigms redesigned, and every minute of underwater exploration can be useful for this purpose. Why do we study the geological features beside the lifeforms below the water? The seafloor shape and the presence or absence of some specific hints can say a lot about the geological history of a site. For instance, the amount of sediment accumulated on the top of an unexplored seamount can give some hints to the exploring crew about the geological activity of the site and how ancient the seafloor could be. Sometimes, we can come through traces of human impacts even beyond hundreds or thousands of meters below the surface. This is what happened both during the exploration season 2023 and 2024 (Wagner 2024), when some traces of marine litter and deep-sea debris, including an aluminum can and some fragments of fishing gear, were detected on a deep-sea ridge and some bottom marks probably related to the presence of underwater cables were observed during an ROV dive off the American Samoa archipelago.

At the time of this writing, the E/V Nautilus initiative is still ongoing, offering many opportunities for involvement—whether for skilled indi-

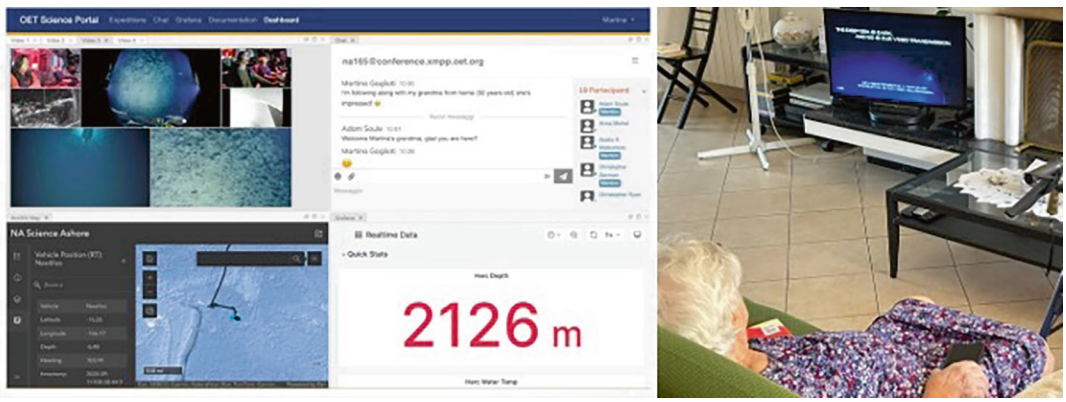


Fig. 8.6 An overview on the telepresence science portal and my grandma joining the live streaming from home



Fig. 8.7 An overview of sampling activities performed during the E/V Nautilus expedition NA165

viduals serving as Scientists Ashore or for students and their teachers planning an interaction with the onboard team. To enhance the outreach dimension of this experience and share its outcomes in Italy, I organized a photo exhibition on the deep Pacific Ocean in my home province of Latina during the 2024 Christmas period. This initiative was hosted within a series of local events including art exhibitions, music and book presentations. More than 500 people attended the event and expressed gratitude for the opportunity to get inside the scientific research dimension in such a remote area of the Planet through the photo exhibition. The photo selection included four thematic sections: a glimpse of deep-sea biodiversity, insights into the marine scientist's job, insights into underwater scientific research methods, human-driven impacts: the example of ghost nets. Additionally, a section dedicated to young people (The Kids Corner) was included in the photo exhibition. In this section, a cartoon version of the exploration was provided to make the exhibition more enjoyable and through some QR codes, they had the opportunity to interact a bit with the exhibition contents accessing the original videos of the exploration from the official YouTube channel of the Ocean Exploration Trust (Fig. 8.8).

8.3 Measuring Impacts: Methodologies for Data Collection and Analysis

Due to the diversity of activities involved and the variety of contexts addressed through the aforementioned initiatives, there is no single shared methodology behind my contributions. The activities developed so far are rather tailored to each context and adapted according to the needs arising during each initiative's development. The unique common methodology retrievable in this multiannual effort is the adoption of the general guidelines outlined in the Ocean Literacy for all Toolkit (Santoro et al. 2017). As a general rule, at the early stages of each initiative, a brief introduction on the Ocean Literacy program and on its seven principles was always done, introducing the audience to the importance to expand our knowledge and improve our relationship with the



Fig. 8.8 Pictures from the photo exhibition made in Latina during the 2024 Christmas period

Ocean as much as we can (Santoro et al. 2023). Since citizen engagement served as the central rationale of these initiatives, a post-hoc analysis was conducted to assess the number of individuals involved (Gaglioti 2023a). Where applicable also a categorized analysis was performed to understand the social background and the age range of the people engaged. In the projects aimed at students, a questionnaire co-developed on an adaptation of the extant Blue Survey (Paredes Coral et al. 2022) with some colleagues from Gent University was provided to the students at different stages: before starting, during the program and after the project finalization. At the same time a debriefing session was performed to give space to students' voices and hear their suggestions for further improvements within similar initiatives.

8.4 Ocean Literacy for Effective Natural Resources Management

Another critical aspect in the development of the Decade objectives is ensuring the availability of proper financing resources to recognize the expertise of people engaged in the educational processes and to ensure the long-term viability of the most promising initiatives. The overall perception of the Decade initiatives achieved so far is quite good. Many stakeholders are finally aware of the foundational principles behind our educational mission efforts and, for sure, the interest in marine life and its fascinating features is more than ever tangible.

What seems to be quite lacking is the environmental awareness to turn the "blue-world fascination" into concrete and long-lasting actions, even to counteract illegal dynamics especially related to the most hot-topics of marine conservation or misuse of natural resources. The mistrust in the institutions, or the lack of knowledge about the correct procedures to be followed, sometimes prevents a timely report of misconduct and the effects of this delay turn into less effective management, both in protected areas and in places located beyond designated sites.

For instance, among the 10 Decade challenges priorities identified, the topic of marine litter or coastal waste management is still being affected by many mismanagement issues, also attracting the bad interest of people engaged in illegal trafficking and unethical trades. The confirmation of

this trend was highlighted in a recently published report by the Italian Institute for Environmental Protection and Research (ISPRA) highlighting a rising number of environmental threats (ISPRA 2024a).

Sometimes, also the transboundary initiatives such as the research dimension of the "Trash Talk in Action" project mentioned above (Gaglioti and Oyugi 2024), can have a great impact to highlight meaningful threats potentially affecting the local communities. Starting from the younger representatives of the local community, empowering women and local representatives, even bottom-up-conceived projects can lead to foundational changes in overall society's behavior. It may happen that some cultural gaps and issues can prevent new paradigms to be effective in the short term, but the effectiveness of the Ocean Literacy mission is also in the small changes obtained day by day. It is tangible, for example, when young students start engaging their relatives in bottom-up conceived environmental campaigns or field activities and the learning process goes beyond the classroom or the educational context itself, changing their mindset toward natural resources around them.

The need to fill the gaps in habitat mapping and deep-sea exploration is also another interesting outcome of the ongoing efforts within the UN Decade mission. According to Ocean Literacy Principle 7, the Ocean is still largely unexplored, and it is particularly true when we go slightly beyond the better-known coastal areas of our regional seas. For instance, during the expeditions in the E/V Nautilus expedition in the Pacific Ocean, we engaged Indigenous people in habitat mapping operations. Combining traditional knowledge and technologies we unveiled many detailed features, going beyond the modeled contour lines of some previously deducted Ocean charts. Accurate and extensive marine habitat maps are essential to support policies (Fraschetti et al. 2024) and a critical approach to historical cartography and its use for restoration and conservation aims is extremely useful even in freshwater and land ecosystems (Gaglioti 2023b). For instance, in Europe this can be useful to deliver the ambitious plans of the European Green Deal and scaling-up the blue economy activities, simultaneously protecting and restoring marine and terrestrial ecosystems within the EU 2030 Biodiversity Strategy and Nature Restoration Regulation frameworks.

If we move to the Global South, considering Small Islands Developing States (SIDS) as low-income Countries, these aspects are more than ever relevant. For example, having an exchange with local communities of Malapascua Island in the Philippines archipelago (end 2024-early 2025) and Indonesia- North Sulawesi (in 2019) I discovered that Ocean education still has significant gaps both at institutional level and among the local populations. Although these communities depend on the marine environment in their



Fig. 8.9 Coastal areas in the Philippines: local residents collecting marine litter along the shores of Malapascua Island, and nearby coastal settlements around Maya Harbor impacted by marine debris

daily lives, they often lack access to the knowledge needed to address environmental challenges such as the consequences due to extreme weather events (e.g., typhoons or tsunamis), or to address environmental issues such as marine pollution or unsustainable uses of marine resources, which are not so obvious. During the development of educational strategies in these contexts, it is increasingly vital to foreground equality and human rights by thoughtfully incorporating environmental justice, the hierarchy of human needs, and the concept of the 'breath of life' into restoration planning (Fig. 8.9).

8.5 Existing gaps within the UN Ocean Decade Mission

The current Ocean Literacy mission status sets the scene for managing the knowledge of ecological concepts, essential to understand also the usefulness of adaptive measurements to counteract biodiversity loss and ecosystem functioning alterations. For instance, these skills and knowledge can be usefully applied to large-scale restoration initiatives, which implies cross-scale actions from ecosystems to landscape scale. Besides the UN Decade of Ocean Sciences, we need to remember that the Decade 2021–2030 is also the UN Decade of Restoration. At the ecosystem scale, one can think of patenting the restoration technologies with their scientific and know-how (tacit, experiential) parts, but this is not possible for objective reasons at the landscape scale, where knowledge-sharing networks exist.

From identification to acquisition, development, sharing, utilization, and maintenance, scientific and experiential knowledge is complementary and equally important for large-scale/landscape restoration and conservation efforts even beyond the designated sites, for instance, through the Other Effective Conservation Measures-approach, delivering new paradigms for a more effective approach to environmental education and conservation practices.

In its current state, there are still many gaps at the management level that hinder the proper implementation of these aspects. There are many circumstances in which participants in Ocean Literacy sessions or environmental education programs are able to recognize key issues (e.g., invasive alien species, climate change-related effects, pollution inputs), representing an important first step. However, these observations do not always translate into effective decision-making processes, and early warning signals are sometimes misinterpreted or insufficiently integrated by those responsible for decision-making. The most tangible consequence is the delay in the adoption of successful adaptation measures with dramatic effects on the ecosystem functioning and equilibria, despite the right contribution of people and their timely observations.

The lack of timely interventions behind the alien species concept has been mis-considered for a long time, leading to uncontrolled spreading of these invasive species and inevitable management issues due to delayed interventions and adoption of plans for mitigation and adaptation strategies. This also happened in designated sites subject to direct vacancies or mismanagement issues led by criminal organizations willing to obstruct the proper management of the natural resources within the protected areas boundaries.

Another troubling reality is the ongoing influence of criminal organizations, which remains a significant challenge to environmental management. Especially after the UN Decade such important topics acquired a great momentum even from the "wrong stakeholders". It was a foreseen outcome of such a high-sounding effort around environmental topics: rising awareness may also encourage other dynamics all around. Therefore, in 2024, a report on environmental crimes in Italy (ISPRA 2024b) highlighted an increasing trend of these unpleasant dynamics. This is also tangible in environmental experts' professional lives, at least for them truly engaged in the most critical social contexts and actively engaged in the field.

Often, research projects or dissemination initiatives are designed and funded based on expert knowledge and contributions; however, their implementation is frequently carried out by individuals who may lack adequate training or align-

ment with the project's objectives. In many cases, oversight and control mechanisms are not sufficiently robust to address these challenges. This is an issue especially when young experts are left alone in the field, and even worse when they are unable to navigate these challenges alone, sometimes forced to give up due to safety issues arising around the projects themselves.

From this perspective, to ensure more successful outcomes for initiatives led by Early Career Ocean Professionals (ECOPs), more experienced professionals, including those in leading roles within the Decade Board, should offer greater support by responding to requests from younger colleagues in a timely manner. Delayed responses or the undervaluing of insights from field experiences can often lead to negative and avoidable consequences. Providing such timely and meaningful support would also transform discussions about ECOP engagement into concrete actions. This shared commitment was emphasized during the Ocean Literacy World Conference held in Venice in June 2024. Hopefully, in the near future, we will be able to turn more of our theoretical aspirations into practical results.

Ultimately, there is an ethical aspect to be considered, especially when, as experts, we are asked to interact with less developed countries or marginalized communities. Personally, I invested more than a year co-designing a project (see the ECOP feature article in the resource section) with local people from an African Country. I volunteered this effort, since more than the economic aspect, I considered the ethical dimension of this effort the key driving force of my personal commitment. It was successful in the end, but I feel the work performed hasn't been recognized or appreciated enough by the wider scientific community. Of course, embarking on such a delicate journey requires a lot of energy and patience. Also, the evaluation criteria for these kinds of projects need to be slightly different from those adopted for properly defined and merely technical scientific projects. Here the human dimension and ethical aspects are at the forefront of the successful outcome of the initiative, therefore even the evaluation criteria should be adapted accordingly.

8.6 Considerations from Field Experiences

Field experiences have shown that there are many ways to interact with different stakeholders, but the most successful initiatives are those that actively engage them. This approach can ensure even the long-term viability of the initiatives. In this way, even spot contributions can turn into long-lasting actions with more positive impacts on conservation and engagement processes. This is in line also with the contribution provided in the Venice Declaration amendment request to better engage the ECOPs representatives in the decision-making processes across the globe and to deliver tailored Ocean Literacy programs to all the different stakeholders (ECOP 2025). The journey toward the accomplishment of all the UN Decade objectives is still so long, but the first part of the journey looked so promising.

There are many cases where even the most resistant stakeholders have changed their behavior—encouraging signs for the future of the Decade's mission. Today a lot of information on environmental sustainability and Blue Education is available, but often practical application is still lacking, mainly due to logistical and economical constraints in some areas. This leads to broad knowledge, but often it is still at a sufficient level. Working in such a fascinating and hostile environment as the sea is, can require a sense of respect that often still being underestimated. Nowadays, we have access to a wide range of technological supports and user-friendly datasets are available through EU and global infrastructures, raising general sense of confidence. This is a good achievement, but it may be confusing, especially for young people starting their career. Without strong mentors and role models to guide them, young professionals may struggle to navigate the available information effectively resulting that significant amounts of information can be easily underestimated or misunderstood.

For this reason, I think it is more important than ever to approach scientific knowledge and Ocean-related disciplines by taking safety aspects as a priority. The main objective of the UN Decade should be creating an "Ocean culture" from the early educational stages, rather than

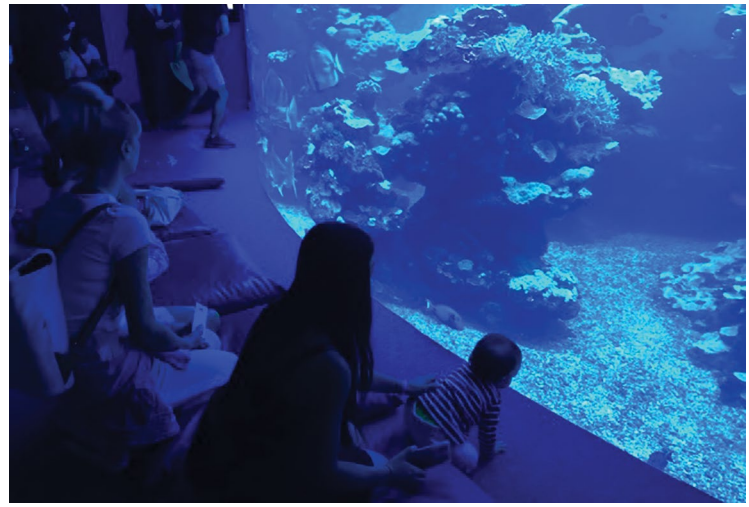


Fig. 8.10 A public engagement session for families held at Palma Aquarium (Palma de Mallorca, Spain, 2022)

sharing only information on marine environments as such within short-term initiatives. Educational infrastructures such as museums and aquaria, if properly addressed, can significantly support these efforts providing training programs for youth and adults, or monographic courses on target species such as through use of the IUCN Red List and developing the outreach dimension of their daily activities along with the conservation programs in nature, as described by the shared quality and animal wellbeing standards of the European Association of Zoos and Aquaria (included in the resources section) (Fig. 8.10).

8.7 Future Perspectives

Despite the substantial efforts made to establish the foundation of an Ocean-literate society, there are still several areas that could be further developed to promote concrete action against misinformation and lack of awareness on Ocean-related topics. These include:

1. Education for Ocean Literacy delivered by properly trained professionals who can translate theory into practice and provide the necessary field support to learners engaged in educational programs.
2. Advancement of academic research to address knowledge gaps and support the restoration of Ocean ecosystems.
3. Ocean science communication aimed at non-specialists, clearly conveying the actions needed to achieve key Ocean-related objectives.
4. Securing funding for action through the creation of specific financing instruments and funds that ensure the long-term sustainability of successful pilot initiatives and provide greater opportunities for project scaling.
5. Creating economic incentives for other Blue Economy sectors to participate in Ocean Literacy efforts. For example, our collaboration with the diving sector enabled them to extend their working season by engaging dive professionals in field research and outreach activities, thus offering both environmental and financial benefits.
6. Building social capital to reduce transaction costs in project implementation, promote the formation of strategic alliances among organizations, and strengthen communities of practice at the socio-ecological level.

8.8 Conclusion

The key themes outlined above for adaptively shaping the knowledge needed to restore the human–Ocean relationship must be considered within the context of an evolving knowledge economy, grounded in a well-established ethical framework.

The techniques and tools used to build relational capital and mutual trust—essential for knowledge sharing at the landscape scale and for financing complex challenges—should not be seen as limited to issues of "relational restoration" alone. More broadly, these approaches are relevant to a wide range of sustainable development challenges. Economies of scale can emerge when education, awareness-raising, and good governance are addressed holistically, rather than in isolation for specific ecological restoration goals. Ideally, communities of organizations and individuals working on landscape restoration should maintain strong connections and open communication with those engaged in other areas of environmental management, fostering collaboration rather than competition.

In most formal Blue Education curricula, the role of experiential knowledge and practical know-how in ecological restoration is neither explicitly addressed nor adequately recognized. This may reflect a prevailing bias toward scientific knowledge that primarily serves academic interests, with comparatively less attention given to practitioners and the restoration industry—including efforts to restore the lost relationship between humans and nature.

To address existing gaps, an alternative approach to traditional conservation measures is emerging, focused on Other Effective Area-Based Conservation Measures (OECMs). This strategy offers an opportunity to expand the area under protection, accelerating progress toward the 30x30 target. It also creates space for Ocean Literacy initiatives to play an active role in supporting conservation efforts, particularly by engaging local communities in the implementation and enforcement of protective measures.

Returning to the safety aspects of operational field research and educational experiences, effective collaboration among scientists, educators, and the broader public must be grounded in greater transparency. This includes recognizing—and appropriately compensating—the roles and expertise of all individuals involved in these efforts. While many important milestones have already been achieved, much remains to be done to ensure the long-term sustainability of these initiatives and to uphold ethical standards.

Marine science communication will be essential in advancing this process, and all best practices developed to date must be shared transparently to better support the achievement of the Ocean Decade goals. For example, communication plays a critical role in addressing conflicts that may arise between the use of marine resources and the implementation of effective marine protection measures. These complex situations require expert explanations that can be clearly understood by non-specialists.

The aim of marine science communication is to raise public awareness about the importance of understanding Ocean science (Seys et al. 2022). By sparking curiosity about scientific discoveries and Ocean-related issues, this approach not only builds awareness but also inspires responsible behavior across all levels of society. Moreover, it empowers individuals to advocate for policies that promote the sustainable management of both the Ocean and the planet (Villasante et al. 2023). The path toward transformative change is long, but we are heading in the right direction. Let's keep the momentum—let's move forward together!

8.8.1 Summary

Key concepts explored in this chapter include:

- Field-based Ocean Literacy initiatives are essential for turning awareness into long-term, community-driven actions.
- Collaboration with the private sector—especially within the diving industry—can help expand conservation goals while aligning with economic interests.
- Projects like *MBioKids*, *Fins into the Water*, and *Trash Talk in Action* demonstrate how

hands-on engagement fosters environmental awareness across age groups and regions.
- Cross-cultural and intergenerational programs—including telepresence experiences—can bridge knowledge gaps and inspire broader Ocean engagement.
- Despite progress, barriers such as institutional mistrust, limited funding, lack of local scientific capacity, and threats from illegal activities still hinder effective conservation.
- Experiential knowledge and ethical collaboration are critical for sustainable marine resource management and must be valued alongside academic research.
- Marine science communication and inclusive education play vital roles in fostering responsible behavior, public participation, and intersectoral partnerships.
- ECOPs (Early Career Ocean Professionals) require stronger support, especially in field safety, ethical recognition, financial sustainability in the long-term and transparent mentoring from senior colleagues.

8.8.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Meet ECOP Martina Gaglioti: https://www.ecopdecade.org/ecopstories/martina-gaglioti/
- Ocean Literacy for All: A Toolkit: https://unesdoc.unesco.org/ark:/48223/pf0000260721
- Ocean Literacy Portal: https://oceanliteracy.unesco.org/?post-types=all&sort=recent
- Ocean Decade Challenge 10 White Paper (Glithero et al., 2024): https://unesdoc.unesco.org/ark:/48223/pf0000390126
- Network of European Blue Schools: https://maritime-forum.ec.europa.eu/theme/ocean-literacy-and-blue-skills/ocean-literacy/network-european-blue-schools_en
- MBioKids Project- Final Report of activities:https://www.researchgate.net/publication/348910689_MBioKids_Project-_Final_Report_of_activities
- Fins into the water—Ocean Literacy into practice: https://maritime-forum.ec.europa.eu/fins-water-ocean-literacy-practice_en
  - Fins in the water Outreach Manual: https://www.youtube.com/watch?v=MUR7AxTHXf4
  - Fins into the water on Linked In: https://www.linkedin.com/showcase/fins-into-the-water/posts/?feedView=all
- European Atlas of the Seas: https://maritime-forum.ec.europa.eu/theme/marine-knowledge/european-atlas-seas_en
  - European Atlas of the Seas Interview with Martina Gaglioti: https://maritime-forum.ec.europa.eu/contents/european-atlas-seas-short-interview-martina-gaglioti_en
- Asinara Camp: https://www.i7mari.it/asinara-camp-national/
- Green & Blue Literacy @ School: https://www.youtube.com/watch?app=desktop&v=wpZrRaFU-ZM
- Plastic Pirates Campaign: https://www.plastic-pirates.eu/it
- REMEDIES Project: https://cinea.ec.europa.eu/featured-projects/remedies-bridging-innovation-and-action-cleaner-oceans_en
- Le Lezioni del MAREdì: https://www.youtube.com/watch?v=rKsbpQNfAIg
- Trash Talk in Action Initiative: https://maritime-forum.ec.europa.eu/node/5357_en
  - Trash Talk in Action YouTube Channel: https://www.youtube.com/@TRASHTALKINACTION-ez1rc
  - Marine Origami Session for Ngarisha kids: https://www.youtube.com/watch?v=sJu6o5p8jSE
  - Letters to the Sea: https://www.youtube.com/watch?v=lEbDu3rLdxM
  - Letters to the Sea from Ngarisha kids hosted onboard R/V Meteor: https://youtube.com/shorts/ueJXjCC7E3s?si=kq5Gr8DWK61vj0si
  - Deep Tales from the Ocean Friends: https://www.youtube.com/watch?v=opA2vHEZ84o
  - Deep Ocean Stewardship Initiative (DOSI) official newsletter: https://www.dosi-project.org/dosi-deep-sea-round-up-23-may-2024/

  - Baus Taka Project: https://webinar.inno-vus.co.ke/
  - Tour of R/V Meteor, UNOC3, Nice France: https://youtu.be/dnv-O42uy0Q?si=7u_veh77v4z4AFFg
- Nautilus Live: https://nautiluslive.org/
  - Deep Sea Sampling Methods: https://www.youtube.com/watch?v=UFQbjQVHu-k
  - Deep Sea Debris: https://www.youtube.com/watch?v=PBpvWewnbm8&t=5s
  - Photo Expedition of the deep Pacific Ocean: https://www.youtube.com/watch?v=EW8NeJksXRY
  - The Kids Corner: https://www.youtube.com/watch?v=xGoTKWj-Hhg
  - Ocean Exploration Trust YouTube Channel:https://www.youtube.com/playlist?list=PLRk9nnqFxr2-0wFS0NgONVqtoF1S4quhG
- "Advanced Citizen Science Campaigns"—Progetto Mediterranea 2023:https://www.youtube.com/watch?v=ES5nOsDHoWA
- Freedivers and Volunteers Training Within Cleanup Sessions: https://www.youtube.com/watch?v=-cegRjGQSOs
- Ocean Sustainability Through Education and Sport Resources (Toolkits and Manuals): https://oses-project.org/ressources-oses/
- IUCN Red List of Threatened Species: https://www.iucnredlist.org/
  - IUCN Reports and Guidance: https://iucn.org/our-work/topic/effective-protected-areas/our-philosophy-protected-and-conserved-areas/oecms/oecms
- European Association of Zoos and Aquaria: https://www.eaza.net/home/
- Copernicus Ocean State Report (OSR 9): https://sp.copernicus.org/articles/6-osr9/
- Ocean Sustainability Through Education and Sport (OSES) Resources: https://oses-project.org/ressources-oses/

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making these advancements smoother and leading me closer to the idea of the marine job I had in mind as a child, when I started exploring the sea as a junior diver with the idea of getting my hands dirty to help conserve it. A heartfelt acknowledgment is due to all of them, to my family for their support in the darkest days, and to my good mentors who helped me to remain motivated over time to keep the momentum going and doing my part to shape this essential sector of marine sciences' development. I wish them continued success in these shared efforts.

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From Waves to Wealth: Harnessing Ocean Literacy for Sustainable Finance

9

Daniel Bowie-MacDonald

Abstract

A deeper mutual understanding between Ocean Literacy (OL) and the finance sector is essential for achieving both environmental sustainability and economic prosperity. Recognising Ocean health as a foundation for sustainable economic growth enables financial decision-makers to better align economic objectives with environmental responsibility. This chapter examines the economic contributions and environmental challenges faced by Ocean-dependent sectors such as shipping, tourism, fisheries, and Ocean energy, and addresses the financial risks associated with declining Ocean health. It explores emerging investment mechanisms, including venture capital, blue bonds, and blended finance, and draws attention to the persistent funding gap in achieving Sustainable Development Goal 14: Life Below Water. Collaborative approaches, including public-private partnerships, are highlighted as essential strategies. The chapter positions Ocean Literacy as a critical tool for guiding sustainable investment, fostering dialogue between the financial and Ocean communities, and advancing a resilient and thriving Blue Economy.

Keywords

Ocean Literacy (OL) · Blue bonds · Blue economy · Economics · Finance · Nature-related financial risk · Public-private partnerships · Sustainable investment

9.1 Introduction

My formative years were spent in Scotland, a country distinguished by its dramatic landscape. My hometown, Edinburgh, nestled along the southern shore of the Firth of Forth, embodies the intimate connection between land and sea that defines many coastal cities worldwide. The city's history, culture, and economy have all been shaped by its relationship with the Ocean.

The connection between Edinburgh and its surrounding waters laid the foundation for my interest in the Ocean. But it was many years later, on one of my first visits to UNESCO's Regional Bureau located in Venice, Italy—another city whose existence is famously shaped by its relationship with the Ocean—that I encountered the term Ocean Literacy (OL) and was introduced to a new way of thinking about this connection.

OL, as I came to learn, encompasses concepts and principles that highlight the profound interdependence between the Ocean and human life (UNESCO-IOC 2022). It encapsulates a broader understanding of how the Ocean influences our

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lives and how we, in turn, influence it. A key concept in OL relates to the term 'literacy', a word with Latin roots traditionally describing an educated person or someone acquainted with literature (Harper 2017). However, in modern contexts, 'literacy' has evolved to encompass diverse ways of interpreting, generating, and conveying knowledge. The OECD further describes literacy as "the kind of knowledge that can be used to solve practical problems" (National Academies of Sciences, Engineering, and Medicine 2016). With this in mind, I like to think of OL as follows: Ocean Literacy refers to the process of understanding how the Ocean influences human life and how human activities impact the Ocean, while integrating a diverse range of learning and communication techniques in doing so.

The more informed people are about the Ocean and its processes, the better equipped they are to make decisions that support both environmental and economic sustainability (McKinley et al. 2023). Building on this understanding, OL fosters awareness of our interdependence with the Ocean, laying a foundation for strategic decision-making across sectors. By adopting OL principles, a wide array of stakeholders can integrate ecological considerations into their decision-making processes (Gerhardinger et al. 2024).

This chapter primarily aims to address the often-overlooked connections between the finance sector and Ocean science—two fields whose collaboration is essential for sustainable progress but has been constrained to date by limited dialogue and differing perspectives. By examining the Ocean's economic contributions and the role of OL, this chapter provides insights for readers with diverse expertise, including those from marine and environmental sciences, as well as professionals in the finance sector. In doing so, it aims to foster a shared understanding that enhances informed decision-making across these intersecting disciplines but also to underscore the need for continued education and engagement across these fields.

9.2 The Finance Sector

In an interconnected world, understanding the relationship between finance & economics and environmental health is essential to balancing ecological preservation with economic growth. However, to lay the groundwork for the remainder of this chapter, it is important to define how terms such as the 'Finance Sector' and 'Economic Perspective' will be used in this context.

The 'Finance Sector' comprises institutions and professionals responsible for managing and investing capital. This includes banks, insurance companies, and investment managers (Corporate Finance Institute 2024). These entities are pivotal in the economy, providing funds that enable governments, businesses, and individuals to drive growth, innovation, and sustainability initiatives (Popov 2017).

Although the primary focus of the finance sector is on the efficient allocation of capital to maximise returns and manage risk, it operates within a broader 'Economic Perspective' that also considers the social and environmental impacts of financial decisions. This perspective encompasses both financial returns and the long-term sustainability of resources, crucial for overall economic health (OECD 2011).

Integrating such perspectives enables a wider group of stakeholders to balance ecological health with economic objectives in the face of growing environmental pressures. As the finance sector's capital allocation decisions can significantly impact conservation efforts and resource use, evaluating natural assets through an economic lens can contribute to a more balanced approach, recognising both tangible and intangible benefits (Fichtner et al. 2023).

While an economic perspective can provide valuable insights, some may feel uneasy viewing the environment in financial terms, recognising its worth extends far beyond monetary contributions. However, applying an economic perspective—of which finance is a key component—need not diminish the environment's

value; rather, it complements and enriches our understanding. Just as scientific or artistic perspectives offer unique insights into the natural world, an economic lens can contribute to a broader, more nuanced view that enhances our appreciation of nature's complex role in society.

To illustrate this, in 2011, a study sought to quantify the economic benefits of Palau's shark-diving industry and compare them to the economic returns of shark fishing. The study found that the lifetime value of an individual reef shark was nearly $2 million USD. In contrast, a reef shark sold for its fins—a delicacy in some regions—yielded $108 USD. The study estimated that 39% of Palau's GDP (the total value of goods produced and services provided during 1 year) comes from diving tourism, with 8% of total GDP directly linked to shark diving (Vianna et al. 2010). While ecological arguments underscore sharks' critical role in ecosystems, they have often failed to halt the ongoing decline in shark populations, as evidenced by the continued global decrease in their numbers (Pacoureau et al. 2021).

But to reiterate the point; an economic perspective can provide tangible incentives for conservation through demonstrating potential financial benefits, enhancing the effectiveness of conservation efforts by providing an opportunity to compare the costs and benefits of conservation versus exploitation (Ward 2016). This perspective includes both direct financial returns—such as revenue from shark diving—and the broader, long-term value of ecosystems in supporting sustainable tourism and community development. By highlighting the substantial financial value of preserving natural assets, this example demonstrates how an economic lens can make conservation efforts more compelling. When applied more broadly, such perspectives can influence policy decisions and encourage sustainable practices across industries. When ecosystems are also framed in terms of their financial benefits, governments, businesses, and communities are more likely to support conservation and adopt responsible resource management (Barbier and Burgess 2017).

It is important to note that determining the economic value of individual species or entire ecosystems is complex and requires various methods. Two prevalent approaches are market and non-market valuations. Market valuation involves using direct market prices for goods, such as fish, providing a straightforward economic measure. Non-market approaches, such as the 'travel cost' method and 'hedonic pricing', infer the value of ecosystem services through related market behaviours. The 'stated preference' approach uses surveys and hypothetical scenarios to estimate the value of environmental assets when market data is absent (Selivanov and Hlaváčková 2021).

A prominent example of ecosystem valuation comes from the World Wildlife Fund (WWF) in 2015. The report used several valuation methods to estimate the Ocean's annual output at $2.5 trillion USD, with a total asset value of $24 trillion USD. At the time, this positioned the Ocean as equivalent to the world's seventh largest economy—ranking between UK and Brazil (Hoegh-Guldberg et al. 2015). Valuations like these help financial stakeholders understand the economic significance of ecosystem services, encouraging strategies that align economic objectives with conservation goals.

Having established the importance of an economic perspective in understanding the value of natural assets, attention is turned to the Blue Economy, where the integration of sustainability and profitability presents both challenges and opportunities for industries reliant on Ocean resources.

It is helpful to clarify the distinction between the terms 'Ocean Economy' and 'Blue Economy' in this context of this chapter. The Ocean Economy includes the entire spectrum of economic activities linked to the Ocean, without an inherent emphasis on sustainability. By contrast, the Blue Economy is a specific approach within the Ocean Economy that prioritises sustainable use and conservation of Ocean resources, as discussed in the following section.

9.3 The Blue Economy

The Blue Economy (BE) is a concept that aims to generate sustainable economic growth by leveraging Ocean resources, while also protecting marine ecosystems. As defined by the World Bank, the BE promotes "sustainable use of Ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of Ocean ecosystem" (World Bank Group 2017). Similarly, the European Commission views it as encompassing "all economic activities related to the Ocean, seas and coasts. It covers a wide range of interlinked established and emerging sectors" (European Commission 2021) including traditional sectors like tourism, fishing and shipping and newer areas such as renewable marine energy, biotechnology, and undersea cabling (EU Blue Economy Observatory n.d.). By emphasising sustainable practices, the BE provides a framework for responsible, long-term use of Ocean resources, aiming to support both economic progress and environmental stewardship.

A key aspect of the BE is integrating economic growth with the sustainable management of Ocean resources—balancing exploitation with conservation to ensure resource availability for future generations. This involves avoiding practices like over-exploitation and excessive waste, while promoting the use of renewable energy, sustainable fisheries and aquaculture (UNEP 2024). Social inclusion is another important element, ensuring all societal groups have opportunities to benefit from BE's growth (United Nations 2019).

Many are more familiar with the Green Economy (GE), yet interest in the BE is growing, driven by concepts like Blue Growth—the stimulation of economic activities relating to the Ocean and seas (Scholaert 2020)—with the OECD estimating that the BE will reach $3 trillion USD by 2030 (OECD 2024). While these two economies are often discussed separately, there is an argument to view them as interconnected. Both the GE and BE also share core principles, including sustainable resource management and social inclusion. An example of such an integration is in Indonesia, where the government have combined the BE into its GE strategy as part of its national development plan, aiming to address environmental and social challenges across land and sea as it moves towards 2045 (Yulaswati 2024).

While the economic potential of the BE is vast, this potential is under threat. Ocean-dependent industries face significant challenges that risk undermining not only economic growth but also the sustainability of our marine ecosystem (WWF and Metabolic 2021).

In the following section, key industries will be examined, chosen for their substantial contributions to both the economic and environmental dimensions of this discussion. These sectors are not only economically significant but also highly dependent on Ocean health.

9.3.1 Fishing and Aquaculture

Fish is a vital source of nutrition for many people across the world, providing a valuable source of essential nutrients, high-quality proteins, fats, vitamins, and minerals (Maulu et al. 2021). According to the Marine Stewardship Council (MSC), more than 3.3 billion people around the world get at least 20% of their animal protein from fish and in some African countries, fish represents more than 50% of animal protein intake (OECD/FAO 2017).

From an economic perspective, the primary sectors of fisheries and aquaculture employ 61.8 million people globally. Approximately 85% of these jobs were located in Asia, 10% in Africa, 4% in Latin America and Caribbean, and the remaining 1% across North America, Oceania and Europe. Aquatic products are also extensively traded internationally—this is particularly important to communities living in coastal and riverine areas where it can be substantial portion of export earnings. From a global perspective, aquatic trade accounted for 9% of total agricultural trade and 1% of total merchandise trade in 2022. In terms of international trade, the value of

aquatic products grew from $7.9 billion USD in 1976 to $192 billion USD in 2022. Looking at total 'first sale value', which refers to the initial sale of aquatic products from the producers to the first buyer, it was estimated at $452 billion USD in 2022 (FAO 2024a, 2024b).

However, the long-term estimate is that one-third of fish are being caught at a higher rate than the fish population can support through reproduction (Ritchie and Roser 2024). This depletion of traditional capture fisheries is one factor driving the growth in aquaculture, which is the farming of aquatic organisms in controlled environments. Aquaculture has now surpassed capture fisheries, accounting for over 50% of global aquatic animal production and 57% of production destined for human consumption (FAO 2024a, 2024b).

The sector faces several challenges in becoming more sustainable. Traditional aquaculture poses risks such as faecal waste, excess pollutants, habitat destruction, and disease transfer (The Ocean Foundation 2024). In traditional fisheries, many species are overfished, and techniques like trawling can cause severe habitat damage and bycatch. Both sectors are also impacted by climate change, which affects fish distribution and survival rates (FAO 2024a, 2024b). According to the World Bank, unsustainable fishing practices result in global losses of up to $83 billion USD annually (World Bank 2017).

The fishing and aquaculture industries are grappling with the consequences of unsustainable practices, and with the world's population expected to increase by an additional 1.5 billion people, taking the total to 9.7 billion by 2050 (United Nations Department of Economic and Social Affairs 2022), without an appropriate strategy, it raises questions about long term economic viability as well as food security for millions of people worldwide.

9.3.2 Tourism

It has been estimated that coastal and marine tourism accounts for at least 50% of all tourism-related infrastructure, impact, visitation and spending, amounting to $4.6 trillion USD, or 5.2% of global GDP (Ocean Panel 2022). The World Travel & Tourism Council (WTTC) estimated that global tourism amounted to 9.1% of global GDP in 2023 (WTTC 2023). These varying estimates highlight that there is no universally agreed-upon methodology for measuring the sector's size, but its significance is undeniable. Tourism is also one of the fastest growing sectors in the global economy (Hinton 2023).

While tourism draws visitors to coastal areas only for short durations, the world's population is increasingly urbanising, and most of the largest cities are at or near coastlines (Ritchie et al. 2024). Almost 1 billion people live within 10 km of the coastline, and one-third of the world's population—around 2.75 billion people—live within 100 km (Reimann and Honsel 2023).

Coastal communities often depend heavily on the Ocean for income, with tourism being a key driver of their economies. In the Maldives, for example, 80% of the economy is linked to tourism (Ocean Panel 2022). Industries such as aviation and hospitality also benefit greatly from global tourism (ICAO 2021), so they too are vulnerable to the state of the Ocean.

Concerns about environmental degradation are widely regarded as justified. Over the twentieth century, up to 70% of the world's wetlands were lost (Ramsar 2016), while nearly 50% of coral reefs have been lost since 1950's (Ashworth 2021). The Great Barrier Reef, for example, has experienced repeated bleaching events due to rising temperatures. Continued deterioration could significantly impact the reef tourism industry, which supports 64,000 jobs and contributes $6.4 billion AUD to the economy (Great Barrier Reef Foundation 2024).

Without adequate management, the rise in global tourism, combined with trends in urbanisation, present serious concerns to local environments and in turn, businesses that depend on it.

9.3.3 Shipping

Shipping is the backbone of global trade, facilitating the movement of goods across the world's Ocean. It enables the transportation of everything

from raw materials to finished products, making it a critical component of the global economy.

According to the International Maritime Organization (IMO), by 2050, maritime trade could increase by between 40% and 115% relative to 2020 levels. The OECD have forecasted that freight demand will triple by 2050 (International Transport Forum/OECD 2024). When considering that between 80 and 90% of all the world's goods are transported by sea, these estimates indicate a staggering level of growth. In 2019, it was estimated that the total value of global shipping trade had reached over $14 trillion USD (International Chamber of Shipping n.d.).

The shipping sector accounts for 3% of global emissions, with international shipping responsible for 9% of transport emissions—equivalent to the total emissions of Germany (Schlanger 2018). Currently, the sector's energy demand is almost entirely met by fossil fuels, and without significant technological advancements, emissions are projected to rise with anticipated growth (IRENA 2021). One estimate suggests that by 2050, shipping could contribute 17% of global emissions if left unregulated. Beyond air pollution, the industry also generates noise pollution, toxic discharges, and facilitates marine species invasions (Sinay 2023a, 2023b).

One example of climate change's impact on the shipping industry is evident in the Arctic region. The Arctic is warming nearly four times faster than the global average, significantly reducing ice cover, particularly during the summer months (Ebbersmeyer 2024). As a result, between 2013 and 2023, the number of ships travelling in the region increased by 37% and the distance they sailed increased by 111% (WWF 2024). While this has created new trade routes and extended shipping seasons (Mudryk et al. 2021), it also leads to increased emissions, increase oil spill risk, noise pollution, and disruption of ecosystems (WWF 2024). These environmental consequences, in turn, contribute to financial risks for the shipping industry, including potential regulatory costs, increased insurance premiums, and reputational damage.

9.3.4 Cosmetics and Pharmaceuticals

The global cosmetic industry primarily consists of fragrances, hair care, makeup, oral care, skin care and toiletries. While the pharmaceutical industry forms part of the global healthcare sector and focuses on the research, development, production and distribution of medications (Statista 2024). In 2022, the global cosmetic market was valued at $429.2 billion USD and is projected to reach $864.6 billion USD by 2032 (Allied Market Research 2023). By comparison, the pharmaceutical industry's market size was valued at $454 billion USD in 2022 and is projected to grow to $1467.7 billion USD by 2032 (Precedence Research 2023).

These industries use an array of marine-derived ingredients, including marine collagen, algae and seaweed extracts, marine proteins and peptides, omega-3 fatty acids, chitosan, marine enzymes, polysaccharides, carotenoids, chlorophylls, phycobilins, and even sea water for its mineral content (World Ocean Review 2021).

In cosmetics, while synthetic chemicals are widely used, demand for natural ingredients is rising due to perceptions of sustainability and safety. Plant-based ingredients remain popular but require significant arable land and are slow to produce. In contrast, the vast potential of marine-based ingredients offers a promising alternative, with many species cultivable in large quantities through modern aquaculture. However, ensuring the sustainability of marine-sourced ingredients and adopting environmentally responsible manufacturing practices will be essential for the industry's future (Data Bridge 2024).

A notable example in the pharmaceutical industry is the use of squalene, an oily compound from shark livers used as an adjuvant in vaccines, including in response to the COVID-19 pandemic. Adjuvants, which enhance immune responses, are widely used globally (Nguyen-Contant et al. 2021). However, the use of shark-derived squalene raises conservation concerns, especially the overfishing of vulnerable species and ecosystem impacts (Macdonald and

Soll 2020). Another example is the development of AZT, the first FDA-approved HIV treatment, inspired by compounds found in sea sponges (Hall 2019).

The Ocean is an invaluable resource for both the cosmetics and pharmaceutical industries. It offers a wealth of untapped potential that can drive innovation and growth. However, as these industries continue to expand, the sustainable sourcing of marine ingredients and the protection of marine ecosystems will be crucial.

9.3.5 Ocean Energy

Ocean energy, a modest but rapidly growing sector, encompasses a range of innovative technologies that harness energy from waves, tides, offshore wind, and thermal differences in Ocean waters. While many of these technologies remain in early stages of commercialisation, they hold significant potential (Dupont 2024).

The sector's promise includes not only environmental benefits, such as reducing fossil fuel reliance, but also substantial economic gains through job creation in construction, operation, and maintenance of Ocean-based energy infrastructure. According to one source, there were 77,000 people employed in offshore wind in Europe in 2021, and this number is expected to increase to 200,000 people by 2030 (WindEurope 2021). Another estimate suggests that by 2050, Ocean energy could create 500,000 jobs in Europe and provide 10% of Europe's energy needs (Ocean Energy Europe 2024). It has been estimated that the market size in 2021 was $0.6 billion USD, with projections it could grow to $7.8 billion USD by 2031 (Allied Market Research 2022).

However, Ocean energy faces unique environmental challenges, including the risk of marine life collisions with underwater turbines, noise pollution, and habitat destruction. On the positive side, according to the International Energy Agency, Ocean energy could help mitigate the effects of climate change by displacing carbon emissions from fossil fuels by an estimated 500 million tonnes by 2050. Ocean energy also has the potential to provide predictable and stable energy, a notable advantage over wind and solar technologies. These technologies are also particularly promising for coastal and rural communities due to their ability to generate power locally, which can, in turn, stimulate economic growth (GAO 2021a).

The potential of Ocean energy is undeniable, offering both environmental and economic benefits. However, its future success rests on the sector's ability to innovate and implement technologies that not only drive economic growth but also minimise environmental impacts. Striking the right balance between harnessing the Ocean's power and preserving its ecosystems will be critical in ensuring Ocean energy plays a sustainable role in the global energy mix.

As one considers the potential of these Ocean-dependent industries, it is also important to acknowledge the broader environmental and economic risks facing the BE as a whole. This next section examines a selection of these broader environmental threats to the BE.

9.3.6 Other Environmental Threats to the Blue Economy

Some of the challenges facing the BE have already been discussed, but it is important to acknowledge that the threats to the BE are both numerous and complex. In this section, we outline additional threats that contribute to the degradation of marine ecosystems and, in turn, affect industries reliant on the Ocean:

In agriculture, farmers apply nutrients on their fields in the form of chemical fertilisers and animal manure which provide crops with the nitrogen and phosphorus necessary for food production. However, nitrogen and phosphorus runoff can have adverse impacts on downstream water quality, leading to eutrophication. A process which can create 'dead zones', decreasing aquatic life (EPA 2024).

The increasing levels of greenhouse gases in the atmosphere are warming the Ocean. It has

been estimated that more than 90% of the excess heat caused by human activities has been absorbed by the Ocean (Lindsey and Dahlman 2023). This Oceanic warming leads to various harmful effects, such as sea level rises, damage to coral reefs, altered circulation patterns that impact global weather, and decreasing oxygen levels in the water (Ocean Visions 2022). Together, these changes threaten marine biodiversity and undermine the resilience of Ocean ecosystems.

Alongside warming, greenhouse gases also contribute to Ocean acidification, another serious threat to marine environments. Ocean acidification decreases the pH of seawater, reduces the availability of carbonate ions, vital for marine organisms like corals, oysters, clams, and lobsters to build their shells and skeletons. This reduction in pH can have far-reaching consequences for marine biodiversity and, ultimately, for industries reliant on healthy ecosystems (Sampaio et al. 2021; NOAA n.d.).

The emerging industry of deep-sea mining involves extracting valuable resources from the Ocean floor, including cobalt, nickel, and other rare Earth elements, which are essential for technologies such as electric vehicles and renewable energy infrastructure, also poses significant environmental concerns. These include potential biodiversity loss, sediment disturbance, and the release of sequestered carbon, all of which can further exacerbate climate impacts (Ashford et al. 2024; GAO 2021b). This tension between resource extraction and ecosystem preservation mirrors the balance sought in other Ocean-dependent industries: while innovation is necessary, sustainable practices must be prioritised.

This list is by no means exhaustive—the challenges faced by Ocean industries are numerous and interconnected, underscoring the need for a comprehensive and coordinated approach to marine resource management. Focusing on sustainable practices, encouraging technological innovation, and strengthening collaborative strategies across sectors are essential steps towards safeguarding marine ecosystems and ensuring the resilience of the industries they support.

9.4 Financial Risks of Ignoring Nature Risk

Nature risk, which encompasses a wide range of environmental factors beyond marine ecosystems, is highly relevant to global economic stability. It has been reported that more than half of global GDP is 'moderately dependent', and in many cases 'highly dependent' on nature (Herweijer et al. 2020). If current trends continue, it has been estimated that $8.4 trillion USD of assets and revenues could be at risk. These potential losses underline the urgent need for the global economy to assess and address financial risks associated with nature degradation. Understanding these risks is the first step in mitigating economic disruption and ensuring sustainable development (WWF and Metabolic 2021).

9.4.1 Industry Exposure to Nature Risk

As ecosystems deteriorate, the risk to business operations increases. These risks can take many forms but are commonly categorised as physical and transition risks. Physical risks refer to the direct impacts of environmental changes on business operations and assets, including those specifically associated with Ocean-related issues such as rising sea levels and marine biodiversity loss. Transition risks are associated with the changes that occur as economies shift towards more sustainable practices. Within these two risk categories, there are a number of subcategories to consider including legal, technological and reputational risks (Network for Greening the Financial System 2023).

Sector-specific analysis by WWF in 2019 provides insights into these risks under a business-as-usual (BAU) scenario compared with a sustainable development scenario, estimating the financial savings that sustainable practices could yield in various industries.

- Ports and shipping: Their assessment shows some risk associated with oil spills and collisions, but the major risk is from event-based

damage, which is significantly reduced in the sustainable development scenario, with Value at Risk—a measure of potential financial loss—shifting from $874 billion USD to $52 billion USD—a saving of $822 billion USD over 15 years.

- Fisheries and aquaculture: Their assessment indicate that risk is driven by a number of factors including nutrient pollution, overfishing and trawling. The total revenues and assets at risk in the BAU scenario are $2.85 trillion USD, falling to $1.9 trillion USD in the sustainable development scenario. For aquacultures, the total revenues and assets at risk in the BAU scenario are $31 billion USD, falling to $28 billion in the sustainable development scenario.
- Coastal tourism: Their assessment showed that the financial risk was $655 billion USD under the BAU scenario, due to degradation of coral reefs and mangroves, increasing storms and plastic pollution, falling to $451 billion USD under the sustainable development scenario.
- Coastal real estate and infrastructure: The report notes that between 1980 and 2019, climate-related extreme events led to €446 billion in economic losses in the European Economic Area alone. The risks are therefore very high in the BAU scenario. Their assessment showed a financial risk of $3.98 trillion USD over a 15-year period, falling to $854 billion USD in the sustainable development scenario.

The WWF report demonstrates that while sector-level risks are substantial in absolute terms, they appear relatively low when considered against total revenue and assets over a 15-year period. This short-term perspective, however, may overlook the acceleration of risks in subsequent decades. Additionally, risks are unevenly distributed across sectors, with industries like fisheries and coastal tourism facing particularly high risks due to their direct dependence on marine ecosystems. Nevertheless, the estimated savings between the BAU and sustainable scenarios amount to a significant $5 trillion USD over 15 years (WWF and Metabolic 2021).

9.4.2 Financial Institutions' Exposure to Nature Risk

As previous discussed, Ocean risk is a crucial subset of broader nature risk, impacting financial institutions through various channels. These exposures typically arise through channels such as investments, loans, and insurance provision. Since the companies receiving investments, loans, or insurance rely on ecosystems for their operations, financial institutions are also exposed to these risks (Network for Greening the Financial System 2023).

Consider coastal flooding risk as an example: if a financial institution provides a loan to a coastal property developer, and if an investor buys shares in that developer, then flooding damage to the constructed property would expose the developer, lender, and investor to loss. Similarly, if an insurance company has underwritten property insurance, they too would bear the financial impact. This risk becomes more pressing as climate change increases the frequency and severity of extreme weather events.

From an investor's perspective, research by WWF & Metabolic indicates that 66% of publicly listed companies in a global equity index are dependent on Ocean health. Another study by Making Oceans Count (MOC), analysed the equity portfolios of six Danish asset owners and found that nearly 40% of the value of their investments is linked to activities that either depend on or impact marine ecosystems (Gardin et al. 2023).

Despite the clear financial exposure, these nature-related risks are rarely priced into assets. This gap often arises because such risks are not considered, data is unavailable, or it is misinterpreted. A survey revealed that the lack of actionable data for financial decision-making is a significant limitation. Even if such data were available, it needs to be actionable for investment decisions and connected to financial instruments (WWF and Metabolic 2021).

This challenge underscores a critical gap in how financial risks related to nature are accounted for—without robust, actionable data, financial institutions struggle to assess the true scope of their exposure to nature risk. The situation highlights the urgent need for enhanced corporate disclosures to better capture these risks, enabling more accurate pricing and risk management (Evison et al. 2023).

9.4.3 Corporate Disclosures

One of the challenges financial institutions face relates to data availability and interpretation, which is essential for understanding their exposure to nature risk. Financial institutions are accustomed to traditional financial metrics such as GDP and inflation, but they are less familiar with environmental data—and even less so with marine data. Gathering and then translating complex nature related data into actionable financial decisions remains a significant challenge (Gardin et al. 2023).

However, there is a noticeable shift towards mandatory, comprehensive, and integrated reporting for corporate disclosures related to climate and nature. New regulations, such as EU's Corporate Sustainability Reporting Directive (CSRD) and the U.S. Securities and Exchange Commission's climate disclosure rule, mandate disclosures for a significant part of the global economy (Carter 2024). While climate reporting has been the primary focus for many years, there is now a growing emphasis on nature and biodiversity disclosures, as evidenced by the EU's Taskforce for Nature-related Financial Disclosures (TNFD). Additionally, there is a trend towards harmonisation of different reporting frameworks—TNFD recommendations are increasingly aligned with the Global Reporting initiative (GRI) and the European Sustainability Reporting Standards (ESRS) (Shahbazian 2024).

To effectively integrate nature risk (and therefore Ocean-related risks) into decision making processes, it is important to understand the risks they are currently exposed to over various time horizons. This understanding will enable investors to manage these risks and shift their investments away from companies that are exposed to or contributing to Ocean-related risks, towards those that have lower risks or produce nature-positive outcomes (WWF and Metabolic 2021).

9.5 Channels of Investment

As financial institutions increasingly recognise their exposure to nature-related risks and respond through more comprehensive disclosures, the finance sector will look to leverage these insights to identify investment opportunities that are both financially attractive and contribute to Ocean health. Investing in the BE is a relatively recent development yet offers a diverse array of opportunities across a variety of sectors. Interest from institutional and individual investors is growing (Stokel-Walker 2023). However, despite this increased recognition, funding for Ocean-related initiatives remains notably insufficient. One indicator of this gap is to look at Sustainable Development Goal (SDG) 14, Life Below Water (United Nations n.d.), which remains the least funded of all of the SDGs (Adamkiewicz 2022). It has been estimated that $175 billion USD per year is needed to achieve SDG 14 by 2030, yet between 2015 and 2019, less than $10 billion USD was invested in total (World Economic Forum 2022). With current levels of investment being so insufficient, closing this funding gap will require private and public investment. To attract more capital to the BE, the investment opportunities must offer competitive returns (BlueInvest 2023).

Despite the vast funding gap, emerging trends signal growing potential for the BE. OL initiatives have significantly contributed to raising awareness about the vital role of the Ocean in supporting ecosystems, economies, and climate systems. This increased understanding is supportive of larger capital allocations from the investment community over time. Additionally, recent developments, such as the UN High Seas Treaty, are driving greater focus on Ocean conservation. The treaty, which seeks to designate 30% of the world's Ocean as Marine Protected

Areas (MPAs), is expected to unlock new investment opportunities by safeguarding marine ecosystems and promoting sustainable, long-term economic growth (European Commission 2023).

9.5.1 Investment Channels for the Blue Economy

As the BE gains traction, a growing number of investors are exploring various channels to allocate capital towards Ocean industries and sustainability initiatives. Investment channels can include public equity (investors purchase shares in publicly traded companies) and private equity (where investors provide capital to privately held companies) as well as in debt (loans or bonds issued by companies or governments to raise capital) and blue loans (loans specifically designated for Ocean-related projects) and blue bonds (debt securities used to finance Ocean sustainability projects). Among these, venture capital, blue bonds and blended finance have emerged as particularly relevant channels, largely due to the limited options within channels such as public equity at this point in time (BlueInvest 2024). The following provides more detail on several of these approaches:

Venture capital (VC) is a type of financing for startups and small companies with high growth potential. Venture capitalists provide this financing in exchange for an ownership stake in the business (Hayes 2024). VC financing in the blue economy has grown rapidly in recent years, increasing fourfold over the last 8 years and projected to reach $1.4 billion USD in 2024. Most of the funding has gone into shipping and ports, such as freight forwarding and supply chain management solutions. BlueTech and Ocean observation technologies have also attracted a significant amount of funding (Dealroom 2024).

Blue bonds are another innovative approach to allocating capital to sustainable Ocean economy projects through fixed income investing. A key challenge in this space is ensuring that capital is directed towards projects that genuinely contribute to a sustainable Ocean economy. To address this, organisations like the International Capital Markets Association and the Ocean Impact Framework are providing guidance for blue bond issuance. For instance, Orsted, a Danish leader in offshore wind power, was the first energy company to issue a blue bond in June 2023. The investment was used to innovate and scale Ocean-based renewable energy solutions (Orsted 2023).

Blended finance combines public, private, and philanthropic capital to finance blue economy initiatives. Investors see significant opportunities in fisheries, aquaculture and water infrastructure (Convergence, Joint SDG Fund 2022). Referring back to the UN High Seas Treaty, meeting its commitments will require a combination of public, private, and philanthropic funds, as well as financial support from non-government organisations (Morgan Stanley 2023). This collaborative approach underscores the importance of blended finance in achieving long-term Ocean sustainability goals.

9.6 Collaboration is Key

As the BE expands and more investments flow into Ocean-related industries, it is clear that the challenges facing the Ocean cannot be solved by individual sectors alone. Collaborative efforts between governments, the private sector, and civil society are crucial to achieving sustainable Ocean solutions. Public-private partnerships (PPPs) are one of the most effective mechanisms for driving Ocean conservation efforts. A PPP is a collaborative arrangement between a government agency and a private sector company (Roehrich et al. 2014). For instance, the World Economic Forum's Ocean Action Agenda serves as a platform for accelerating collaboration and innovation in Ocean conservation (World Economic Forum 2023). Another example is The Ocean Breakthroughs initiative, launched at COP28, which brings together businesses, governments, and civil society organisations to accelerate Ocean solutions in five key sectors: marine conservation, shipping, Ocean renewable energy, aquatic foods, and coastal tourism (Ocean Breakthroughs 2023).

For complex challenges such as establishing Marine Protected Areas (MPAs), a key strength of PPPs is their ability to combine government authority with private sector resources and NGO expertise. PPPs play a crucial role in advancing Ocean conservation goals by leveraging the strengths and resources of different sectors—a necessity when addressing the complex challenges facing our Ocean (Giron 2024).

9.7 Promoting Ocean Literacy for Informed Decision-Making

As the BE continues to grow and investments in Ocean-related industries increase, it becomes crucial for all stakeholders to have a shared understanding of the value and sustainability of Ocean resources. OL plays a pivotal role in ensuring that decision-makers across various industries are informed and equipped to contribute to sustainable outcomes. An economic perspective can be instrumental in defining and supporting key initiatives aimed at advancing OL, including those articulated by the OL Group of Experts. By integrating this perspective into the dialogue surrounding Ocean health, a wide range of stakeholders can better understand the benefits of sustainable practices.

For instance, initiatives that quantify the economic contributions of healthy marine ecosystems—such as the estimated $2.5 trillion annual output of Ocean resources—highlight the financial imperatives for conservation efforts. This economic lens not only facilitates informed decision-making among policymakers but also encourages investment in OL programs by demonstrating their potential return on investment. Furthermore, the finance sector's focus on risk management has led to the identification of nature-related risks, prompting initiatives that aim to improve corporate disclosures. By fostering collaboration between finance professionals and the environmental science community, these initiatives enhance public awareness and engagement with OL, ultimately promoting sustainable economic growth while safeguarding marine ecosystems.

As such, the finance perspective is not merely an adjunct to environmental considerations; it is a fundamental component in shaping effective strategies for advancing OL and ensuring the long-term viability of Ocean-dependent industries. In this context, the UNESCO Intergovernmental Oceanographic Commission (UNESCO/IOC) formed a Group of Experts on OL, consisting of 20 professionals from diverse disciplines, stakeholder groups and geographical locations. As a member of this group, contributions are made to key initiatives aimed at advancing Ocean Literacy. The Group's work includes:

- Defining good practices in Ocean Literacy based on lessons learned in Member States;
- Developing Ocean Literacy global and regional programmes guided by the IOC Ocean Literacy Plan of Action and the Ocean Literacy Framework of Action for the UN Decade of Ocean Science;
- Coordinating Ocean Literacy networks at regional, national and local levels;
- Identifying modalities for the mobilisation of financial and in-kind resources to enable the implementation of global and regional Ocean Literacy activities;
- Identifying synergies with relevant UNESCO Sectors, international organizations, academic institutions, NGOs and private sector associations; and
- Coordinating Ocean Literacy research activities relevant to the development of tools and methodologies and the assessment of impact of Ocean Literacy initiatives (IOC/UNESCO 2023).

9.8 Conclusion

Securing the future of the Ocean and unlocking the full potential of the Blue Economy requires a multifaceted approach that integrates Ocean Literacy with sustainable business strategies and robust policy frameworks. The efforts of groups

like the UNESCO/IOC Group of Experts on Ocean Literacy are playing a pivotal role in this transformation.

While my personal journey with Ocean Literacy began in Venice, the efforts of this community have been global. Since that initial encounter, there has been a remarkable surge in public interest and awareness. This growing recognition underscores Ocean Literacy's crucial role in shaping evidence-based policymaking, encouraging sustainable business practices, and enabling financial markets to adopt environmentally conscious strategies.

When considering the Ocean's economic significance—across industries such as shipping, fishing, tourism, and energy, its contribution is undeniable. Yet, these benefits are inextricably linked to the health of marine ecosystems. The more informed people are about the Ocean and its processes, the better equipped they will be to make decisions that balance environmental needs with economic growth.

By empowering investors, educators, and local communities with Ocean Literacy, we not only safeguard marine resources but also ensure inclusive economic resilience. While the intersection of Ocean Literacy and the finance sector remains relatively underexplored, this chapter offers a foundational perspective on how these fields can converge to support both sustainable economic development and Ocean health. Drawing from a broad and interdisciplinary range of sources—including international reports, peer-reviewed literature, and credible grey literature—it identifies emerging opportunities for financial mechanisms such as blue bonds, blended finance, and sustainable investment strategies.

Although constrained by limited direct research explicitly linking finance and Ocean Literacy, the thematic synthesis of related work in economics, nature risk, and sustainable development highlights a clear need for greater integration of Ocean knowledge in financial decision-making. This exploratory approach underscores the potential of Ocean Literacy to inform risk assessment, promote responsible investment, and ultimately reshape the way economic actors engage with the Ocean. Future work in this evolving area may benefit from deeper empirical investigation and stronger cross-sector collaboration, laying the groundwork for a more resilient and inclusive Blue Economy.

9.8.1 Summary

Key concepts explored in this chapter include:

- Ocean Literacy (OL) plays a vital role in bridging the gap between environmental responsibility and financial decision-making.
- Ocean health is fundamental to long-term economic prosperity, particularly for sectors that are directly dependent on marine ecosystems—such as tourism, shipping, energy, and fisheries—which face immediate operational and financial risks from Ocean degradation.
- The finance sector must consider the value and risks associated with Ocean-dependent industries to foster sustainable economic growth.
- Nature-related financial risks, including those affecting marine ecosystems, are often unpriced and underreported in traditional financial systems.
- Ocean Literacy enhances investment decision-making, corporate disclosures, and risk management by complementing traditional financial tools with ecological understanding and cross-sector perspective.
- Understanding the Ocean's economic value requires recognising the ecological systems that underpin it, highlighting the importance of systems thinking in financial decision-making.
- Innovative financing mechanisms—including blue bonds, blended finance, and public–private partnerships—are promising tools for supporting the Blue Economy and addressing the Ocean funding gap.
- Greater integration of OL in finance can help shift capital toward nature-positive outcomes and support Sustainable Development Goal 14.
- Collaboration across sectors, especially between financial institutions and the OL community, is essential to advance shared goals for Ocean health and sustainability.

- The growing awareness of Ocean Literacy underscores its importance in shaping evidence-based policy and guiding financial markets toward sustainability.
- Despite the limited existing research connecting OL and finance, thematic synthesis from related fields shows clear potential for integrated solutions.
- Increased collaboration between the UNESCO/IOC Group of Experts on Ocean Literacy and finance leaders can accelerate the shift toward Ocean-positive investment frameworks.
- Empowering communities through Ocean Literacy enhances both environmental and economic resilience.

9.8.2 Recommended Resources

The following resources provide further insights and support on this topic:

- The role of the IOC Group of Experts and emerging initiatives to mainstream OL into global efforts: https://www.unesco.org/en/articles/unesco-assembles-global-group-experts-ocean-literacy
- A foundational report linking Ocean degradation to financial risk, offering sector-level data and investor implications: https://www.wwf-baltic.org/newsroom/finance/navigating-ocean-risk-value-at-risk-in-the-global-blue-economy
- Blue Invest: Investor report unlocking the potential of the Blue Economy, discussing current investment trends, challenges, and opportunities: https://blueinvest-community.converve.io/upload/fck/file/Report_Blue_Invest_FINAL_7march-compressed.pdf

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Ocean Art as an Integral Part of Kenya's Blue Economy

10

Jacqueline Uku, Susana Kihia, Sarah Ater, Nelly Isigi Kadagi, and Nina Wambiji

Abstract

Approaches to addressing marine resource use issues have often been limited to relying on scientific research to propose technical solutions and policies that affect Ocean spaces. The communication of these solutions typically occurs through scientific publications and policy briefs, which have a restricted reach and impact. Creative arts can uniquely connect scientific findings to human values and emotions, motivating behavioral change. To explore this idea, we conducted a study in Kenya to understand the role that coastal and marine artists play in fostering awareness of the Ocean and marine life through their art. Findings revealed that the content of the artwork is driven by market demand with wildlife and terrestrial themes dominating coastal artwork. Art sales depend highly on foreign tourists and contribute significantly to the Blue Economy. The market preference in Kenya is on terrestrial art and impediments to the purchase of Ocean art by locals were identified as a lack of awareness of the Ocean, religious barriers, and purchasing power.

There is a need to focus on co-creation and partnerships with key allies in both the public and private sectors. Additionally, incorporating Ocean Literacy into the Marine Spatial Planning process in Kenya is essential. Our foundational work provides an opportunity to expand the use of art in advancing the Blue Economy discourse, amplifying the active participation of local and Indigenous communities.

Keywords

Ocean art · Ocean Literacy (OL) · Policy · Curriculum · Blue economy · STEM education · STEAM education

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10.1 Introduction

The expression of ideas through art is not new in Africa. Ancient civilizations used artist forms to convey values, knowledge, and history—as seen in prehistoric cave paintings and the pictorial hieroglyphic scripts recorded in Egypt (Harris 2008) as well as in narrative scrolls (Orthmann 2008). In contemporary society, we continue to

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observe the visual transmission of ideas through mediums such as film, drama, and visual arts, particularly, in the realm of wildlife conservation.

Kenya, a nation rich in biodiversity, has a long-standing tradition of wildlife conservation. A common feature of public spaces throughout the country is the presence of artwork that visually represents various themes of nature and conservation. It is common to encounter statues showcasing the Big Five—elephants, lions, buffalos, leopards, and rhinos—in a variety of public areas. Additionally, art illustrating terrestrial elements of nature, such as forests, lakes, and rivers, as well as local communities, depicting homesteads, people dancing, and landmarks like Mt. Kenya, is also widespread.

The focus on the marine environment gained momentum when Kenya hosted the first Sustainable Blue Economy Conference in 2018 (see the resources section for summary reports and videos from this landmark global event). The conference was held at the Kenyatta International Conference Centre (KICC), co-hosted by Kenya, Canada and Japan. Over 17,000 participants from 184 countries were involved in the conference, engaging political leaders and government representatives from across the world, the African Union, United Nations organizations, and the Commonwealth. With the theme *"The Blue Economy and the 2030 Agenda for Sustainable Development,"* the conference provided countries with an opportunity to initiate national dialogue on sustainable use of Ocean resources. This event shifted national attention from terrestrial ecosystems to the Ocean, prompting national discourse on sustainable economic opportunities associated with the marine environment—collectively referred to as the Blue Economy (BE) (Fig. 10.1).

As a response to this new focus on the Ocean, we expected to see artwork that highlights the Ocean space, representing the coastline, open waters, boats, and the rich diversity of marine life, including various fish species. Kenya's Ocean territory is home to numerous charismatic creatures, such as whale sharks, giant manta rays, dolphins, humpback whales, turtles, and billfish. Therefore, it is reasonable to expect the emergence of artwork depicting these marine animals, mirroring the artistic representations commonly seen for terrestrial wildlife.

In this context, we conducted an art survey to examine the presence of visual representations of the Ocean and its organisms in public spaces and marketplaces (Kihia et al. 2023; Catlin 2018). With the growing interest in the Blue Economy, our objective was to highlight how local communities engage with art, creating pieces not only for trade but also to express their understanding of the environment, and thereby contributing to Ocean Literacy. As noted by Hansen and Machin (2013), visual images of the environment serve as powerful tools for learning and gaining knowledge about our surroundings (Brennan 2018; Boswell 2021). Most Ocean creatures remain hidden underwater, making it challenging to raise awareness about Ocean spaces and their inhabitants (Dupont and Fauville 2017). We anticipated that artwork along the coast would depict these unique marine species. The purpose of our study was to assess the extent to which artwork produced and sold along the Kenyan coastline reflects themes related to the Ocean and marine life. We believe that this approach could help bring the hidden and often overlooked aspects of the Ocean closer to the public and foster greater interest in conservation. Our focus was on the content, consumption, and production of marine-related artwork, as identified by Hansen and Machin (2013), to evaluate its role in visual environmental communication.

We conducted the survey in the coastal counties of Mombasa and Kilifi from 24 May to 16 June 2021. Mombasa County, often regarded as



Fig. 10.1 Sustainable Blue Economy Conference 2018 in Kenya. Picture credit: University of Nairobi. https://dca.uonbi.ac.ke/achievements/sustainable-blue-economy-conference-2018

the gateway into Kenya, is a coastal town with a rich cultural history dating back to 900 AD. As the second largest city in Kenya, Mombasa is a major port city with an estimated population of 1.2 million according to the 2019 national census (Kenya National Bureau of Statistics 2022). The city is known for its vibrant culture and lifestyle, shaped by its cosmopolitan population, diverse architecture, rich cuisine, and dynamic entertainment scene. Kilifi County, located to the north of Mombasa, recorded a population of 1.4 million in the same census. Watamu and Malindi, located within the greater Kilifi County, are popular tourist destinations featuring numerous foreign-owned and serviced establishments. Kilifi town has traditionally been known as a fishing hub, where both artisanal and recreational fishing continue to thrive. The area regularly hosts sports fishing competitions, particularly those targeting billfish species (Kadagi et al. 2011; Kihia et al. 2023).

In both counties, the specific study sites were selected based on the presence of artists and active art markets, through which we were able to reach 29 individuals. We employed a variety of techniques to interact with the artists and to observe the artwork on display across different locations. The COVID 19 pandemic limited the number of artists we were able to access. We used a mixed methods approach, collecting data through direct observations of artwork, interviews with artists, and reviews of school curricula as well as national and county policy documents.

This chapter presents an overview of the case study results and explains how the findings were used to underscore the role of art in promoting Ocean Literacy within the context of Kenya's Blue Economy.

10.2 Results and Discussion

10.2.1 Artwork in Public Spaces and in Art Stalls and Studios

A total of 41 images from public spaces were analyzed across Mombasa and Kilifi counties. Figure 10.2 presents the results of this analysis, comparing the visual content found in public spaces at both locations.

Land based art was dominant in Mombasa County, with 66% of the observed art featuring wildlife. Ocean-themed art was less prominent, with depictions of fish appearing in 25% of the samples and other marine species in 19%. Notably, billfish were also featured in public space art within Mombasa County. In Kilifi County, fewer categories of public art were observed, with artwork containing text or messages being the most common. Of these, 40% referenced land-based features, while 33.3% included Ocean-related themes. Other popular subjects included marine species and boats or ships, each accounting for 33.3% of the Ocean-based artwork.

In recent years, beautification efforts in the public spaces of Mombasa have resulted in the installation of numerous wildlife statues, including buffaloes, giraffes, camels, and crocodiles. For many years, only two Ocean-themed statues depicting dolphins existed in public spaces. It is only recently that a *Shark Zone* has been created at a roundabout, featuring two dolphins and two sharks. Based on our data on the current public installations, we infer that there is a strong societal familiarity with terrestrial wildlife concepts in Kenyan. This is reflected in the prioritization of land-based themes in public art, even in a coastal city like Mombasa.

Where artists' consent was obtained, we photographed their full art collection at their points of sale. A total of 195 images were collected. The findings from these artist collections closely mirrored those observed in public spaces. In Mombasa County, 42% of the land-based artwork featured wildlife. In Kilifi, land-based themes similarly dominated artist collections, with 34% depicting wildlife. Additionally, 20% of the land-based art included human figures and 15% depicted trees or forest scenes (Figs. 10.3 and 10.4).

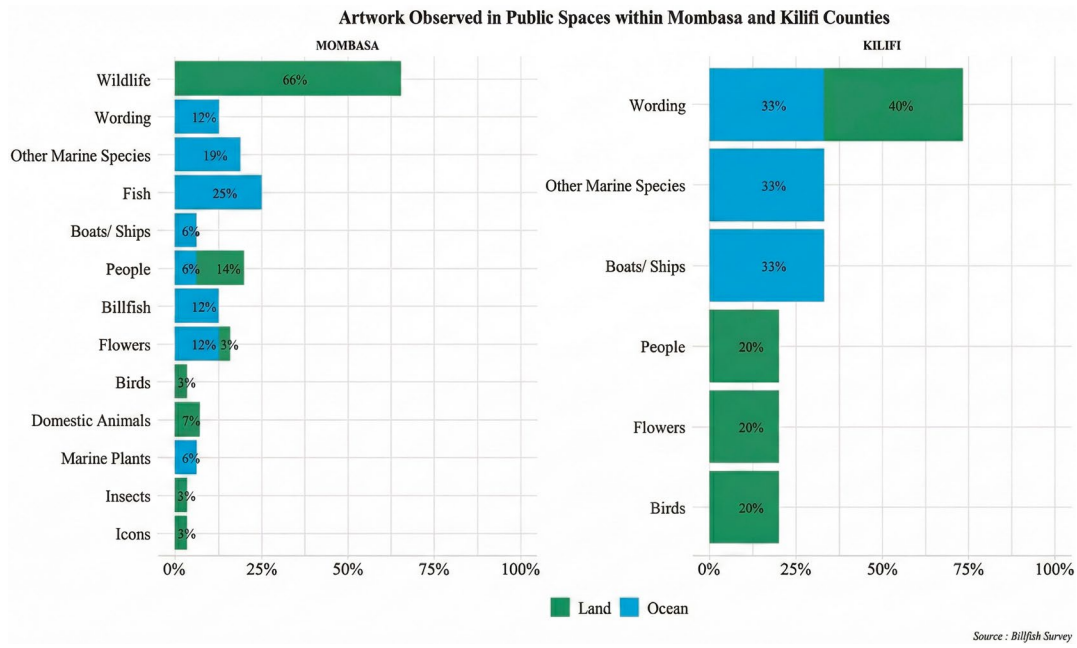


Fig. 10.2 Artwork in public spaces in Mombasa and Kilifi Counties (n = 41)



Fig. 10.3 Artwork displayed in the marketplace in Watamu, Kilifi County (Photo credit: Dr. Jacqueline Uku, 2021)



Fig. 10.4 Artwork in a stall in Watamu, Kilifi County (Photo credit: Dr. Jacqueline Uku, 2021)

10.2.2 Production of Artwork for Market Demand and Ocean Literacy

Approximately 63% of the respondents indicated that they sold the majority of their artwork directly from the studios where the pieces were created. 13% of the work sold was through direct orders or commissioned, while only a few respondents reported hawking their artwork or supplying it to gift and curio shops. Only one respondent indicated having sold their artwork online. Reported sale prices ranged from a minimum of KES 400 (US$3) to a maximum of KES 1,300,000 (US$10,000), with pricing determined by the type of materials used as well as the time and effort invested in creating the piece. A large majority (96%) of respondents noted that most of their buyers were repeat customers. Additionally, 88% confirmed that sales were seasonal, peaking during the high tourist months. During this period, foreigners were identified as the primary

clientele, while local buyers were more common during the low tourist seasons.

Most respondents (67%) indicated that they did not sell any art pieces during the COVID-19 period, largely because their primary market—foreign tourists—was absent. They reported that local buyers generally do not purchase paintings, and when they do, they tend to favor more traditional imagery, such as scenes with coconut trees and huts, often opting for smaller-sized pieces. In Mombasa County, affordable magnet art was also available, blending both terrestrial and Ocean themes along with textual messages. Artwork containing written messages was especially prevalent in Kilifi County.

Several artists attributed the low sales of artwork featuring people and animals to religious prohibitions rooted in Islamic beliefs. This is linked to the principle of aniconism in Islam, which discourages the depiction of living beings. As explained by Maryan Osman (personal communication, 13 August 2021), one of the things prohibited is projecting the soul onto another subject outside of oneself. It is not permissible to create or display representations of humans or animals—whether in paintings, figurines, or statues—as it is believed to be an attempt to replicate forms endowed with a soul. Such representations are also discouraged within private homes.

However, this restriction does not negate the importance of appreciating, protecting, and revering nature. Islam promotes moderation and balance, and there are specific contexts where the use of images is not only allowed but required—for example, in educational settings. When knowledge is conveyed in a clear, concise, and accessible way, and when illustrations, diagrams, or pictures aid the teaching process, their use is considered permissible (Maryan Osman, personal communication, 13 August 2021).

Our findings revealed that although several of the artists we encountered were also fishers with substantial knowledge of the marine environment, their artistic production was primarily shaped by market demand. This trend was consistent in both public art displays and at points of sale throughout the coastal counties. While familiarity with the Ocean and marine life was evident, marine-themed artwork was not commonly found in art stalls; instead, it often appeared in commissioned pieces tailored to buyer preferences (Kihia et al. 2023). This pattern emerged during a focus group discussion with an art collective in Kilifi that produces billfish models for sport fishers, as well as in paintings by Watamu-based artists depicting Ocean scenes. Commissioned artwork also extended to murals on residential buildings and hotel establishments.

Although market forces strongly influence their work, many artists expressed a genuine interest in using their art to share their knowledge and perceptions of the environment. Several artists indicated a desire to learn more about the Ocean and its underwater organisms. Furthermore, they expressed interest in forming organized groups to improve access to government support and related opportunities.

10.2.3 Art and Tourism

The impact of COVID-19 led to low sales due to a decline in tourist numbers (Muoki 2021; Ondicho and Irandu 2021). Many artists relocated to spaces where they could earn an income to support their families. The COVID pandemic affected artists significantly, as they rely on physical sales of their artwork through studios, commissioned pieces resulting from encounters with tourists, curio and gift shops, and hawking. Online trading, which was embraced by only a few artists, represents a niche that could be further developed to ensure continuity in art sales—even when artists are displaced from their usual points of sale. The target market for online sales could include Germany, France, and Italy, as tourists from these countries were identified as some of the most frequent buyers of art, particularly in Mombasa County.

The significance of revenue from the sale of art to the Blue Economy in Kenya has been overlooked, and art should be supported through policies that promote the growth of the sector. In her paper, Markusen (2006) emphasized the contribution of artists to economic development by

highlighting that their work constitutes an export. When well-integrated into society, artists make significant and positive contributions to the vitality and diversity of cities (Markusen 2006; Matias et al. 2023), as evidenced by the presence of artwork in public spaces. In the Kenyan context, there is a need to regard art through the same lens as other professions, recognizing its contribution to the economy. The majority of artists in this study are self-employed and may be classified as entrepreneurs, which underscores the importance of integrating them into the Small and Medium Enterprise (SME) segment to ensure they receive appropriate support.

10.2.4 Public Response to Artwork and Ocean Literacy

The connection between art and science was recently examined during a workshop funded by the Western Indian Marine Science Association (WIOMSA). This event took place at the Kenya Marine and Fisheries Research Institute (KMFRI) and facilitated discussions between scientists and visual and theater artists. The workshop highlighted the increasing interest in enhancing the relationship between art and Ocean Literacy. This approach aligns with the growing global emphasis on STEAM (Science, Technology, Engineering, **Art**, and Mathematics), which recognizes the value of integrating artistic and creative practices into scientific inquiry and education. As a result, this dialogue has contributed to advancing the national conversation and has led to the incorporation of Ocean content into the draft National STEM policy review process.

Initiatives to involve the public in combining art and Ocean Literacy are undertaken at various levels. For example, these include hosting meetups for children and scientists to connect; creating of a children's corner where Ocean matters are displayed at the Kenya Marine and Fisheries Research Institute's (KMFRI) exhibition stand at the Mombasa Agricultural Society Show; organizing Science Cafés hosted by KMFRI and Alliance Française, Mombasa; and conducting teacher training on Ocean matters in partnership with the Wildlife Clubs of Kenya, Coast region.

Within the devolved government system, development support is channeled from the National Government to County Governments. The County Integrated Development Plans (CIDPs) are used to capture each county's development agenda, along with implementation budgets for the duration of the government's term. Priority areas are determined through a consultative, participatory process. In past County Governments, there was clear evidence of investment support dedicated to the creative arts, particularly with linkages to tourism as a marketing outlet. In Kilifi County, the previous focus was on training in music, dance, and film development. There is now a growing need for the creative arts sector to become more organized, visible, and empowered to advance its agenda.

Advancing public participation in marine education is closely linked to the need for greater awareness of the Ocean. This can be achieved by integrating Ocean Literacy into national education policies and revising curriculum guidelines to include Ocean-related themes, as was the case in Australia (Hannigan et al. 2023). In Victoria, for example, curriculum changes led to a significant increase in Ocean Literacy. Additionally, developing tourism packages that allow both local and international tourists to experience marine life, similar to existing tours of terrestrial parks, is essential. Such initiatives would foster greater familiarity with the Ocean and could expand the market for Ocean-themed art. For Ocean art to be truly valued, the general public must be exposed to more Ocean experiences (Boswell 2021; Brennan 2018).

A hidden consideration is that access to the Ocean is restricted by aspects of town planning (Arthur Tuda, personal communication, 31 March 2022). In several coastal towns across the Western Indian Ocean region, major roads are constructed near the Ocean, with other infrastructure developments positioned inland and at higher elevations. As a result, citizens travel alongside the Ocean daily during their commutes, providing regular opportunities to observe the Ocean in its many forms and seasons, including the migra-

tion of large marine species. In contrast, in Kenya, city and hotel infrastructures are often built directly along the Ocean's edge, creating physical and visual barriers that limit everyday interaction with the Ocean space. To view the Ocean, citizens must make deliberate efforts to visit designated access points, often incurring a cost. One exception is the public space at Mama Ngina Drive in Mombasa County, which offers access to the Ocean near the country's major port and presents a valuable opportunity for integrating Ocean learning into public engagement.

10.2.5 Ocean Literacy in Relation to National and County Education and Policy Instruments

Support for Ocean education begins with the integration of Ocean studies into high-level national policy documents. Recently, at the national level, opportunities have emerged to incorporate Ocean content into the Science, Technology, Engineering, and Mathematics (STEM) Education Policy, which is currently under review by the Ministry of Education. This policy document has historically lacked Ocean content, and members of the Ocean community have been actively contributing key insights to support the inclusion of Ocean science. A further review of the current Grade 10 science and geography curriculum—developed by the Kenya Institute of Curriculum Development (KICD) under the Competency-Based Curriculum—has also revealed a lack of material on Ocean and freshwater ecosystems.

In Kenya, national policies are expected to be cascaded for implementation at the County level with the expectation that there will be resource allocation and implementation support for education priorities within the local school curriculums. Our investigation was focused on exploring how to forge linkages between art (creative art) and STEM as well as other streams of education. With this in mind, we reviewed County Integrated Development Plans (CIDP) for Mombasa and Kilifi Counties for 2018–2022 and 2023–2027 to ascertain support for the creative arts at the grassroot level (County Government of Kilifi 2018; County Government of Mombasa 2018, 2021, 2023). A word search was undertaken on these documents using the word *creative art(s)*. The importance of art and support towards the creative arts was gauged based on the number of times the word appears in the CIDP. Additionally, investments and budgetary allocations to the creative arts sector were also interrogated in the documents.

The Mombasa County CIDP for 2018–2022 mentioned *creative art* 16 times. The development plan incorporated creative arts under the broader category of Sports, Culture and Creative Arts which provided recognition of art and its importance in the county. It also prioritized investment in the sector, with initiatives such as the creation of a one-stop youth center focused on resources, empowerment, and creative arts, as well as support for Youth Talent Academies. Capacity building in culture and creative industries was also included in the implementation plan. The document also acknowledged the need to market Mombasa as a preferred tourist destination and emphasized organizing more open-air market days to encourage the participation of youth and women in culture and creative arts. In contrast, the CIDP for 2023–2027 mentions *creative art* five times and identifies broader opportunities based on the availability of grants from national and international organizations for culture and heritage, the existence of talent academies and hubs, and the establishment of cultural centers and empowerment programs for cultural practices. However, there is less budgetary support allocated to this sector in the current plan.

In Kilifi County, the term *creative art* was mentioned four times in the 2018–2022 CIDP, primarily in the context of filming and libraries. At the time, the CIDP acknowledged the absence of an Artistic Talent Academy in the county and recognized the potential of the creative arts sector. It also noted that Community-Based Organizations (CBOs) were actively involved in performing and creative arts. The development

plan emphasized the establishment of cultural villages, training in music and dance for leisure, recreation, and economic benefit, as well as training in film documentary and production, alongside support for library services. In contrast, the 2023–2027 CIDP does not mention creative arts or propose any investment in this sector (Maarifa Centre 2022).

These policy-level findings highlight a lack of understanding regarding the potential of the creative arts to generate revenue at the community level. As a result, efforts to integrate art into the dissemination of scientific content, particularly through creative mediums, remain difficult to operationalize.

10.3 Conclusion

We embarked on our study with the expectation that artwork in coastal towns would reveal what lies hidden beneath the Ocean's surface and help raise awareness of the creatures and ecosystems that inhabit it. However, we found a dominance of terrestrial themes, including representations of the Big Five, which was attributed to the fact that tourists are more likely to visit national parks and encounter land animals than marine species. Kenyan tourism is largely marketed through the lens of safari experiences and the vast terrestrial national parks, where sightings of the Big Five are common. Rarely do we see sustained tourism campaigns focused on the Ocean, and where such campaigns do exist, they are typically centered around specific beaches, such as the award-winning Diani Beach (see the Resources section for more information on Diani Beach).

Our findings present several opportunities to reshape the narrative surrounding Ocean content, helping to popularize it in our living spaces while enhancing Ocean Literacy at community, local, and national levels. These opportunities may include naming roads in coastal towns after Ocean creatures; incorporating conservation messages about the Ocean into public artworks; creating small, affordable Ocean-themed art pieces, such as magnets, to spread awareness; developing affordable Ocean tour packages for locals; supporting online sales of Ocean-themed art; utilizing art to communicate scientific messages related to the Ocean and integrating Ocean access into land planning within coastal counties. Additionally, Islam allows for the use of images, diagrams, and illustrations in teaching, providing an opportunity to incorporate people of all faiths into Ocean Literacy initiatives through Ocean-themed educational materials. Since science is expressed through various mediums—words, maps, tables, diagrams, pictures, graphs, equations, and charts (Dupont and Fauville 2017)—our study suggests that Ocean art can be added as a valuable mode of expression and communication in educational resources.

Ocean Literacy is vital for not only Kenya but also for Africa's sustainable Blue Economy (BE). It is important to highlight the interconnectedness between African communities and the marine environment when envisioning what a sustainable Blue Economy in Africa should look like (Okafor-Yarwood et al. 2020; Matias et al. 2023). Our foundational work provides an opportunity to expand the use of art in advancing the BE discourse while amplifying the active participation of local and Indigenous communities. These communities are central to shaping our perspectives and interactions with marine education, which in turn helps achieve equitable economic development while ensuring social and ecological integrity.

There is significant potential for more extensive discussions during the public participation processes mandated by the Kenyan Marine Spatial Planning initiative. Since the Ocean is recognized as land under the Kenyan Constitution (Constitution of Kenya 2010; Kenya National Bureau of Statistics 2022), it is increasingly important to elevate this discussion and raise awareness of the hidden treasures within this part of Kenya's landscape. Although our work primarily focuses on Kenya, our findings are also relevant to various regions in Africa and around the world, particularly in areas where art plays a crucial role in promoting the value of local artists in fostering Ocean Literacy (Matias et al. 2023).

10.3.1 Summary

Key concepts explored in this chapter include:

- Traditional methods for addressing marine resource issues often focus primarily on scientific research, leading to technical solutions and policies that impact Ocean spaces.
- The dissemination of these technical solutions and policies is largely restricted to scientific publications and policy briefs, resulting in limited outreach and influence.
- Creative arts offer a unique opportunity to bridge the gap between scientific findings and human emotions, inspiring meaningful behavioral change through relatable narratives.
- Coastal and marine artists in Kenya play a vital role in fostering awareness of Ocean and marine life through their artwork; however, their creations are often guided by market demands, with a predominance of wildlife and terrestrial themes overshadowing marine subjects.
- Effective solutions require collaboration through co-creation and partnerships with key stakeholders in both the public and private sectors to amplify impact.
- Expanding the integration of art in Ocean Literacy in collaboration with local and Indigenous communities can significantly advance the discourse on the Blue Economy, promoting sustainable economic use whilst ensuring cultural and ecological integrity.
- This chapter reinforces the importance of transitioning from a purely STEM-based approach (Science, Technology, Engineering, and Mathematics) to a STEAM framework that includes the Arts as a critical component. By incorporating creative arts into the dissemination of marine science and Ocean Literacy, STEAM enables more inclusive, emotionally resonant, and culturally grounded communication strategies—broadening the reach and impact of scientific knowledge and fostering greater community engagement in sustainable Blue Economy initiatives.

10.3.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Report on the Global Sustainable Blue Economy Conference: https://kenyaclimatedirectory.org/resources/66fce3bfc953a
- President of Kenya H.E. Uhuru Kenyatta, High-Level Sustainable Blue Economy Conference (SBEC): https://www.youtube.com/watch?v=U_MCK3Vqs8o
- Sustainable Blue Economy Conference, Nairobi, Kenya 2018: https://www.youtube.com/watch?v=xsTUi47VnbU
- Kenya's Sustainable Blue Economy Conference Summary report, 26–28 November 2018: https://enb.iisd.org/events/sustainable-blue-economy-conference/summary-report-26-28-november-2018
- Africa News—Kenya hosts inaugural Sustainable Blue Economy Conference: https://www.africanews.com/2018/11/26/kenya-hosts-inaugural-sustainable-blue-economy-conference//
- The award-winning Diani Beach: https://www.worldtravelawards.com/award-africas-leading-beach-destination-2023

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11 Community Empowerment and Ocean Conservation Through Education

Daniela Hill Piedra

Abstract

Our purpose as a community in our world of rapid change is to reconnect people with the Ocean. We need to understand its role and impact on our lives, and this can be achieved through Ocean Literacy. Since 2021, Amiguitos del Océano (FADO), a grassroot non-profit organization, has been working with underserved coastal communities in mainland Ecuador. Our pilot model, located in Ayangue (province of Santa Elena-Ecuador), aimed to achieve community development based on Ocean education, management, and sustainable use of resources. Over the past four years, we have now scaled this pilot into a full program that now reaches 10 additional communities, six in Santa Elena and four in Guayas.

We address the conservation of marine-coastal ecosystems through integrated personal, sectoral and community action. The program has several projects that holistically co-construct Ocean knowledge and relationships through educational, experiential, and experimental processes with different groups ranging from children to youth to adults. Our signature methodology, Explore, Feel, Reconnect and Act (ESRA), is based on the power of personal action on environmental problems, reconnecting us with the bond we have with water. ESRA encourages reflection and critical thinking; emotions play an important role and participants are the protagonists. Metrics have been developed for each ESRA phase in every sector we serve, allowing us to generate primary data on the behavioral changes and improvement of practices among beneficiaries, demonstrating how Ocean Literacy functions as a tool for conservation and preservation.

Keywords

Ocean Literacy (OL) · Coastal communities · Ocean education · Environmental education · Marine education · Marine conservation · Community empowerment · Amiguitos del Océano · EcoClubs · SDG4 · SDG12 · SDG14 · SDG17

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11.1 Introduction: Education for Marine Conservation

For many years, the science community has talked about Ocean "goods and services" as it tries to weigh and place an economic value on Nature. The aim being that mankind can better understand the role and importance of ecosystems in human well-being to make better decisions regarding the management, use and conservation of natural resources (Camacho Valdez and Ruiz Luna 2012). This approach has made most people think, and construct an unconscious vision, that the unique Blue Planet we live in is exclusively a provider, and not a living and dynamic being to whom we are connected, depend on, and rely on.

The latest Intergovernmental Panel on Climate Change (IPCC, 2022) reports that human activities have unequivocally caused global warming. When reflecting on valuing the ecosystem services, Costanza and Folke (1997, pp. 49–68) point out that "we cannot avoid the valuation issue, because as long as we are forced to make choices, we are doing valuations." As a result, we have been valuing and making choices that have compromised both human and planet health, and still have not addressed the best approach for the Ocean crisis we are facing. Improving our relationship with our Ocean by understanding the role we play in its health could not only mobilize but accelerate the changes we need for the future we want.

As a result, our nonprofit organization has been working for 7 years in coastal communities in Ecuador, focusing on two aspects. One, we develop educational strategies based on seven Ocean principles so people can improve their knowledge and relationship with the Ocean. Two, we demonstrate that science needs a stronger complementary social approach to reach the conservation milestones and measurable outcomes set forth by the Sustainable Development Goals (SDGs) and the ten Challenges of the Ocean Decade.

11.1.1 The Beginning of our Journey

In 2018 we started working in public schools in Santa Elena province. We had an Environmental Education Program that was carried out over a 1 week period in each school. This program was structured with a three step methodology:

- Awareness: We visited each classroom and carried out workshops together with the students, from kindergarten to high school. An audiovisual presentation provided insight on the goods and services of the Ocean, showing the pollution of the ecosystems and the impact on marine species due to the presence of plastics in the sea. One of the most important aspects of this step was to encourage each student to reflect on "What can I do as a child?" The main topics addressed included: (1) Marine Biodiversity: Focus on local species and marine and coastal ecosystems; (2) Ocean Problems: Plastic pollution, ghost fishing gear, illegal fishing, shark fining, and others; and (3) Best Practices and Behavior: Plastic production and consumption.
- Hands-on: We planned a beach clean-up together with the students, parents, and teachers, so that they could have a personal experience about the topics that were presented in class. Collected waste was classified, weighed, and ranked, generating a top five waste list for each site, so that the students can see and analyze the problem quantitatively and qualitatively. Recyclable or up-cycled materials were handed over to local recycling associations or to local schools.
- Activism: Following the beach clean-up, the students together with a local artist painted a mural to deliver an Ocean conservation message. The concept and drawing for the mural were developed between the students and the artist and was painted outside the school for public view. During the first year, we glued pieces of marine plastic to the mural, but they either fell off or passers-by pulled them off the wall, so we discontinued this practice in later years.

Table 11.1 Results of the first 2 years

Number of Students	10,235 (52.4% boys—47.6% girls)
Son/daughter of fishermen	31.5%
Didn't know how to swim	62.1%
Number of communities	34
Total collected waste	13.9 tons
Total volunteers	1,712

Fundación Amiguitos del Océano (2023)

Table 11.2 Results of post-surveys

- 91% of students indicated they learned new things about the Ocean.
- 49% of students remember what they learned.
  - 24% recall the message of caring for the environment and animals;
  - 23% remember the underwater videos shown;
  - 17% remember the diving signs they learned;
  - 17% remember the beach clean-up that was carried out to collect trash;
  - 19% other subjects.
- 70% of students changed their habits (31% in class; and 39% at home), and 30% of students did not.
- 87% of students took the initiative to pick up trash in places of recreation (beach, park, river, mangrove, other).
- 75% of students mentioned having talked at home about what they learned at the workshop.
- 91% of students would like to be part of an environmental club.

Fundación Amiguitos del Océano (2023)

The results after the first 2 years implementing this program are summarized in Table 11.1.

In 2019, 12–18 months after of our first visit, we were able to conduct a follow up of the first-year beneficiaries. We carried out personal surveys with 30% of the students at each school visited (n = 1,522) and interviewed teachers. The results are presented in Table 11.2.

11.1.2 National Environmental Education Overview

While visiting public schools in the coastal communities in 2018 and 2019, we realized that the National Environmental Education Strategy was mostly focused on terrestrial rather than Ocean education despite the fact that Ecuador has five times more marine territory than land since its signing of CONVEMAR (Convención de La Naciones Unidas Sobre El Derecho Del Mar CONVEMAR 2012).

As an example of this, the Environmental Program "Tierra de Todos" was implemented in every national school as project "TINI". This project was a foreign experience brought to Ecuador to link science with diverse classroom subjects by working in green spaces, sowing and gardening experiences. The Ministry of Education aimed to mainstream environmental education and strengthen human values and practices to prevent environmental damage and improve the quality of life, health, and environment of the educational community (Ministerio de Educación del Ecuador 2018). Over the 2-year period that we frequented the local schools, we noticed that the Tierra de Todos methodology was not fostering a connection to local context nor developing any relationship between students and their marine and coastal ecosystems. This realization highlighted the importance and relevance of our work to bring the Ocean into classrooms.

We challenged ourselves to address this need and continue developing the ESRA methodology. The education community immediately became very supportive, manifesting that the Ocean Literacy topics discussed during our presentation and the way we demonstrated the inter-connection were new for them even though they live in front of the sea and see the problems but don't always know how to act. They particularly valued the experience of beach clean-up and the mural painting, which were new for them. They mentioned that those activities made students gain greater awareness of local issues regarding Ocean Challenges. Due to the COVID-19 crisis, we were not able to implement our program for a third consecutive year.

11.1.3 Waves of Change: Ocean Literacy and the Ocean Decade Movement

During the pandemic, we took time to look at our preliminary results and revise our program. We also connected with and joined networks in Latin American such as RELATO (see the resources section for more information). As we acquainted ourselves with various global initiatives, we not only discovered the concept of Ocean Literacy (OL), but a Blue Community to whom we relate in many ways.

Ecuador started positioning itself as a Territory for Sustainable Development Goals from 2020 onwards. Several different goals were prioritized for different provinces of the country. However key goals, such as marine ecosystems SDG14 (ODS Territorio Ecuador 2019, 2023), were often overlooked. The Ministry of Education and the Ministry of Environment started working together in 2019 to redefine "Education for Sustainability" which then became "Plan Natura" (Ministerio de Educación 2023). This momentum was an opportunity for us. We started to talk the "SDG language" before introducing the Ocean Literacy (OL) concept to different stakeholders. This made it easier for us to connect, communicate and get support to continue our projects. This strategy worked, and in 2021 we launched an Ocean Education Kit (see the resources section) and built our OL Program for Coastal Communities.

Later, in 2023, we were invited to participate in the Environmental Education National Strategy (ENEA) 2023–2030 up-date consultancy workshops, during which we promoted Ocean Literacy inclusion in formal, informal and non-formal education (Ministerio del Ambiente de Ecuador 2023).

11.2 Ocean Literacy Program for Coastal Communities

Ocean Literacy Program for Coastal Communities (OLPCC) is our new 5-year flagship program. It is built on our initial 2-year experience with schools, the new educational dynamics due to Covid, the global and national public policy initiatives, and the results about data concerning marine education interest and lack of physical connection with water. The OLPCC program works in territory, building a human-Ocean relationship over the long-term. The program seeks to work with the different sectors and groups in Ayangue to build a sustainable community based on Ocean Literacy to make people aware of the Ocean's importance and benefits; to show people how their activities influence the Ocean; and to boost Ocean connection through personal and collective experiences.

11.2.1 Our Dear Blue Spot

Ayangue is a community that borders El Pelado Marine Reserve (REMAPE) in Santa Elena province which has an approximate population of 1,464 residents and can accommodate up to 3,000 people in high season. Surrounded by cliffs and lush vegetation, this U-shaped Bay has historically been home to a community dedicated to artisanal fishing and the production of handicrafts. Around 30 years ago, the arrival of scuba diving established tourism as the main economic activity. Nowadays, Ayangue attracts many local and international tourists due to its various natural attractions and food specialties.

Table 11.3 Key sectors of Ayangue community who were surveyed

Key Sectors	Number of surveys
Tour operators	10
Hotels	10
Restaurants	35
Beach workers, vendors, and service providers, etc.	46
Farmers	12
Fisherman	35
Youth	80
Families	110
Teachers	11
TOTAL	349

Fundación Amiguitos del Océano (2023)

In August 2021, we held meetings with the community President and signed a cooperation agreement. Then we worked on a survey ($n = 349$) gathering information about the community through interviews conducted with representatives of different working groups, and key actors within the community (fishermen, tour operators, the hotel sector, and the education sector) (Table 11.3).

The information obtained was based on five parameters:

- Community's Ocean knowledge and connection.
- Previous knowledge about sustainability and environmental issues.
- Presence of pro-environmental behaviors and participation in environmental projects.
- How the population sees their community and how they envision it in the future.
- Interests of the community for capacity building.

After gathering the data, we organized workshops with every sector, socialized the survey results, and worked together with 139 participants to create word cloud responses to the questions *How do I perceive Ayangue today?* (Fig. 11.1a) and *How do I envision Ayangue by 2026?* (Fig. 11.1b).

These word clouds depict the present-day appreciation of the community, defining Ayangue as quiet (tranquila), pollution (contaminación), disorganization (desorganización), opportunities (oportunidades), beautiful (bonita), and development (desarrollo). The desired future is expressed through words such as clean (limpio), organized (organizado), unity (unión), tourist (turístico), safe (seguro), example (ejemplo), ecological (ecológico), and calm (ordenado).

Both word clouds provided a basic road map for determining the answers to our third question: "How can we embrace sustainability in Ayangue?" To guide participants, we built a three-pronged methodology:

1. Personal insight: "What can I do so Ayangue turns into a sustainable community?"
2. Me as part of a group: "What can we, as a fishery association, for example, do so Ayangue turns into a sustainable community?"
3. Me as part of the community: "How can we work to be a sustainable community?"

The insights, results and shared experiences from this study helped us to build the content of our program, prioritize the project to be implemented, and create a baseline for us to align follow-up.

11.2.2 The Ocean Literacy Program for Coastal Communities Projects

The Ocean Literacy Program for Coastal Communities (OLPCC) program has several projects that, in a holistic way, seek to co-construct oceanic knowledge and relationships

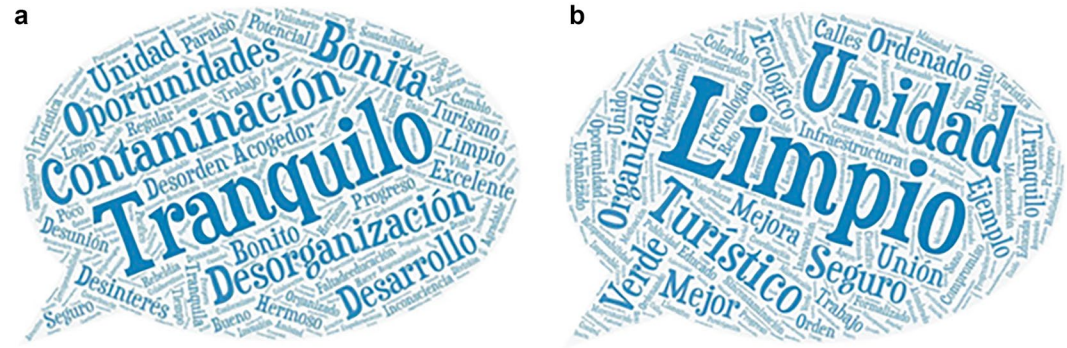


Fig. 11.1 (**a**) (left) Word cloud representing the present situation of Ayangue. (**b**) (right) Word cloud representing the envisioned situation of Ayangue for 2026. Elaboration: FADO (2021)

through educational, experiential, and experimental processes with the different groups with whom we work through our ESRA methodology (Explore, Feel, Reconnect and Act), which is based on the power of personal action on environmental problems by reconnecting us with the bond we have with water. Through the activities and workshops carried out, we seek to:

- Emphasize analysis, reflection and critical thinking about the environment that surrounds them.
- Promote participation, teamwork, and collaboration.
- Involve participants in all educational and experiential processes.
- Increase participants' interest and commitment to environmental issues.
- Understand the importance of the Ocean and its interrelationship with their lives and work.

A brief overview describing all projects implemented since 2022 follows, based on the results of our original 2021 survey. Within each project, we've identified the target audience, start date, duration, and whether the project has been replicated.

11.2.2.1 Ocean Literacy for Children–EcoClubs

The EcoClubs follow a non-formal environmental education process where didactic content and hands-on experiences are reviewed so that students and their families learn about environmental care, sustainability, and Ocean Literacy, to improve the relationship with their environment and promote the empowerment, participation, and leadership of children in their community.

- Target audience: 6–12 years old
- Cohorts: 2022, 2023, and 2024
- Duration: 11 months
- Replication: 6 communities: Ballenita and La Libertad in Santa Elena province, and Puerto Hondo, Batallón del Suburbio, Chongón and Miraflores in Guayas province.

EcoClubs encourage children to be agents of change that contribute to local conservation and sustainability (see Figs. 11.2, 11.3, 11.4, and 11.5).

At the end of the EcoClub period, participants create a project to address an environmental problem in their community and implement it the following year. Two of these projects are outlined in the "Other Projects" section of this chapter.



Fig. 11.2 Children from the EcoClub La Libertad "Guerreros Acuáticos" (FADO, 2024)



Fig. 11.3 Children from the EcoClub "Ayangue Limpio" (FADO, 2024)

11.2.2.2 Ocean Literacy for the Artisanal Fishery Sector

We work with artisanal fishermen to improve fishing practices through a program where concepts such as sustainability, Ocean Literacy, regulatory analysis of the fishing sector, and conservation and fisheries are addressed. At the end of the program, participants build an action plan to implement in their fishing group. The action plan includes a list of agreed upon commitments. These have included: collecting marine litter when fishing; returning their litter back to land after fishing; getting together once a month for a beach clean-up; releasing marine species that are not allowed e.g. sea turtles (Figs. 11.5 and 11.6).

- Target audience: Fishery association and independent fisherman (wide range of age)
- Implementation: since 2023
- Duration: 2.5 months
- Replication: 5 communities: San Pedro, Monteverde, Jambelí, San Pablo y La Libertad in Santa Elena province.

11.2.2.3 Ocean Literacy for the Tourism Sector

We have worked with groups from the tourism sector to address sustainability, marine-coastal ecosystems, socio-economic development, and Ocean Literacy with the goal of enhancing sustainable ecotourism. In 2023, we worked with a native tourism guides group named "Centro de Turismo Comunitario" (CTC) for ten months (see Fig. 11.7). The work with the CTC focused on empowering participants through self-discovery processes with external coaches, entrepreneurship courses, and support to regulate and manage their organization. Open water diving and subtidal monitoring courses were provided to participate in two citizen science projects, which will be detailed in the "other projects" section.

During this period, we began working with different sub sectors identified in the diagnosis held in 2021: tour operators and restaurants. For tour operators, a logo is being created to identify that their establishment has completed our training process. In the case of restaurants, we are linking them with chefs to improve their culinary offering, customer service, and obtain personalized



Fig. 11.4 Children from the EcoClub "ChiquiGuardianes al Rescate de Ballenita" on a fieldtrip at Machalilla National Park (FADO, 2024)



Fig. 11.5 Members of an Artisanal Fishery Association from Monteverde community (FADO, 2024)

mentoring. At the end of the program, participants build an action plan to implement in their group.

- Target audience: wide range of age for adults.
- Implementation: since 2023
- Duration: 2.5 months
- Replication: 1 community, Palmar.

11.2.2.4 Waste Management

We collaborated with the Ministry of the Environment (MAATE) and the Zero Waste Alliance (Alianza Basura Cero Ecuador) to improve consumption and production habits in individual households, specifically in the context



Fig. 11.6 Members of an Artisanal Fishery Association from San Pedro community (FADO, 2024)



Fig. 11.7 Members of Centro de Turismo Comunitario (CTC) in Ayangue community (FADO, 2023)

of the circular economy. Through these experiences, we have been able to activate community recycling and create a community compost project (Figs. 11.8 and 11.9).

- Target audience: Children, young people, and adults.
- Implementation: since 2023
- Duration: 4 months of implementation but still active.
- Replication: 1 community, Ballenita.

11.2.3 Other Projects

Amiguitos del Océano also carries out community projects to raise awareness of the importance of mangroves, improve relationships with the Ocean by offering swimming and snorkeling classes, remove pollution and waste from the environment through organized beach clean-ups, and update local biodiversity data through community underwater surveys.

11.2.3.1 Mangroves

We carry out eco routes in electric boats in the estuarine ecosystem that surrounds Guayaquil. Our goal is to raise awareness among visitors and residents of Guayaquil about the importance of the goods and services of the mangrove ecosystem. We combine cultural, educational, and tourism experiences to revalue the natural spaces within the city. Additionally, we partnered with non-profit organizations and private companies to reforest the mangroves areas in the Gulf of Guayaquil. (see Figs. 11.10 and 11.11).



Fig. 11.8 Some beneficiaries of Ayangue Composta project (FADO, 2024)



Fig. 11.9 Beneficiaries of Ayangue Composta project working (FADO, 2024)



Fig. 11.10 Transporting red mangroves (*Rhizophora mangle*) for planting activity in Balao community, Gulf of Guayaquil, Guayas province (María Paz Acosta, 2023)

11.2.3.2 EcoDivers

Our EcoClub initiative showed us that a high percentage of youth do not know how to swim. In 2023 and 2024, we awarded 18 children a scholarship for a swimming and snorkeling course. Our goal was to help these children continue to improve their relationship with the Ocean and maintain their activist spirit. For their graduation, we took the participants to El Pelado island (in the marine reserve), to spend a day snorkeling and identifying marine species (see Figs. 11.12 and 11.13).



Fig. 11.11 Planting red mangroves (*Rhizophora mangle*) in Balao community, Gulf of Guayaquil, Guayas province (María Paz Acosta, 2023)



Fig. 11.12 Ecodivers receiving their snorkel gear (FADO, 2023)

11.2.3.3 Beach, Underwater and Bay Clean-ups

Prevention is our highest priority, however, cleaning the beach (Figs. 11.14 and 11.15), the seabed, and Ayangue Bay, help us to continue promoting Ocean care by raising awareness and removing polluting waste from the environment. We encourage activities to recover poorly managed and forgotten waste on our beaches together with volunteers and private companies. Together with volunteer certified divers from EcoDivers, CTC members snorkel in Ayangue Bay to recover underwater garbage along the coastline see (Fig. 11.16).

11.2.3.4 Underwater Survey

Together with the Centro de Investigación Marina y Acuícola de la Escuela Superior Politécnica del Litoral (CEANIM-ESPOL), CTC members carry out underwater surveys in two diving sites of El Pelado marine reserve to collect information on groups of fish and sessile and mobile invertebrates. This data collection empowers native guides through research so that they learn about marine species, get involved in the identification of the species, and use this information in their diving outings (Figs. 11.17 and 11.18).



Fig. 11.13 Ecodivers graduation in El Pelado island (REMAPE Marine Reserve) (Alex Pozo, 2023)



Fig. 11.14 Beach clean-up with members of EcoClubs (FADO, 2024)



Fig. 11.15 Project of the second cohort of EcoClub "ChiquiGuardianes al Rescate de Ballenita" (FADO, 2024)



Fig. 11.16 Underwater clean-ups held Marine protected areas (Sebastián Peña, 2024)



Fig. 11.17 Diving Team for Underwater surveys (FADO, 2024)



Fig. 11.18 Underwater surveys at the REMAPE Marine Reserve (Pablo Coronel, 2024)

11.3 Results

The following results focus on three aspects of our programs: (1) the general statistics; (2) a focused look at EcoClubs, our oldest project with the utmost extension of content and metrics; and (3) our Ocean Literacy Network.

11.3.1 Statistics and Data

Over the past 7 years, Amiguitos del Océano has directly benefited 18,888 people, of which 37% are children, 36% are girls, and 27% are adults. We have involved 4,354 national and international volunteers. Ten EcoClubs have been implemented in seven coastal communities, and their participants have created 14 different projects during their programs. We have organized 522 workshops and 88 field trips reaching a total of 2248 h of marine education. We have been able to recover 10,355 kg (10.4 tons) of waste from the coastal marine ecosystem, 2475 kg (2.5 tons) of which could be recovered for recycling. All the data presented is found in Table 11.4.

Beyond just looking at impactful numbers which reflect the consistency of our efforts, growth, reach, scaling and trust in the community, we wanted to visualize the scope of Ocean Literacy extension into the Ayangue community. Together with an external consultant, we found a fantastic way to do it. The firework-shape flowers shown in Fig. 11.19 represent the different projects we have implemented in Ayangue in 2022 and 2023, and the relationship between beneficiaries.

Figure 11.19 displays Ocean Literacy as a common factor that brings together and connects people from different sectors/groups for tackling environmental issues. The blue dots symbolize each project, and the size of the dot represents the time of implementation. The EcoClub blue dot is the bigger one because it was the first project we started in Ayangue and the one with more beneficiaries.

There are 250 "elements" mapped (240 beneficiaries, 7 projects, 1 public school, 2 fisheries associations), 334 connections between them, and 71 are family related. Besides the family relationship, we could also realize the multiple interventions that some beneficiaries have between projects, which maximizes the impact of the program.

11.4 Discussion

Four key aspects emerged from our experience, lessons learned, and preliminary results: (i) the organizational planning phase of the program; (ii) the implementation phase; (iii) financing; and (iv) replication experiences.

11.4.1 Planning Phase

A key component of the success of our program was the inclusion of different sectors of the community within the planning phase of the program itself. The analysis of the survey results from 319 people allowed us to define three core values from the community ideas. This helped us recognize that the program needed to address: i) marine litter affecting their community and their economic activities, ii) lack of understanding of the meaning of sustainability and how Ocean knowledge is applied to their daily lives, and iii) all sectors envisioning their community as "Ayangue Limpio" and "Unido" (*Ayangue Clean and United*). This in turn raised the bar to working with all sectors not just children.

As a result of this process, we know that the program is not "our program" but the community's program and we are just facilitators. We are thrilled to show there is a way to create a path based on fostering Ocean Literacy through all sectors in Ayangue, reaching also other communities building up with the different sector's perspectives, feelings, and shared experiences.

11.4.2 Execution Phase

Small grassroots non-profits often encounter challenges similar to those faced in social impact

Table 11.4 Detail of reach and impact results from 2018 to august 2024 (FADO, 2024)

	Detail	2018	2019	2020	2021	2022	2023	2024	Total
REACH	No. beneficiaries (boys)	2,631	2,513	347	102	442	470	442	6,947
	No. beneficiaries (girls)	2,445	2,375	567	103	507	485	417	6,899
	No. beneficiaries (adults)	203	2,226	61	191	1,640	441	280	5,042
	No. direct beneficiaries	5,279	7,114	975	396	2,589	1,396	1,139	18,888
	No. volunteers	747	965	0	143	933	1,389	177	4,354
	No. EcoClubs	NR	NR	NR	NR	6	2	2	10
	No. projects created by EcoClubs	NR	NR	NR	NR	NR	8	6	14
	No. workshops	NR	NR	NR	NR	NR	278	244	522
	No. plans of action created	NR	NR	NR	NR	NR	9	2	11
	No. field trips	NR	NR	NR	NR	NR	57	31	88
	No. Ocean Literacy hours	300	450	50	78	376	551	443	2,248
IMPACT	(kg) collected in bay clean-ups	NR	NR	NR	NR	NR	2	9.2	11.2
	(kg) collected in beach clean-ups	2,299.69	1,683.5	0	193.4	1,807.83	3,318.2	931	10,233.62
	(kg) collected in underwater clean-ups	NR	NR	NR	NR	NR	63	47.5	110.5
	(kg) recycled in beach clean-ups and community recycling project	NR	NR	NR	NR	NR	2,017.3	458	2.475.3
	Total of (kg) collected	2,299.69	1,683.5	0	193.4	1,807.83	3,383.2	987.7	10,355.32
	No. greenhouses	NR	NR	NR	NR	NR	3	3	6
	No. composting sites	NR	NR	NR	NR	NR	4	17	21
	(kg) organic waste managed	NR	NR	NR	NR	NR	1,380.7	422	1,802.7
	(kg) compost obteined	NR	NR	NR	NR	NR	601.1	415.4	1,016.5
	Hectareas of mangrove restored (ha)	NR	NR	NR	NR	NR	2	3	5

entrepreneurship, particularly in areas such as prototyping, measuring results, and scaling. Each of these phases requires significant investment of time, resources, and strategic planning.

We began the EcoClubs project with the goal of starting to build metrics so sponsors could see the results and support our idea. Many collaborations and alliances were fundamental for this initial part of the execution of the Program. Amongst these are in-kind contributions like volunteering and internships. We received support from universities and their students, and this partnership had a significant impact on both sides. The students gained valuable experience in community project implementation, while we benefitted from having additional hands-on support during EcoClub sessions and for data collection.

Building trust, developing a relationship and being honest with the community is crucial for the success, active involvement, and consistency

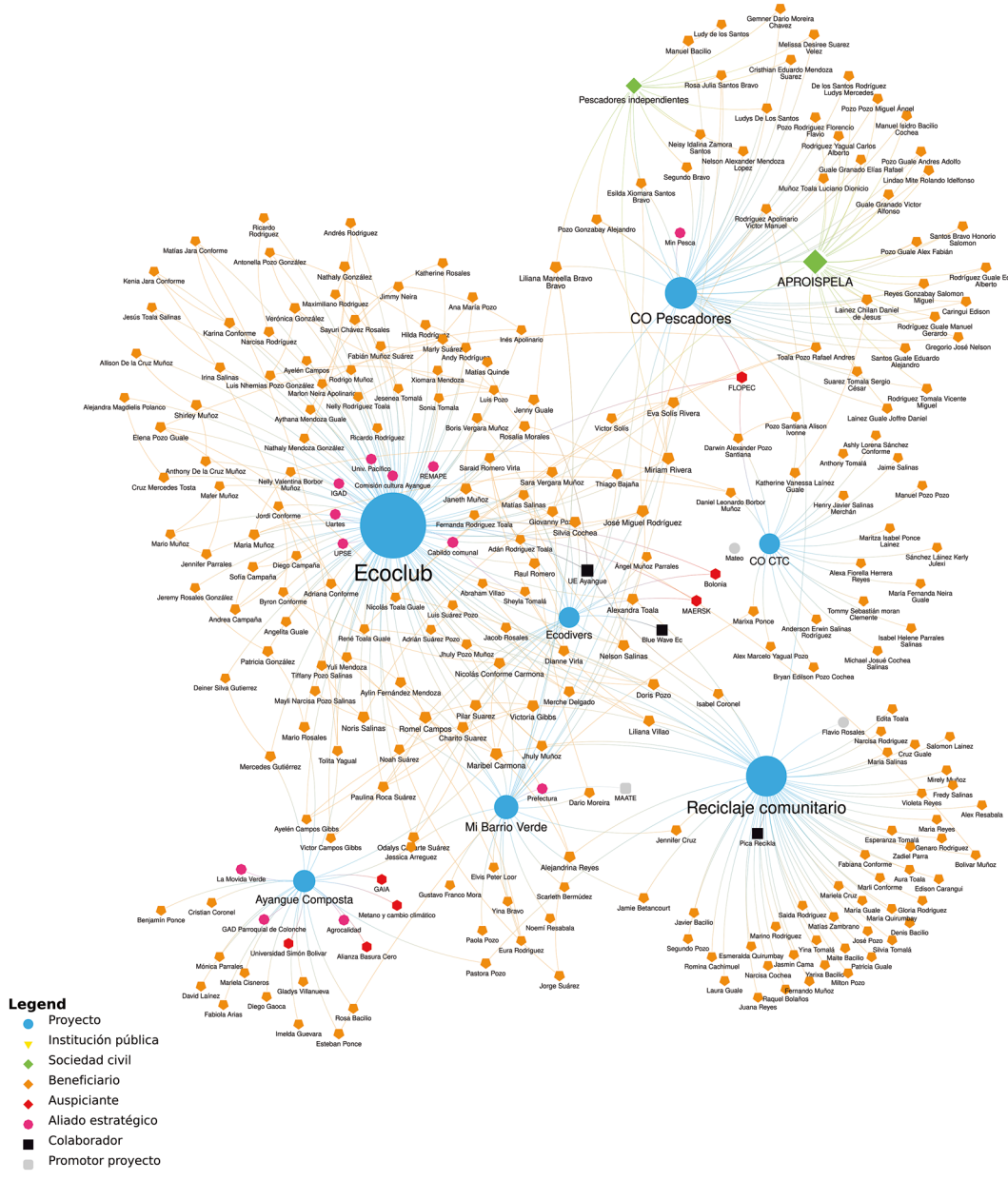


Fig. 11.19 Ocean Literacy Program for Coastal Communities network analysis. Elaboration by: Alberto Viteri (2024)

of any project. While conducting the surveys, we heard a lot of comments from the community suggesting that this may be a short project, that the survey was another way of taking information from them, and that later nothing would happen, along with other comments about lack of trust in some institutions due to past experiences. To avoid this, we settled down in Ayangue with our "Casa Marina" (Ocean House), started getting involved with local events, planning activities in our courtyard, getting to know different people from local sectors and allowing them to get to

know our team. Casa Marina is not just our residence and office, but a place of getting together with the different beneficiaries and a symbol of a blue community base. This building trust process lead that after the first year of work, some parents from the EcoClub also became direct beneficiaries in other projects of the Program, and in these 2 years they have been involved in projects for the artisanal fishery and tourism sector, and Mi Barrio Verde and Ayangue Composta projects for inorganic and organic waste management, as you may see in the analysis of our Ocean Literacy Network.

Diversity, equity and inclusion are subjects which are gaining greater attention within our work. Locally, gender equality (providing more opportunities for girls) and youth empowerment (providing young people with a sense of purpose) are subjects we have explored within our work and continuously strive to include more of. Working with the CTC on citizen science projects, and involving them in the EcoClub project, increased the interest of some of the members to pursue new Ocean jobs as snorkeling teachers; Ocean facilitators and developing new skills for underwater research and scuba diving practices. There are specifically two of them who want to run for President and Vice-president of Ayangue, so we can see how the different projects and experiences under the OL Program influenced them in a positive way, and that Ayangue holds a new generation of Ocean leaders for certain. Besides this young empowerment insight, we also are facing some challenges in our workshops regarding lecture disabilities in 6–7 years old children who need assistant for reading and writing, and less intervention of girls—comparing to boys—when speaking out and participate in some dynamics of the sessions.

Sense of ownership, local pride, inclusion, equality, and leadership can be approached through environmental projects, so it is important to include art, social and other areas and ideas into Ocean Literacy programs. As years go by, we realize the spaces we are creating based on environmental matters also need attention and insights from social science, and that this complement and boost results.

11.4.3 Financing the Program

What comes first? The funding or the program? We figured out we need to change our mindset first. We started with very little financial backing. When we started moving beyond our technical "project" mindset to a business model type mindset it allowed us to start connecting with private sector to ask for support and speak their same language. After 7 years, we can additionally say that paying attention to the constant improvement of our inner organizational processes has been a very healthy practice. It has allowed us to continue exploring and growing our relationship with the private sector, international cooperation agencies, and local institutions, not just by showing technical results.

And what about volunteers? We have had and still have volunteers. And some of our volunteers have now become our key staff. This is the key take-away message. Volunteers can be an important part of an organization for specific tasks or punctual activities. Beyond that there needs to be a plan in place for ensuring proper staff salaries because without key professionals, results can't be reached and the volunteers you have invested in cannot be given an opportunity to stay. Developing divers fundraising strategies was crucial for continuing our Ocean Literacy Program for Coastal Communities.

11.4.4 Replication Experiences

As mentioned before, the EcoClub project has been replicated in other communities in Santa Elena and Guayas province but in different circumstances important to consider. In Ballenita, the EcoClub "ChiquiGuardianes al Rescate de Ballenita" started in 2021 as an online experience for a university graduation project. After that, we worked with that group in 2022 and 2023 and so far, they have remained active this third year with their project "Centro de Acopio" which takes place each month. With ChiquiGuardianes we were able to start implementing our full Ocean Literacy program which includes field trips, local activities, and different projects with the children and their parents.

In Guayaquil we carried on a project together with the local Municipality and worked in four communities in the city for 5 months in 1 year (2022). In this case, we were not able to cover our full program and due to local interest in the mangrove ecosystem, we adapted the content of the workshops. After working with these four groups, we had good results for Ocean knowledge, but the water relationship was still something to work on because of lack of time and funds for field trips. In 2023, when we implemented the EcoRutas in a mangrove area, we reconnected with these four groups to take them to this field trip, but couldn't evaluate because the intervention was something very punctual.

The case of Ayangue where every year an EcoClub opens with our full program—and every year there is a better version of it because of the children and their parents feedback, as also because of our team evaluation and reviews—has showed us that is important to highlight that permanence, stability, consistency and the inclusion of outdoor experiences approaches are key to foster pro-Ocean habits and reach action results from communities.

11.5 Conclusion

Our results show that our Ocean Literacy Program for Coastal Communities has increased Ocean knowledge and encouraged pro-Ocean behaviors. Most of the changes occurred in the EcoClubs project where children and adults increased their participation in environmental practices and activities.

We have been able to successfully replicate the EcoClub model in several communities, adapting the content according to local needs and local ecosystems. This has allowed us to improve the themes, tune ESRA metrics, and create new dynamics for the weekly sessions according to the feedback we get from participants, their representatives, and the on-site observations and experiences of our educators in the workshops. In addition to the pro-Ocean behaviour in children, we have seen similar changes in their representatives and each year the involvement of adults is more active with their presence and collaboration during field trips and various activities carried out by the EcoClub. The EcoClub has created a safe space for recreation and education for the children of the community leading to new conversations and intra-family activities based on the environmental issues that we work on. We have noticed that in the Commune of Ayangue these positive changes are maintained and maximized since we see members of past cohorts who remain active by assisting and collaborating with the projects they created in their cohort. With the experiences and lessons learned with other communities, we look forward to also including results from these projects in future publications. Our experience with these communities has been different than Ayangue because of different backgrounds, time of permanence, funds, and others. The outlook for 2025 is to replicate this EcoClub experience in two communities in Salinas (Santa Elena province) and two communities in Guayas province.

In conclusion, our Ocean Literacy Program has successfully fostered positive change and strengthened the bond between people and the Ocean through the various projects we have implemented, resulting in increased community empowerment across the sectors we engaged.

11.5.1 Summary

Key concepts explored in this chapter include:

- Ocean Literacy fosters marine identity, pro-Ocean habits, and speeds changes needed to tackle Ocean Challenges and reach SDG goals.
- Ocean Literacy should be the baseline for Blue Economy sectors. No sustainability could be practice if those stakeholders do not understand the importance of their relationship with the Ocean.
- It is necessary to create Ocean Literacy metrics to evaluate changes in communities and generate more confidence in sponsors to support financing on OL education and research projects.
- Ocean Literacy should be included in SDG14 goals with Ocean education metrics.

- The concept of "environmental education" as a talk given in a single visit should be abolished. Environmental education takes time, should have an experiential or immersive component and an action component. It can be carried out in many ways depending on the objective, target audience, and circumstances.
- Including experiential and field trip experiences maximizes the internalization of Ocean Literacy concepts in participants and promotes a genuine and personal relationship with the Ocean.
- Environmental Education, Ocean Literacy and Education should work together with Social Sciences to develop and enhance evaluation programs and boost OL Program results.
- It is recommended to carry out continuous processes on site to generate strong and visible changes in the short and medium term. Continued permanence and accompaniment generate confidence and facilitate people's commitment to project activities.
- It is essential to consider the social, environmental, cultural, and economic aspects of each site where work is being conducted. These factors inform how the program should be adapted to the specific needs of the location and its communities. The more effectively the program is tailored to its context, the more successful the Ocean Literacy outcomes will be.
- Including representatives when working with children is necessary to complement and strengthen the changes in habits that are generated during the process.
- Making strategic alliances according to the groups of beneficiaries with whom we work will help to implement the project more easily and engage the participants faster.
- It is urgent for grassroot organizations to start developing entrepreneurship capacity building to work in fundraising.
- We need to understand that not because a project is carried out by a non-profit organization means that everybody is volunteering. Projects need energy, time and full-time effort from professionals that deserve to be paid, so financing and sponsorships also must be open to cover staff costs, not just infrastructure or give in-kind donations.
- Including Ocean Literacy in the SDG Agenda will make this Blue Community visible and help increase funds for Ocean Science and Ocean Literacy.

11.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Amiguitos del Océano: https://amiguitosdeloceano.com/
  - Fundación Amiguitos del Océano. (2023). *Informe de Gestión FADO 2018–2022*. https://drive.google.com/file/d/1DPUltpPLeo06C3VDK_hD9MPf68IGzhZ1/view?usp=drive_link
  - Daniela Hill Piedra, TEDxISMAC, Educación para la Conservación, November 2021: https://www.ted.com/talks/daniela_hill_educacion_para_la_conservacion
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- Ocean Education Kit (Kit de Educación Oceánica: 7 pasos divertidos para conocer el océano desde casa): https://www.youtube.com/watch?v=YBjZB9nyfiE&list=PL5Cl05dzKfT9Lfx2Nx9iF114XYvPg3iXh&index=6
- Red de Educación Latinoamericana para el Océano: https://relatOceano.org/
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- UNESCO-IOC. (2021). *Ocean Literacy Framework for the UN Decade of Ocean Science for Sustainable Development 2021–2030.* www.unesco.org/open-access/terms-use-ccbysa-en
- UNESCO-IOC. (2024). *Ambition, Action, Impact: The Ocean Decade Pathway to 2030. Consolidated Outcomes of the Vision 2030 Process.* http://www.unesco.org/open-access/terms-use-ccbysa-en

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[1]*Daniela Hill Piedra: Conceptualization; Writing—Original Draft, Review, and Editing.

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Perspectives for Ocean Justice: Imagining Fishing Communities as Ocean Literacy

12

Alison Laurie Neilson

Abstract

This chapter explores the assumptions underlying Challenge 10 "Restore Society's Relationship with the Ocean" (formerly Change Humanity's Relationship with the Ocean) of UNESCO's Ocean Decade and those underlying the related policies, education and actions from which this challenge originated, and the impact of these uncontested ideas. It calls for acknowledging and interrogating the relative power advantage that may be latent in our points of view and positions in society. It begins by discussing the recommendations of the Vision 2030 White Paper on Challenge 10 to show how it aims to recognize more existing diversity via the concept of "Etuaptmumk" (two-eyed seeing) and by changing the wording of the challenge from "change humanity's" to "restore society's" relationship with the Ocean. By deconstructing the drivers of the Paper, it shows how power imbalances inherent in the Ocean Decade remain intact thereby maintaining marginalization of other ways of knowing. The chapter reviews the underlying images of Ocean science and UNESCO videos to uncover dubious stereotypes and ideas about history and people and the impact this has on education. In moving from the top-down direction of the Ocean Decade, the chapter takes a bottom-up view and offers a list of sources of literacies directly from those who continue to live Ocean/human epistemologies and ontologies. The chapter includes excerpts from a photo-narrative book based in the Azores Islands, Portugal, showcasing alternative expressions of Ocean–human relationships.

Keywords

Blue justice · Epistemologies · Power · Decolonisation · Deconstruction · Images · Perspectives · Azores · Fishing communities · Photo narratives · Ocean Literacy (OL)

12.1 Introduction

My art teacher suggests that I practice drawing boxes similar to the blue plastic bins used to carry fish from the incoming boats to the Lota (fish auction house) (Fig. 12.1). I am learning about perspective and how to draw what my eyes actually perceive from my point of view, instead of how I think the box/fish bins should be drawn…The box in front of me and the fish bins in the photo have 2 parallel sides with 2 parallel ends and four right angles. I draw this, but to my dismay, my drawing doesn't look like what I see. In fact, I don't seem to be able to "see" what is in front of me, until I use a

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> method of finding the horizon and measuring the relative size of the sides of the box using a carefully held stick in front of my face. I try this method of "seeing" the perspective over and over again…slowly, I begin to perceive what's in front of me differently than before… truer to what my eyes actually "see". With the photo, it is not until I draw lines on top of it, that I can see that the parallel sides of the fish box do not appear parallel at all.

I share this narrative about perspective drawing to refocus consideration from "changing humanity's relationship with the Ocean" to instead, paying attention to the perspectives from which the programs, policies and funding sources arise. Like my struggle with drawing, this is not a simple task because consideration of epistemology is largely missing from Ocean Literacy as well as the natural marine sciences, which tend to be underpinned by the dominant objectivist epistemology. This way of knowing assumes the possibility to discover an objective truth that is empirically verifiable, valid, generalisable and independent of social thought and conditions (see Moon et al. 2021). Reflecting on what we think we know, can make us aware of the ways our scholarship may colonize other peoples and their ways of knowing (Two Convivial Thinkers 2024).

This chapter argues for exploring the assumptions underlying Challenge 10 as well as those underlying the related policies, education and actions from which this challenge originated, and the continuing impact of these mostly uncontested ideas. It calls for acknowledging and interrogating the relative power advantage that may be latent in our points of view and positions in society. It is not clear how normative Ocean Literacy activities supported by UNESCO and the work of various marine education associations serve perspectives beyond that of the dominant natural sciences and the covert technocratic capitalist economy. The strength of neoliberalism in education lies in its invisibility as neutral while it colonizes knowledge to be simple, linear, and pre-determined, rather than embedded in a multitude of social and ecological systems and multiple levels of being, knowing, and doing (Neilson and São Marcos 2019). When advocating for specific issues, care must be taken not to conflate scientific and political debate. By focusing only on the science and not the socio-economic impacts, we can end up as "stealth issue advocates" instead of "honest brokers" who acknowledge conflicting values and political aspects of science (Pielke Jr. 2007). The chapter ends by identifying example sources of Ocean literacies from other stories that live around us; and sug-



Fig. 12.1 Left two photos: The box and my 2-h attempt at drawing it below, beside the photo I want to eventually draw (Image credit: Neilson 2021, p. 71)

gests listening to perspectives of Indigenous peoples and others whose ways of living are based on continual relationships with the Ocean.

12.2 Changing or Restoring Relationships? Revealing the Currents Flowing Through Challenge 10

The United Nations Decade of Ocean Science for Sustainable Development 2021–2030 seeks to encourage behavioural changes through Ocean Literacy. Yet, educational scholars concerned with environmental and social justice have questioned the ethics of this type of prescriptive teaching for decades (Jickling 1992; Clover 2002; Giroux 2004). They are also informed by justice approaches (e.g., "Blue Justice", Santha 2023), informed by the disparity between people who benefit from the wealth of the Ocean and those who disproportionately are harmed by destructive resource use, and the policies which promote this industrialisation. The Ocean Decade Coordination Unit of IOC/UNESCO sought review and improvements to the various documents, policies and actions for the decade, but have left the focus on behaviour change intact. Politics, inequities, laws, and institutions are merely listed as additional factors to consider in reference to "pro-Ocean behaviour." As discussed below, the official review dealt with superficial wordsmithing and failed to use the opportunity to identify specific Indigenous networks or collectives of Ocean peoples who are not represented well by the goals for the Ocean Decade.

The first recommendation of the Vision 2030 White Paper on Challenge 10 is to reword it from "Change Humanity's Relationship with the Ocean" to "Restore Society's Relationship with the Ocean" (Glithero et al. 2024, p. 9). This acknowledges a somewhat more complex understanding of human/Ocean relations and suggests a fuller reading of history. Nevertheless, the White Paper is constrained by assumptions that largely leave existing power imbalances unchanged, thereby maintaining and recreating marginalization of other ways of knowing and living with the Ocean. The Paper uses the two-eyed seeing, "Etuaptmumk", concept (Bartlett et al. 2012) as a way to incorporate broader ways of knowing from First Nations on the territories known as Canada and other Indigenous peoples around the world. But it largely glosses over the history of power differences between the "scientific" view and other epistemologies and ontologies, and continues the marginalization of other ways of knowing. The power differences within the canons of research and accepted knowledge colonizes education and policy. Diverse ways of knowing are based on diverse ways of being and situated knowledges (Santha 2023). Practices of using these knowledges require ways of writing, speaking, teaching and otherwise sharing which are beyond the norms of formal education at all levels and nonformal education, e.g., much Ocean Literacy activity.

Discussing the successes within three case studies from small-scale fisheries in Canada which seek to put two-eyed seeing in practice, Reid et al. (2020) point to the substantial inertia of current practices and prevailing paradigms. "Illusions of certainty" as well as hierarchical and paternalistic approaches based on "command and control" dominate the sector. To reimagine alternatives to top-down management, we need alternatives to knowledge production that do not perpetuate asymmetric power relations (Strand et al. 2022). The White Paper on Challenge 10 identified four key drivers that are available to restore society's relationship with the Ocean: (1) Multiple Knowledge Systems, (2) Communications, (3) Education, and (4) Cultural Connections. No substantive improvements are offered. The aims and indicators of these drivers reinforce the power imbalances of the initial policy statements. They maintain and recreate marginalization of other ways of knowing and living with the Ocean.

Driver 1 has progress indicators that call for more marine social science but only a generic mention of an "increase in diversity of voices." Calls for further research ignores myriads of existing social science research (Neilson and São Marcos 2019), including that done by Indigenous scholars and local communities. "An increase in

diversity of voices", could have been identification of actual community leaders, elders, and other individuals who offer alternative approaches to Ocean Literacy based on continuing relationships with the Ocean and Ocean-based livelihoods. Decades of marine social science suggests direct learning from these otherwise marginalised ways of knowing, and calls for scientists, "Ocean Literacy" professions, and the broader public to learn from these sources.

Driver 2 looks to increase skills for knowledge transfer, but what about skills to listen, to see? This driver calls for working with political campaigners, advocates and influencers, but what about participation? Indigenous scholars practice knowledge as existing as an enactment between people, all living things and existing within relationships, ecosystems and spiritual systems (Cajete 1994; Absolon 2010; Johnson 2024). Supporting increased abilities to promote particular points of view must be coupled with increased abilities to reflect on power and understand the danger of prescriptive teaching becoming propaganda.

Driver 3 "education" promotes funding networks; specifically, those in which the authors of the White Paper participate, with no mention of supporting or creating any Indigenous networks, institutions or communities. This driver takes a normative approach to existing education, while much research shows how education has colonized Indigenous peoples (Battiste 2005; Ingersoll 2016) and does not serve coastal fishing communities well. In 2024 important calls for decolonisation of education, for example, by the Truth and Reconciliation Commission (TRC) in Canada, require reflection on privilege, and transformation of power dynamics within existing education (Strand et al. 2022).

The key recommendations for Driver 4 "cultural connections" prioritize scientific validation and technical, knowledge transfer approaches regarding cultural engagements and other ways of knowing. It fails to engage with other unique epistemologies and ontologies (Strand et al. 2023). The seminal work by Philip E. Steinberg (2001) details the changing view of the Ocean as a social space. His work begins in early periods of non-modern Ocean governance and follows through from 1450 to the present using a territorial political economy perspective to analyse the social construction of Ocean-space. UNESCO, however, follows the normative natural science view of marine areas, and conceptualizes the Ocean as a resource space to be used by society. Furthermore, the rhetoric of UNESCO is filled with broad generalisations; using "humanity" and "society" to flatten the incredible diversity of people and their histories across the world. This leaves the goal of wanting to "change" (or "restore") relationships with the Ocean to be empty of meaning, and far from dealing with actual political problems and global injustices (Gani and Marshall 2022). This is why Ocean Literacy must come to terms with questions of epistemology rather than transfer knowledge about any Ocean science with an aim to change behaviour of the general public or fishing communities.

The next section calls for working together across seemingly insurmountable differences in ways of knowing, in order to remember, imagine and create as of yet, unimagined collaborations that will support the continual wellbeing of Ocean ecosystems and coastal fishing communities (Neilson and São Marcos 2019). It furthers the call for a framework of empathy for educators, scientists and fishers to appreciate their commonalities, but to do so requires being aware of what we think we know and having humility to learn diverse Ocean literacies.

12.3 Listening for Ocean Literacies: Looking from the Bottom Up

Ocean Literacy based on natural sciences cannot answer post-colonial scholars and activists in regard to the understanding that the current ecological crisis is a result of a One-World-doctrine (Law 2015), and a product of western evolutionary thinking, that sustains itself in a disruptive nature-culture theoretical divide (Escobar 2016). Strand et al. (2023) suggest that "more contextual participatory methodologies are required to

expand our understanding of the intricacies, pluriversality and complexity of marine cultural heritage" (p. 4), and improve our approaches to complex marine social-ecological systems. Two-eyed seeing is much more than broader collections of "knowledge," and instead leads to the realization of what we are compelled to do with these unified knowledges (Reid et al. 2020). We learn that there are other existing practices of teaching about the sea, which compel a more inclusive building of Ocean justice literacies. There is a lack of reciprocity within Ocean scientists and holders of local knowledge. Fishers and social scientists need to be fluent in marine natural and physical sciences, while these scientists largely remain ignorant of the ways that fishers know the Ocean, and do not know marine social science, particularly how science and society relations have been discussed in the last 20–30 years (Neilson and São Marcos 2019).

To "hear" these other sources of knowledge, educators who have yet to take transformative and social justice approaches, may be the ones who need to change their behaviour. Besley and Dudo (2022) suggest that scientists do not prioritize changing their own behaviour without substantial guidance from communication experts as deficit model approaches persist in much science communication, and few trainers emphasize listening, self-reflection and behaviour change for the scientists themselves as a priority for science communication training. Further, many do not believe that listening to others' perspectives to help make community-informed scientific decisions is as important as trying to shape other peoples' decisions (Besley and Downs 2024). However, it is not a simple question of methodology or an easy choice particularly for those precariously employed in academia since the weight and history of the paradigms and practices of knowledge production, "sustainability", "sustainable development" and "Ocean Literacy" wield considerable power (Neilson and Seixas 2022).

Words are not the only form of communication that colonize. Around the world, stereotypes and fallacious images underlie public and scientific opinion about people and their relationships with the sea (Neilson and Seixas 2022), which makes the images used in the UN communications about the Ocean so seriously flawed. Figure 12.2 shows two screenshots obtained from UNESCO's video used to discuss Challenge 10 (UNESCO 2021). The video, rather than showing actual people, uses stereotypical cartoon images with women and children as exotic, with other race and gender biases, for example, science is represented by white men. The video presents technology as fixes for political and economic problems and the image of leisure craft, i.e., sailboats is offered as a positive way to interact with the Ocean, while images of fishing boats are shown as negative ways to engage with the Ocean.

Furthermore, ideology, including points of view, concepts of what is the world and what is knowledge, are easily cued visually (Dan and Arendt 2021) and power in society relies on these images to project strength, maintain influence and gain traction in broad scientific communities (Bucy and Joo 2021). Given that decades of globalised sustainability policy and fisheries gover-

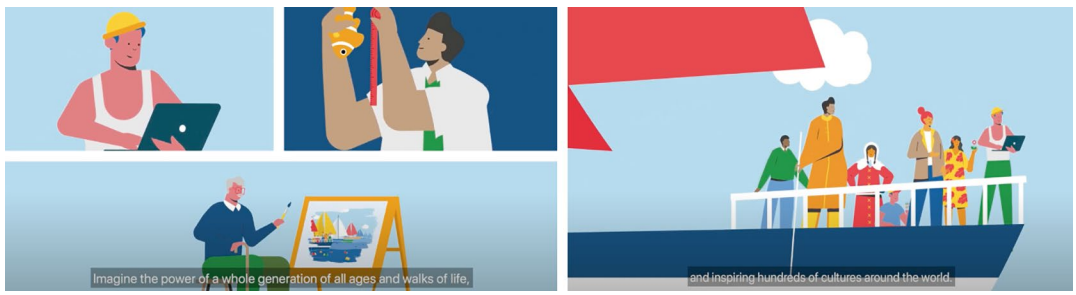


Fig. 12.2 Screen captures from the Ocean Decade Challenge 10 video. UNESCO (2021)

nance are framed primarily on the images and models built from the ontology and epistemology of natural sciences (Neilson and São Marcos 2019; Neilson and Seixas 2022), Ocean Literacy practitioners need increased competence to read and use images critically. After discussion of diversity and sources of Ocean literacies from around the world, this chapter will highlight a literacy project which uses photo narratives to invite readers to reflect on how they know the Ocean.

Embracing a fuller knowing of our place and our diverse relationships with the Ocean in collaboration with other people who have different experiences, opportunities and privileges, can lead to decolonizing Ocean Literacy instead of naïve attempts to save the world (Battiste 2005). By seeking to include a plurality of Ocean Literacies, we can celebrate sacred and spiritual ways of being with an Ocean as Ancestor, and concurrently mourn traumatic events such as the legacy of the Middle Passage, the forced voyage of enslaved Africans across the Atlantic Ocean to the New World. As well as seek justice for contemporary refugees crossing the Mediterranean and the small-scale fishers from Greece whose livelihoods and emotional health continue to be damaged from finding bodies in the sea. Just Ocean Literacies can embrace the experiences of building an Ocean relationship through surfing as sport and leisure, while confronting the colonization of Indigenous Hawaiian Oceanic literacies by the surf tourism industry as well as the 1820 arrival of missionaries (Ingersoll 2016).

Specific histories and contemporary situations influence the ways people can engage with the Ocean, fulfil their worldviews and create specific Ocean literacies. Rivers et al. (2023) point out that "Indigenous and Local Knowledge (ILK) holders remain largely excluded in Ocean governance in South Africa, on the African continent and even on global scales" (p. 2), citing top-down fortress conservation approaches as a legacy from colonial and Apartheid rule. This research was co-created through an arts-based participatory research project within the One Ocean Hub, an international programme of research and it helps inform the educational materials on One Ocean Learn (see the resources section for links to the One Ocean Hub and all online platforms discussed in this section).

The *One Ocean Learn* online platform translates Ocean knowledge into action-oriented learning for activists, communities, development practitioners, policymakers and researchers on the ways in which global, national and local communities depend on and relate to the Ocean, coastal areas and marine. It builds upon research in Ghana, Namibia and South Africa, as well as at the international and regional levels (South Pacific and the Caribbean), on the integration of human rights, marine and social sciences, and the arts, to support fair and inclusive decision-making for a healthy Ocean whereby people and planet flourish. There are numerous island states and Oceanic peoples in the Pacific Ocean, for instance, Karin Amimoto Ingersoll shares an "Oceanic Literacy" from her Indigenous identity, as she hits "the first whitewall of water, [she] become[s] a Kanaka Maoli (Native Hawaiian) surfer" (Ingersoll 2016, p. 1). She shares a seascape epistemology in her book, "Waves of knowing".

Art/Science engagements routinely involve pluralities of peoples and epistemologies Ocean literacies (e.g., Brennan 2018; Jung et al. 2022; Whittaker 2023). Other online platforms include TBA21 Ocean Academy, Oceans Network Canada's Art/Science working group, and the project "Watering Words", an experiment in the form of a long-term poetic conversation flowing between three artists and various water bodies from their surroundings.

Artisanal and small-scale fishermen and fisherwoman are the last peoples who gather wild fish; they rely on their knowledge of winds, and waves and small wooden boats to obtain food. Their hands, their bodies, their memories hold Ocean literacies not taught in schools and marine centres, yet this is a literacy that connects humans to the more-than-human world. Who tells the stories and how they do the telling influences meaning. The TBTI Global Foundation (see the resources section) represents small scale fishers

and fisheries in over 50 countries around the world. TBTI or "too big to ignore" is a research centre and knowledge mobilization hub that provides open access to social science research as well as perspectives directly from individual fishers, elders and community leaders through their own voices and images.

The next section highlights a book that shares images and perspectives from fishers from an island archipelago in the Atlantic Ocean.

12.4 Ocean Literacy of the Azores Islands

For the past two decades, Azorean community and fishing associations have collaborated with researchers to understand the social dynamics and transform political realities of small-scale and artisanal fisheries in the Azores. Images of fishers are absent from tourism, and cultural institutions do not promote fishing communities, A growing recognition of all the ways that fisher knowledge of the sea are hidden and not widely valued, lead to the collaboratively-created bilingual, photo-narrative book, "A sea full of life: Visions from the Azores" (Neilson 2021). Rather than construct an artificial homogeneity for Azorean communities and perspectives, the book contains juxtaposed divergent scenes and ideas aiming to be truer to the ambiguities, conflicts and challenges that arise from trying to live by the rule of the Ocean while needing simultaneously to engage in the economic and political systems which threaten living in relation to the Ocean.

The structure of the book and the themes highlighted, were drawn from research data and co-created with multiple collaborators. To disrupt colonialism and prominence of the coordinator's perspectives required continual consideration of the ways power flowed through every word chosen and design decision made. At all steps of its creation, the coordinator sought to keep in mind Tuck and Yang's questions of "What knowledge is desirable? Who profits? Who loses/pays/gives something away? Who is coerced, empowered, appointed to give away knowledge?" (Tuck and Yang 2014, p. 812). Through the use of questions, readers are encouraged to uncover and reflect on their own assumptions about the Ocean and human nature relationships: *When you think of Azorean fishing communities, whom do you envision? Which window do you look from (when looking toward the sea)? What vision of the future determines progress?* These questions invite the reader to view the assumptions used in the book with critical reflection as well.

There are over 300 photos in the book. Fishing communities freely gave photos to be used resulting in several hundreds of individual people being included, with as much identification as possible sourced from the individuals, or their families and communities who wanted to honour them by inclusion in the book. Fishers and fishing heritage are treated with the utmost respect through the proper identification of names of people in the photographs, names of the photographers, and the precise location and year the photograph was taken. Also treated with value are the names of the boats, the fish shown and the specific fishing gear used. Names have power. Aside from naming and describing important details for readers not from the communities shown, most of the text in the book is from oral statements made by people who live in the fishing communities. The aim was to privilege their voices as they were used, instead of interpreting meanings of the words spoken by the people in the interviews and other research interactions.

The book also includes excerpts from other publications about research instigated by UMAR-Açores (association for women and gender equity) and carried out by women fishers from the islands. *"A sea full of life"* offers parts of these Portuguese language works in English and provides details for finding these books which are largely unknown outside of the Azores. Additional notes and extensive sources, including books, scientific literature, films and videos are listed at the back of the book as well as a detailed list of all individuals and organizations who contributed to the crowdfunding, collection of photos and creation of the book.

12.5 A Taste of "A Sea Full of Life: Visions from the Azores"

It is in the entirety of the book, that an Ocean Literacy of the Azores Islands may be encountered; readers are encouraged to download the full book (see the resources section). The examples shared here highlight a diversity of themes from the book.

12.5.1 Questions of Gender

Women are part of fishing communities and whether they go to sea or not, they are knowledgeable, experienced and motivated to protect the Ocean/human relationships and ways of living with the Ocean. Each island has different specific fishing and social cultures in which women engage in fishing at sea, preparing gear on land, as well as multiple activities from selling of fish, canning tuna, preparing food, craft with fish scales and shells, as well as teaching these skills in formal and informal settings. They are also involved in research and advocacy and hold leadership positions in multiple regional and international fishing associations. Figure 12.3 uses juxtaposed photos to visually translate the question which appeared on the prior page: When you think of Azorean fishing communities, whom do you envision?

12.5.2 By Our Own Hands

Figure 12.4 focuses on the hands which gather wild food/fish instead of growing or manufactur-



Fig. 12.3 Neilson (2021, pp. 4–5) designed by Rebecca Barclay



Fig. 12.4 Neilson (2021, pp. 196–197) designed by R. Barclay

ing food, and which live according to the dynamic cycles of Ocean ecosystems. Family crews in open stern boats, "boca aberta," go out, return within 24 h, and only go to sea in good weather. The weather, tides and wind restrict the fishing; boats do not carry much gear and especially in winter, the waves are big, suggesting that nature itself regulates the fishing effort. Azorean fishers use small-scale and traditional methods such as pole-and-line and handline fishing, often catching fish one-by-one. These practices reflect a deep respect for the Ocean and a commitment to living in harmony with the Earth's natural systems. Azorean fishers are among the last group of people who catch wild food. Like their counterparts around the world, they do this while concurrently negotiating the political and economic systems that are mostly out of sync and harmful to eco and social systems. Their experiences offer valuable insights into how to live sustainably with Ocean ecosystems and fishing cultures, while also working to protect both from harm.

12.5.3 Innovative Traditions

Azoreans continue to adapt to changing conditions, sometimes maintaining traditional ways of gathering algae, for instance, while other times creating opportunities to introduce old and new foods to new markets. The images and narratives of gathering wild food offer a hopeful counterpoint to the common narratives of environmental destruction and crisis. Solutions for living in tune with the Ocean do still exist. Continuing as well as newly revived traditional practices of fishing and other Ocean activities bring innovative ideas to counter industrial processes which have caused harm to the Ocean and coastal communities. Azoreans use one hook on one pole to catch tuna one at a time, avoiding catching the dolphins who are also hunting the tuna. In Graciosa and Terceira Islands, in particular, communities are salt drying different types of fish which are not well known or exploited in order to reduce pressure on more popular fish and offer alternatives to the traditional "bacalhau" (salted cod) which appears on most Portuguese Christmas dinner tables.

12.5.4 Lives That Feed Us

Figure 12.5 highlights the joy of eating. Coastal families tell us that they eat fish every day; they understand it to be a pure and healthy food because the powerful Ocean is safe from the contaminants found on land. Fish has fed the souls of humans for centuries. Fish are symbols of emotional well-being and social healing in religious and medical practices around the world. The fishing communities in the Azores are among the last peoples in the world who maintain a lived connection with wild food, which includes being able to read and respond to the Ocean regardless



Fig. 12.5 Neilson (2021, pp. 264–265) designed by R. Barclay



Fig. 12.6 Neilson (2021, pp. 284–285) designed by R. Barclay

of any opposing forces from the existing political and economic systems.

> I often look at a fish, a fish that I caught.
> I look at it and think that it had to die for me to live.
> Life in the depths is also about this truth.
> For me, and everyone else who eats
> fish, to survive, fish have to die.
> We're all part of the chain.
> The bigger eat the smaller.
> —Genuíno Madruga, Horta, Faial 2009 (Neilson 2021, p. 156)

12.5.5 Boats Are People Too

Figure 12.6 highlights the importance of fishing boats. The way the Azoreans understand the Ocean is intimately connected to the small wooden boats that they take to the open sea, to the rocks they use to weigh the end of their fishing lines, and those things that allow them to be free men and women. Some boats need to be dragged to shore or lifted onto piers to protect them from the strong waves. These boats are often named after wives and children, and are cleaned and cared for by multiple family members. A huge contradiction exists in the way that some boats are treated. In the Azores, former whaling boats have been restored and celebrated by way of European funding for heritage. There are teams of whale boat racers who are the highlight of regattas across the islands in the summer, as well as in immigrant communities in the US. Tourists can admire these wooden boats in multiple museums and learn about them in brochures and books. The tangible heritage of small wooden fishing boats, however, have been the target of fleet reductions driven by the European Common Fisheries Policy (Kapantagakis 2012). It has been difficult to find exact numbers of wooden boats destroyed in the Azores via implementation of EU capacity reduction directives to absorb the available European funds.

12.6 Conclusions

Ocean Literacy to serve the wellbeing of the Ocean and her peoples, needs practitioners to decolonise knowledge processes and actively work toward justice for people who continue to live in close relationship with the Ocean (Blue Justice). Seeking individual behaviour change ignores decades of social science which reveals socioeconomic processes of blue injustice. It can be difficult to pay attention to the perspectives from which our understandings of Ocean Science and Ocean Literacy arise if we do not consider the inherent epistemologies of the science and policies at play. Even with the revisions to Challenge 10 which proport to recognize diversity of existing Ocean/human relationships, the Ocean Decade continues to recreate marginalisation of other ways of knowing. It is based on covert technocratic approaches disproportionately sourced from natural and physical science. These sciences are based on apolitical processes of knowledge creation complicit in the continual growth capitalist economy that drives policies of Ocean Science. Meanwhile, knowledge, ways of knowing and a multitude of ideas, metaphors and

images are still alive within communities who have daily lived relationships with the Ocean. There are peoples around the world who can offer unique Ocean literacies within a multiverse of Ocean relationships. The fishing communities on the Azores Islands are but one of many.

12.6.1 Summary

Key concepts explored in this chapter include:

- Ocean Decade policies encourage continuing growth and industrialisation of the Ocean.
- Myths and stereotypes that drive normative Ocean science dominate communications in Challenge 10.
- Some recommendations from the White Paper on Challenge 10 continue the marginalization of other ways of knowing that colonizes education and policy.
- This chapter encourages Ocean Literacy practitioners to listen and learn directly from Indigenous peoples, people whose livelihoods are based on close relationships with the Ocean, and others they might not have been previously valued as knowledge holders.
- A photo narrative book, "A sea full of life: Visions from the Azores" offers examples of image-based communications of voices and perspectives from fishing communities.
- Learning and local cultural knowledge are not just pedagogical tools, but essential components for sustainable futures.

12.6.2 Recommended Resources

The following resources provide further insights and support on this topic:

- One Ocean Hub: https://oneoceanhub.org/
- Highlighted online platforms:
  - One Ocean Learn: www.oneOceanlearn.org
  - TBA21 Ocean Academy: https://tba21.org/academy
  - Canada's Ocean Network Art/Science working group: https://community.Oceannetworks.ca/feed
  - The "Watering Words" Project: https://wateringwords.com
- The TBTI Global Foundation: https://tbti-global.net
- A sea full of life: Visions from the Azores: https://nineislands.wordpress.com/

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Three Hearts, Nine Brains, and Infinite Camouflage: How the Wizardly Octopus Casts Us Back to Our Oceanic Home

13

Barbara J. Krystal

Abstract

This chapter invites readers into a profound exploration of our human relationship with the octopus, an animal whose intelligence, fluid form, and adaptive behavior challenge the boundaries of how we perceive life in the Ocean. As beings so unlike us in structure, yet deeply embedded in the shared evolutionary story of our planet, octopuses offer a powerful lens through which to rediscover our connection to the Ocean as both origin and home. Drawing from science, symbolism, and cultural narratives, the octopus emerges as a charismatic marine ambassador capable of awakening curiosity, empathy, and a renewed *sense of place* within the Ocean system.

Viewed through this lens, encounters with the unfamiliar—such as with the wizardly octopus—can catalyze emotional and cognitive shifts that foster deeper awareness and care for the marine world, contributing to a broader understanding of Ocean Literacy. By anchoring the narrative in both imaginative reflection and actionable insight, the author encourages educators, communicators, and community members to harness the octopus's compelling story to inspire Ocean engagement and shared responsibility. In this way, personal meaning-making becomes a pathway to collective action, casting the octopus not only as a marvel of marine biology but also as a guide in re-establishing humanity's place within the Ocean's living narrative.

Keywords

Octopus · Ocean · Ocean Literacy (OL) · Oceanscape · Evolution · Sentience · Intelligence · Camouflage · History · Myth · Pop culture · Hypersea Theory

13.1 Introduction

Earth is a water planet. Water is real magic, making all kinds of life appear. Water also transforms. Indeed, many a soft-bodied creature from the Mollusca phylum (a group of invertebrates inhabiting marine water, freshwater, and land, characterized by unsegmented bodies, bilateral symmetry, and the ability to secrete a calcium carbonate shell), of which the octopus is a member, extracts calcium ions and carbonate ions from the Ocean to build protective shells. Water also acts as a bonding agent, bringing together dispersed male and female reproductive cells to produce life via sexual reproduction. Life thrives in the Ocean, and the forty-nine known elements comprising the briny liquid, hydrogen being the most abundant at 11%, support a marvelous col-

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lage of colorful, geometrically awe-inspiring creatures whose biological purpose contributes to safeguarding the Ocean. Among those creatures are octopuses.

Octopuses belong to the class *Cephalopoda*, meaning "head-footed," together with their closest relatives—squid, nautilus and cuttlefish—and live in virtually every water type and habitat of the Ocean. The biology of octopuses is spectacular. Octopuses possess three hearts, and copper-based blue-blood courses through their boneless bodies. They are endowed with shape-shifting powers, instantaneously becoming something other than itself (magically mirroring the animate or inanimate alike), squeezing into or out of any space, propelling themselves via jet propulsion, spewing clouds of black ink to thwart predators, and regenerating lost arms. In addition, octopuses are masters of disguise, changing the color and texture of their skin and contorting their bodies to mimic the behavior of other organisms as well as their surroundings. With nine autonomous brains and distinct personalities, octopuses are marveled at for their keen minds, which are capable of learning from mere observation and able to recognize individual people. Artfully characterized as "liquid within liquid," octopuses are potent examples of the creative power of the Ocean. Octopuses personify the biotic and abiotic make-up of the Ocean; to consider the octopus, is to consider the Ocean.

Examining humanity's deep saltwater relations with octopuses, creatures that are completely "other" in terms of relatability due to their spineless, faceless, tentacled bodies and refusal to stay put, constantly transforming into every other organism or *oceanscape,* returns our attention to a shared oceanic existence. With uncanny wateriness, octopuses, so unlike humans, draw us into the magic of the Ocean as a creative force, awakening a sense of wonder that can lead to deeper awareness and engagement. By observing the octopus, we are reminded of our connection to the Ocean and inspired to explore its influence on us, and our responsibility toward it. I argue that by looking at octopuses, we find ourselves returning to the aquamarine basis of all life, and thus, returning home. In this return, we are invited into a deeper sense of place, not just a geographic location, but a lived, relational awareness of the Ocean as a vital and formative presence.

This chapter explores how engaging with the octopus, through both scientific understanding and cultural interpretation, can deepen our sense of the Ocean's influence on life and invite reflection on our shared Ocean dependence and interconnected fates. In doing so, it contributes to the goals of Ocean Literacy by encouraging awareness, curiosity, and responsibility through multiple ways of knowing. In exploring the biology and iconography of spellbinding octopuses, I also examine the active Ocean *umwelt* where all living organisms, including ourselves, are inseparable from it, even if we are rooted with a terrestrial footing. *Umwelt* is a term coined by nineteenth-century German biologist Jakob von Uexküll to center an organism's subjective experience of its environment. The troubling and revelatory provocation marked by the concept of *umwelt* is the notion that the world also comes into existence via the body and behavior of the organisms who call this watery world home—a concept that enriches our sense of place within this system. There is a reciprocal symbiotic relationship binding the biotic and abiotic forces, and a disturbance in either carries a ripple effect.

13.2 Embodying an Ocean *Umwelt*

The Ocean and octopuses are so deeply entangled that tremendous maelstroms responsible for sinking ships were mythologized as giant octopuses. One classic illustration titled "Colossal Octopus" (1801) painted by French naturalist Pierre Denys de Montfort features a giant octopus encircling the ship's rigging and drawing it beneath the raging waters. Montfort was influenced by the shanties of seafarers and perhaps the famed sixteenth-century detailed map of real and imaginative Ocean life in Scandinavia created by Swedish geographer Olaus Magnus (1490–1557).

Drawing from a variety of sources, many of the Ocean creatures depicted by Magnus are piecemeal, chimeric assemblages of other aquatic and terrestrial animals. As such, animals became a way to chart the Ocean, raising attention to the congregation of diverse life, environmental forces such as temperature and current, and migration routes and patterns (Fig. 13.1).

The translation of land animals into aquatic ones laid the foundation for *Hypersea Theory*. According to paleontologists Mark McMenamin and Dianna McMenamin, the progenitors of Hypersea Theory, terrestrial organisms are indebted to the Ocean for their successful migration from water to land. They argue that terrestrial organisms are relics of the sea and evolved precise physiologies to effectively move fluids (nutrients) between one another in ways that imitate flowing Ocean currents. Hypersea Theory proposes a new channel for predicting the future of evolution, based on the belief in organismal interconnectedness and the idea that land organisms "took the sea beyond the sea, and folded it back inside itself to form the Hypersea" (McMenamin and McMenamin 1994). Kinship, with the Ocean as our shared ancestor and the progenitor of life, can serve as a meaningful entry point into fostering curiosity, connection, and a deeper understanding of our interdependence with the Ocean system.

Kinship is a troublesome concept because our perception of time and the conglomeration of life forms do not always favor that kind of thinking. At the same time, nature writer Sy Montgomery, in *Soul of the Octopus: A Surprising Exploration into the Wonder of Consciousness,* describes meeting Athena the octopus at an aquarium in Boston and finally feeling at home on a "sweet blue planet." Embracing Athena, Montgomery reflects on the affection she feels for all the octopuses she met—creatures who recognized her and, she felt, "liked" her. While there certainly are ways to claim kinship with octopuses, notably through the impressive evolution of intelligence, the point of departure between humans and octopuses, traced back to a flatworm trawling

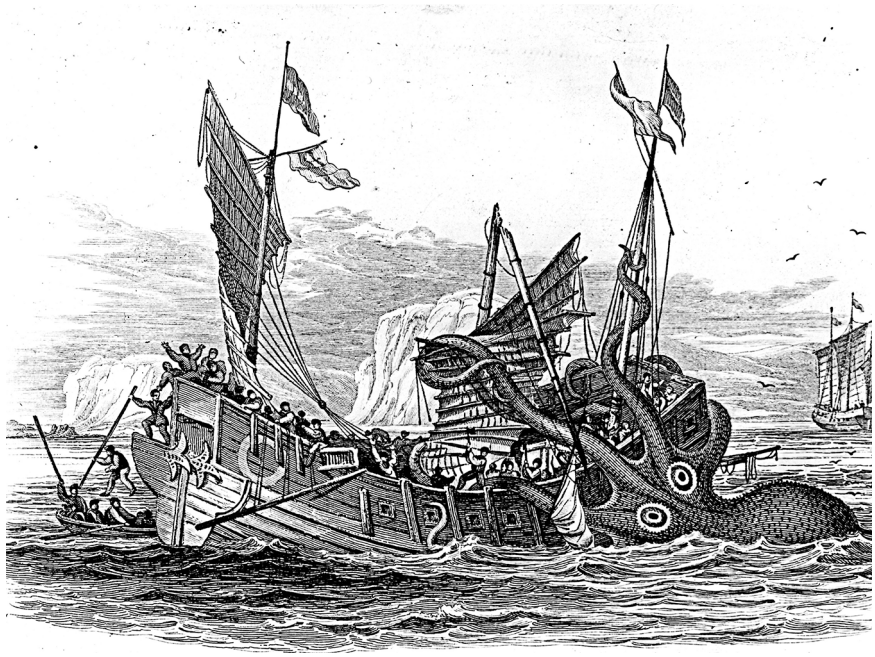


Fig. 13.1 *Colossal Octopus*. Pierre Dénys de Montfort. *Note.* Labeled as an 1810 pen-and-wash drawing and marked public domain in the U.S. Adapted from Montfort, P. D. de. (1810). *Le Poulpe Colossal* [Public domain image], in *Histoire naturelle, générale et particulière des mollusques* (Vol. 2)

the Ocean floor 750 million years ago. My approach is to examine how the scientific study of octopuses and their representation in culture have inspired humanity to be social with the Ocean as a real entity that birthed such an awe-inspiring creature.

13.3 The Thinking Octopus

13.3.1 Ocean Smarts

What made octopuses smart? This rhetorical question invites reflection on the role of the Ocean in fostering an intelligent, short-lived creature gifted with acute capabilities to adapt to changing environmental conditions and convey that knowledge to offspring they do not parent. Naturally, both *smart* and its synonyms—intelligent, witty, cunning, clever and conscious—are relative. Nonetheless, the Cambridge Declaration on Consciousness, a 2012 forum of international neuroscientists, convened to evaluate and measure neural conscious experience in humans and non-humans, declared that octopuses possess consciousness:

> Furthermore, neural circuits supporting behavioral/electrophysiological states of attentiveness, sleep and decision-making appear to have arisen in evolution as early as the invertebrate radiation, being evident in insects and the cephalopod mollusks (e.g., octopus).

There is no single scale to measure *smarts*, yet it is generally accepted that *smarts* equate to the ability to make decisions that are beneficial to survival and to solve complex problems.

Octopuses exhibit both. Octopuses (and other cephalopods) have been around for approximately 520 million years, and over that vast span of time, through encounters with other life forms and changing Ocean conditions, they built a repertoire of flexible, adaptive behaviors (Fig. 13.2).

Competition from bony fish and mammals drove octopuses to deeper waters, and once there, the increased water pressure contributed to the loss of their cumbersome shells. While in deep water, their body plan became more streamlined, increasing their mobility. In addition, their vulnerability as soft-bodied creatures led to the development of camouflage and acute vision. These combined adaptations chartered an opening for octopuses to exploit all Ocean habitats, and consequently, created a need to learn how to navigate specific ecological niches (Packard 1972). The immense, spectacularly diverse Ocean *umwelt* shaped octopuses, investing them with versatility of behavior, or behavioral plasticity, to solve the challenges of living in a fluid world.



Fig. 13.2 Octopus in the Ocean. Revital Salomon, Courtesy of Wikimedia Commons CC By SA 4.0 [Public domain image]

The Ocean created an octopus with brains spread throughout the body. Nourished by the physics (heat, light, density, temperature) and chemistry (chemical compounds) of the Ocean, along with interactions with a wide array of predators and prey, octopuses evolved a unique biology to live in a world without boundaries. The body, brain, and behavior of octopuses illustrate what neurobiologist and octopus researcher Binyamin Hochner classifies as "embodied intelligence" (Hochner 2013). Hochner believes that the shape of the body along with the organization of the nervous system and interaction with the environment, spawns sophisticated behaviors, including learning and retention, as tested and observed in octopuses. Numerous experiments and field observations reveal that octopuses are quick learners. Remarkable students, octopuses soak up lessons taught to them, or picked up by watching fellow octopuses, and adeptly translate those lessons to novel situations.

An early experiment in learning was conducted by Jakob von Uexküll in 1905. He starved aquarium octopuses for 15 days and then released hermit crabs carrying sea anemones on their backs into the tank. The famished octopuses scurried to eat the crabs but were immediately stung by the tentacles of the sea anemones. The octopuses learned to avoid the crabs carrying sea anemones. Other experiments, such as pulling levers to obtain food rewards or guiding an arm outside the aquarium tank to achieve a goal, illustrate that the minds of octopuses are designed to explore. Simply summarized, octopuses are who they are because of the Ocean, and they reciprocally respond to the information they receive, process, and store from it. We are still in the process of learning about octopuses, one of a multitude of creatures living in the Ocean, and if the Ocean is not protected, we may lose more than we can imagine.

13.3.2 Nine Brains and Attitudes in One Body

Octopuses possess nine independent centers of neural control (brains), and their brains are comparably large compared to their body size. Their nervous system houses approximately 500 million neurons (the same number as a dog), distributed among one central brain, two optic lobes and eight sucker-lined arms designed to taste, smell, and feel their environment. Octopuses can also command the suckers on their arms to fold toward the center to create a pincer grasp precise enough to untie knots or unscrew jar lids. Around three-fifths of their neurons are contained in the arms, whose muscular hydrostatic movement allows for infinite degrees of freedom to plan and execute actions. Each autonomous arm is a brain unto itself, able to take action without the need to communicate with the central brain. The extraordinary multi-brained octopus certainly inspired twentieth-century American poet Ogden Nash to imagine himself in conversation with an octopus, fascinated by the riddle of its identity and closing with an emphatic statement of its prestigious status: "I marvel at thee; Octopus; If I were thou, I'd call me, Us" (Nash 1943).

Though playful in tone, there is an air of sincerity in addressing the octopus as being more than one. Plurality of existence is a sentiment championed by philosopher Sidney Carls-Diamante, who suggests that octopuses have a kind of multi-consciousness, that is, multiple simultaneous subjective experiences. Nine *umwelts*, to be exact. Since each arm and central brain operate almost unaware of the other, and without interference, it is conceivable that octopuses contain multitudes. Philosopher and author of *Other Minds: The Octopus, the Sea, and The Deep Origins of Consciousness* (2017), Peter Godfrey-Smith, also questions the singularity of the octopus mind, considering that the nervous system is laid out to allow one arm to completely obscure its position and movement from another arm, rendering the octopus incapable of mapping its body in its mind.

Metaphorically, we can imagine one unified Ocean layered with varied chemistries, densities, and life forms. Metaphors may be what is needed to position the Ocean as a living entity. Numerous scholars argue for the agency of water, and that water's alterity is deserving of merit. The various ways in which water shapes the world and culture are collaborative, and a group of humanist schol-

ars present the ways in which water can teach us about ways of knowing and knowledge itself in a book of water-buoyed essays titled *Thinking with Water: An Aqueous Imaginary and an Epistemology of Unknowability* (2012). Using water as a stage for creating knowledge resonates with marine biologist Wallace J. Nichols, who writes of the power of water to increase the concentration of grey matter in the human brain—the region associated with learning, memory, emotion, and perception—a phenomenon he calls "Blue Mind" (Nichols 2014). The science behind Blue Mind also posits that water activates the parasympathetic nervous system, responsible for slowing down heart rate, relaxing muscles, and decreasing blood pressure.

Octopuses are genetically "programmed" to think; however, not "preprogrammed" to respond in fixed ways. That is a trademark of intelligence and learning. A pioneering study on the ability of octopuses to discern shapes was conducted by biologist William R. Muntz in 1970, in which he trained ten octopuses to distinguish between two shapes and then introduced them to new shapes that were rotations of the original training choice, or contained some element of the original, to determine if learning was transferred. Muntz concluded that octopuses actively learned, and also learned what to learn (Muntz 1970). Octopuses learn to distinguish between shape, size, and orientation of an object and, according to octopus researcher Martin J. Wells, can differentiate between objects irrespective of their visual distance. Wells introduced two separate shapes to octopuses, both having the same surface area,  and  to test his hypothesis that octopuses can count the number of corners to tell objects apart (Wells 1962). They can.

Excitement surrounding connectedness of learning and memory directs attention to evolutionary convergence between octopuses and vertebrate brains. What this means is that human beings and octopuses are not far removed from one another in the evolutionary selection for brain development, and the Ocean environment demands an acute ability to differentiate between threats and non-threats and to remember the past in order to thrive and survive in a realm in constant flux (Fig. 13.3).

13.3.3 Inner Mechanisms

Research indicates protocadherins are the reason why octopuses exhibit complex behavior. Protocadherins adhere cells to one another and instruct nerves on how to distinguish themselves during development. Scientists note that the pur-

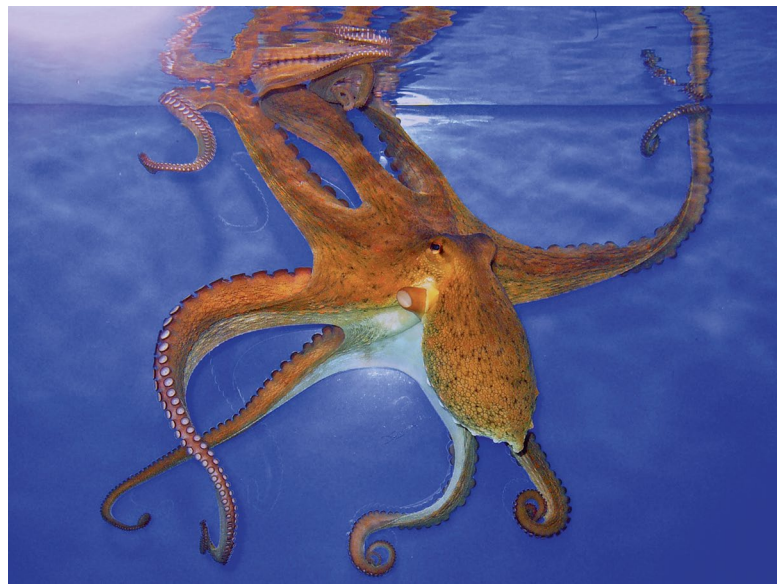


Fig. 13.3 Octopus exploring its tank. H. Zell, Courtesy of Wikimedia Commons CC BY SA 3.0 [Public domain image]

pose of protocadherins is to provide "name tags" for nerve cells. Once assumed to be unique to species with backbones, recent mapping of the octopus genome reveals that octopuses have 168 protocadherin proteins, whereas human beings possess approximately 60. According to the research, "expression of protocadherins in octopuses' neural tissues is consistent with a central role of these genes in establishing and maintaining cephalopod nervous system organization, as they do in vertebrates" (Albertin 2015). The presence of protocadherins enhances the octopus's capacity for rapid thinking and action. This system is considered advanced, even though their nerves are not covered by the myelin sheath, which is responsible for transmitting signals quickly in the human nervous system.

Another prominent theory explaining the advanced thinking capabilities of octopuses lies in their ability to "recode" themselves. They can reprogram the proteins that express genes. Genes are the "basic physical and functional unit of heredity." They make octopuses *octopuses*, and us, *us*. Though not restricted to octopuses alone, the physiology of octopuses is such that they can temporarily reconfigure their genetic makeup without altering the hard-wired template of their body plans, namely deoxyribonucleic acid (DNA), the blueprint instructions for building an organism.

The process of altering the information encoded from DNA is known as RNA editing (*RNA* stands for ribonucleic acid). An adaptive response to varying Ocean conditions, octopuses detour from the genetic map of DNA, momentarily changing how genes are expressed, most commonly by recoding proteins through adenosine-to-inosine (A-to-I) editing which utilizes the enzyme adenosine deaminase acting on RNA (ADAR) as a catalyst to modify neurons. RNA editing changes the function of specific proteins, producing a temporary character trait that is advantageous to the octopus in connecting with fluctuating environmental conditions. What this means is that the octopus does not mutate. Instead, it can test out other versions of itself without sacrificing its original blueprint (Liscovitch-Brauer 2017). The ability to produce proteins that were not encoded by DNA opens a space for octopuses to improvise—adding new riffs to their behavioral output.

Recoding RNA reads like a plot of a science-fiction novel. Images of a mad scientist tinkering with mazes of boiling flasks of colored liquid expelling plumes of smoke come to mind. Yet, there is a method to madness, as the success of octopuses shows. The ability to create a series of proteins from a single gene, as a way to promote fitness, flexible thinking, as well as support the need to acclimate and adapt to changing conditions, positions octopuses as emblems of the Ocean.

It is certainly unusual to inversely anthropomorphize octopuses into Ocean. However, it invites an appreciation of the living Ocean as an intricate mosaic of fluid parts, much like the octopuses it begets. In unraveling the materiality of octopuses and what makes them smart, we can also consider the material Ocean, one that recodes itself, stores memories, and possesses an anatomy of its own.

13.4 Personality, Masquerade and Dreams

13.4.1 I Am Myself and It Shows

Despite sharing similar nervous systems, octopuses are not all the same. Each has a distinct personality. Psychologists use the term *temperament* to define personality, marked by genetic behavioral patterns shaped by environmental influences. Examples of temperament include aggression, sociability, stubbornness, affection, and curiosity. Similar to the concepts of *umwelt* and embodied intelligence contributing to the development of octopuses, the combination of genes and lived experiences also contributes to individual personality. We cannot collectively lump octopuses into a species classification chart that dismisses their individuality.

Octopus scholar Jennifer Mather discovered that individuals display unique behaviors when she witnessed one repeatedly leave its den to carefully select rocks and build a rock wall at the

entrance. Another octopus in a nearby den remained a recluse. The only clue of its presence, a growing pile of discarded clam and crab shells outside its den (Mather 2007). Mather also references a personality test-study conducted by David L. Sinn, who raised laboratory-born octopuses and noted that those who shared a mother exhibited similar responses to a series of tests. Sinn also observed that the octopuses responded to the tests in predictable ways as they matured. In addition to assessing fitness, that is survival and reproductive success, personalities showcase the varied influence of diverse Ocean habitats.

Notably, personalities are not measured by one character display alone, and there are many sides to an individual, where "distinct individual-level characteristics of octopuses influence distinct stages of the problem-solving process" (Dissegna et al. 2023). How octopuses play speaks to individual character. Play behavior follows a criterion based on spontaneity and unstructured freedom. For octopuses, play registers in tales of Houdini-like escapes from enclosures or antics that flood a lab or short circuit a fuse (Godfrey-Smith 2016). The purpose of play is to refine skill sets and develop new behaviors to adapt to a transforming and transformative Ocean. The low-stakes risk of play gives octopuses many chances to devise plans of action from repeated encounters—to repeat, or not repeat, the behaviors they observe.

These problem-solving processes are differentiated into proactive or reactive behaviors, impacting the overall welfare of the octopus and future generations. Indeed, personality influences where an octopus chooses to call home.

So, is it possible to like the company of one octopus and not another based on its personality? A funny question to ask. Yet one that Sy Montgomery explores in recounting her interactions with eight different octopuses, describing their distinctive characters and regaling audiences with tales of individuals who escaped their tanks in the middle of the night to steal fish from a neighboring tank, or who took an instant dislike to particular people, squirting them with water whenever they were near. As described earlier, Montgomery wrote of her deep affection for the first octopus she met, Athena, who reciprocated her affections. Embraced in Athena's arms, Montgomery felt as if a portal had opened, one that invited her to consider new ways of thinking.

A more provocative question to ask regarding personality is the degree of influence organisms receive from nurture and nature—namely, the environment (and consequent experiences) and genetics—in shaping the temperament of octopuses. The question prompts us to reflect on the deeply intertwined nature of genetic inheritance and environmental responsiveness. Octopuses serve as a compelling example of how complex life forms evolve in constant interaction with their surroundings. By studying how their behaviors and temperaments develop in tandem with their habitats, we deepen our understanding of how the Ocean environment shapes marine life, and in turn, how our actions may impact the health and behavior of its creatures. This broader perspective encourages us to recognize the Ocean not just as a setting, but as a dynamic system that both shapes and is shaped by life within it. This dual influence can help deepen our understanding of the Ocean and our relationship with it.

13.4.2 Becoming Ocean

Octopuses easily win the "Best Costume" award. They do more than pretend to be the plant, animal, or thing (sunken ships, for example); they take on the sway and posture of living organisms and mimic the textures and indentations of nonliving objects. This is true for octopuses that call coral reefs, kelp forests, sand plains, rocky shores, and seagrass meadows home.

Through the evolution of camouflage techniques, octopuses gained tactical self-defense and communicative strategies to protect their soft bodies. Though camouflage was first recorded by Greek philosopher Aristotle (384–322 BCE), regarded as the Father of Marine Biology for being the first to record observations of marine life in *History of Animals*, it was not until the nineteenth-century that scientists discovered the mechanism behind it.

Skin cells made up of chromatophores (which hold pigments), iridophores (which scatter light), and leucophores (which reflect light) work in concert to conduct costume changes. Chromatophores are innervated by nerves, and when muscles contract, the chromatophores compress, washing the octopus in color. Each species of octopus possesses a unique composition of chromatophores (see videos in the resources section). You can say, it is part of their personality.

A layer of chromatophores is also found in the iris of the eye, enabling octopuses to vary the color of their eyes to match their skin. The eyes are laterally placed on the body (mantle) and are engineered to independently track movement. Remarkably, octopuses don't have a blind spot—their vision is panoramic. In addition, the pupil is designed to orient into a circle shape in darkness and into a horizontal shape in bright light.

These marvelous adaptations allow the octopus to compensate for shifting light conditions, such as when visibility is dulled by algal blooms, silt, or run-off. Their eyes are survival tools. Another adaptive advantage exploited by octopuses is the ability to alter pupil size to better receive a range of color wavelengths, despite the cost of sacrificing visual acuity in exchange for a larger color palette. This process, known as chromatic aberration (or image blurring), provides octopuses with a refined picture to better "blend in." Convincing predators to believe the ruse demands acute assessment of numerous variables defining the original, such as contrast, brightness, outline, edges, and size, all of which are moving parts.

Optical illusion is another adaptive trait octopuses exploit to seemingly vanish into water. By quickly expanding and contracting their chromatophores with split-second timing, octopuses give the impression of a moving cloud (or shadow), when in fact, they remain in place. Hence, the trick is referred to as "Passing Cloud." Marine biologist Roger Hanlon (Hanlon and Messenger 1996) calculated that octopuses are capable of producing 177 color changes and 50 patterns in 1 h. This is a daunting challenging task to quantify, especially with respect to varying gradations of patterns. In the wild Ocean, octopuses must constantly adjust color resolution and pattern to be believable. If caught between two predators, octopuses artistically display one color and pattern on one side of their body and a completely different color and pattern on the other. That gives new meaning to the idea of special effects.

The transforming octopus immerses us in the cauldron of tangled, teeming life and inanimate, life-giving forces. After all, Ocean water was born from the cooling of rocks inside a newly forming Earth. The Ocean takes on another life through the body of octopuses, who take snapshots of the Ocean world, capturing the complexity of habitats enriched with organisms ranging from microscopic plankton to the blue whale, the largest creature to ever inhabit the Earth.

The octopus acts as a historian to the book of Ocean. Its remarkable ability to respond to environmental cues draws our attention to the Ocean's ever-changing textures—rock, sand, seaweed, and animal life—and sharpens our awareness of the complexity within marine habitats and the broader, interconnected system of the Ocean as a whole. In this way, octopuses become ambassadors for Ocean Literacy, reminding us of the need to observe, understand, and respond to the Ocean's dynamic systems with both curiosity and care. They help us sharpen our focus on the fine details in an *oceanscape* that is always churning, always creating something new through the art of constant interaction.

13.4.3 In My Dreams

All animals sleep. Whether they all dream is debatable. We cannot enter the mind of an animal, but we can observe outward physical signs that the body is experiencing something during sleep, something that may point to an active, dreaming mind. Specific regions in the brain register patterns of activity indicating a dream state. Dreaming is the mind's way of reconfiguring waking experiences and provides the brain with a conduit to sort out and process past lived experiences with extraordinary possibilities. It is a

space to learn and contextualize alternative ways of dealing with the messy, stressful act of living, and for octopuses, living in a busy Ocean. With nine brains, perhaps octopuses are replaying multiple experiences at once.

Numerous observations of sleeping octopuses present "rapid chromatophore changed accompanied by skin texture changes, rapid eye movements and arm twitching" (Medeiros et al. 2021). One research team of scientists distinguished the sleep of octopuses into two states: active sleep and quiet sleep. The team documented an active sleep state that "resembles vertebrate REM (Rapid Eye Movement) sleep in terms of wake-like neural activity accompanying eye and body twitches" (Pophale 2023), including a series of body pattern changes like those presented while awake.

One research study conducted at the University of Washington involved applying electrodes to separate octopuses to map brain activity while awake and asleep. The findings indicate that octopuses replicated the camouflage patterns used while awake during sleep. On a domestic front, marine biologist David Scheel brought "Heidi" the octopus home to live with the family, becoming the subject of a 2019 documentary titled, *Octopus: Making Contact* (view videos in the resources section). One day, Scheel observed Heidi motionless in her tank while her body flashed successive waves of colors and patterns, including the morphing of the skin from smooth to dimpled. That led him to speculate that Heidi was dreaming. It is speculative, as body twitches and color changes may represent subconscious neurological activity consolidating long-term memory. But for Scheel, the discovery reinforces the importance of expanding our scientific understanding of marine life. Rather than viewing the Ocean as an empty space to cross or mine for resources, his experience with Heidi highlights the need to integrate complex animal behaviors—like possible dreaming—into our research and education. Such findings can support and enrich public understanding of the Ocean's systems and our interconnectedness with them.

13.5 History, Myth and Pop Culture

13.5.1 Ancient and Modern World Views

The Greek poet Theognis (570–485 BCE) features the octopus as a sage in advising people how to live, writing: "Adopt the disposition of the octopus, crafty in its convolutions, which takes on the appearance of whatever rock it has dealings with. At one moment follow along this way, but at the next change the color of your skin: you can be sure that cleverness proves better than inflexibility" (Theognis 1931). Ancient Greek culture was hypnotized by octopuses, often representing them in poetry and art as cunning creatures full of twists and turns. Pindar, a poet of the fifth century BCE, writes in his *Hymns*, "O son, make your mind most like the skin of the rocky sea creature." Plutarch, a writer of the first century CE, describes the octopus as "crafty." In the chapter "Whether Land or Sea Animals Are Cleverer" in *Moralia,* Plutarch presents the octopus as a thinking-oriented creature: "But this same action on the part of the octopus is not an emotional response, but a deliberate change, since it uses this device to escape what it fears and to capture what it feeds on: by this deceit it can both seize the latter, which does not try to escape, and avoid the former, which proceeds on its way" (Plutarch 1957). Octopuses embodied what was revered in people as *metis*. Scholars Marcel Detienne and Jean-Pierre Vernant define *metis* as a type of intelligence encompassing "a complex but very coherent body of mental attitudes and intellectual behavior which combine flair, wisdom, forethought, subtlety of mind, deception, resourcefulness, vigilance, opportunism, various skills, and experience acquired over the years" (Detienne and Vernant 1991).

All the traits ascribed to octopuses placed them on a pedestal of real and supernatural beings. The perception of octopuses as crafty creatures translated into the role of protector for seafarers. Octopuses were prominently featured in pottery by the "Sea People" of Minoan culture (circa 2700–1500 BCE) and Mycenaean culture (circa 2000–1100 BCE). Both cultures independently

developed the "Marine Style" or "Octopus Style." The majority of unearthed pottery artifacts feature an octopus with protruding, hypnotic eyes. The eyes were often drawn as a series of concentric circles with a prominent black pupil in the middle, dwarfing the size of the head and giving the eerie impression of following the observer. These cultures intertwined the Ocean and octopuses, believing that honoring both in art would guard them from the perils of an unpredictable Ocean (Fig. 13.4).

The Greeks were not alone in portraying octopuses as supernatural. In Japanese culture, the "octopus" God Akkorokamui was worshipped for its creative and regenerative powers but also feared as a monster capable of swallowing sailors into the blue abyss. Indigenous Polynesian People of Hawaii honored the octopus god Kanaloa, representative of a potent Ocean. Just as the octopus was associated with the idea of God, it was also linked to the idea of monster, reviled with the title "devil-fish." Ther terms octopus and "devil-fish" became synonymous in the nineteenth century, renowned as an age of Ocean exploration. Magazines and newspapers published an abundance of stories narrating harrowing escapes from the clutches of the octopus/"devil-fish." An octopus craze swept the world after Victor Hugo published *Toilers of the Sea* in 1866, featuring a wrestling match between the main character, Gilliatt, and a "devil-fish" octopus that Hugo repeatedly described as strange, undefined, monstrous, and Hydra-like (a reference to the mythological sea monster with several heads). It became common to find women parading along the seaside under the shade of large hats adorned with long, dangling, tentacle-like extensions. On March 31, 1866, the magazine *La Vie Parisienne* featured a line drawing titled "La toilette de la pieuvre" (Toilette of the Octopus), depicting a woman dressed in a nautical-themed gown embroidered with clam shells and anchors at the hem, and a bodice decorated with octopus eyes prominently placed at the breasts, and a flowing array of tentacle-like ribbons down the shoulders (Fig. 13.5).



Fig. 13.4 Minoan Vase, circa 1500 BCE. W. Sauber, Courtesy of Wikimedia Commons [Public domain image]

We may be bewildered by historical attitudes towards octopuses, yet the twentieth century was not immune to fantastical hypotheses. The publication of a joint scientific paper, "Causes of Cambrian Explosion-Terrestrial or Cosmic," published in the *Progress in Biophysics and Molecular Biology Journal,* argues that the octopus's unique ability to edit its expression of genes without affecting its foundational heredity material—its Deoxyribonucleic acid (DNA)—makes it alien. Though the article was met with skepticism and some ridicule, the scientists believed that the complexity of the approximately 33,000 protein-coding genes present in the octopus, along with its singular ability to edit the ways in which these genes are featured, most likely means that octopuses are "extraterrestrial imports to Earth." The premise that octopuses are out of this world challenges the evolution of all species and how relationships among species influence this Ocean planet. The scientists speculate: "Thus the probability that the cryopreserved Squid/Octopus eggs arrived in icy bolides several hundred million year ago should not be discounted as that would be a parsimonious cosmic explanation for the Octopus' sudden emergence on Earth ca. 270 million years ago" (Steele 2018). Through the prism of the supernatural and alien, the taxonomic immensity of Ocean life and its evolution cannot be ignored. We are directed to marvel at the intricate systems working to build one creature alone, in concert with an intricate Ocean system that supports and



Fig. 13.5 "The Toilette of the Octopus." Courtesy of Bibliotheque nationale de France [Public domain image]

has supported the composition and transition of such octopuses for millions of years.

13.5.2 Pop Culture

The alien-monster motif used to characterize octopuses has infiltrated popular culture. Science fiction novels, such as *War of the Worlds* by H.G. Wells, describe alien invaders on planet Earth as octopus-like, with "two large dark-colored eyes" and a "mass that framed them. The head of the thing was rounded, and had, one might say, a face." A cosmic entity in the form of an octopus is the object of worship in the novel *Cthulhu* by H.P. Lovecraft. A twin sense of attraction and repulsion was projected onto octopus-like beings whose existence eviscerated how people understood themselves as human in a world full of such diverse life forms, though none like us. Perhaps science fiction provides an opportunity to closely examine form, and in doing so, deepen our understanding how what we can learn the Ocean from the very creatures the Ocean creates.

Hollywood certainly took the monster theme of octopuses to the big screen. Disney created one of the most infamous octopus-like "monster" villains: Ursula from *The Little Mermaid*. While the original nineteenth-century story by Hans Christian Andersen does not name or describe the character other than referring to her as a "sea-witch," Disney introduces audiences to a heavy-set, half human/half octopus character named Ursula, brandishing long, black tentacles and adding her own blood to a cauldron of goop to transform Ariel the mermaid into a human. Here Ursula demonstrates the transformative powers of octopuses and extends those powers beyond herself. Is there some latent wish fulfillment at play? It is true that humans also have the ability to edit RNA, though not in the same capacity as octopuses. In learning more about the properties of octopuses, we are learning more about ourselves and reconnect with our Ocean origins.

Another famous octopus-like villain is Otto Octavius, otherwise known as Dr. Octopus, antagonist to Marvel Comics' hero, Spiderman. Introduced by creator Stan Lee as a brilliant sci-

entist, cunning inventor, and committed to developing clean energy, Octavius created a set of artificially intelligent mechanical arms to assist him with experiments. The aftermath of a radioactive explosion permanently fused the arms to his body, and because the "neural inhibitor chip" controlling the arms was destroyed, the arms took over and Dr. Octopus the villain was born. Endowed with super strength, Dr. Octopus wreaks havoc in New York City, becoming more than human, more powerful, and seemingly explosive with evolutionary potential to survive an increasingly nuclearized world. Can we look to octopuses as evolutionary heroes who can teach us how to adapt to a changing Ocean? Is the message to take a step back and allow octopuses to teach us why it is important to maintain a healthy Ocean? These are the rhetorical questions charted by looking at octopuses.

13.6 Conclusion: Why Look at Octopuses

Octopuses direct us to their versatility and plasticity, traits that also characterize the Ocean. The complexity of their flexible behaviors illustrates an active mind primed to adapt to change and make decisions in concert with current conditions. This is remarkable for an animal that is dominantly a solitary creature, where generations never meet. The *braininess* exhibited by an octopus building a rock wall to fortify its den (home) or plugging up a water valve to flood a lab is astounding in both the Ocean world and our human one. Sy Montgomery playfully refers to octopuses as "gelatinous geniuses." The value of octopuses is deep and in surplus. They act as key informants of changes in the Ocean's health due to pollution, acidification, deep-sea mining, tourism, invasive species, and global warming. In reacquainting ourselves with octopuses, we reacquaint ourselves with the significant roles they perform in maintaining a complex Ocean system, one that gave birth to their own complexity. Their well-being is our well-being.

Marine biologist Jacques Cousteau recounts a tale of an octopus kept in a home aquarium of a friend. One day, his friend came home to find the aquarium empty and the octopus in the library turning the pages of a book with its arms. Obviously, it is a tall tale; however, the message is one of continued literacy. If we are to continue to learn about the Ocean and cultivate Ocean Literacy, we need to look at the octopus and read its existence as the historian of the book of Ocean. By inviting us to see the Ocean through the eyes of octopuses—creatures shaped by and responsive to their marine environment—this chapter exemplifies the intent of Ocean Decade Challenge 10: to restore society's relationship with the Ocean through empathy, awareness, and renewed understanding. In attuning to the world of octopuses, we attune to the Ocean itself, not as 'other,' but as origin and partner. This is not only a call to curiosity, but a call to care; a call echoed in the goals of the Ocean Decade.

13.6.1 Summary

Key concepts explored in this chapter include:

- Octopuses embody the Ocean's dynamic nature, demonstrating how adaptability, flexibility, and complexity are essential traits of life in marine environments—mirroring the ever-changing Ocean system (Ocean Literacy Principles 1 and 5).
- Octopuses are more than biological curiosities—they are active agents and indicators of how life in the Ocean interacts with, and even reshapes, the marine environment and human perspectives of it (Ocean Literacy Principle 2).
- The study of octopuses deepens our understanding of marine ecosystems**,** highlighting how animal behavior reflects both environmental conditions and evolutionary adaptations (Ocean Literacy Principles 4, 5, and 6).
- Octopuses as "historians" of the Ocean metaphorically represent how species reflect and respond to the Ocean's physical, chemical, and biological changes (Ocean Literacy Principles 1, 3, and 5).
- Camouflage, play, and dreaming in octopuses illustrate the complexity of life in the Ocean**,** encouraging learners to approach marine life with scientific curiosity and respect (Ocean Literacy Principle 5).

- The cultural and historical symbolism of octopuses across civilizations underscores how the Ocean and its creatures have long influenced human belief systems, reinforcing the Ocean Literacy tenet that the Ocean is a major influence on human history and culture (Ocean Literacy Principle 6).
- Octopuses highlight the interconnectedness between human activity and Ocean health**,** as their well-being is impacted by pollution, deep sea mining, and climate change—reminding us of our reciprocal relationship with the Ocean (Ocean Literacy Principles 5 and 6).
- Popular media portrayals of octopuses reflect evolving human perceptions of the Ocean, offering a platform to challenge myths, expand scientific understanding, and promote stewardship grounded in respect rather than fear (Ocean Literacy Principle 6).
- Octopus intelligence and behavior encourage a rethinking of Ocean life beyond extractive or utilitarian views, inviting a more reciprocal, ethical relationship with the Ocean (Ocean Literacy Principle 6).
- Octopuses invite a reimagining of how humans relate to Ocean life, offering a powerful entry point for Challenge 10: *Restoring Society's Relationship with the Ocean*. By showcasing the intelligence, agency, and vulnerability of marine life, this chapter encourages a cultural shift from viewing the Ocean as a resource to be exploited to recognizing it as a living system of which we are a part—one deserving of respect, protection, and shared responsibility (Ocean Literacy Principles 1, 5, and 6).

13.6.2 Recommended Resources

The following resources provide further insights and support on this topic:

Celebration:

- World Octopus Day: https://www.worldanimalprotection.org/our-campaigns/sentience/animal-awareness-days/world-octopus-day/.

Research:

- MBARI scientists solve mystery of why thousands of octopus migrate to deep-sea thermal springs:https://www.mbari.org/news/scientists-solve-mystery-of-why-thousands-of-octopus-migrate-to-deep-sea-thermal-springs/
- MBARI researchers deploy new imaging system to study the movement of deep-sea octopus: https://www.mbari.org/news/mbari-researchers-deploy-new-imaging-system-to-study-the-movement-of-deep-sea-octopus/

Videos:

- Octopus camouflage—Changes color, texture and shape: https://www.youtube.com/watch?v=XocHDvHlcJM
- Amazing Octopus Color Transformation (National Geographic): https://www.youtube.com/watch?v=yE0QqxwyL_8
- Octopus Color Change: https://www.youtube.com/watch?v=EvlEPW3lkQc
- Octopus changes color and texture—Eilat: https://www.youtube.com/watch?v=ydrc489USbM
- Octopus: Making Contact (Official Preview, Nature PBS): https://www.youtube.com/watch?v=daRf2cetXZ4
- Octopus Dreaming (Nature on PBS): https://www.youtube.com/watch?v=0vKCLJZbytU
- Octopus Social Life: Secrets of the Octopus (National Geographic): https://youtu.be/p0RLERl3TmU?si=YMeqiRpI0jDNCvA9

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14

Something Very Fishy: Musical Theatre Performance Enhances Gains in Ocean Literacy STEAM Program for Young Children

Michael J. Childress, Kathy L. Prosser, and Meghnaa Tallapragada

Abstract

Something Very Fishy (SVF) is a STEAM program for children ages 5–10 that presents Ocean Literacy lessons via a musical theatre performance, where actors and marine puppets tell the story of our changing Ocean, paired with a marine science exhibit where university student docents portray different careers in marine science. Here we compare the efficacy of our program before and after a modality change caused by the COVID-19 pandemic. We found (1) knowledge of human's impact on the Ocean increased after attending the program, (2) the emotional connection to the Ocean increased more with the theatrical element and hands on science exhibit, and (3) career interests changed from before to after the program with increasing interest in STEM careers connected to the Ocean. These results demonstrate that pairing a musical theatre performance with a hands-on marine science exhibit helps raise Ocean Literacy knowledge, emotional connection, and identity. Its impacts extend beyond the children attending the program to the parents, teachers, performers, production crew, and university student docents involved. Our program addresses the UN Ocean Decade Challenge 10 to inspire and generate the motivation, capability, and opportunity for communities to educate children, make decisions, and behave in ways that ensure a healthy Ocean, to sustain all life—current and future.

Keywords

Ocean Literacy (OL) · Musical theatre · Science, Technology, Engineering, Math (STEM) · Science, Technology, Engineering, Art, Math (STEAM) · Personal meaning map · Emotional connection · STEM identity · Theory of Change

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14.1 Introduction

The Ocean is in trouble, and it needs our help. This is the message we share with children in our *Something Very Fishy* (SVF) STEAM Program. STEAM programs use Artistic approaches to enhance teaching about Science, Technology,

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Engineering, and Math (STEM). In our program, we combine a musical theatre puppet performance with a hands-on science exhibit designed to engage and inspire children ages 5–10 (Tallapragada et al., 2023). In this chapter, we describe how we evaluated the efficacy of our marine science STEAM program and the importance of the live performance component. We make a case based on the Theory of Change in the Public Engagement of Science framework (AAAS n.d.) that if we wish to change the attitudes of our community, we must begin by engaging our children, teachers, and the public about the challenges our Ocean faces using informal educational settings.

The plot of our musical theatre SVF performance and the design of the accompanying science exhibit seeks to increase knowledge of Ocean Literacy principles #5: The Ocean supports a great diversity of life and ecosystems, #6: The Ocean and humans are inextricably interconnected, and #7: The Ocean is largely unexplored (NOAA 2020). The theatre production is comprised of professional performers and technicians, while the science exhibit is presented by university student docents trained as marine science communicators. In this chapter, we evaluate (1) the efficacy of our program to increase knowledge, emotional connection, and career interests in the Ocean and (2) how a change in format from an in-person program to an online program caused by the COVID-19 pandemic revealed the value of our in-person musical theatre STEAM program.

We are in the midst of a climate emergency. The combined effect of a growing global population and increasing living standards has led to rapid burning of fossil fuels and rising atmospheric carbon dioxide (Ripple et al. 2019). Increasing carbon dioxide traps heat within our atmosphere which is stored in our Ocean. Consequently, the Ocean is experiencing marine heat waves, lower pH, harmful algal blooms, fish kills, and mass coral bleaching (Hoegh-Guldberg and Bruno 2010). Given the severe consequence we all face due to this climate emergency, it is astonishing that these issues are rarely discussed in school or at home (Leiserowitz et al. 2021).

This deficit in teaching the science and consequences of climate change and Ocean health is not unique to the United States, for other countries have also identified similar gaps in their primary school curricula (Freitas et al. 2022; Mogias et al. 2019). But teaching about climate change in the United States is much more challenging due to a pervasive skepticism that either climate change isn't happening or that it won't negatively affect us personally (Plutzer et al. 2016). Much of this mismatch between parents wanting teachers to teach about climate change (86%) and the number of teachers that teach about climate change (42%) is revealed by the reasons that teachers report why they don't teach about climate change (Irfan 2019). A recent NPR/Ipsos teacher survey found that 20% say children are too young to learn about climate change, 17% say they don't know enough to teach about it, 8% say they don't believe in climate change, and 4% say it is against school policy to teach it (Kamenetz 2019). The good news is that informal STEAM programs can speak directly to children in ways that teachers may be hesitant or are unable to do.

Children love the Ocean and the amazing life within. Even if they have never seen the Ocean, they know about it from literature, television, and popular culture. It is not surprising then that using music, theatre, puppets, and art fits so easily into talking with kids about the Ocean. The innate empathy that children feel toward marine life is a powerful force which opens them up for lessons about Ocean health which affects our changing climate and contributes to healing our planet. The key is storytelling, especially through conservation theatre (Heras and Tàbara 2016) and artistic expression (Tallapragada et al. 2021). As McKinley et al. (2023) points out, there is a lot about Ocean Literacy that goes beyond the seven knowledge principles we hope to instill. Our SVF program strives to reach all Ocean advocates and to "show, not tell" (Escobar and Gutiérrez-Graudiņš 2019).

14.2 Studying the Efficacy of Our Musical Theatre STEAM Program

Our SVF program began as a collaboration between a marine scientist (MJC), an artist (KP), and a communication scientist (MP) (see Tallapragada et al. 2021). The SVF STEAM program combines a musical theatre puppet performance followed by a four-exhibit science expo at a local performing arts center. Elementary school classes from inland, rural South Carolina (Anderson, Oconee, Pickens counties), ages 5–10, were invited to attend the performance. More than half of these schools are considered Title I public schools with >40% of their students qualifying for a low-income free-lunch program. *Something Very Fishy* the musical, includes a cast of human and marine animal puppets tell the story of the mysterious disappearance of marine life from the water surrounding "Little Fishing Town." After a series of disasters, the fishermen, the marine scientist, and the marine critters band together to save the Ocean through creation of an eco-tour to benefit all the town folk and the local marine life (full script available in Tallapragada et al. 2021 supplemental). As the performance ends, the science exhibit begins as if it were the actual eco-tour described in the performance. Children rotate through exhibits that illustrate careers of the community members that support a health Ocean. These include a sea turtle biologist protecting a sea turtle nest, a coral biologist leading the children on a coral transplanting expedition from a coral nursery to a coral reef, a marine animal veterinarian sharing live invertebrates and raising awareness of habitat and biodiversity loss at a marine life hospital, and a SCUBA diving marine explorer describing the gear needed to live and work out of the Aquarius Undersea Laboratory (Fig. 14.1).

As an assessment of our program, the children were given a SVF workbook before attending the performance. In their workbook they were asked to "draw a scene under the Ocean" (Ocean Vision Assessment). They were also asked to circle three careers that interested them (I 'Sea' Myself assessment) from a list of 24 possible STEM, arts, and other options (Fig. 14.2). After attending the performance, these same assessments were repeated and the gains (differences from post-performance drawings and surveys and pre-performance drawings and surveys) were evaluated as our assessment measure. A total of 13 schools, 69 teachers, and 1900 children attended the live performances which ended 2 weeks before the COVID-19 pandemic shutdown all public performance (Table 14.1). As a result, only 49 completed workbooks were received for analysis because the teachers were unable to collect the workbooks after the performance due to the COVID-19 pandemic (four classes, three schools).

The following year (March 2021), the SVF program pivoted to an online only format where the children attended a Zoom call hosted by Dr. Sea (marine scientist) and Sunny the Seal (puppet from the musical) rather than the entire cast of *Something Very Fishy* the musical. The children were then rotated through different Zoom breakout rooms that corresponded to the four-exhibit eco-tour described above (see Fig. 14.1). University student docents still portrayed the same marine science careers as in the live performance STEM exhibits including a marine veterinarian, a sea turtle biologist, a coral scientist, and an Aquanaut in the Aquarius Underwater habitat. Each STEM exhibit script was similar in length and content as the in-person STEM exhibits associated with the live musical performance. A total of 26 schools, 62 teachers, and 1300 children attended the online performances, and we received 246 workbooks (24 classes, 10 schools). It is important to note that 60% of students that attended our performances, both live and online, were from rural schools with a high proportion (> 40%) of low-income families qualifying for free lunches, commonly referred to as Title I schools (Table 14.1). While we didn't specifically collect data on gender and ethnicity of the children that participated, our live performances and online exhibits had similar proportions of non-white

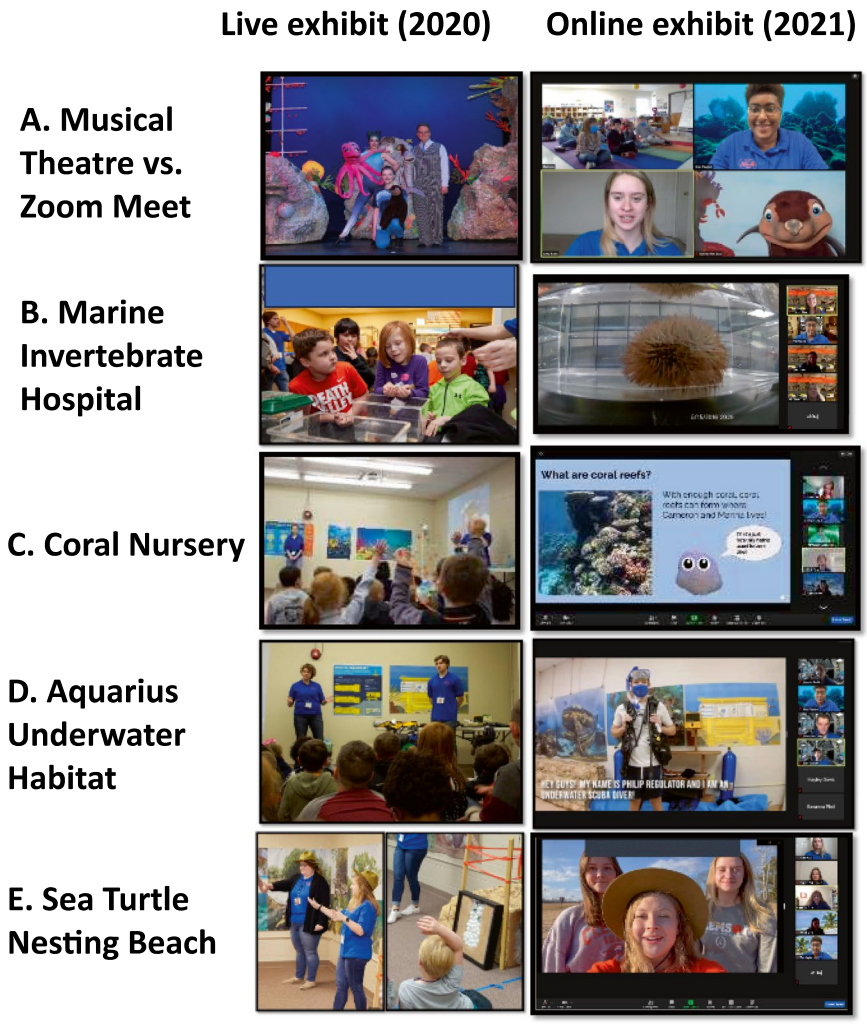


Fig. 14.1 Comparison of program year differences between live musical theatre + live virtual field trip (2020) with online virtual field trip only (2021). (A) Musical performance was only performed live in 2020 although some of the characters attended the online program Zoom sessions in 2021. Four virtual field trip stations remained the same in both years of the program (B) marine animal hospital, (C) coral nursery, (D) Aquarius undersea habitat, (E) sea turtle nesting beach. In the live performances children encountered four arts careers (musician, actor, photographer, singer) whereas children encountered four STEM careers in both the live and online performances (coral biologist, park ranger, marine biologist, veterinarian)

students ranging from 15% to 50% of each class attending depending on the school.

Our Ocean Vision assessment consisted of the drawings the children made in their workbook which included a prompt to "write about your drawing" (Fig. 14.2B). This personal meaning map (Falk 2003) allowed us to use the same assessment for children ages 5–10, albeit with variable levels of difficulty in scoring of the drawings. Drawings from the youngest children were sometimes difficult to determine what was in the drawing, and we relied on their explanations

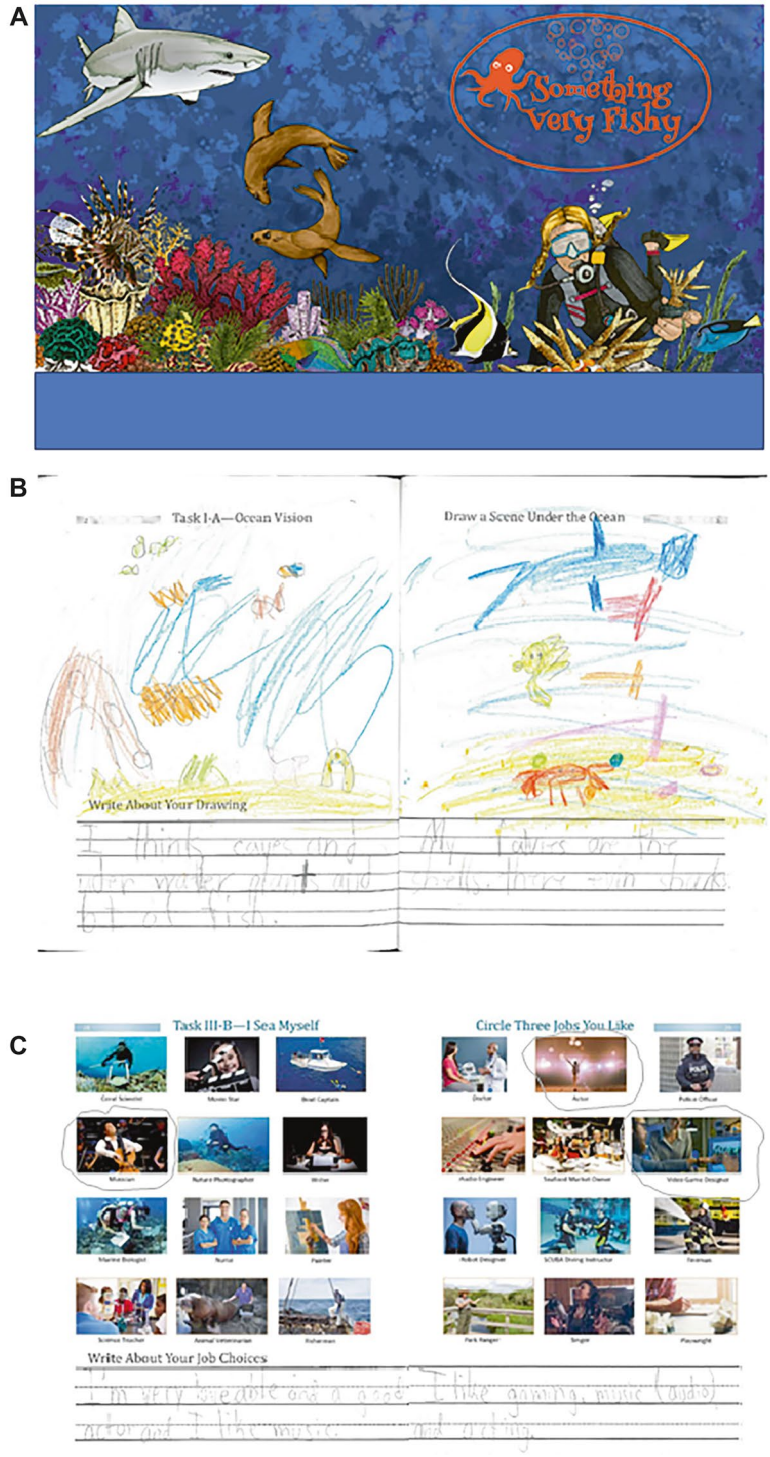


Fig. 14.2 Children were given a Something Very Fishy Student Workbook (A) and asked to complete two tasks prior to attending and immediately after attending our program. (B) Ocean Vision—draw what it looks like under the Ocean. This student wrote "I think caves and underwater plants and lots of fish. My favies ar the shells. there evin sharks." (C) I Sea Myself—circle three careers that you like the most. This student wrote "I'm very loveable and a good actor and I like music. I like gaming, music (audio) and acting." We used the same workbook assessments for both the in-person and online years of our study

Table 14.1 Summary of program participants and workbook analyses. Musical theatre performance occurred only in 2020, but virtual field trip led by docents portraying STEM careers occurred in both 2020 (live) and 2021 (online)

						Workbooks per grade					
	Year	# schools	# teachers	# children	# workbooks	K	1	2	3	4	5
2020	13(7)	69	~1900	49(34)	10	0	24	0	15	0	
2021	26(15)	62	~1300	246(122)	16	11	101	20	58	40	

() Title I public schools = schools with >40% families qualifying for the free lunch program

below the drawing to assist us in identifying the drawing elements. The drawings were then evaluated by a code book with specific rules to simplify the presence/absence of critical elements in the drawings for the purpose of classification. We previously confirmed the reliability of this drawing assessment code by having multiple coders code the same drawings and then confirming the reliability using Krippendorf's alpha. We settled on only those assessment elements (centricity, construct, scenario) with a high value of reliability across coders (> 0.7 Krippendorf's alpha) (see Tallapragada et al. 2021).

Workbooks were scored by our university undergraduate student docents after a training session on how to use the code book. We used the rubric of Tallapragada et al. (2021) for three measures of Ocean Literacy awareness (centricity, construct, and scenario) and for career interests in three fields (STEM, arts, and other). In our "Ocean Vision" assessment, centricity was evidence of our program elements, construct was our measure of Ocean Literacy knowledge, and scenario was our measure of Ocean Literacy emotional connection. In our "I Sea Myself" assessment, children were presented 24 photos of people representing different careers with the name of the career below each photo (Fig. 14.2C). The prompt was to "circle three jobs you like" and included a free response section with a prompt "write about your job choices." Eight of the careers were chosen to represent "STEM" careers, eight to represent "arts" careers and eight to represent "other" careers. Within each of the three categories, 50% of the careers were represented in our SVF program, and 50% of the careers were not represented in our SVF program. This would allow us to distinguish between a general interest in STEM or arts careers versus a specific interest in the STEM or arts careers associated our SVF program (see Tallapragada et al. 2021).

14.3 Analysis of Gains in Ocean Literacy Knowledge, Emotional Connections, and Identity

The visual arts are a powerful window into the mind of a child. When asked to draw what it looks like under the Ocean, children tell us not only what they see in their heads when thinking about the Ocean but also how connected they feel to the Ocean. Here we show how analysis of children's drawings can be a powerful assessment for understanding the messaging of our Ocean Literacy efforts.

14.3.1 Ocean Vision Assessment—Program Evidence (Centricity)

All drawings were assessed for the presence of elements present in the musical theatre performance/science exhibit. These program elements included the puppets characters of Sunny the Seal, Octavia the Octopus, Boss the Shark, as well as performance/exhibit human characters including marine biologist, fisherman, coral biologist, marine veterinarian, sea turtle biologist, and SCUBA diver (see Tallapragada et al., 2023).

Other program elements on our list of SVF elements include a coral tree or nursery, a marine animal hospital, the Aquarius Underwater Laboratory, or Little Fishing Town. The presence of program elements in the drawings were a check to see that attending our program had the potential to influence the child's Ocean Vision drawings. These elements differed slightly between our live performance and our online program which lacked some of the characters present in the musical theatre production. But we didn't necessarily find a higher abundance of program elements from the live performances than from the online presentations. Each modality typically had approximately 8–10 elements that we felt confident that were associated with our program. The Ocean Vision assessment scores for centricity were converted into binary scores of 0 = no evidence of elements from our SVF program or 1 = evidence of elements from our SVF program. Gains were then represented as the post-performance score minus the pre-performance score for a variable range of +1 to 0 due to no pre-performance drawings including elements of the SVF program. Thus, positive net gains indicate increased inclusion of SVF performance elements in the post-performance drawings. Gains in program evidence (centricity) were evaluated using analyses of variance test evaluating three fixed factors, program modality (live vs online), ages (5–6, 7–8, 9–10), and public-school type (Title I vs non-Title I).

Children in all age classes and in both modalities of the program did include more references in their drawings to SVF elements after attending our program indicating that changes in their drawing were consistent with the idea that our program influenced their Ocean Vision drawings (Fig. 14.3A). Evidence of elements of our program increased from 0% to 14% of the drawings from our live program attendees and from 0% to 28% of the drawings from our online program attendees. These results indicate that both the live and online programs had similar potential to influence the Ocean Vision drawings. These gains were similar across all program modalities ($F(1,290) = 2.158$, $p = 0.1429$), age classes ($F(2,290) = 1.527$, $p = 0.2190$), and school types ($F(1,290) = 1.389$, $p = 0.2396$).

14.3.2 Ocean Vision Assessment—Ocean Literacy Knowledge (Construct)

All drawings were classified into one of eight construct categories depending on what was included in the drawing. Drawings without any marine life, humans, or human artifacts (boats, fishing gear, anchors, treasure chests, etc.) were given a score of 1. Drawings that included all three elements of marine life + humans + human artifacts were given a score of 8. All other combinations of these three elements made up the remainder of the scale from 2 to 7 (see Tallapragada et al. 2021). To further simplify this scale as a measure of Ocean Literacy Principle #6 (Humans and the Ocean are inextricably linked) we collapsed our eight categories into a binary measure: humans / human artifacts absent = 0 and human / human artifacts present = 1. Gains were then represented as the post-performance score minus the pre-performance score for a variable range of +1 to −1. For example, a child who did not include humans / human artifacts in their pre-performance drawing (0) but included them in their post-performance drawing (1) would have a gain score of 1 (1–0) while a child who included human/ human artifacts in their pre-performance drawing (1) but not in their post-performance drawing (0) would have a gain score of −1 (0–1). Children whose drawings were the same pre- versus post-performance with regards to the inclusion or exclusion of humans/human artifacts would have a gain score of 0 (1–1 or 0–0). Thus, positive net gains averaged for all children indicate increased inclusion of humans and human artifacts in the post-performance drawings. Gains in Ocean Literacy knowledge (construct) were evaluated using analyses of variance test evaluating three fixed factors, program

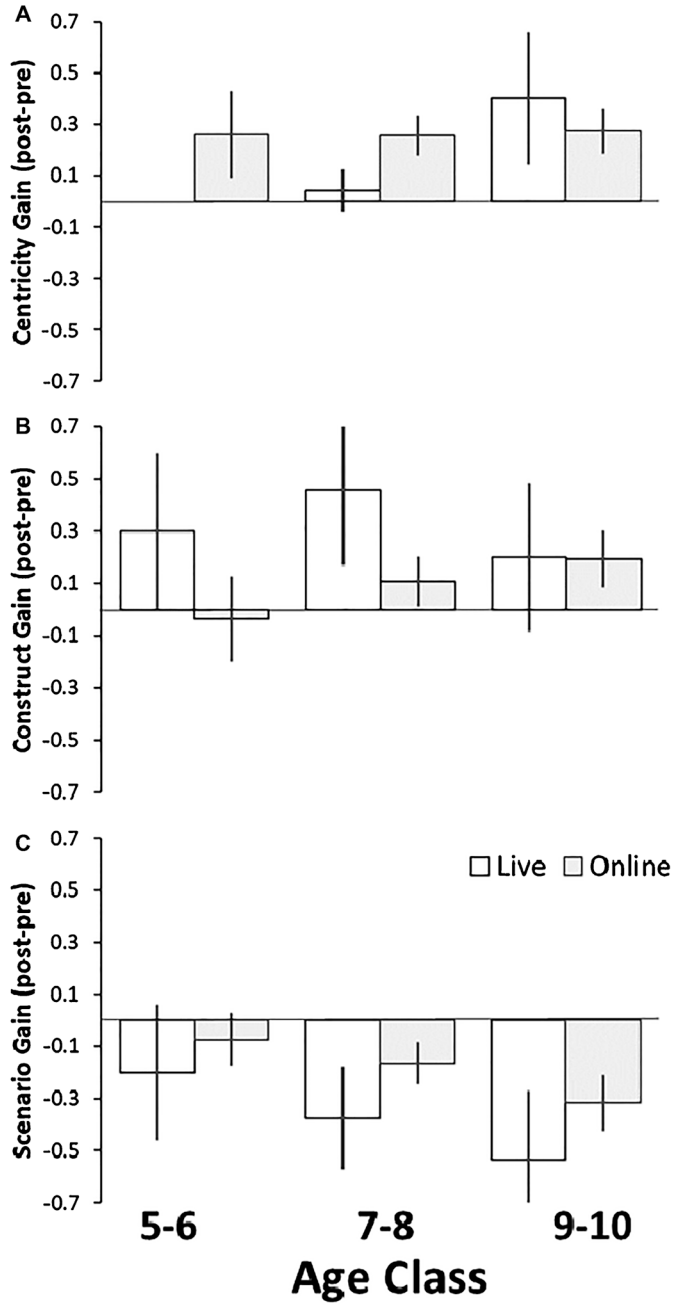


Fig. 14.3 Ocean Vision assessment results (means +/− 95% CI). Pre performance scores were subtracted from post-performance scores as a measure of gain so that positive values (those above the center reference line) indicate increases in the metric and negative values (those below the center reference line) indicates decreases in the metric. The bars indicate mean values for each metric and the error bars indicate the 95% confidence interval. When error bars do not overlap the center reference line, then the gain is significant at the $P < 0.05$ level. Gains for three measures related to drawings of what it looks like under the Ocean by exhibit modality and age class. (A) Centricity (Program Evidence)—increasing values have more elements from the STEAM exhibit in the drawing. (B) Construct (Ocean Literacy Knowledge)—increasing values have increased frequency of humans and human artifacts in the drawing. (C) Scenario (Emotional Connection)—decreasing values have more negative scenarios or expressions of concern in the drawing. Live (open bars) = live performance and exhibit. Online (gray bars) = online exhibit only

modality (live vs online), ages (5–6, 7–8, 9–10), and public-school type (Title I vs non-Title I).

The gains in Ocean Literacy knowledge (construct) as measured by the degree to which children included humans and human artifacts in their drawings were significantly higher for the live program over the online program (Fig. 14.3B). Drawings before the program included humans/human artifacts 33% for the time for the live program (23% online program) while post-performance drawings included humans/human artifacts 67% of the time for the live program (36% online program). Not only were these gains significantly higher for the live program ($F(1,290) = 5.310$, $p = 0.0219$), they also were highest for age 7–8 years old ($F(2,290) = 3.328$, $p = 0.0372$), and for Title 1 schools ($F(1,290) = 7.528$, $p = 0.0065$).

Children from Title I schools showed higher gains in Ocean Literacy knowledge than children from non-Title I schools primarily because their scores prior to attending the program were lower pre-program and then equal post-program. That means whatever the starting gap was in Ocean Literacy knowledge before attending the program was eliminated by participation in our exhibit.

14.3.3 Ocean Vision Assessment—Ocean Literacy Emotional Connection: Scenario

All drawings were assessed for the emotional tone of the drawing. Docents worked together to come up with a rubric which would allow them to classify the tone of a drawing to be either a positive, neutral, or negative emotional connection (see Tallapragada et al. 2021). Positive tone was animals and/or humans engaged in natural activities without causing harm to another animal or human. Neutral tone were animals and/or humans engaged in natural activities where any suggestion of harm was within expected natural interactions (larger fish eating smaller fish, humans fishing for fish). Negative tone were animals and/or humans engaged in overtly harmful activities (fish caught in a plastic bag or discarded fishing net, human in distress, anthropogenic marine debris). The Ocean Vision assessment scores for scenario were converted into binary scores of 0 = neutral or positive tone and 1 = negative tone. Gains were then represented as the post-performance score minus the pre-performance score for a variable range of +1 to −1. Thus, positive net gains indicate an increase in positive scenarios and negative net gains indicate an increase in negative scenarios in the post-performance drawings. Gains in Ocean Literacy emotional connection (scenario) were evaluated using an analyses of variance test using three fixed factors, program modality (live vs online), age class (5–6, 7–8, 9–10), and public-school type (Title I vs non-Title I).

The gains in Ocean Literacy emotion connection as measured by the Ocean Vision drawings with a positive or neutral tone, decreased from pre-program to post- program (Fig. 14.3C). Drawings before the performance had a negative emotional tone 12% for the time for the live program (2% online program) while post-performance drawings had a negative emotional tone 51% of the time for the live program (17% online program) which is a statistically significant difference ($F(1,290) = 6.976$, $p = 0.0087$). Younger children (ages 5–6) were significantly less likely to represent negative tones in their drawings whereas older children (ages 9–10) were most likely to represent negative tones in their drawing ($F(2,290) = 5.450$, $p = 0.0047$). However, there were no differences for children from Title I or non-Title I schools ($F(1,290) = 0.177$, $p = 0.6745$).

This strongly suggest that the message conveyed in the musical theatre STEAM production had more emotional impact on the children than simply learning about the same issues in an online program. It is important to note that while the number of children drawing pictures with a negative tone increased after attending our program, their hope for the future and resolve to address these issues remained optimistic based on their description of their own drawings. One

student attending the live performance wrote "We need to save or oshin stop litring" and another student attending the online program wrote "This is a sea turtle is eating a bag he thinks that is a jelly fish and can die from it if we put trash in the water."

14.3.4 I Sea Myself Assessment—Ocean Literacy Identity (Career Interests)

Career interests from the I Sea Myself assessment were estimated by summing the number of career choices identified as STEM, arts, or other careers and dividing by the total number of careers selected. While the instructions asked for only three career selections, some students selected less or more than three, so we represented these as values between 0 and 1 based on the proportion of careers selected in each category over the total number selected. Therefore, the maximum interest in one career type was 1 regardless of the number of careers selected. Career interest pre-program for the live performance were 35% STEM, 43% arts, 22% other (37%, 38%, 25% online program). Career interest post-program for the live performance were 39% STEM, 38% arts, 23% other (42%, 30%, 28% online program). Gains were then represented as the post-performance score minus the pre-performance score for a variable range of +1 to −1. Thus, a positive net gain indicates an increased interest in that career type post-performance. Gains in Ocean Literacy career interests were evaluated using an analyses of variance tests using three fixed factors, program modality (live vs online), age class (5–6, 7–8, 9–10), and public-school type (Title I vs non-Title I).

In general, interests in STEM careers increased (Fig. 14.4A) and interests in arts careers decreased (Fig. 14.4B) after attending our program. Interestingly, this was true regardless of the program modality (live versus online) (STEM $F(1,249) = 0.009$, $p = 0.9262$; arts $F(1,249) = 0.001$, $p = 0.9791$). Other careers were not influenced by program modality ($F(1,249) = 0.011$, $p = 0.9164$), age class ($F(1,249) = 0.259$, $p = 0.7720$), or public-school type ($F(1,249) = 0.085$, $p = 0.7706$) (Fig. 14.4C). STEM career interests were statistically higher ($F(1,249) = 4.039$, $p = 0.0188$) and arts career interests statistically lower ($F(1,249) = 4.124$, $p = 0.0173$) in children ages 9–10 but were mostly unchanged for children ages 5–8. A finer look at the specific career interests within each category clearly indicate that interest in the art career "actor" was ranked fourth (gain +3.0%) for students attending the live performance but was ranked 22nd (gain −1.5%) for students attending the online program (Fig. 14.5). The top two career interest gains were similar for both years of the program: marine biologist (live gain +7.5%, online gain +3.0%) and coral scientist (live gain +3.5%, online gain +4.5%). These results strongly support the idea that career interests in the short term were influenced by seeing careers presented in person and online, especially for children ages 9–10.

14.4 Impacts and Future Directions

Our greatest science communicators, such as Bill Nye (the Science Guy) or the BBC's Sir David Attenborough, are also great storytellers. Their ability to bring you into the drama of the moment while teaching you the science behind some spectacular natural phenomenon combines the essential elements of curiosity and wonder. The more we can teach children about our changing climate and perils of the Ocean by instilling wonder and curiosity, the greater reach we will have for the children themselves will be inspired to assume the role of the storyteller to others.

14.4.1 Informal Settings Helps Teaching About Climate Change

Teaching about our climate emergency can be a challenging subject for elementary school teachers to address (Irfan 2019; Plutzer et al. 2016).

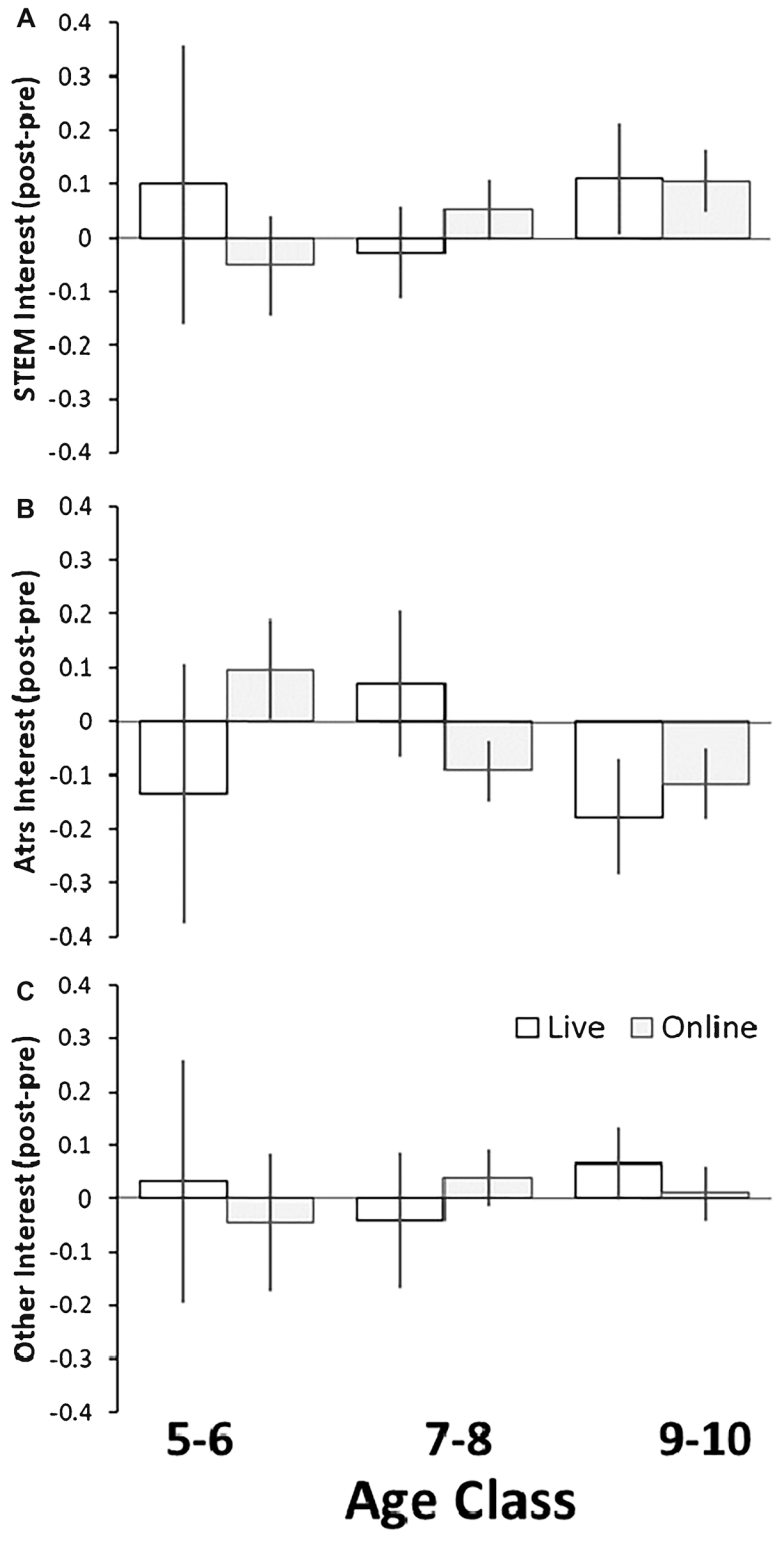


Fig. 14.4 I Sea Myself career interest assessment results (mean +/− 95% CI). Pre performance scores were subtracted from post-performance scores as a measure of gain so that positive values (those above the center reference line) indicate increases in career interests and negative values (those below the center reference line) indicates decreases in career interests. The bars indicate mean values for each metric and the error bars indicate the 95% confidence interval. When error bars do not overlap the center reference line, then the gain is significant at the $P < 0.05$ level. Gains for interests in careers in (A) STEM, (B) Arts, and (C) Other by exhibit modality and age class. Live (open bars) = live performance and exhibit. Online (gray bars) = online exhibit only

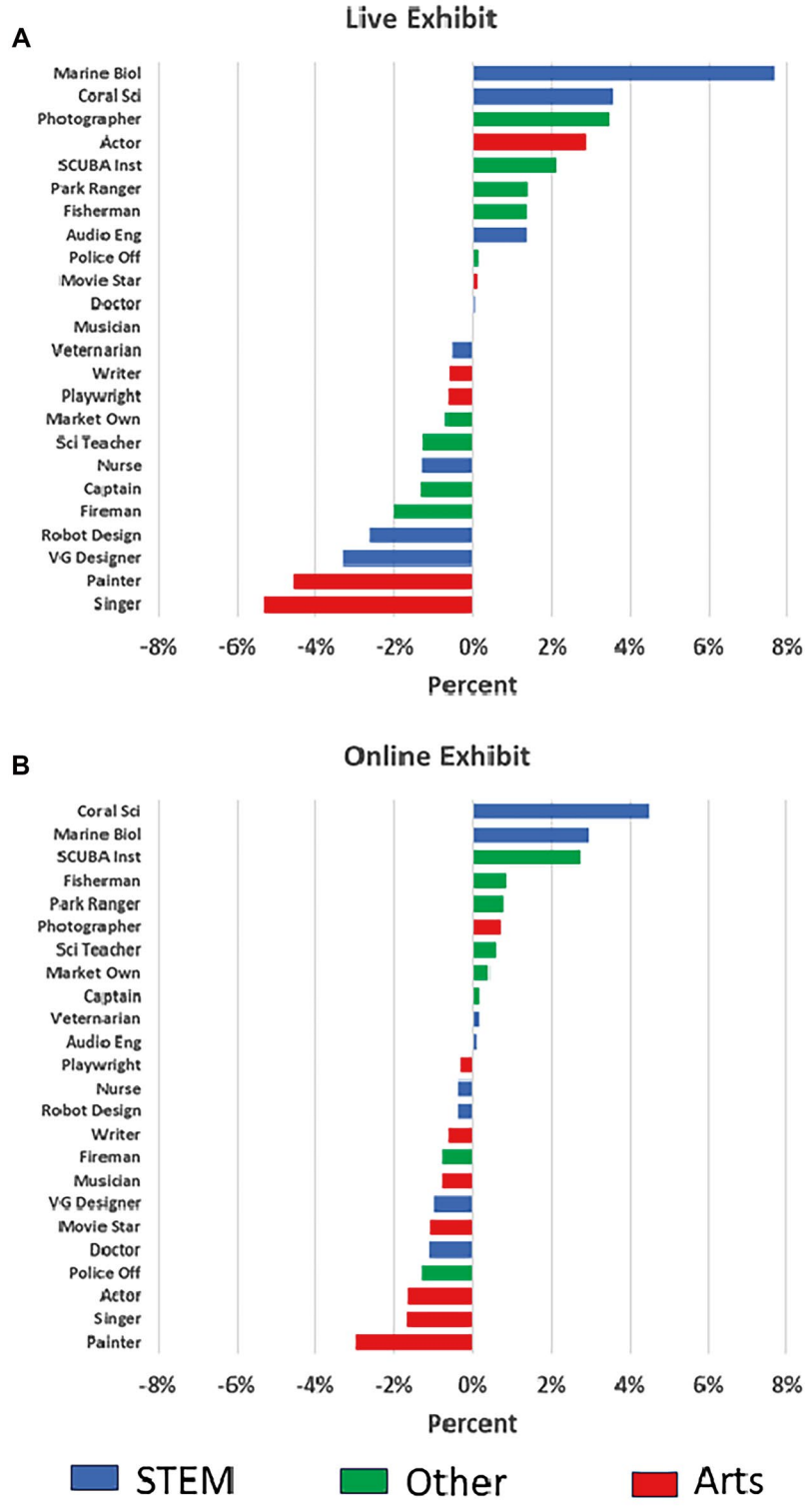


Fig. 14.5 I Sea Myself career interest assessment results gains (post-pre differences) for interests in careers in STEM (blue bars), Arts (red bars), and Other (green bars). (A) Live performance and exhibit and (B) online exhibit only

However, Ocean health is a topic that children are prepared to learn about and ready to take action to address. Programs for young children that involve hands on experiences can be very successful (Lai 2021) and may be even more effective than traditional classroom methods of instruction (Tugurian and Carrier 2017). These gains are not just limited to children who are familiar with the Ocean due to their geographic proximity. It may be even more important for children in rural inland areas who have never seen the Ocean (Hartman et al. 2017). This messaging is even more effective when the story can be told in song (Tallapragada et al. 2021). Two teachers in upstate South Carolina (USA) shared their unsolicited positive reviews about our conservation themed musical performances.

> I am very excited about all your resources…your educational content is spot on with our standards. I appreciate all of the work you are doing to educate our children and make learning innovative and fun. Melissa Stovall—First Grade Teacher, McKissick Academy

> Our K-4 adored your presentation! You are amazing! Thank you so much for sharing your time with us. My students enjoyed your presentation! I loved how you combined education with your music and stories! Thank you so much for the great presentation! Thanks for making it so interesting! Jennifer Steele—Fourth Grade Teacher; Lauren Ready—Special Education Teacher, Ravenell Elementary School

Three schools developed their own units on the Ocean and have invited us into their classrooms. By eliminating the barriers that might prevent teachers from teaching climate change through participation in an informal marine science musical theatre STEAM program, we hope SVF will become a community model for how to engage children, parents, and teachers to take ownership of their future and the future of our planet. The keys are to (1) bring the Ocean to the children in a comfortable informal setting such as an aquarium, a community theatre, or a performing arts center, (2) tell the children a moving story or sing them a song about what is happening right now to our Ocean and the critters they love, (3) show them that many people in their community are helping, and (4) motivate them towards hope and action to heal the Ocean and the planet. In this study and in previously published studies (Lai 2021; Tallapragada et al. 2021) children ages 7–8 show the greatest gains in Ocean Literacy knowledge and emotional connection. Gains for younger students attending the live performance might have been more apparent if we were to increase our sampling effort. This helps us to focus our framework for future programs to strike that critical balance between teaching about real world problems while inspiring and empowering our youth to be part of the solution.

14.4.2 Storytelling Is the Key to Telling a Meaningful Story

Ocean Literacy is best learned when it enters through the heart. The emotional connections we form in our early years of development set the stage for the actions we take as adults (Escobar and Gutiérrez-Graudiņš 2019). But sometimes it is difficult for children to express their emotions. That is why we choose to use a personal meaning map approach to assess our program. Personal meaning maps have been used for many years to evaluate the impact of museum exhibits by having children draw what they experienced. The drawings provide a glimpse of how the exhibit appears to the child, but also how they feel about the experience (Falk 2003). By including a drawing assessment before and after attending our SVF performance, we were able to use one assessment that could be administered to children ages 5–10, that revealed the elements of our program with the greatest impact, while engaging the overall emotional response to the story. Post-assessment drawings were much more likely to include animals in distress such as a sea turtle caught in a net or discarded plastic bottles littering the sea floor. But the free response portion of the drawings often included messages of hope about how we can do better and why saving the Ocean matters to them personally.

The emotional connection was not just on the children, but also on the parents, caregivers, teachers, and performers that were involved in the program. Previous and ongoing assessments

of our university student docents indicate that participation in our SVF exhibit influences knowledge, careers, and attitudes, and specially, a sense of belonging and identity in science (Sims et al. 2021). Parents and teachers have shared stories of how their children, after attending our program, instigated new recycling efforts in their home or classroom or wanted to visit an aquarium to learn more (Tallapragada et al., 2023).

14.4.3 Children Could Be Effective/ Helpful Messengers

There are many experiences that children have during their development that influence their identity. Our SVF program seeks to portray numerous different identities that show a strong affection for the Ocean both onstage and in our science exhibit. Through our musical theatre performances, we expose children to visual and performing arts careers such as singers, actors, and puppeteers. Through our hands-on science exhibit, children transplant plaster corals back onto the reef, hold live marine invertebrates, and meet veterinarians, marine biologists, park rangers and SCUBA divers. Our assessments show that children do alter their own career interests after attending our program. In general increases in Ocean related STEM careers (marine scientist, coral biologist) increased for both live and online programs, but we also saw increased interest in performing arts careers (actor) for those children who attended SVF the musical (Tallapragada et al. 2021). This was particularly true for children from impoverished families attending rural schools (Title I). These children saw the greatest gains in Ocean Literacy knowledge, but more importantly, they saw performers and docents that looked like them (60% female, 15% non-white) as scientists, engineers, teachers, and artists all helping do their part to save the Ocean (Hartman et al. 2017).

Children are great storytellers and more importantly, they are capable of great influence on their parents' attitudes. The recent study by Lawson et al. (2019) found that parents of children that participated in environmentally focused programs showed significant gains in their concerns about climate change. So, if the goal is to get more adults to "behave in ways that ensure a healthy Ocean, to sustain all life–current and future" (Glithero et al. 2024), we need only to inspire and empower our children (Corner et al. 2015; Dou et al. 2019; Tugurian and Carrier 2017). As the finale song from SVF the musical teaches us "Together we are, stronger by far."

14.4.4 Changing Our Public Engagement of Science

Our SVF program uses the logic model proposed by the Theory of Change for Public Engagement with Science (TCPES), developed by the American Association for the Advancement of Science (AAAS n.d.). This theory of change model was designed to provide a foundational framework for engaging scientists, practitioners, and the public. The model suggests using engagement through deliberation, dialogue, knowledge co-production, university-led cooperatives, and informal practices to achieve outcomes such as improved perceptions, increased trust, interest, affect, and skills, as well as a sense of identity and connection among scientists, practitioners, and the public. Our program has benefited greatly from this collaborative partnership of a marine biologist, a musician, and a communication scientist working with children, teachers, performing arts professionals, and university students to educate children, teachers, and the public about the challenges our Ocean faces and the ways we can help (Tallapragada et al. 2021). We hope it can be a model "to inspire and generate the motivation, capability, and opportunity for people to make decisions and behave in ways that ensure a healthy Ocean, to sustain all life–current and future." (Glithero et al. 2024).

14.5 Conclusion

Children are our best hope for saving the Ocean. Their natural empathy, willingness to work hard, and unwavering believe in their ability to change the world must be carefully nurtured while helping them to understand the severity of the crisis our Ocean faces. We owe it to them to give them the tools to face an uncertain future, but also to listen and learn from them about the power of hope and the determination to make a difference.

14.5.1 Summary

Key concepts explored in this chapter include:

- Ocean Literacy is important for raising awareness of our changing climate.
- Personal communication with teachers, parents, and community members helps to overcome hesitancy.
- Live in-person performance outperforms online presentations.
- Children's drawings show much about their knowledge of the Ocean.
- Children feel an emotional connection to Ocean well-being.
- Exposure to Ocean STEM careers influences children's Ocean identity.
- Performing for children positively affects the lives of the performers.

14.5.2 Recommended References

The following resources provide further insights and support on this topic:

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15 Transdisciplinary Approaches to Ocean Literacy Through Student Agency and the Performing Arts

Daniel Kasnick, Elena Bentin, and Jonathan González

Abstract

This chapter shares best practices for advancing Ocean Literacy in formal education through transdisciplinary approaches that prioritize student agency. Drawing on the example of a student-led theater production created and performed by third to fifth-grade students (ages 9–12), the chapter explores how Ocean Literacy can transcend the traditional boundaries of science education and permeate an entire school culture. Emphasizing a cultural shift toward a more Ocean-connected society, the chapter highlights the intentional integration of *Challenge 10: Restore Society's Relationship with the Ocean* across all elements of the production. Key factors contributing to the project's success include transdisciplinary learning, authentic stakeholder involvement, social responsibility, the creative process, soft skills development, and a strong sense of legacy. The chapter illustrates how a holistic, experiential approach—guided by student voice and agency—can create meaningful educational experiences that foster lasting connections between students and the Ocean.

Keywords

Student agency · Transdisciplinary education · Ocean Literacy (OL)

15.1 Introduction: A Transdisciplinary Approach

In the International Baccalaureate Primary Years Programme (IB PYP), *transdisciplinary learning* is described as an approach that transcends traditional subject boundaries, encouraging students to explore broad, real-world concepts and issues through an integrated framework. This type of learning emphasizes inquiry-based methods, allowing students to connect knowledge across disciplines and engage with meaningful, real-life contexts (International Baccalaureate Organization 2018a, 2018b). Similarly, Drake and Reid (2018) define transdisciplinary learning as an approach that "seeks to relate all disciplines around a particular theme or concept" in order to foster a holistic understanding and application of knowledge across subject areas. This method enables students to engage with content in ways that transcend conventional academic silos, inte-

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grating skills and ideas to address complex problems.

For the purposes of this chapter, we define *transdisciplinary learning* as an educational approach that blends traditional subject areas in formal education through holistic, experiential learning including knowledge building, skill development, and conceptual understanding. The learning takes place not only in traditional classroom settings but also in real-world contexts, and is fundamentally driven by student agency, an educational approach that positions students as protagonists in a social-constructivist environment. Through this lens, students are encouraged and supported to take active roles in their learning processes, express their voices, and engage in authentic experiences that extend into real-world action.

The success of the student-led theater production described in this chapter was shaped by its transdisciplinary foundation. The production did not remain confined within the theater arts department. Instead, it became a fusion of disciplines including science, humanities, language, music, visual arts, and inquiry-based learning. This integrated approach allowed both students and teachers to explore Ocean Literacy from multiple perspectives, fostering deeper reflections on humanity's relationship with the Ocean. In this context, Ocean Literacy extended beyond the traditional science curriculum and emerged as a multidimensional, collaborative, and creative endeavor.

This approach aligns directly with the Ocean Decade Vision 2030 White Papers issued by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which advocate for a transdisciplinary strategy to address *Challenge 10: Restore Society's Relationship with the Ocean*. Within the white paper, a visual framework outlines the "Drivers of Ocean Connection and Behaviour Change" under the theme *An Ocean Connected Society* (Glithero et al. 2024). These drivers include "Knowledge Systems, Education, Communication, and Cultural Connections," all of which are addressed and illustrated through the case study presented in this chapter (see Fig. 15.1).

By embedding Ocean Literacy in a transdisciplinary context led by student agency, this chapter offers a compelling model for fostering deeper connections between learners and the Ocean, empowering students not only to understand the Ocean system but to take meaningful, creative action toward a more sustainable and interconnected future.

We made a deliberate and consistent effort to make Challenge 10 visible in every aspect of the play wherever possible. An important factor was the documentation and storytelling of the process leading up to the play that promoted student agency. The desire to tell our story added an extra element of detail to the journey and kept us on track with the Ocean Decade Challenge 10.

> With this experience, I have been able to confirm that age is not a limitation to being a "generator of awareness" about the conservation of our natural wealth and biodiversity. Children of different ages, teachers, parents, school staff, etc. have participated in this work and all are committed to the same message: we must be part of the change and do it now.—Mother of Student

15.2 Context

The school featured in this example is an international school in Latin America, serving students from age 3 in Preschool through age 17 in Secondary School. All grade levels offer learning in a bilingual setting with an inquiry approach offered by the International Baccalaureate Program. This chapter employs storytelling as a key feature to share how the school followed a methodology created by their teachers to guide students toward meaningful learning and action in Ocean Literacy and how similar actions can take place in other formal educational settings.

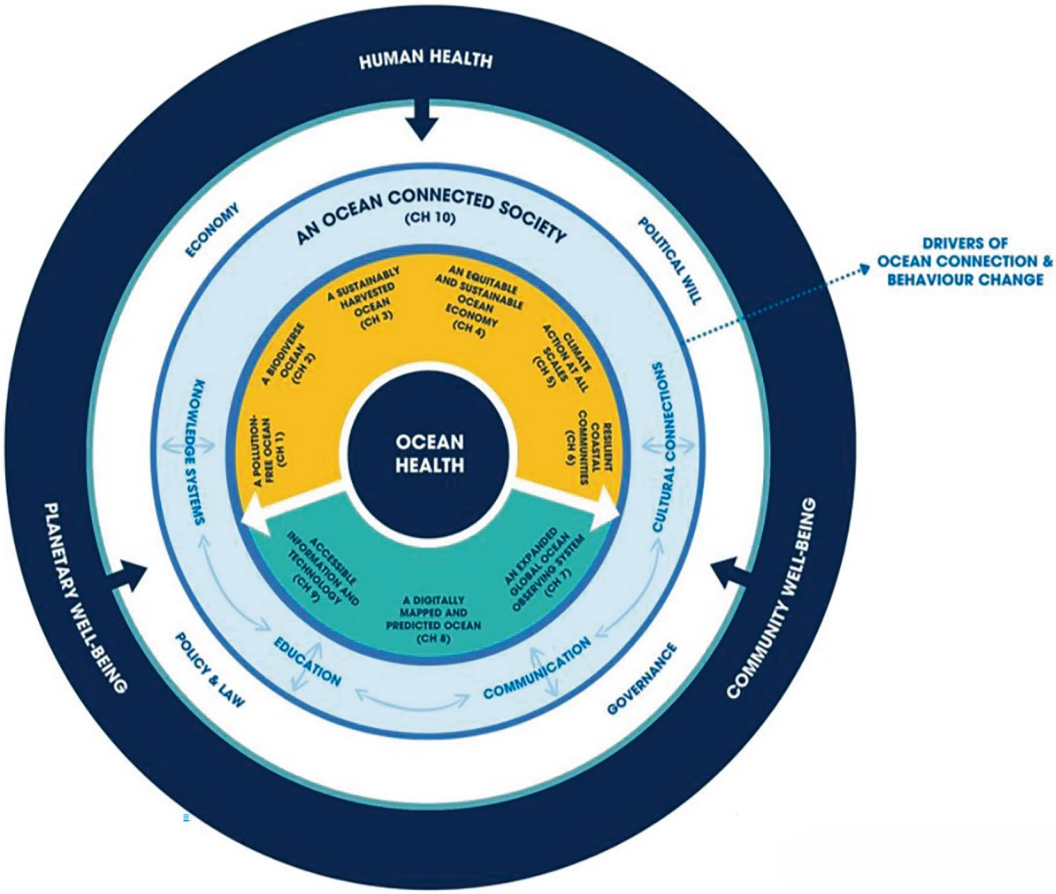


Fig. 15.1 Challenge 10 conceptual framework

Incorporating the storytelling approach in this chapter is exemplified in *Making Learning Visible* by Harvard Project Zero. The chapter uses narrative to emphasize learning experiences and insights as central themes. This method, inspired by Project Zero's focus on collaborative, visible learning, leverages storytelling to deepen understanding and engagement, making abstract ideas more tangible and relatable (Ritchhart et al. 2011). Studies and definitions that support the creative process are provided in this chapter and aim to show theory in practice.

The "Creative Process" as illustrated in Fig. 15.2, displays visually the route taken by students, teachers, and various stakeholders to the final production. It follows the steps from the outermost circle toward the innermost circle:

1. Presenting the Project: Learning theatre arts languages and introducing the themes and associated inquiry topics.
2. Inquiry time: Exchanging information with experts and creating the story, script and characters.
3. Designing the stage, settings, and props, and composing music and dance.
4. Memorizing the words and exploring characters.
5. Montage and Rehearsal.
6. Play and Action.

These steps are provided as a roadmap for creating similar projects with learning in the process leading up to the production. Each stage of the process is explored and the connection made to Ocean Literacy is presented.



Fig. 15.2 Outline of creative process

Although the school presented in this chapter had always placed a priority on Education for Sustainable Development (ESD), it was only in recent years that Ocean Literacy took the stage within the school and this project was its opportunity to reach more of the school's stakeholders. Once the play was taking shape, with Ocean Literacy becoming embedded into various aspects, it was decided to apply as an official Ocean Decade event to help raise this awareness. Joining the Ocean Decade in an official manner opened further opportunities to involve additional stakeholders and expand the reach of the project.

15.3 Soft Skills and Student Agency

In the IB Primary Years Programme (PYP), *student agency* is defined as the ability of students to have responsibility for their learning through voice, choice, and ownership. This involves students actively participating in the learning process by making choices, setting goals, and reflecting on their progress. Student agency empowers learners to take initiative, make decisions, and pursue their interests, promoting a sense of control and engagement in their educational journey. Through agency, students become "partners in the learning process," fostering independence and self-motivation (International Baccalaureate Organization 2018a, 2018b).

Another definition of *student agency* describes it as the capacity of students to act purposefully and constructively to shape their learning. This involves students not only setting personal goals and making choices in their educational activities but also being motivated to engage actively and independently in their learning. Student agency is viewed as essential for fostering autonomy, self-regulation, and a sense of ownership over only educational outcomes (Kaput 2018).

Student agency is defined by the authors of this chapter as an educational approach that places the students as the protagonists in a social constructivist setting to encourage and support authentic learning experiences, voice in all aspects of learning and action in real-world contexts.

There is a growing focus in education on the need for students to develop soft skills to meet the challenges of our modern world and student agency is an essential element for developing soft skills. Schools must be more explicit than ever in

the fostering of self-management, collaboration, and creative thinking skills that are later applied in real-world settings. The processes and demands of theater productions naturally call on students to apply these soft skills authentically.

During this process, students took roles on a rotating basis of researchers, playwrights, set designers, producers, directors, and audience members. This versatility drives them and inspires them to make a constant and meaningful contribution toward the final production.

This dynamic not only enriches the project but also infuses the production with their identity, originality, and perspective. In this way, theater becomes a holistic educational tool that teaches students teamwork and responsibility while nurturing new passions, talents, and forms of expression, all within the context of a project that creates meaningful impact beyond their local community. It is student agency that provides this element and enhances the learning experience, which in this case responds directly to "*An Ocean Connected Society*".

> I have learned the importance of the Ocean in the world and how it affects us. From now on I am very committed and connected with SDG 14 and its objectives to help the sea.—4th grade Student

15.4 The Final Production: The Curtain Call

The curtain reopens in the theater for the curtain call; however, the actors are not lined up for yet another bow as one would expect. An all-out dance party is taking place on the stage and the student actors run out into the audience to start an impromptu dance session as the live student orchestra continues to jam. The screen behind the stage rolls videos of students, teachers, parents, staff members, tech support members, and other key players from the production grooving over vibrant backdrops of the Ocean. The third through fifth-grade students have just completed the final night of their much-anticipated production and have only left to let loose in the excitement of the evening (see Fig. 15.3).

Our precious and diverse Ocean is not just being learned about on this occasion, but truly and fully celebrated. Ocean awareness has converted into a deep passion, transcending traditional perimeters of course subjects, ages, roles, and interests.

This transdisciplinary theater arts production has brought together various grade levels, multi-



Fig. 15.3 Final bow moment. Photo by: Mauricio Terán

ple school departments, non-profit organizations, stakeholders, and communities; all elevated by the focus on student agency throughout the process.

15.5 The Creative Process

As stated above, the educators in this project designed what they refer to as the "*Creative Process*" with six concentric circles leading up to the final production of the play. The next section of this chapter will unpack each of these steps and relate them to Ocean Literacy through transdisciplinary learning.

15.5.1 Presenting the Project: Learning Theatre Arts Languages and Introducing Themes and Inquiry Topics

During the initial step of the process, clear guidelines were set out for students to engage with to ensure success in the final production as well as in terms of sharing its message. Student agency is sometimes misunderstood as an entirely open-ended approach to education, lacking structure and boundaries. However, as demonstrated in this case, students were required to meet several defined expectations throughout the process. This aligns with the findings of Robinson and Aronica (2015), who emphasize that while fostering student agency is vital for encouraging self-regulation and intrinsic motivation, it should not be mistaken for a free-for-all model. In reality, effective student agency relies on well-defined frameworks and consistent support from educators to guide purposeful decision-making within academic parameters.

The project was presented to students with guidelines around academic outcomes as well as the Ocean Literacy principles. This allowed students to still have plenty of agency in the process and encouraged their curiosity to learn more about the topics. It was also important at this stage to provide students with knowledge of the theater arts languages that would be their medium for their final product.

15.5.2 Inquiry Time: Exchanging Information with Experts and Creating the Story, Script, and Characters

The Primary Years Program of the International Baccalaureate is one based on inquiry learning. As students began to explore the various concepts, principles, and topics of Ocean Literacy and the performing arts, their learning naturally took them beyond the classroom into an experiential learning state including research, interviews with experts, and drawing conclusions.

The original script for the play provided the baseline for the students to work from and build on. As their inquiry deepened, the students made adaptations to the script to explicitly include the Ocean Literacy principles they had come to understand. This freedom to adapt the script is an example of how student agency lives within parameters (the original script) but also can evolve with the inquiry (the adaptations). Student created scripts exemplify how students exercised agency throughout the process (see Sect. 15.5.4.1 for excerpts).

As supported by Kolb, by reaching out to experts in the field, students can build understandings in relevant and meaningful ways. "Experiential learning engages students in direct experiences and focused reflection to increase knowledge, develop skills, and clarify values. Through inquiry-based methods like interviews with experts, students actively construct understanding, moving beyond passive learning to engage directly with real-world perspectives and complex problem-solving." (Kolb and Kolb 2017).

The conclusions made by students were not based on a predetermined set of facts, however, based on the conceptual understandings built by students that drove the performance forward with



Fig. 15.4 Lower school students' orchestra playing. Photo by: Mauricio Terán

purpose and clarity. These conclusions laid the foundation for the script itself and the characters within it.

15.5.3 Designing the Stage, Sets, Props, Music and Choreography

The third stage is where we see an overlap of the visual and performing arts occurring as students design and build the stage elements and piece together the musical aspects of the play (see Fig. 15.4). Due to the high level of agency and the conclusions made by students in the inquiry process, this stage was completed with a high level of pride, creativity, and ownership.

The transdisciplinary nature of the project ensured that the artistic features of the project were enhanced and supported by the inquiries that had taken place. There were many decisions made during this stage that were the direct results of their inquiry, and the conclusions made from it. For example, a floating island of plastic was created on stage with accompanying projections that intensified their findings about the current risks to the Ocean.

15.5.4 Memorizing the Words and Exploring Characters

Although this stage of the process may seem to take away from the inquiry-based, transdisciplinary approach, it is far from that. By learning their lines and exploring their characters, the student actors entered the world of the play and still maintained their agency. At many points in the process, lines were rewritten, and entire sections were included based on their learnings. The exploration of the characters also held true to the transdisciplinary approach as students researched their roles and questioned how they would portray them.

15.5.4.1 Excerpts From the Script

The two excerpts provided here are from the script which are adaptations written by the students after coming to various conclusions during the inquiry process. In both cases, the students acted on their agency and approached their teachers to include these scenes. These additional scenes are examples of how student agency works within a provided framework with flexibility for voice and choice which built their sense of ownership further.

1st Script Excerpt:

CORDELIA: (to the sea and its inhabitants) Isla, come, look… isn't it beautiful?

ISLA: It is, but be careful if you fall, Cordelia

CORDELIA: Do you know why I am a marine biologist?

ISLA: because we like the sea so much?

CORDELIA: Since I was a child, yes. But I have always felt the call of the Ocean, many times during our afternoon journeys, standing here, I have dreamed of being one of them, a grain of sand, a little foam that plays in the waves, a turtle, a star of the sea, a mermaid… a beautiful and wonderful mermaid who swims freely and without fear through the Ocean, a clean one… But mermaids do not exist, and humans pollute the sea and harm other species.

ISLA: Do you think that one day, we humans will stop seeing other species as inferior to us?

CORDELIA: Stop feeling like we are the owners of the world.

ISLA: Yes.

CORDELIA: We will have to change our way of thinking, our way of acting, make decisions thinking about everyone, not just ourselves, respect the spaces and ways of life of each species, understand that the planet is the home of many and that everything we do to it, from when we buy a plastic bag in the supermarket, to when we prefer something new before reusing, wearing new clothes every season, not being aware of our waste and how it affects them, do they affect us? Do their actions destroy our ecosystems?

ISLA: Cordelia, don't worry, that's why we are here, fighting on the high seas, so that the world is a better place for everyone, for now, we can only dream that tomorrow will be the first day in which we have the best of both worlds, dream!

CORDELIA: Let's dream Isla!

2nd Script Excerpt (see Fig. 15.5).

SABRINA: They don't care about the damage our Ocean is facing.

SHIRIN: It's true, humans continue to pollute, and we no longer have another place to live.

SERENA: Humans contaminate our home without us contaminating theirs.

SIMONA: Have you started to think that no human being would like to live under tons of garbage?



Fig. 15.5 Play characters performing the scene about human damage to the Ocean. Photo by: Mauricio Terán

SERENA: We are thousands of marine beings who suffer from pollution.
SIMONA: There is an island of garbage on every continent, if the garbage continues to increase it will take over our Ocean.
SHIRIN: I think Dad is right, humans don't deserve to know us.
SABRINA: Is there any human who cares about life in the sea?

> I learned that to make a play it is super important to know how to work as a team and take it from the heart.—4th-grade student

15.5.5 Montage and Rehearsals

The second to last stage of the creative process involves all the pieces coming together. It was during this step that several stakeholders joined the project that were not involved at the start. It was always mapped out that the audience on the night of the production would learn a valuable lesson in Ocean Literacy, however, this stage engaged members of the school's administration, maintenance, and technology teams that became heavily involved in the cause. Rather than only focusing on the technical aspects of the production, these stakeholders shared their own personal connections to the Ocean and learned about Ocean Literacy through the students.

15.5.6 Play and Action

The final step in the process includes the production itself, as well as additional actions taken as outcomes of the inquiry process. As a leading expert in inquiry-based learning, Kath Murdoch's inquiry process involves students moving through phases of *tuning in*, *finding out*, *sorting out*, *going further*, *making conclusions*, and *taking action*, guiding them from initial curiosity to meaningful real-world application by organizing, exploring, and synthesizing knowledge at each stage (Murdoch 2015). The creative process spelled out here follows such an inquiry cycle and also includes the crucial step of action.

In the Primary Years Programme (PYP), types of action include: personal action, where students make changes in their own lives; social action, involving collaboration with others; and advocacy, which encourages students to share ideas and inspire change, fostering responsible and impactful participation in their communities (International Baccalaureate Organization 2018a, 2018b). In the case of the play, students participated in all three forms. The play itself brought both personal action and advocacy through its inquiry process with students and the message shared with the audience. Social action took the form through the funds raised to support the student-founded non-profit organization, Oceanica, which supports Ocean Literacy among schools in Peru. These forms of action were presented to the students as a form of reflection on their learning, further deepening their agency in the project.

> With this work, I have been aware of how important the sea is for human life. I am very committed to SDG 14 and willing to continue helping the sea.—5th grade Student

15.6 The Stakeholders

Although the actors and musicians that performed in the play were third, fourth, and fifth graders, they were supported by an entire learning community that was either fully convinced already of the importance of the Ocean in our lives or organically became passionate throughout the process of creating the play. This deep connection expands beyond knowledge to include an emotional relationship with the Ocean, which was transmitted to the stakeholders that came on board along the way.

The first group of stakeholders, after the students entered the scene, included teachers from various subject backgrounds. Their involvement was crucial, and they educated themselves about the various Ocean Literacy topics explored in the



Fig. 15.6 Lower school actors on their way to start the play. Photo by: Mauricio Terán

play. This was soon supported by the arrival of secondary school students who joined in the formation of the young actors.

A group of secondary students had previously won the Sea Beyond award from UNESCO-IOC and Prada Group and had since established their own not-for-profit, Oceanica, to increase Ocean Literacy awareness. Oceanica's members aided in the preparation of the play and guided the student actors to learn more about Ocean Literacy principles. Oceanica also became the beneficiary of the ticket sales to support them as they promoted their work to a wider audience.

Additional stakeholders became involved in the process such as parents, administrators, and technical crews (see Fig. 15.6). Although the majority of these stakeholders did not have a need to learn about Ocean Literacy to fulfill their role in the play, we witnessed them taking this measure naturally.

Including all the various stakeholders in the production also raised the visibility of Challenge 10 and made the multidisciplinary nature of the production more transdisciplinary. No longer were various stakeholders like stagehands, recording crews, and maintenance workers behind the scenes, but active participants in the sharing of the play's message. As valued members of the team, they converted into Ocean Literacy champions and expressed their own personal connections with the Ocean.

> In this collaborative project, in which students, educational and administrative staff, maintenance, conservation, and parents participated, we learned that there is strength in unity and that we can achieve anything we set our minds to. We were able to appreciate the talent of the young actors, their desire to teach everyone what they had learned and, above all, put what they learned into action. It has been a very rewarding job for everyone.—School Administrator

15.7 Social Responsibility

As a theater production, we were already making an impact through the message being shared with the audience, however, reaching beyond the rows of the audience was a factor that made it even more impactful. The selection of the student-led not-for-profit, Oceanica, was a clear match for this project as the beneficiary of the funds raised. Oceanica is completely run by secondary students, and their role was crucial in the inquiry process with the younger students. Their mission is to take on responsibility for conserving our Ocean, through surface-level changes which ben-

efit our communities and environment in the short term, to structural and institutional changes which set the ground for Sustainable Development. Additionally, their vision is to inspire young people from all over the world to be active agents of change in the context of marine conservation and the preservation of our planet, through hands-on project-based actions and learning.

The members of Oceanica educated the primary students about Ocean Literacy principles and organized various aspects of the production itself. Their presence at the event was quickly recognizable by their blue shirts and Jacques Cousteau-inspired red stocking caps. They served as ushers and ran the refreshments stand to raise funds for their cause.

As a result of the production's success, Oceanica has been able to expand to other schools and increase its impact in spreading Ocean Literacy. It has also opened the door for students who were once primary-aged students learning from secondary students to someday evolve into leadership roles in the future.

> I reaffirm my connection with sustainability and motivate my community, in the first instance students and teachers, preparing them for global challenges. My pedagogical approach is participatory, promoting meaning learning.—Music Teacher

15.8 The Legacy

There was, without a doubt, a culture shift following the performance. Ocean Literacy had taken the stage, and a feeling of momentum could be felt at all levels of the school. It was a new normal to include the Ocean in school life, both inside and outside of the curriculum.

Audiences members were not merely passive spectators; they became active participants, inspired by the performance to take meaningful action in protecting our Ocean. The students immersed themselves in this project with impressive energy and enthusiasm, giving themselves names such as "The Guardians of the Sea," "The Heroes of the Ocean," and "The Superheroes of Sea Animals." These names are not just titles but represent a deep sense of identity and belonging to the project. From day one, the children have shown great motivation to participate, as the connections with their own life experiences have inspired the themes of the play and the message that will be seen on stage in years to come.

These types of experiential experiences not only enrich the learning process but also strengthen the students' emotional bond with the sea and its biodiversity. Through theater, children not only learn about the Ocean and the challenges it faces but also develop a deeper understanding of their responsibility as citizens of the world. The play, therefore, is not just an artistic representation; it is an educational platform that inspires young people to be agents of change, committed to the protection and conservation of our Ocean for future generations (Fig. 15.7).

Transdisciplinary approaches to Ocean Literacy in formal education are an outstanding example of what it means to create "an Ocean-connected society".

> "I was inspired by biologists because they studied marine species and how to help them so they don't become extinct."—5th grade Student

15.9 Insights for Educators

The narrative of this theater production tells the success of Ocean Literacy in a transdisciplinary and cross-grade-level school setting. Realizing that educators come from a wide variety of contexts and realities, it is important to highlight some insights and takeaways for any institution hoping to bring Ocean Literacy alive in their communities. Here are a few of our thoughts and takeaways for educators:

- Focus on student agency: Allow students to make key decisions in the process and celebrate their voices in any Ocean Literacy movement. Taking on a more mentor than traditional teacher role is essential in sending the message that we trust students and that they are capable of being agents of change. The result-



Fig. 15.7 Lower school students on stage showing their commitment to the Ocean. Photo by: Mauricio Terán

ing actions will be more authentic, longer lasting, and more effective in their message.

- Consider the stakeholders: Take the time to consider all stakeholders in the production. We were pleasantly surprised by the amount of involvement and development of Ocean Literacy by stakeholders we did not think to involve from the start. A culture shift is only possible when all stakeholders are seen and valued in their efforts. Including staff members like maintenance workers and office secretaries along with teachers and parents encouraged the production to break out of the theater walls and seep into all aspects of school life. In Spanish, Ocean Literacy is translated as "Ocean Culture" which sums up this idea well. It is not about one-off actions but cultural shifts towards sustainability that involve the entire school community.
- Bridge age groups: Bring in students from various grade levels to be involved in the production. The lessons the secondary students taught the younger students were far more interesting coming from them than their regular teachers. The older students conveyed a great passion for the Ocean while deepening their knowledge as they prepared to host sessions for the primary school students. There also exists the important aspect of younger students projecting themselves in the future through these interactions. Providing positive interactions across grade levels allows younger students to have role models for the Ocean that can heavily influence their trajectories.
- Involve experts and support locally: Reach out to local organizations and make them part of your project. Students learn a lot from interactions with experts, and they can make an impact beyond the school walls. These opportunities provide glimpses into the professional world of Ocean Literacy and the blue economy. In addition, giving students a voice in the selection process of a beneficiary organization increases students' voices and sends the message that they are never too young to support the local efforts around them. This support expands their action from advocacy to also include supporting actions in their local context.
- Celebrate: Keeping a flexible and playful element to our project invited a deeper connection to the Ocean and a sense that we were making progress. An important component of Ocean Decade Challenge 10, *Restore Society's Relationship with the Ocean*, is the social-emotional side that must be included.

> It has helped me see the profound value of integrating global issues, such as the Sustainable Development Goals, into education from an early age. This project has shown me how learning can go beyond the classroom and have a real impact on the training of young citizens committed to sustainability. It has also made me reflect on the power of the arts in education, and how theater can be a transformative tool to transmit values and generate meaningful learning.—School Leadership Member

15.10 Conclusion: An Ocean-Connected Society

An Ocean-connected society is a central outcome of our inquiry program. Step by step students build knowledge and understanding that instill a deep care for the Ocean. Discovering the wonders of the sea and its vast mysteries were all present in this project, as well as other inquiries that take place throughout their school life.

Taking their love for the sea seriously now has a clear route within the school community thanks to the development of Oceanica. Younger students now dream of joining this group and visualize themselves becoming professionals within the Ocean sector and the blue economy. From the earliest years of the school through graduation, opportunities are provided for students to interact with the Ocean on academic and social levels.

The vast and complex Ocean can be an overwhelming topic to engage with young learners. Challenge 10 has been our gateway that has led students into immersive inquiries with rich knowledge being obtained. The creative cycle sets out to achieve this human connection and follows the larger concepts of concept, motif, and identity.

First, it is essential to present the concept of the play in an attractive and accessible way to students. This involves not only teaching them about the majesty of the Oceans but also explaining how they will contribute to bringing this artistic project to life (Fig. 15.8). We must invite students to dream together with us, showing them how their ideas, actions, and efforts can be an active part of a representation that inspires others to care for our blue planet.

Secondly, it is necessary to introduce the reason behind the creation of a play. The key here is



Fig. 15.8 Lower school students' choir singing on stage. Photo by: Mauricio Terán

to highlight the importance of the learning that is generated by exploring the Ocean and how this knowledge can be transformed into a powerful stage message that has a significant impact on our local and global community. It should be a constant reflection that guides students to stay focused on the objectives of the project, helping them understand that they are contributing to something bigger than themselves.

Finally, identity plays a crucial role in the process. It is essential to help students see themselves reflected in the project, understand their unique role within the work, and how their artistic participation contributes not only to the success of the production but also to the well-being of the planet. By getting children to identify with the cause and understand the value of their actions on stage, we are not only teaching them about the Ocean, but we are also helping them forge a deep and meaningful connection with the natural world. In this way, the play they present becomes much more than a simple performance; it is an act of love toward our planet, a powerful statement that has the potential to inspire others and transform realities.

Following the play, students had the opportunity to present the proceeds raised to Oceanica. It was a moment of gratitude, unity, and celebration, marking not only the achievement of our goals but the surpassing of them (see Fig. 15.9). Students were seen and heard by their community and were empowered to create changes. The students pictured here accepted a challenge and rose to the occasion. Their message was written in their own words and was well received. The presentation of the proceeds was the final stroke in their masterpiece, but a lifetime of Ocean actions awaits each one of them. A new generation of Ocean-Literate individuals had been formed.



Fig. 15.9 Lower school students' cast presenting the proceeds raised to Oceanica. Photo by: Mauricio Terán

15.10.1 Summary

Key concepts explored in this chapter include:

- Transdisciplinary learning empowered students to explore Ocean Literacy through multiple lenses, enabling them to make meaningful connections across disciplines and take informed action aligned with Ocean Decade Challenge 10.
- Emphasizing student agency allowed learners to take ownership of their educational journey, resulting in increased motivation, collaboration, and creative problem-solving rooted in real-world sustainability challenges.
- Using a clear creative process framework provided structure and guidance, helping students navigate from concept development to final performance with confidence, while promoting deeper engagement and purposeful learning.
- Experiential learning—such as interviews with experts and community-based collaboration—led students to construct authentic understanding, develop communication skills, and build lasting connections to Ocean issues and solutions.
- Involving a wide range of stakeholders fostered a shared sense of purpose and collective responsibility, turning a school project into a transformative cultural shift that embraced Ocean Literacy throughout the community.
- The final student-led theater production served as a platform for advocacy and outreach, successfully raising awareness, inspiring action, and securing tangible support for Oceanica's continued impact.
- Through the creation and performance of student-written scripts, learners deepened their understanding of environmental issues while strengthening their voice, creativity, and commitment to becoming agents of change for the Ocean.

15.10.2 Recommend Resources

The following resources provide further insights and support on this topic:

- Kaput, K. (2018). *Student agency: The key to personalized learning*. Education Evolving.
- Murdoch, K. (2015). *The power of inquiry: Teaching and learning with curiosity, creativity and purpose in the contemporary classroom*. Seastar Education.
- Ritchhart, R., Church, M., & Morrison, K. (2011). *Making thinking visible: How to promote engagement, understanding, and independence for all learners*. Jossey-Bass.
- Robinson, K., & Aronica, L. (2015). *Creative schools: The grassroots revolution that's transforming education.* Penguin Books.

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Robinson K, Aronica L (2015) Creative schools: the grassroots revolution that's transforming education. Penguin Books

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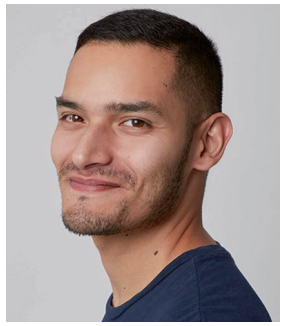
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Daniel Kasnick is the Head of the Early Learning School at Colegio Altair in Lima, Peru. He is an educator dedicated to creating authentic and experiential learning for students to foster sustainability, social inclusion, and innovation. His roles have also included director of nonprofits, teacher, and coordinator of a community center in the United States, Peru, Haiti, and Australia. Additionally, he is the founder and director of a camp program to bring youth into direct contact with nature and provide an environment for personal and social growth. He is part of the UNESCO-IOC Group of Experts on Ocean Literacy and first prize winner of the Sea Beyond contest hosted by UNESCO and the Prada Group. Daniel has presented at conferences such as the COP28, the UN Ocean Conference, the International Camping Fellowship, and the Latin American Heads Conference on topics of Education for sustainable development, student agency, and social inclusion. He holds a master's degree in international education policy, organization, and leadership from the University of Illinois.



Elena Bentin has dedicated herself to the study of theater, exploring various workshops and schools in Lima, Peru since 1994. Throughout her career, she has had the privilege of participating in a wide range of settings, however she found her true passion in projects that encouraged collective creation, where creative freedom and emotional connection were fundamental to bringing life to the works. In 2000, she took her first steps as a theater teacher, sharing her knowledge and experiences with enthusiasm. Since 2007, she has served as a professor and Deputy Head at Newton College, in the Theater Arts department within the framework of the PYP program. She graduated from the National School of Dramatic Arts of Peru, where she specialized in theater pedagogy, and is currently immersed in the process of obtaining another degree in the same area. Her professional and academic career has allowed me to develop a deep understanding of the nature of theater and its potential as an educational tool. Her commitment lies in continuing to explore new forms of teaching and theatrical creation to enrich the cultural and educational landscape of her community and she is firmly committed to promoting environmental awareness and action to care for the planet, integrating these values into her theatrical practice and educational work.



Jonathan González is a Theater teacher and Tutor at Lower School at Newton College in Lima, Peru. He is originally from Venezuela and has a bachelor's degree in Acting from the Universidad de los Andes in Mérida, specializing in Project Based Learning with the Innova Teaching School. He has taught in institutions and schools with different educational models (e.g., MALI—Saint Gerard School) before joining Newton and has experience in the classroom with elementary, primary, and secondary school students. In his free time, he likes to train in Theater Improvisation, read, sing, listen to podcasts, and visit new places in Peru.

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WE ARE OCEAN_Wadden Sea: Ocean Literacy and Youth Empowerment Through the Arts

16

Anne-Marie Melster

Abstract

Interdisciplinary art-science projects play a pivotal role in advancing Ocean Literacy by linking scientific knowledge with creative expression. Art and culture serve as influential vehicles that engage society on both emotional and intellectual levels, making complex Ocean issues accessible and inspiring broader audiences. The *WE ARE OCEAN_Wadden Sea* project, delivered by the curatorial collective ARTPORT_making waves, exemplifies how such projects can empower youth to take concrete, informed action toward Ocean conservation. This chapter highlights the potential of these collaborations to raise scientific understanding and political awareness through the arts. *WE ARE OCEAN_Wadden Sea* fostered participating students' awareness of humanity's deep interdependence with the Ocean, prompting shifts in perception that encourage behavioral change and social responsibility. Through experiential and embodied learning methods, the project offered immersive experiences that cultivated a profound personal connection to the Ocean, ultimately driving both social and political engagement.

Keywords

Ocean Literacy (OL) · Youth empowerment · Art-science workshop · Interdisciplinary collaboration · Creativity · Social action · Participation · Youth agency · Non-Governmental Organization (NGO)

16.1 Introduction

This chapter describes the WE ARE OCEAN_Wadden Sea project, which was implemented in Germany, The Netherlands, and Denmark from 2022 to 2023 under the umbrella of the WE ARE OCEAN Global Program, an initiative endorsed as a Decade Action of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) by the UNESCO Intergovernmental Oceanographic Commission (IOC). The title *WE ARE OCEAN* references the book *We Are the Ocean* (Hau'ofa and White 2008) by Tongan writer and ethnographer Epeli Hauʻofa, which explored topics related to the Ocean in Oceania—such as globalization, external influences, and alternative ways in which people can reorganize themselves to effectively respond to a changing world. According to Hauʻofa, the people of Oceania can only strengthen their ability to use the forces of globalization through creative originality in all areas of life. The title serves as a symbol of possible solutions worldwide regarding our

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Ocean and the important role of art in drawing attention to these issues.

With this title and the book, we intended a poetic reference that links Germany with the Pacific and situates the artist Lisa Rave, who contributed her knowledge of the Pacific region into the project's context in Berlin and Brandenburg. We deliberately separated ourselves from the "the" in Hau'ofa's original book title, to have the book as a reference, instead of appropriating its title. Our aim was to view the Ocean not as something distant or exotic, but as a presence that surrounds us and lives within us.

The project introduced the topic of the Wadden Sea to hundreds of school students across three countries through a unique art-science workshop methodology and public activities held in conjunction with an international Wadden Sea Conference.

The chapter focuses on the importance of Ocean Literacy within WE ARE OCEAN_Wadden Sea and how Ocean Literacy and Youth Empowerment can be achieved through interdisciplinary work across art, science, and education.

> The collective resources of artistic creativity are vital in generating a new "we". By reassembling the social, art's newfound commonality must expel the destructive agents of racial and colonial capital. … Ocean is us when we participate in the co-construction of new worlds, predicated on the rejection of social atomization and bounded subjectivity—when we recover interdependence and multispecies justice as the cosmopolitical truth of existence. The arts can help elevate that communist affect, propelling it into transformative collective power. The Ocean is rising; so must we.—Demos 2023

16.2 ARTPORT_making waves

ARTPORT_making waves, founded by Anne-Marie Melster and Corinne Erni in 2006, originated in New York and Valencia (Spain), and has grown into a reputable international arts organization. It is registered as a non-profit association in Germany, France, Spain, and Sweden.

This international curatorial collective focuses on art-science-education projects that explore Climate Change, sustainability and Ocean protection.

ARTPORT_making waves has Observer Status on behalf of the United Nations Framework Convention on Climate Change (UNFCCC), including participation in the Climate Conferences of the Parties (COPs), and is accredited for UN Ocean and other UN conferences. It has organized numerous innovative art and cultural projects worldwide that promote tolerance, sustainable development, and youth empowerment. At the beginning, the aim was to raise awareness of socially relevant issues as well as to stimulate public discussion for positive change, and consequently, shift dominant narratives. Today the vision remains the same, and the goal in recent years has been to focus more on interdisciplinary art-science projects through informal education and implementing solutions. This is because we firmly believe that societies can only be changed through education.

The collective has drawn attention to the causes, consequences, and possible solutions of climate change through themed exhibitions, film productions, competitions, workshops, conferences and educational programs. It is an unparalleled pioneer in its field and has brought together experts from various sectors—notably the arts, academia, science, education, and politics—and has collaborated with numerous leading international organizations, including the United Nations, national governments, universities, schools, museums, both formal and informal institutions, and festivals.

In my introduction to the book WE ARE OCEAN Berlin+Brandenburg (Melster 2023), I wrote:

> In 2004, in a conversation with the co-founder of ARTPORT_making waves, Corinne Erni, in New York, this became clearer to me. It was in a moment of professional change, and we sat together thinking about the mission and vision of what we wanted to do together in an art project. It quickly became clear that our common interest was not only art and culture, but also the preservation of nature. Both children of nature, grown up in the countryside, one in the Swiss Alps, the other on the German North Sea coast, we wanted to link these two areas together and give art a different value—far beyond the visual, beyond exhibitions, art fairs and biennials, the concept of "responsibility" became the centre of our attention: Responsibility in the sense of the Franco-

> Lithuanian philosopher Emmanuel Lévinas, who in his text "Totality and Infinity: An Essay on Exteriority" already in 1961 considered responsibility in the sense of responses to and beyond social norms of duties. Responsibility becomes greater the more we take it over, responsibility is infinite (Levinas 1979).

Through ('ART') we wanted to connect different ('PORT')s of the world with each other ('_') to be ('making waves').

The book "An Inconvenient Truth" by Al Gore (2006) offered another impulse—perhaps a door opener for many during that time even if today it seems a bit outdated and also needs to be looked at critically. However, it was a point of momentum and an inspiration for me, because I understood that the issues of climate change and global warming were going to affect humanity extensively, and because it is a thematic area, where a lot of environmental and social issues that are influenced by humans, converge: The quality of the air, the health of the seas and the Ocean, the preservation of forests, nutrition, the production of food and agriculture, transport, CO_2 emissions, the preservation of biodiversity, and much more. Through our projects, we aimed to contribute positively to social change; to raise awareness of a previously neglected subject through the Arts, sciences and education. As an organization, we were one of the few pioneers in the field at the time, because in 2005 (when we started creating the concept of ARTPORT) and in 2006 we mostly reaped incomprehension and damning comments from the art world. The United Nations experts were also very hesitant about the idea of cooperating with art, while the sciences were still quite isolated in their safe zone. In January 2006 we went public with ARTPORT_making waves and started with video projects on the topic of climate change (COOL STORIES FOR WHEN THE PLANET GETS HOT), which we produced with international artists and consequently presented worldwide. The first major assignment for an exhibition on "Gender and Climate Change" ("(Re-) Cycles of Paradise") came in 2009 from various UN organizations and governments for COP15, the UN Climate Change Conference, held in Copenhagen in 2009. It travelled afterwards to Mexico and the USA. This was followed by many more projects, steps, commissions and assignments. Meanwhile, ARTPORT_making waves has grown into an international Non-Governmental Organization (NGO) with non-profit associations in various countries, and brings together a large number of partner organizations for each project, all of which contribute with a specific expertise to the success of the respective assignment.

We started ARTPORT_making waves long before the international corporations and philanthropists recognized the value of sustainability and environmental protection—we wanted to initiate a wake-up call. The subject of art and sustainability has become a global topic, and that is a good thing, because art and culture can stimulate the public to open-up to challenging matters and encourage people to reflect on them. Certainly, it would be desirable if the aims and motivations were in fact founded in purely societal-ethical terms and not in profit maximization and social prestige, as also indicated by Arundhati Roy in her text "Capitalism: A Ghost Story" (Roy, 2014). But we at ARTPORT_making waves are grateful about this social development in general. It is important that the problem is discussed extensively, brought into society, and innovative solutions are sought.

Since then, art and culture have proved to be effective vehicles to advance new ideas and influence social norms. The critical engagement of the creative sector complements the engagement of other sectors in society (Ostendorf, 2015).

From the very beginning, ARTPORT_making waves was conceived as a hybrid between art, science, education, and ecology, rather than as a pure arts organization. The interfaces, the new approaches and project results arising from interdisciplinary work were and are of special concern to us. We deliberately wanted to be independent and to examine environmental issues, each of which requires special attention in society, emancipated and free from conventional expectations. With our projects, we usually dock to events and conferences in the fields of environment, art, science, society, and education. The reason for this is to directly address and involve our primary target audiences (policymakers, scientists, civil

society, students), but also to generate new exchange platforms where we can connect with diverse stakeholders to push solution-oriented processes.

16.3 Introduction to the WE ARE OCEAN Global Program

Connecting people and institutions, while acting on the education of youth, stimulates individuals' and organizations' action, thus transcending the limit of knowledge dissemination and awareness raising, directly inspiring and empowering concrete action. We are achieving this through multidisciplinary didactics and an approach able to inspire several different audiences, pushing them to think outside of their usual disciplinary and personal boundaries. The project inspires different targets and instigates new projects.

The WE ARE OCEAN Global Program is an interdisciplinary art program which gathers Indigenous leaders, artists, students, scientists, policymakers, art collectors, teachers, and curators to raise awareness and engage in dialogue about the environmental condition of the Ocean and the role humans play in its current and future state. As an endorsed Ocean Decade project, the program and each of its projects investigate how we interact with the Ocean and how interdependent humans and the Ocean are. The overall goal is to raise scientific and political awareness through the arts, particularly among young people, to stimulate behavioural change and social action and help them to act responsibly and become conscientious citizens. Ultimately, WE ARE OCEAN seeks to shift the narrative surrounding the Ocean from that of an Ocean for human use and exploitation with infinite resources to an Ocean that offers numerous yet precarious benefits to humankind which is its steward and caretaker.

The program combines the following to raise awareness about human interdependence with the Ocean and to address the question of how citizens can contribute to a solution-finding process through behavioural change and political participation:

- art-science workshops led by a selected artist per city/region in cooperation with scientists and teachers for schools which will then lead to participatory performances and other art forms to be presented in local exhibition spaces,
- a curated film and sound art program,
- interactive interventions, and
- interactive and participatory panel discussions with dynamic formats.

With these proposals we intend to explore, together with the audience, a different way of looking at the Ocean and the world we inhabit and create a movement with civil society. All of this means Ocean Literacy for us.

ARTPORT_making waves has been effectively promoting Ocean Literacy through this program since 2019 involving the youth, but also adults, in creative and interdisciplinary education projects.

Between 2019 and 2021 WE ARE OCEAN brought together the European cities Berlin (and the neighbouring state Brandenburg), Venice, and Marseille to begin the interactive journey. Partners with different expertise offered insight: universities, scientific research institutes, sustainability think-tanks, curatorial collectives, artists, art and research foundations, private companies, city governments, schools and private foundations among others.

The journey of the WE ARE OCEAN Global Program continued in Vancouver, the Wadden Sea region, Stockholm, Honduras, Montreal, Mallorca, Nice, Tanzania, all German Federal States, and is accompanying the UN Decade of Ocean Science for Sustainable Development until 2030 with numerous projects in countries worldwide. We were an active part of the Marine Regions Forum Berlin in 2019, participated in COP26 in Glasgow together with the Glasgow School of Art, as well as the IUCN World Conservation Congress in Marseille in 2021,

COP Biodiversity in Montreal in 2022, Stockholm+50 in 2022, we organized our own weeklong WE ARE OCEAN symposium during the Venice Art Biennale opening week in the Palazzina Canonica in 2022, we were part of the official program of the Trilateral Wadden Sea Conference in Wilhelmshaven in 2022 and produced side events at COP28 in Dubai in 2023 and the UN Ocean Decade Conference in Barcelona in 2024, as well as at 2025 The Third UN Ocean Conference in Nice, France, and COP30 in Belem, Brazil in 2025.

Through this international program, ARTPORT aims at reflecting upon several questions regarding the cause and effects of the man-made alteration of the Ocean. It illustrates how we all, citizens of every country, both cause and are impacted by the state of the Ocean, but that we are also potential contributors to positive change. WE ARE OCEAN acts in an inclusive way by actively integrating visitors and participants in the discussions to search for and support grassroots and bottom-up initiatives towards political change.

16.4 What Is the WE ARE OCEAN_ Wadden Sea: The Trilateral Project

The WE ARE OCEAN_Wadden Sea was an ambitious socio-cultural project connecting three different national contexts united by the same intertidal environment. Its core idea was to create a network that will live beyond the timescale of the project itself, generating concrete and coordinated change in different corners of the region.

WE ARE OCEAN_Wadden Sea, curated by Anne-Marie Melster for ARTPORT_making waves, was delivered by two artists (Insa Winkler and Sophia Bulgakova) in Germany, The Netherlands (here with co-curator Anastasia Loginova) and Denmark, where local students reflected on the effects of climate change on the Wadden Sea and how this is affecting the ecosystems and the culture of the land.

Between 2021 and 2023 we invited the artists to work together with students from the three countries. Insa Winkler for Germany and Denmark, Sophia Bulgakova for The Netherlands. Interactive and interdisciplinary excursions to the Wadden Sea were organized on a regular basis to bring together thinkers, policymakers, students, teachers, and artists with the people from the region. They discussed local environmental issues, their causes and possible solutions, along with ways in which Indigenous perspectives can be accommodated and traditional knowledge can be of support in a more sustainable, respectful manner.

Project outcomes included two short films, a collective art installation, and an interactive educational performance. These results served as a trigger for genuine discussions which might lead to a process of citizen-science solutions. The outcomes of these discussions and the formats, as well as two groups of students travelled to an international conference, the 14th Trilateral Wadden Sea Conference and partially as well to the WE ARE OCEAN Symposium at the Palazzina Canonica in Venice during the Venice Art Biennale opening week in April 2022, and the UN Ocean Decade Conference in Barcelona in April 2024 (we screened the film by Insa Winkler WE ARE OCEAN Wadden Sea_ KUNSTreusen during our side event and as point of departure for the open discussion). The German word *Kunst* means art and *Reusen* means fish traps.

Our WE ARE OCEAN projects always have three different stages as described below.

1. Scientific-artistic workshops at schools, universities or conferences (learning, understanding marine science, creating, performing, production of collective artwork).
2. Enactment, performances, discussion rounds, exhibition of the collective artwork bringing the students to national/international conferences to empower them.
3. Production of publication or educational toolkit, presentation of the artwork or film at further conferences.

This methodology enables ARTPORT to engage young people in Ocean Literacy not only in the short term through one-time projects, but also to create a lasting impact on students.

16.5 WE ARE OCEAN_Wadden Sea: Why? How Did It Come About? Who?

I grew up on the shores of the North Sea. Always a stiff breeze in spring, summer, fall and winter. A limitless horizon in the mostly grey Wadden Sea mudflats. Endless pastures. Forests. Tiny villages. Small ponds with frogs in summer. Swimming with all sorts of wild animals in warm summer nights in small creeks (which in local language are called "Wasserlösen"). A jungle of "Priele" (small waterways in the Wadden Sea). Horseback-riding on the meadows and the mudflats. Stormy winters with walks on the dike. Leaning contests against the storm, which sometimes meant falling on your face once the gust of wind subsided. Chilly summers on the green beaches (no sand but grass in that region) with no sun burns. Swimming in the plankton-enriched green and mud brown waters. Feeling reactivated afterwards. Collecting wild cabbage on the dikes enjoying the air containing loads of iodine. Riding my bike to school 27 km away in summer. Endless freedom. Endless inspiration. These moments and landscapes became the foundation of my life. Back then, nature was still relatively undisturbed, offering me the strength and inspiration that shaped who I would become. These are the memories I always return to when asked what inspired me to start ARTPORT_making waves.

It was time to give back to this region, this ecosystem and UNESCO World Heritage Site (https://whc.unesco.org/en/list/1314/). "The Wadden Sea is the largest unbroken system of intertidal sand and mudflats in the world. A playground of more than 5000 floral and faunal species, more than 30 different bird species only." When you read the scientific fact sheets about the Wadden Sea, it sounds like a fairy tale. If you grew up there, you know it is a fairy tale, a miracle, a wonderland.

> The Wadden Sea is the largest unbroken system of intertidal sand and mud flats in the world. The site covers the Dutch Wadden Sea Conservation Area, the German Wadden Sea National Parks of Lower Saxony and Schleswig-Holstein, and most of the Danish Wadden Sea maritime conservation area. It is a large, temperate, relatively flat coastal wetland environment, formed by the intricate interactions between physical and biological factors that have given rise to a multitude of transitional habitats with tidal channels, sandy shoals, sea-grass meadows, mussel beds, sandbars, mudflats, salt marshes, estuaries, beaches and dunes. The area is home to numerous plant and animal species, including marine mammals such as the harbour seal, grey seal and harbour porpoise. Wadden Sea is one of the last remaining large-scale, intertidal ecosystems where natural processes continue to function largely undisturbed.—UNESCO World Heritage Convention n.d.

I wanted to develop a project in the region, Land Wursten, where I had been growing up and where my father had been pushing the implementation of the Wadden Sea National Park in the 1980s as a local politician. I also wanted to make it trilateral, because the Wadden Sea doesn't care about borders, it is a transnational ecosystem of three countries. I first contacted an artist I have been working with for more than 20 years who is based in Northern Germany. Insa Winkler was fascinated by this opportunity telling me that she had several ideas she could work on. I contacted the local municipality, and they connected me with the National Park House—where marine biologists take care of the Wadden Sea in that region, guide visitors, and maintain a small local museum. I called the local school; the director was immediately on board. Now we just needed the funds to implement everything. After several attempts and fund applications I found two supporters: one lottery (for us the most democratic funding tool) and through the BUND Niedersachsen (Bund für Umwelt und Naturschutz Deutschland, Friends of the Earth Germany) we were able to apply for a public fund from the country Lower Saxony supporting also the fact of the trilateral structure, linking the three Wadden Sea countries through one project.



Fig. 16.1 WE ARE OCEAN_Wadden Sea_KUNSTreusen, aerial view Wadden Sea, 2022 (Photo: Robert Geipel for ARTPORT_ making waves)

At the same time, I found a way to implement the project in The Netherlands by inviting a local artists' association, one of their curators and one of their artists on board as our partners: The iii The Hague (instrument inventors), Anastasia Loginova and Sophia Bulgakova. We created the project in The Netherlands together, but they were independent in regard to the financial construction. WE ARE OCEAN Wadden Sea Denmark was supposed to happen with the Danish artist Tue Greenfort in collaboration with several local and national institutions. Alas the fundraising situation for the project we had created was too challenging for the Danish partners so that we decided to make a smaller version commissioning the German artist Insa Winkler again and to close the trilateral project in summer 2023 on the Danish coast.

As part of every WE ARE OCEAN project we aim at bringing the young participants to an international conference concluding the project. We planned this together with the 14th Trilateral Wadden Sea Conference co-organized by the German Government, which happened in November 2022. We were able to bring students from the German and Dutch schools to the conference to perform, to meet, to exchange with the international experts, and to present their works.

At the end it was a perfect time schedule, despite the COVID crisis hindering our first planning to start the workshops in 2021 (Fig. 16.1).

16.6 Art-Science-Education Interface in Ocean Literacy Explained Through Our Project

We believe in the power of the contemporary artist when it comes to bringing young people on board of Ocean Literacy. For us art, particularly contemporary art, is more than the creation of artefacts. Artists are a powerful connector between disciplines, between parts of society. They are translators of complex ideas, bridges between science and society. For us Ocean Literacy, Ocean and Climate Action, is not about learning scientific facts by heart and then possibly act. The ABC of the Ocean is about diving into nature, with the learned scientific input, consequently transferring this newly gained knowledge into experiences by understanding what all of this means. The moment when you know and appreciate the complex beauty of our planet, of the Ocean, of nature, you become genuinely able to identify yourself with them and gain the power and entitlement to defend nature in its entirety.

In this case we asked the teenagers: What is the Wadden Sea? Why is it a UNESCO World Heritage Site? Which are the species at stake? Why is the water brown and not crystal clear? What does this ecosystem mean for an intact habitat, an intact global Ocean system? Why is overfishing contributing to the destruction of the Wadden Sea? Why is traditional fish-trap fishing more respectful? Why is shelling the little North Sea prawns at home with your own fingers more sustainable than buying the already shelled prawns in the shops? All these questions and many more were discussed and answered in our WE ARE OCEAN_Wadden Sea_KUNSTreusen workshops.

This is how it worked: We invited artists who are or are not already familiar with the topic we want to work around. We bring the artist(s) together with the scientific research institute which is partnering with us. Together with everyone and the school we discuss the potential topics and then we put our hands on and start.

For WE ARE OCEAN_Wadden Sea_KUNSTreusen with Insa Winkler in the German Wadden Sea we only decided the topic in a second attempt: Insa clearly wanted to work around the idea of sustainable fish-trap fishing in the region. Fish-traps are a traditional way of fishing which is almost extinct because the last "Reusenfischer" are passing away and there are few or no successors because traditional knowledge is not fashionable in that region.

16.6.1 WE ARE OCEAN_Wadden Sea_KUNSTreusen (Insa Winkler, DE), 2021–2022

The artist Insa Winkler had structured her workshop at the Oberschule Dorum based on how traditional fish-traps were built: with willow branches following a specific pattern. She explained the technique to the students age 8–11, divided tasks (the different parts of the North Sea shrimp {lat. *Crangon crangon*} each group should weave), and we let them create their own little sculptures. During the workshops most of the participants (there are always more or less two teenager boys who drop out because they find it boring) were totally immersed and inspired by the work with their hands, using their creativity and persistently working on their tasks. The marine biologist Matthias Mertzen wove his scientific and pragmatic part regarding the Wadden Sea into the artistic part, so that the students were able to learn about marine science in a rational way and about the effects of fishing in a creative way at the same time.

They were diving deep into how these shrimps are structured, each student developed their own tricks and techniques, some of them preferring group work and dividing tasks, others preferring solitary work because they felt themselves working more efficiently like this. For ARTPORT one of the benefits of this kind of workshop has always been giving the young people greater self-esteem through the learning of new skills, and experimenting with their own creativity, discovering strengths they always had and not focusing on weaknesses anymore. Once you provide them with the right tools and guidance, and explain what the final result could be, each individual began to discover a new part of themselves. They learned that in a collective attempt; despite elaborating individual parts, they can build something bigger collectively. Like the North Sea shrimp, they created: made of more than 13 different pieces, once put together you see the whole shrimp.

16.6.2 WE ARE OCEAN_Wadden Sea_The Beauty of Proximity (Sophia Bulgakova, NL), 2021–2022

The artist Sophia Bulgakova wanted to work around the topic of "Sensing the Wadden Sea", using all the senses to create a catalogue of memories. Throughout the period of April and June 2022, a series of art-science workshops were held in collaboration with two secondary schools bordering the Wadden Sea; Inspecteur Boelensschool in Schiermonnikoog, in the province of Vriesland and Het Hogeland College in Uithuizen, Groningen.

The overall aim of these workshops was to raise awareness among young adults about the interdependence of human society and the Ocean. Specifically, each workshop consisted of activities which combined scientific information and artistic exploration to engage students, age 12–16, in re-examining their knowledge of and relationship with the Wadden Sea. The workshops were conducted in two parts: part I in April 2022, part II in June 2022. The workshops were co-led by a science communicator and an artist. A short film was made of the events.

A multidisciplinary team was delivering the workshops and activities: artist, science communicator, curator, educational coordinator, photographer, and teachers. In April 2022 the team went to Uithuizen, Groningen, visited the collaborating school Het Hogeland College and collected sounds at the Wadden Sea. The students experienced the Wadden Sea with multiple senses (touch, sound, smell, movement) to gain curiosity and information about the Wadden Sea, and its importance for global biodiversity.

In June 2022 the team went to the island of Schiermonnikoog, Friesland together with the Inspectuer Boelensschool and experimented the *Blindfold experience* of the Wadden Sea. The excursion was intended to collect materials and perform associative word exercises, to embody a creature of the Wadden Sea. The students worked together to create a multi-sensory artwork conveying an element of the Wadden Sea. The excursion was concluded by an interactive lecture about the Wadden Sea.

In November 2022 the students from both schools were part of the 14th Trilateral Wadden Sea Conference by enacting the performance of becoming a creature of the Wadden Sea in the Wadden Sea UNESCO World Heritage Visitors Centre in Wilhelmshaven.

16.6.3 WE ARE OCEAN_Wadden Sea_Painting the Wadden Sea (Insa Winkler, DK), 2023

The workshop in Denmark was based on the ones we performed in Germany. The project happened at MARSK CAMP together with students of the Tønder Gymnasium and the Vadehavsskolen Vittenberg in Ribe. The first part consisted of a general explanation of the WE ARE OCEAN Wadden Sea project and the methods of ARTPORT_making waves in bringing together art, science and education; a scientific explanation following the content in Germany; and a dynamic discussion hour led by the artist where the students discussed ecological, social, economic, and cultural aspects of the Wadden Sea.

During the following artistic part of the workshop, pairs of students were asked to think about specific topics, one of the two was blindfolded and asked to paint the chosen subject, while the other was assisting with instructions.

At the end, the painted motifs were cut out and glued together into one big collective artwork. The workshop was concluded with a joint performance by the students, wherein they completed the collective painting by adding water (paint) to the five-meter-long paper by controlling the liquid and preventing its drip over the edges.

The pedagogical idea behind this methodology is that young people are not protesting against something to create societal change, but rather learning and experiencing, constructively, what can be done. Within this activity they create something in a collective effort following the question: "What do we want to avoid, what do we want to achieve?" (Fig. 16.2).

16.7 Impact and Relevance of Interdisciplinary Ocean Literacy (with Testimonial Statements)

With 20 years of experience in interdisciplinary work and 7 years with Ocean Literacy, we know the impact of our workshops on the young participants, but also the older ones, even professionals in environmental fields, such as delegates of the COP 16 Biodiversity celebrated in Montreal in 2022.

We usually speak with the students before each workshop begins. We ask them how they feel about the topic, in this case the Wadden Sea; what they know about it, what they know about



Fig. 16.2 WE ARE OCEAN_Wadden Sea_ Painting the Wadden Sea, Skaerbaek, Denmark, 2023 (Photo: Anne-Marie Melster for ARTPORT_making waves)

marine biology, about contemporary art and if they have ever heard about this kind of work bringing two disciplines together. Their answers, disregarding whether they live close to the sea or further away, are almost 80% the same: they don't know anything about it, they don't care, they take it for granted, and so on. The curatorial and scientific introduction opens their minds, they understand, but don't really transfer the information into knowledge. However, when we, the scientists and the artist (supported by the team) start to involve them in science games and the artistic part of the workshop, most of them get excited, ambitious, even competitive to contribute to the collective activity. And last but not least, our evaluation conversations and questionnaires are gathering the final impressions of the participants.

In all three workshops we gathered approximately 120 school students from three countries. These participants talked about the project in their respective schools reaching around 2000 other students and teachers in total. This had the effect of bringing the topic also to their parents, families and friends, which we calculate to be approximately ideally another 3000 persons. The published newspaper article in the "Nordsee-Zeitung" reached around 44.000 readers (printed and online edition). Furthermore, we presented the film which Insa Winkler produced at the Side Even which we hosted in the framework of the UN Ocean Decade Conference in Barcelona in April 2024 to an audience of 40 persons. Our combined social media presence, website, and newsletters related to this project reached approximately eight million people including our activities and followers at WeDontHaveTime. Our diverse national and international outreach generated a good visibility for the topic of the Wadden Sea and Ocean Literacy.

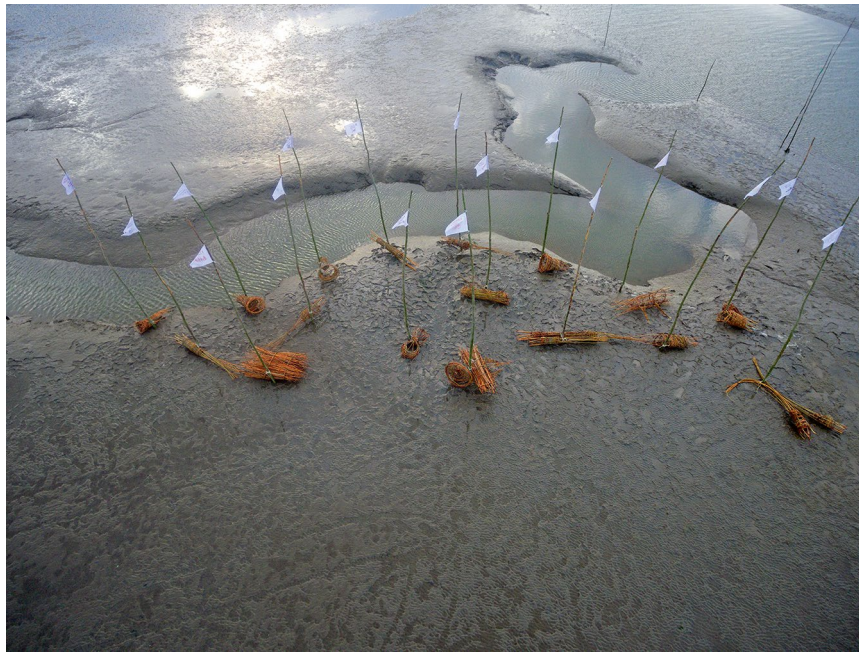


Fig. 16.3 WE ARE OCEAN Wadden Sea_KUNSTreusen, installation of sculpture with 14 SDGs, aerial view Wadden Sea, 2022 (photo: Robert Geipel for ARTPORT_making waves)

16.7.1 WE ARE OCEAN_Wadden Sea KUNSTreusen (Insa Winkler, DE)

During workshops at the Oberschule Dorum (Germany), the artist Insa Winkler and the curator Anne-Marie Melster together with the students created 'KUNSTreusen' made of willow sticks, which formed a giant North Sea shrimp and were suspended in the Wadden Sea in early July 2022. This commemorates the uniqueness of Erhard Djuren, the last remaining willow trap fisher in the region. Particular attention was paid to the feasibility of alternative ecological techniques in the future (Fig. 16.3).

Why did this project testify that Ocean Literacy can better be transmitted through interdisciplinary work? The fact that an artist, a curator, a marine biologist and the teachers of the partner school worked together with the students on a forgotten topic of their region, opened the minds and hearts of the participants to marine topics (mentioned above) in an artistic and interactive way. The project took them on a performative excursion into the mudflats and inspired them to think about their region as a treasure, a wonderland, a valuable common which needs to be protected. All of this demonstrates that interdisciplinary collaboration is more impactful than working within a single discipline (Fig. 16.4).

The director of the Nationalpark-Haus in Dorum, Wurster Nordseeküste, Germany, Dr. Matthias Mertzen, said:

> Art projects that understand themselves not only as pure art but also as mediators between the disciplines, I find a very valuable link between different views and motivations. In the project "WE ARE OCEAN Wadden Sea" activities were based on the fish trap fishery, where the pots used to consist of braided pastures, and were emptied with sleigh and dogs at low tide. This method of fishing with willow husks is a gentle fishery in harmony with nature: because the seabed is not ripped open, no fuel is needed, and the pots, when lost, simply rot and do not put plastic in the sea. Against the backdrop of the willow-weaving art as an intangible cultural heritage and the UNESCO Wadden Sea natural heritage as a unique habitat with the motto "Let nature be nature", the connection with the Reusenfischerei was ideal.



Fig. 16.4 WE ARE OCEAN_Wadden Sea_KUNSTreusen, mud flat performance with sculpture, aerial view Wadden Sea, 2022 (photo: Robert Geipel for ARTPORT_making waves)

> This unique art project has combined science, art, fisheries and environmental education, and has shown that everything is interconnected. The young people had the opportunity to gain access to the other disciplines through different interests, whether through art or through natural sciences or sustainability, with the transition being fluid. In the mediation work for sustainable development, it has shown all of us of the Nationalpark-Haus new possibilities and expanded our network. In my view, it is important to recognise and understand issues from different perspectives, in exchange for art, nature and culture. Only in this way is it possible to inspire and achieve (coming together of) many people with different interests, views and ideals for protection. The international exchange (Germany, Denmark, the Netherlands) between the pupils, who all participated in a joint workshop at the trilateral Wadden Sea Conference, was also great.

The commissioned artist Insa Winkler (for Germany and Denmark) underlined the following:

> The Ocean, the seas are underworlds, not visible, and traditional culture is equally becoming increasingly invisible. Artistic practice is becoming more valuable in highlighting the conditions of the unique location, the tides, because a finely tuned perception of the Wadden Sea is required. The merging of artistic practice, the scientific knowledge, the local knowledge of fish trap fishers, the young participants: It is a unique format that offers an immersion in the moving Wadden Sea. The artistic activities of this project are based on the analogue reproduction of an essential yet lost practice: the willow weaving of the fish traps, the sled dogs that, with the support of the traditional fisherman's skills, make the whole process of crab fishing possible in a surprising way.
>
> The goal of the project was to recreate the skills of this extinct practice in an analogue way, to feel them and to experience the nature of the Wadden Sea World Heritage Site together. The mission is achieved through action. It is not a protest against something, but an empathetic experience of what can be done. What can I do? Many people assume that you can only bring about change through money. But creative and artistic work makes it possible to experience low-threshold processes and thus also to stimulate the courage of alternative and sustainable wealth: What do we want to avoid, what do we want to achieve? What is our and my next step?
>
> All of this was addressed and achieved by our projects in the German and Danish Wadden Sea. Because the students understood the interdependence of human and Ocean, their impact, their power and their possibilities to change towards a more respectful and sustainable life.



Fig. 16.5 WE ARE OCEAN_Wadden Sea_The Proximity of Beauty, field trip and workshop with Inspecteur Boelensschool in Schiermonnikoog, 2022 (photo: Anastasia Loginova for ARTPORT_making waves)

16.7.2 WE ARE OCEAN_Wadden Sea_The Proximity of Beauty

The artist Sophia Bulgakova together with the co-curator Anastasia Loginova created a different type of experience for the students. They engaged the participants on a sensory journey, inviting them to feel, smell, listen to the Wadden Sea. Specifically, each workshop consisted of activities which combined scientific information and artistic exploration to engage students, age 12–16, in re-examining their knowledge of and relationship with the Wadden Sea. The workshops were conducted in two parts: part I in April 2022, part II in June 2022. The workshops were co-led by a science communicator and an artist.

The feedback of the students to the project was very positive. The team made an internal evaluation: The students said they liked going to the Wadden Sea, they were proud of their final artworks saying things like "I think we made the best one!" and many said they gained new knowledge about the Wadden Sea and/or about using art to interact with the world, e.g. "I learned that art is more than just painting and drawing", "I learned about all the different animals living at the Wadden Sea." (Fig. 16.5).

16.8 Conclusion

The interdisciplinary and inclusive methodology of WE ARE OCEAN has been proven effective in many places and countries. In the Wadden Sea region we were able to work with different types of students; the school systems in the three countries are different as well.

Nevertheless, in all countries we saw how the students developed their own ideas, interpretations and knowledge transfer of what they had learned about the Wadden Sea from the perspective of marine biology into an artistic interpretation. This knowledge transfer happened by using their own hands, minds, bodies and senses. Some of them gained self-esteem through their activities and understood that they are, through their actions and engagements, powerful in society, that they can have a voice if they choose to.

The participants in Germany made statements like:

- *"We liked this project very much because we learned that we young people can change something, we have the power: We can choose to conserve nature as long as possible"*
- *"We learned about our region, the Wadden Sea, and that we can do things with our own hands."*
- *"I learned something about the Wadden Sea, the ecosystem which is just in front of my door and that I can do something, even if these gestures are small".*

At ARTPORT_making waves, we always adapt to the circumstances, needs and pressing topics of the region where we are asked to host a project. We work with local people and experts, and our teams are always interdisciplinary and familiar with the topics that matter most to the area.

We will further develop the program, introducing new pedagogical parts, educational tool kits, listening to new partners and scientists, working with artists who come with new expertise, and focusing on different topics (which is natural, given the fact that we implement projects in new places every year).

16.8.1 Summary

Key concepts explored in this chapter include:

- Interdisciplinary art-science projects can enhance Ocean Literacy by translating scientific knowledge into emotional, experiential learning.
- Art and culture are powerful tools for social transformation and public engagement with complex Ocean and climate issues.
- The WE ARE OCEAN Global Program uses collaborative, regionally-adapted approaches to empower youth and strengthen Ocean–human connections.
- Artistic methodologies like sensory experiences and collective sculpture deepen awareness of local ecosystems like the Wadden Sea.
- Projects grounded in place-based learning and community memory promote meaningful youth participation in Ocean advocacy.
- Creative expression fosters embodied knowledge transfer and helps students understand their potential for social and environmental impact.
- Artists are vital connectors across disciplines, linking science, education, policy, and local knowledge.
- The program models a participatory and inclusive approach to Ocean Literacy through international, grassroots collaboration.
- Performance, public exhibition, and artistic dialogue empower students to share their voices on Ocean sustainability with diverse audiences.
- Interdisciplinary Ocean Literacy initiatives create ripple effects—extending beyond classrooms into families, communities, and policy forums.

16.8.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Wadden Sea: https://whc.unesco.org/en/list/1314/
- Welcome to the Wadden Sea World Heritage: https://www.waddensea-worldheritage.org/
- Interview with Anne-Marie Melster (2024): https://illuminem.com/illuminemvoices/interview-with-annemarie-melster
- WE ARE OCEAN_Wadden Sea Kunstreusen (Insa Winkler): https://www.youtube.com/watch?v=M1whMPCq5IM
- Ocean Decade Conversations: Anne-Marie Melster (ARTPORT_WE ARE OCEAN PROJECT): https://Oceandecade.org/news/Ocean-decade-conversations-anne-marie-melster-artport_we-are-Ocean-project/

- *ARTPORT_making waves* video shorts: https://www.youtube.com/channel/UCyXtJCIJtxM8SmnVcE3jyAA/videos?view=0
- *Dragonflys Den ARTPORT making waves Full Pitch:* https://www.youtube.com/watch?v=B8Wx2Skpm64
- *ARTPORT_making waves is Open for Climate Dialogue:* https://www.youtube.com/watch?v=sdp5kKStW1Q
- *WeDontHaveTime* Interview with Anne-Marie Melster at COP28, Dubai, UAE, 6 December 2023: https://www.youtube.com/watch?v=3n-rX7BZHXE
- *Anne*-Marie Melster @ Critical Conditions: The mind of nature: https://www.youtube.com/watch?v=ALZywRH5aCw
- The Climate Reality Project: https://www.climaterealityproject.org/
- The book: *Mein Leben vor dem Krabbenbrot. Die Nordseegarnele Carngon crangon erzählt* by Inge Kronberg
- The book: *UNESCO Weltnaturerbe Wattenmeer. Der offizielle Reiseführer* by Common Wadden Sea Secretariat
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In Denmark: Marsk Camp Skaerbaek; Tønder Gymnasium; and Vadehavsskolen Vittenberg.

In The Netherlands: iii instrument inventors, The Hague (co-coordinator The Netherlands, for project collaboration with Sophia Bulgakova); Stichting Werelderfgoedcentrum Waddenzee: Wadden Sea World Heritage Center; Het Hogeland College Uithuizen, Groningen; Inspectuer Boelensschool, Schiermonnikoog, Friesland; and Wadden Sea World Heritage Centre, Lauwersoog; WEC Wadden Zee (Stichting Werelderfgoedcentrum Waddenzee); Stimuleringsfonds Creatieve Industrie; and Stroom Den Haag.

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Anne-Marie Melster is an interdisciplinary curator and ecology advocate dedicated to social and environmental issues since 2004. As the co-founder and executive director of ARTPORT_making waves, she creates interdisciplinary projects which search for environmental and social solutions, such as WE ARE OCEAN. She is the pioneering curator focusing on informal education through arts and sciences. She has curated numerous international art exhibitions and projects including film and video in collaboration with renowned institutions, organizations and governments worldwide, also for several UN Climate Change Conferences. She is a Climate Reality Leader for Al Gore's Climate Reality Leaders Program and as well Salzburg Global Seminar Fellow since 2016. She is a member of the German UN Ocean Decade Committee (Deutsches Komitee der UN-Ozeandekade ODK) (2021–2030) since 2024. *Note.* Picture of Anne-Marie Melster taken in The Green Zone, Beyond Borders Pavilion, UNOC3, June 2025.

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From Shores to Shelves: Nonfiction Children's Books as Tools for Ocean Literacy

17

Rochelle Strauss

Abstract

Children's nonfiction books can be powerful tools for cultivating Ocean Literacy, shaping young readers' understanding of marine science, and empowering them to take actions to become Ocean stewards. This chapter explores how children's nonfiction serves as immersive educational resources, bridging fact-based information with engaging narratives that foster critical and creative thinking. Through meticulously researched content, vivid storytelling, and engaging illustrations, children's nonfiction brings Ocean science to life, allowing readers to grasp complex ecological processes and recognize their roles in preserving Ocean health. This chapter highlights how these books support layered learning experiences that are accessible and inspiring. Additionally, it addresses the role of nonfiction in mitigating eco-anxiety by providing hope and agency through stories of positive change and action. The chapter ends by offering several tips to help educators, librarians, parents and guardians select quality nonfiction books. Through these insights, the chapter serves to illuminate the unique ability of children's nonfiction books to inform, engage, and inspire the next generation of Ocean-literate, environmentally conscious citizens.

Keywords

Ocean Literacy (OL) · Nonfiction · Children's books · Reading · Education · Eco-anxiety

17.1 Introduction

We are storytellers. It is woven into the very fabric of our existence. We have told and shared stories forever, using them to document our history, convey information, create meaning and share knowledge. With stories such an embedded part of who we are, it should come as no surprise that many of us may also learn best through stories.

Children's nonfiction books are just that—stories that give readers the chance to explore the world around them. They share multiple perspectives, offer recent scientific discoveries, address historical events and showcase diversity. They allow readers to see and experience things they may not otherwise be able to. They can be powerful tools for building knowledge, helping readers make observations, ask questions and draw conclusions, laying the foundation for further inquiry, discovery and learning. Through these books, readers explore concepts, processes and events, as well as people, species and spaces. Readers can start to track patterns and see rela-

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tionships. They discover explanations and begin to make meaning about the world they live in.

> Contemporary nonfiction addresses historical silences; explores historic and contemporary events rooted in racism, oppression, and violence; and highlights courageous trailblazers and organized groups working toward societal transformation and liberation. It presents cutting-edge research, offering readers not just settled information, but access to emerging understandings at the vanguard of scientific knowledge and exploration.—National Council of Teachers of English 2023, para. 3

Children's nonfiction books have already been shown to be effective tools in science, technology, engineering and math (STEM) inquiry and learning (Butzow and Butzow 2000; Harvey and Goudvis 2007; Hosington and Diaz 2024; Pringle and Lame 2005; Sackes et al. 2009). Their stories help readers understand, remember and apply concepts, build comprehension and support inquiry-based learning.

Butzow and Butzow (2000) also emphasize that for science instruction to support learners to develop an understanding of the world around them, educators must provide students with opportunities to make observations, formulate hypothesis, develop ideas and draw conclusions. But science, including marine science learning, is often taught through textbooks, presented in didactic and dry language with a focus on memorizing concepts, terms and vocabulary. This can often be overwhelming. Students may even begin to believe they aren't interested in a topic, simply because the textbook itself is unapproachable. Children's nonfiction books, however, offer an alternative way to teach science, using stories to build strong science foundations. Their narratives are often easier for learners to process and understand because they provide readers with scientific information in an inviting and familiar format. The concepts, content and facts are embedded within captivating and engaging language, illustrations and the overall design. Through their stories, children can begin to see and understand relationships, connections and causality.

> My young student's interest for fossils was ignited by her nonfiction reading and then grew into a passion for these geological marvels of Earth's history. Her reading of nonfiction now guides the beginnings of her lifelong learning journey which can take her everywhere she desires to go.—Chris Carlton, Term Adjunct Professor, Faculty of Education, Queen's University, personal communication, November 2024

By extension, nonfiction books about the Ocean will also have a similar capacity to educate readers about marine science, not only shaping what they think about the Ocean, but influencing how they act and behave towards it. They can offer readers the opportunity to learn about concepts and content within marine science and provide more in-depth Ocean exploration and understanding. Unconfined by curriculum requirements, children's nonfiction books about the Ocean also have the potential to explore more than just what is needed to check off a curriculum objective.

This chapter will explore the important role that children's nonfiction books can play in building Ocean Literacy.

17.2 Nonfiction Books for Children

Children's nonfiction books come in all shapes and sizes—from board books and picture books to graphic novels, beginner readers and chapter books. But no matter their format, nonfiction books all have one thing in common, a shared goal to educate readers about a topic or subject. They use storytelling elements—such as vivid imagery, a clear narrative flow, and relatable perspectives, to make factual content accessible and emotionally resonating for young readers. They are written and illustrated with the intention of interpreting, organizing and presenting documentable and fact-based information. This approach is especially powerful in environmental education and by extension building Ocean Literacy, as it allows children to connect personally with the material, fostering both an understanding and empathy for the natural world.

Stewart and Correia (2021) explore two types of nonfiction writing styles, narrative nonfiction and expository nonfiction. For both writing

styles, authors meticulously research their topics, and every single fact or idea is verifiable. The main difference between the styles is how the story is told. In narrative nonfiction, the author tells a factual story, using real characters and events, often following a traditional story arch with tension, climax and conclusion. Expository fiction, on the other hand, describes or explains a concept, such as a scientific phenomenon.

Within nonfiction, Stewart and Correia further group books into five categories; active, browsable, traditional, expository, and narrative. Each style has a role to play in building Ocean Literacy. Active nonfiction books are very interactive and often teach readers a skill. For example, an active nonfiction book could be field guide that helps readers identify species within a tidal zone, or a hands-on learning book with Ocean-themed crafts or experiments. Through browsable nonfiction, readers can read a book in its entirety or pop in and out of the book, exploring the sections that appeal to them most. *Ocean Anatomy the Curious Parts & Pieces of the World Under the Sea* by Julia Rothman is a good example of a browsable nonfiction book. Traditional nonfiction books are often published as "all about books", using descriptive text and images, they can teach readers about specific animals, for example whales or sharks, or ecosystems such as kelp forests. National Geographic Kids books are good examples of these traditional nonfiction books. In expository nonfiction, authors use a writing style that explains and informs using a strong voice, carefully structured sentences, and dynamic and engaging language. Authors may also use creative approaches, such as metaphors, analogies and humour, to share information as well as inspire and engage readers. Books such as *The Global Ocean* and *One Well: The Story of Water on Earth* by Rochelle Strauss, are examples of expository nonfiction (Figs. 17.1 and 17.2). Finally, narrative nonfiction books as explained above, share a story or experience. These books might include biographies, such as *Life in the Ocean the Story of Oceanographer Sylvia Earl* by Claire A. Nivola, or a story about an event, such as *A Window into the Ocean Twilight Zone, Twenty-four Days of Science at Sea* by Michelle Cusolito. They may also tell a story of an ecological moment in time, using a lyrical or more traditional storytelling approach, such as *Whale Fall: Exploring an Ocean-Floor Ecosystem* by Melissa Stewart).

> Nonfiction is literature, and nonfiction authors use the same literary techniques as novelists. We contextualize, tap into emotion, leverage suspense, surprise, and humour, and incorporate vivid language and figures of speech.—L.E. Carmichael, Children's Author, personal communication, November 2024

17.3 Children's Nonfiction Books and Ocean Literacy

Building an Ocean-literate society requires more than just teaching about Ocean science, the stats and data. It also involves developing an understanding of how the Ocean and humans are inextricably linked. The National Council of Teachers of English (2023) defines nonfiction as "…a rich and compelling genre that supports students' development as critically, visually, and informationally literate 21st century thinkers and creators" (para. 1). These skills—critical, visual, and informationally literate—are the same skills we aim to cultivate in young people as they learn about the Ocean. Ocean Literacy goes beyond understanding science and our relationship with the Ocean; it also means fostering a generation of critical thinkers and problem solvers ready to address Ocean-related challenges.

This is where nonfiction children's book can play a particularly valuable role in building Ocean Literacy in readers of all ages. "Selection and use of developmentally appropriate and scientifically accurate literature can be effective tools to help children understand their place in and connections to the natural world" (Wells and Zeece 2007, p. 285). These books can educate about marine science, build a sense of connection to the Ocean and inspire and empower readers to think differently and take action.

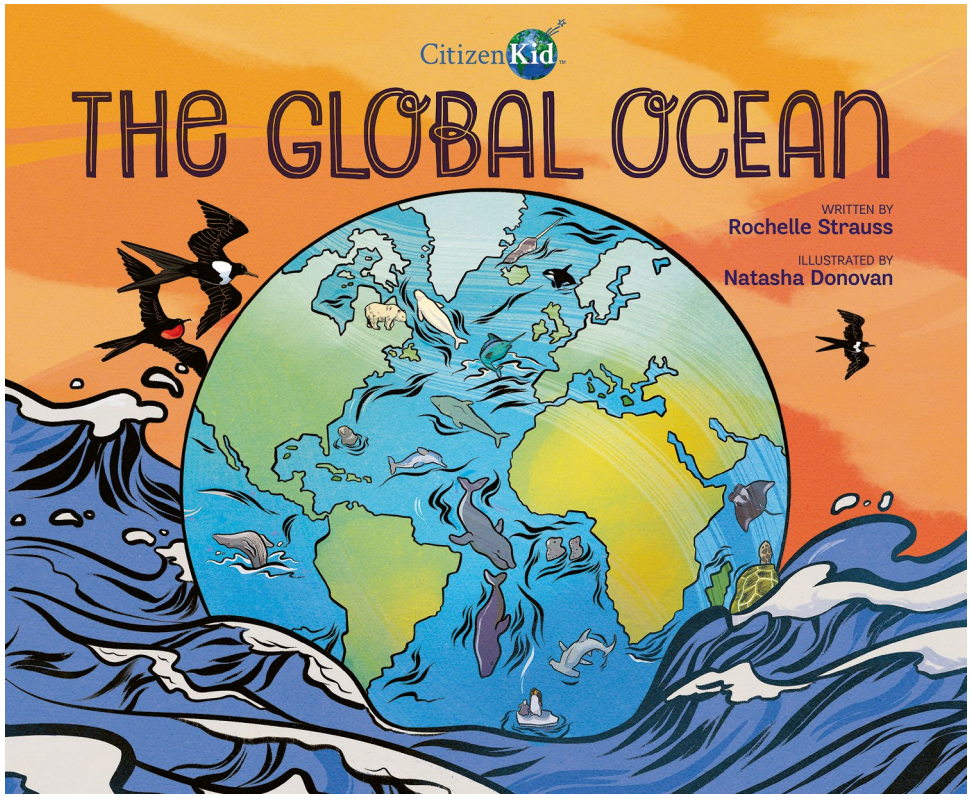


Fig. 17.1 *The Global Ocean,* written by Rochelle Strauss and illustrated by Natasha Donovan (Kids Can Press, 2022), was developed using the seven principles of Ocean Literacy as its guiding structure. Through its engaging narrative and illustrations, the book touches upon each principle, while offering good news stories, called "*ripples of change*" intended to inspire and empower readers to take action. *The Global Ocean* is a UNESCO endorsed Ocean Decade Activity. Material from *The Global Ocean* is used by permission of Kids Can Press Ltd., Toronto. Cover illustration © 2022 Natasha Donovan

Let's take a deeper dive into why children's nonfiction books can be valuable tools to build Ocean Literacy.

17.3.1 Teach and Contextualize Marine Science

> Nonfiction empowers young people in the face of current and emerging challenges locally and globally, such as racial, cultural, social, and economic injustice, censorship and disinformation, and the climate crisis. In the urgency of this moment, nonfiction for young people has never been more vibrant or vital.—National Council of Teachers of English 2023, para. 4

Ocean-themed nonfiction books bring the Ocean to readers—no matter where they live. To paraphrase Sylvia Earle, *knowing is the key to caring, and with caring there is hope that people will be motivated to take positive actions*. Ocean-themed nonfiction books support readers to learn about the Ocean, helping them to see how the Ocean has an impact on their everyday life. They can teach readers about scientific concepts, while providing rich content that builds their knowledge about the Ocean. They give readers the opportunity to make observations and ask questions, plan further exploration and learning, and reach their own conclusions. The narratives also offer a mechanism for problem solving—by explaining the science, readers can better understand the issues and identify potential solutions. Finally, they encourage readers to share their findings and observations, as well as their thoughts and feelings about the Ocean.

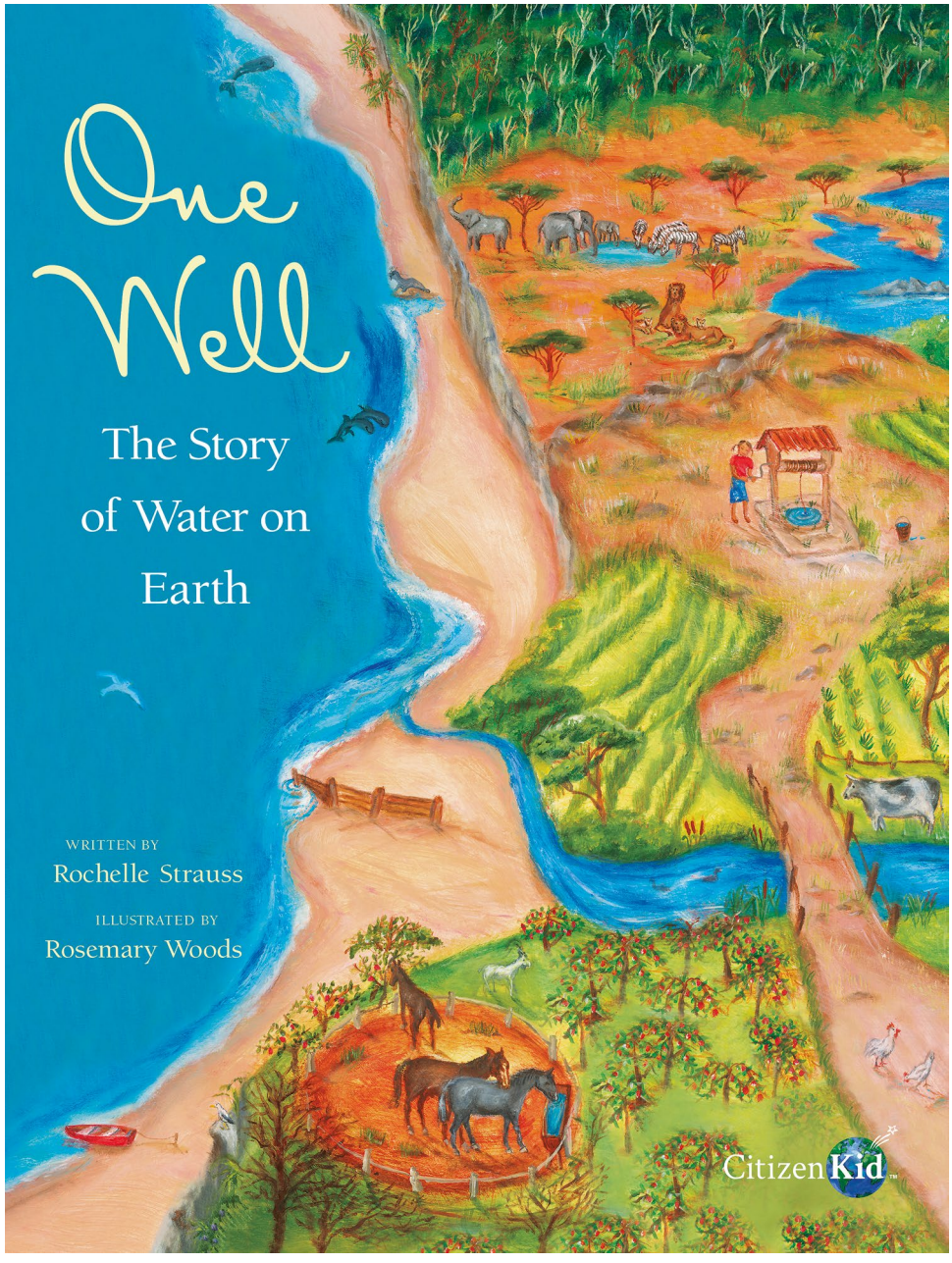


Fig. 17.2 *One Well: The Story of Water on Earth*, written by Rochelle Strauss and illustrated by Rosemary Woods (Kids Can Press, 2007) uses the metaphor of a well to show readers how all water on Earth is connected—from the Ocean, to lakes, rivers and underground streams—even the morning dew. It's a call to action, showing how we can all help protect our shared "well" for every species, now and in the future. *One Well* was selected as part of the United Nation's Sustainable Development Goals Book Club in support of SDG 6, Clean Water and Sanitation. Material from *One Well* is used by permission of Kids Can Press Ltd., Toronto. Cover illustration © 2007 Rosemary Woods

Moreover, nonfiction books help to contextualize the information that is presented, more so than the textbooks that are traditionally used to teach science or marine science. Consider the iceberg analogy. A textbook about science or marine science is just the tip of the iceberg when it comes to building Ocean Literacy. It represents the stats and data, the science, the curriculum requirements. And that is where most learning will stop.

But beneath the surface lies the rest of the iceberg, a myriad of complex and fascinating stories within the Ocean that will surprise and excite readers. Nonfiction books for children tell these captivating stories—the stories that will enrich their learning and move the needle towards Ocean Literacy. Their storytelling, imagery, and language is more engaging than textbooks and not limited by the same constrictions as a standard textbook (Ansberry and Morgan 2010). These stories encourage readers to explore the Ocean in greater depths, building their knowledge of the intricate systems, connections and relationships within the Ocean. Metaphors, analogies, as well as dynamic and engaging language, capture tales that help readers build understanding and make meaning, inspire wonder and awe, pique curiosity, and challenge them to see new perspectives and think about what they are learning. For example, in *The Global Ocean*, the author asks the question *"what if Earth had a beating heart that powered everything on the planet?*", using the metaphor that the Ocean is Earth's heart to draw readers into the story. Where textbooks solely educate, nonfiction books capture the imagination, hearts and minds of readers. These are the foundational experiences of Ocean learning that need to be part of every Ocean Literacy program. They are the learning experiences that help readers shape what they know and what they think about the Ocean, as well as how they act towards it.

Additionally, many teachers have spoken of the lack of marine specific science content in science programs, as marine science is not yet part of many science curriculum requirements. Children's nonfiction books provide opportunities for teachers to bring Ocean learning into the classroom, teaching Ocean science and conservation, building Ocean Literacy. Books that support each of the seven principles of Ocean Literacy can be found across every type of nonfiction. Through a variety of well written and researched books, educators will find picture books, board books, graphic novels, etc., that can help address the lack of marine science in their curriculum, as these books can be used to teach that:

- Earth has one big Ocean with many features
- The Ocean and life in the Ocean shape the features of Earth
- The Ocean is a major influence on weather and climate
- The Ocean is what makes Earth habitable
- The Ocean supports a great diversity of life and ecosystems
- The Ocean and humans are inextricable interconnected
- The Ocean is largely unexplored

17.3.2 Cross Curricular—More Than Just Science Class

Nonfiction children's books can do more than just build Ocean Literacy; nonfiction books can be used to build Literacy. While teachers tend to default to fiction in their literacy programs, there is no reason *not* to include Ocean books or stories to help students learn to read or write, become active listeners, communicate effectively and make sense of the world. And while many adults and teachers often default to fiction books for the readers in their lives, research has shown that children are just as, if not more, interested in nonfiction (Stewart et al. 2021). Not only do literacy programs that focus on fiction books fail to meet the diverse interests of children, but they may also make some children believe they don't like reading, since they aren't being offered the types of books that would appeal to them. Bringing Ocean-themed nonfiction books into your literacy programs not only appeals to a greater diversity of learners and supports literacy activities, it also brings opportunities for Ocean learning into your programs.

As environmental educators, we've been talking for years about moving environmental education away from being exclusively taught in science classes. Additionally, with the amount of time devoted to science learning decreasing steadily over the years, children's nonfiction books about the Ocean should not be compartmentalized in science classes. Beyond including them in your literacy programs, these stories can be used in language arts programs, reading, writing, math, social science, computer science, history, music and even art. And when paired with classroom activities like discussions, readings, drama, storytelling etc., students continue to build their Ocean Literacy, while learning across all their other subjects (Fig. 17.3).

> Nonfiction is fabulous for building literacy skills, because we often read nonfiction differently than we read fiction. Instead of moving through the text from beginning to end, we might use the index or table of contents to find topics that interest us. Or we might browse until an interesting illustration catches our attention, pulling us deeper into the text.—L.E. Carmichael, Children's Author, personal communication, November 2024

17.3.3 Build Key Skills for Inquiry

Nonfiction books can foster scientific inquiry, build science skills, as well as develop critical and creative thinking skills. They awaken curiosity and offer opportunities for further learning—all from the comforts of the reader's home, school or library.

By supporting inquiry-based learning, nonfiction books foster creativity, imagination and critical thinking. They encourage readers to explore new ideas and discover innovative ways to address challenges. Through nonfiction, readers learn to ask questions, make connections, and organize information by classifying and categorizing it. These books help readers build the skills to connect ideas both within a single book and across multiple texts. Additionally, nonfiction strengthens the reader's ability to assess and critique information sources, as well as develop research and evaluation skills, form hypotheses and draw meaningful conclusions (Job and Coleman 2016).

In a study by Wendt et al. (2018), nonfiction books were found to provide a strong springboard for inquiry-based learning. They sparked rich discussions among readers which included questioning and peer-to-peer dialogue, foundational building blocks that support the development of creative and critical thinking skills. The study further discussed the importance of inquiry-based learning through nonfiction books as a fundamental key to children's capacity to engage in scientific argumentation. "The practice of defending an argument based on evidence is an essential skill for elementary children to acquire and can be accomplished through the use of inquiry-based lessons initiated by children's trade books" (Wendt et al. 2018, p. 38).

With the addition of classroom activities and discussions, nonfiction books also support teachers to engage students in challenging conversations as well as critically and creatively tackle difficult subject matter. With more and more misinformation circulating and greater exposure to false narratives, there is a need for accurate scientific narratives that will support young people to learn how to decipher and interpret scientific content, as well as share accurate, fact-based content.

Exposure to credible scientific information about the Ocean through nonfiction books will help readers build a greater capacity to disseminate content and build trust in scientific knowledge. By connecting readers to real world Ocean issues and stories, these books invite readers to think critically about their place in the world and their connection to the Ocean.

17.3.4 Provide Accessible Entry Point for Ocean Learning Across All Ages

According to a recent study by the North American Association for Environmental Education (2022) while teachers showed concern for and a desire to teach about climate change, the lack of formal curriculum and available resources, as well as a confidence gap in their knowledge, are creating educational barriers.

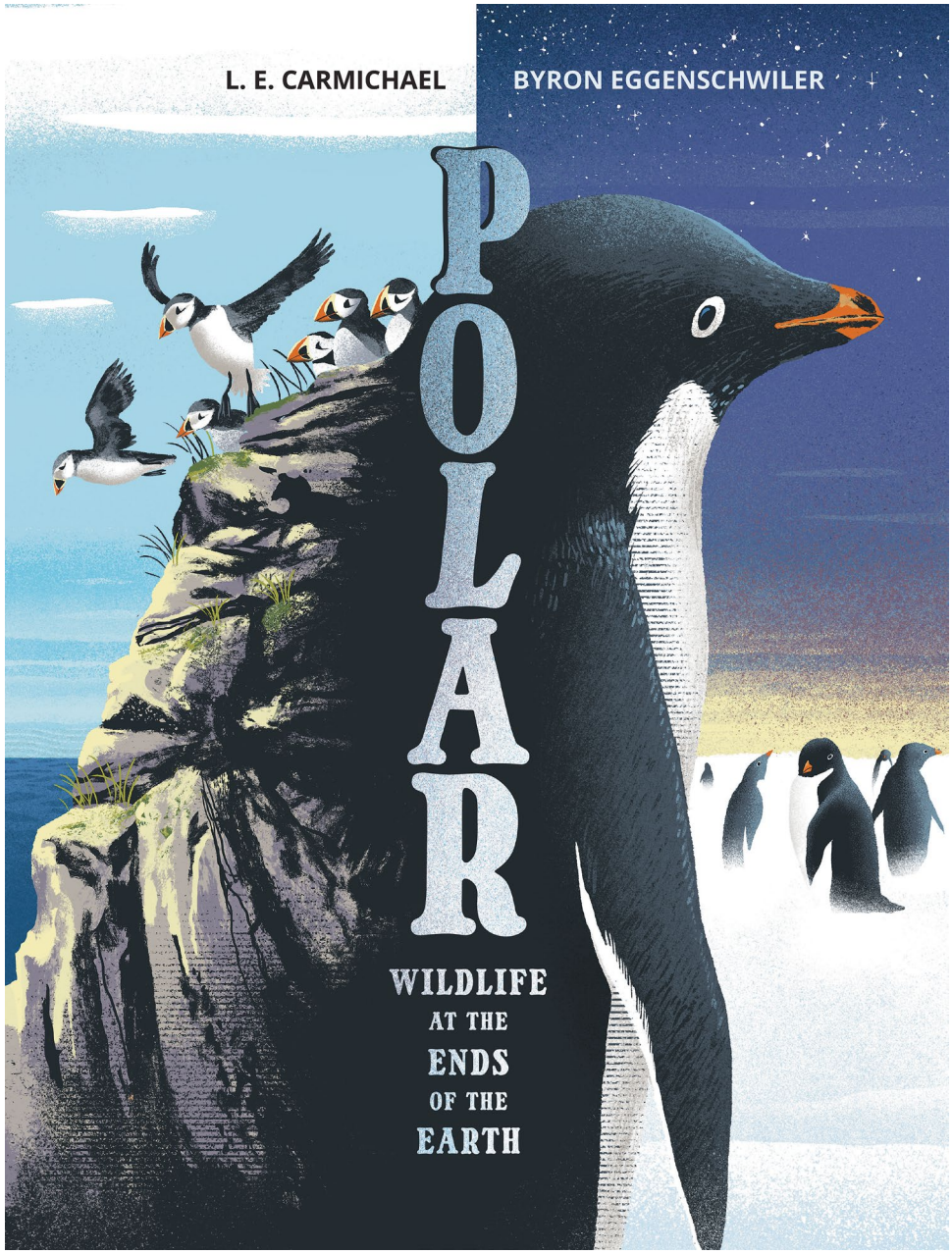


Fig. 17.3 *Polar: Wildlife at the Ends of the Earth*, written by L.E. Carmichael and illustrated by Byron Eggenschwiller (Kids Can Press, 2023), introduces readers to adaptations that help animals survive on land and at sea. Winner of the Science Writers and Communicators of Canada Book Award, *Polar* is an excellent book to bring Ocean-themed learning into all subjects. Material from *Polar* is used by permission of Kids Can Press Ltd., Toronto. Cover illustration © 2023 Byron Eggenschwiler

The same sentiment can be extrapolated to teaching about science and marine science. As Stewart and Chesley (2014) note, "Many elementary teachers do not have a strong science background. Some even report being intimidated by their school's science curriculum and feel ill equipped

to teach basic science concepts. Building science lessons around children's books enables many elementary educators to approach science instruction with greater confidence" (p. 4).

Children's nonfiction books are brilliant resources for educators and parents to use themselves to learn about new or unfamiliar topics. They can provide entry points for a teacher's own learning and help build their confidence to teach about complicated and complex topics. Even many children's authors start their own investigative research by sourcing children's nonfiction books. "The power of well-written picture books cannot be overestimated. Traditionally viewed as a genre reserved solely for younger children, picture books lend themselves to comprehension strategy instruction and guided discussions at every grade level" (Harvey and Goudvis 2007, p. 66).

Using children's books is also a tool that most educators are familiar with, yet they are often overlooked as a resource. They are relatively cost-effective and barrier free—usually available in the school or public library. They offer easy entry points for parents and educators to introduce new concepts and teach about Ocean science in accessible ways with clear and engaging language. They can be used as an icebreaker at the start of a lesson, or even as a tool to wrap up a unit.

Many nonfiction authors also promote learning about the subject or topics of their books to teachers through conferences and professional development workshops. Through these programs, authors use their nonfiction books to help teachers learn the science and discover ways to incorporate their books into their classrooms. Many also offer free teacher's guides, activity sheets, lesson plans and other resources to further support teachers.

17.3.5 Create Layers of Connections

Nonfiction books about the Ocean are filled with with engaging narratives and appealing illustrations, which combined with the dynamic book designs, draw readers in. This marriage of text, imagery and design helps readers engage deeper with the story by allowing them to "see" things they may never be able to in real life, such as Ocean processes or species. They also help readers to explore the content at a macro level, through the story, and at a micro level, through the details within the images. This textured and layered approach is evocative and creates an emotional engagement and connection. These connections help ensure the information is processed and remembered, which creates the building blocks needed for further inquiry and sparks the curiosity that will drive learning. As educators we know these strong, personal connections are needed to build empathy and inspire young people to think and act differently (Fig. 17.4).

In nonfiction children's books about the Ocean, language, illustrations (such as images, diagrams, photos, graphics) and the design of the book work together to provide visual cues to the meaning of the words, further helping connect readers to the story. They often extend the story by telling secondary or tertiary narratives within the illustrations. Narratives combined with illustrations or images are also more likely to hold the reader's attention thus providing greater engagement with the story. This depth of engagement is more likely to help a reader to remember what they've read as well as to incorporate their learning into their day to day. According to Wells and Zeece (2007), "Books will…be most effective in environmental learning and place-based education if these present accurate information in both the text and illustrations." (p. 287).

Reading children's books is often a warm experience of connection—between the book and the reader, or between the reader and the person being read to. They offer moments when adult, parents, guardians or teachers, and children learn together. In a classroom setting, reading out loud offers opportunities for classroom discussions and/or debates, creating connections between learners through conversations and idea sharing. These discussions give learners the opportunity to ask questions, formulate thoughts, ideas and opinion and provide moments of self-reflection, helping each learner create their own meaning. By building these moments of connection, nonfiction books

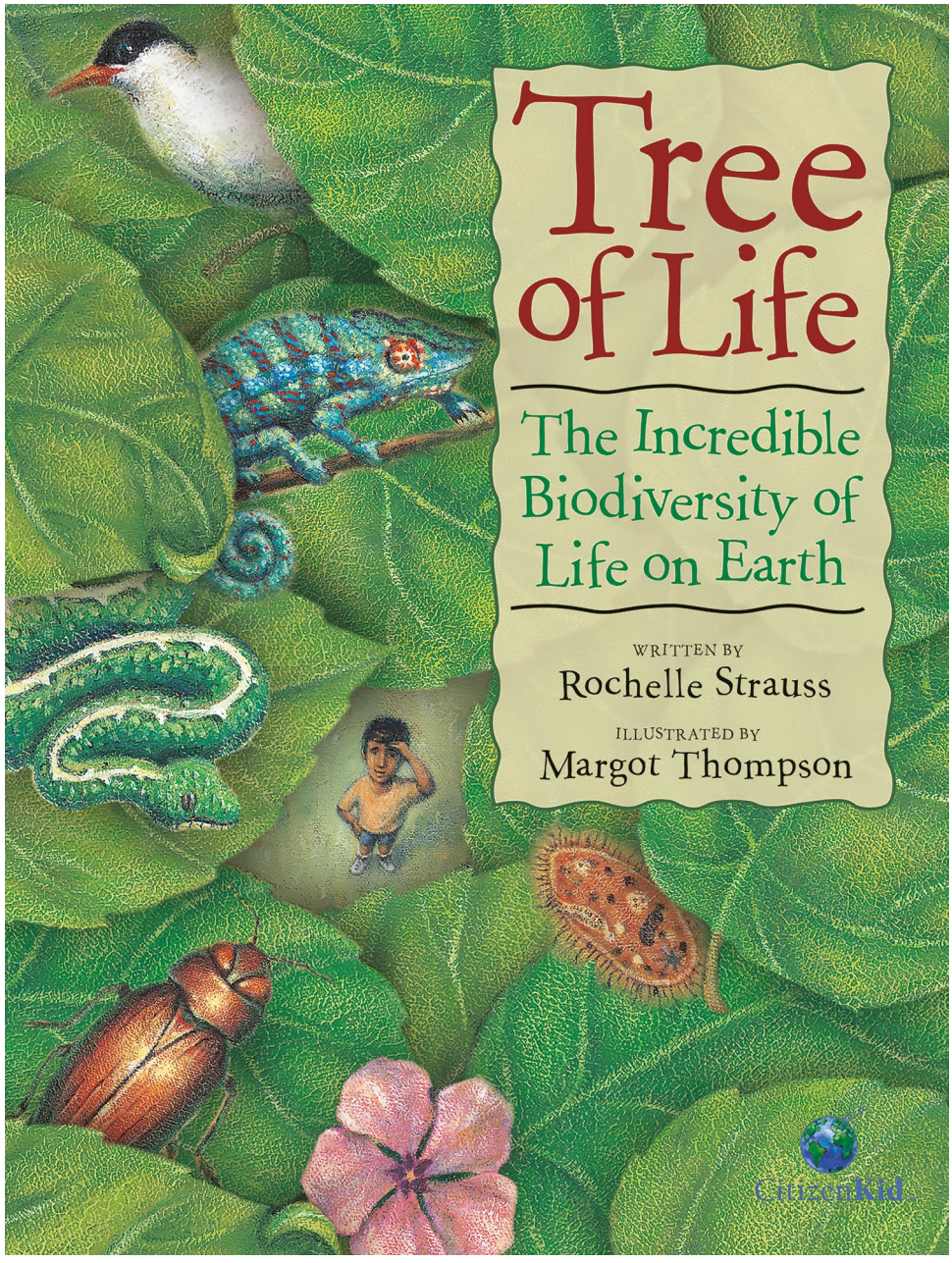


Fig. 17.4 *Tree of Life: The Incredible Biodiversity of Life on Earth*, written by Rochelle Strauss and illustrated by Margot Thompson (Kids Can Press, 2004, 2013) offers a wonderful example how children's books successfully pair rich content with vivid and accurate illustrations and dynamic design to engage readers, building a sense of awe and wonder, piquing their curiosity. Material from *Tree of Life* is used by permission of Kids Can Press Ltd., Toronto. Cover illustration © 2004 Margot Thompson

become more than just powerful tools that build an understanding of marine science and issues. They create the emotional connections that can drive positive behavioural change.

Finally, stories beget stories. When we hear a story that we like or care about, it sticks. When it sticks, we share it with others. Younge people often bring stories home to their families or share stories with their friends. By sharing stories, we create connection—a shared knowledge, a common understanding and a bond. Through these shared moments of connection, learning ripples out and we create opportunities for people to rally together in response to that information.

17.3.6 Inspire and Empower

Building Ocean Literacy is, as discussed, more than just learning about Ocean science and building an understanding of Ocean issues. It's also about becoming curious about species and spaces and how everything works together. Fostering a sense of awe and wonder about the world, will help readers to care—not just about the impact the issues have on themselves or their families, but on all species on Earth. To that end, nonfiction books about the Ocean are effective tools for inspiring wonder and curiosity and empowering readers. Through their stories, they offer opportunities for taking action—whether that's becoming an Ocean advocate through rallies or art, hosting or leading a shoreline clean up, or inspiring changes within their own families. Ocean-themed nonfiction books can also showcase avenues for careers in marine science, the blue/green economy, conservation and climate action.

> The power and importance of nonfiction reading is highlighted when you hear a new teacher explain how a captivating nonfiction book on Jane Goodall over 20 years ago set her on her professional path. Both her teaching pedagogy and her personal passion continue to be fuelled by her love for nonfiction reading.—Chris Carlton, Term Adjunct Professor, Faculty of Education, Queen's University, personal communication, November 2024

17.3.7 Offer Hope

> If adults hope to see children develop a greater appreciation of environmental protection, children are best taught to love the natural surrounding world before being asked to heal its wounds… books should be shared that instill a sense of hope and a feeling that the child, though small, can create a big difference. (Wells and Zeece 2007, p. 287)

Nonfiction children's book about the Ocean can educate and inspire to be sure, but they can also raise anxiety and foster fear. Stories may be told that share devasting news of natural disasters such as Ocean levels rising, flooding, extreme storm events, etc. Though sharing these stories has an important place in learning about and understanding the issues, they can be stressful to read and may contribute to eco-anxiety—the feeling of worry, fear and despair that can come with hearing about stories of climate change, Ocean plastic, habitat loss, rising sea levels, endangered species, etc. These stories can leave readers feeling hopeless and helpless. They may also do the reverse of what was intended by causing fear paralysis in young people who don't feel that they have the agency or capacity to make a difference. As difficult as these challenges may be, we don't want young readers to become overwhelmed and disengaged. We want them to remain very much *engaged.*

Many Ocean-themed books will, and should, teach about the issues, but the *best* books will also offer stories of hope—snippets of good news, real solutions and real people working to repair our relationship to the planet and the Ocean. Sharing good news stories allows readers to see solutions. They offer insights into how others have identified an issue, ideated solutions and applied their solutions to real world problems. Young people who are informed about the issues and provided with stories of inspiration are more empowered to take positive action. Even when the innovation or action isn't a huge difference maker, the very act of sharing an initiative highlights people's creativity and showcases to the readers what is possible.

> Reading is not only about developing foundational literacy skills but teaching patience, connection, and focus. When you couple this with climate topics, young people are able to understand the world on a deeper level and process it more effectively. Nonfiction books offer a glimpse into bigger ideas, places, and people. They provide a sense of hope and wonder beyond the immediate world. This sense of hope will ultimately help young people battle eco-anxiety as they learn about the complexities of climate change and the planet in which they live.—Emily Walker, Senior Education Coordinator, EARTHDAY.ORG, personal communication, October 2024

In *The Global Ocean* (2022), for example, these stories are called *ripples of change*. They are short narratives that share positive news stories about what is being done in and around Ocean conservation, from global initiatives, to community and individual efforts. They show the reader that yes, the challenges are serious, but there are people in the world taking action and making a difference. They also highlight to readers what is possible and provide them with inspiration and ideas about what their own actions can be or what their engagement might look like. By showcasing good news stories, nonfiction books like *The Global Ocean* arm readers with information and offer pathways to action, thus building a sense of agency.

Action + Agency = Hope…and hope is a valuable tool in combatting eco-anxiety.

17.4 Eight Tips for Selecting Nonfiction Children's Books

Of course, not all nonfiction books about the Ocean are created equal, and it's very important to ensure that the stories you select, as an educator, librarian, parent, or guardian are scientifically accurate, and support your learning objectives and goals. The following tips will help you select quality nonfiction books about the Ocean (Francis et al. 2021; Carmichael and Strauss 2023):

1. Check the copyright date. Finding books with a recent copyright date is a good way to ensure the information in the book is reasonably current and up to date. Of course, there are exceptions to this rule, as sometimes the science hasn't changed, so older books can still hold significant meaning and value. Additionally, authors may provide updated and/or additional content on their websites as stories evolve and develop.
2. Look for backmatter. Nonfiction authors want to support teachers and parents every step of the way. Look for nonfiction books that offer a glossary to help kids acquire topic-specific vocabulary, further reading suggestions, and a source list or abridged bibliography. Keep in mind that not all publishers require this, so some authors may have their research sources and bibliography on their websites. You can also check their listed sources for currency and look for a balance of primary and secondary sources.
3. Did they engage subject matter experts? Nonfiction authors are not necessarily experts in the fields they are writing about. They are choosing their topics out of a personal passion or curiosity and interest in the subject. Check the copyright pages and/or the acknowledgements for the name of any expert reviewers who the author may have consulted with and/or asked to review the book for accuracy. You may also see endorsements on the book or the author's website from experts who support the book.
4. Are the illustrations correct? Are species, habitats and ecosystems accurately portrayed? Nonfiction authors go to great lengths to ensure the accuracy of all graphics and illustrations so again, look to see if the book has been reviewed or endorsed. Many reviewers will review the illustrations too.
5. Check the author's own biography. What is their background and where do their interests and experience land? What is their expertise or their educational and professional

background? Have they, or their books, won any awards?
6. What are the learning goals and curriculum objectives you hope to meet? Do the books you are selecting meet those goals? Do they align with your local or national curriculum standards? Many nonfiction authors and/or publishers provide resources that show teachers how their books align with certain curriculum requirements or standards.
7. Is the book developmentally appropriate for your audience? Keep in mind that nonfiction picture books can often be just as valuable for older students or children, or even teachers and adults, as they provide easy introductions into new or complex topics.
8. Does the book offer hope? Ensure that if the books you select explore difficult and challenging stories, that those stories are complemented by stories of hope and/or good news. If a book you are interested in using doesn't offer good news stories, then consider pairing it with one that does.

17.5 Conclusion

Children's nonfiction books have a vital role to play in building Ocean Literacy. They are a strong platform and offer a unique voice for teaching about science and providing grounded scientific learning about the Ocean. They can explain processes and systems, show the connectivity of the issues, and offer opportunities for problem-solving by showcasing stories of hope and positive action. They can work in tandem with more science-forward textbooks, as well as help teachers take Ocean learning out of the science class and infuse it throughout the curriculum, across all subjects and grades. Young people who are provided with opportunities to learn about and connect with the Ocean, who hear inspiring stories of action, and who are offered opportunities for engagement, are more likely to develop both a sense of empowerment and the agency they need to take to take action themselves. Nonfiction books are valuable tools for building Ocean Literacy and inspiring engaged environmental citizens.

17.5.1 Summary

This chapter highlights key ideas, including:

- Children's nonfiction books are powerful tools in STEM learning and can be used effectively to build Ocean Literacy.
- With engaging texts, vivid imagery and dynamic design, they bring the Ocean to life for readers, no matter where they live.
- Using storytelling to make factual content accessible, they create emotional connections to the Ocean that resonate with young people.
- Nonfiction books about the Ocean offer more than just stats and data, they contextualize the learning and build a much deeper understanding of the Ocean.
- Nonfiction children's books are cross-curricular and therefore can be used across multiple subjects and grades, infusing Ocean Literacy across the curriculum.
- Nonfiction books also provide accessible entry points for Ocean learning across all ages.
- By sharing good news stories, they can inspire and empower readers to take action, helping them develop a sense of agency and build hope.
- While not all nonfiction books are created equal, the chapter provides several tips for selecting nonfiction books for home or school.

17.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Carmichael, L.E. (2023). *Polar: Wildlife at the ends of the Earth*. Kids Can Press.
- Cusolito, M. (2024). *A window into the Ocean Twilight Zone: Twenty-four days of science at sea*. Charlesbridge.
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Rochelle Strauss is on a mission to change the world—one book at a time! She is an environmental educator and best-selling children's author from Toronto, Canada. She has dedicated her career to building environmental literacy and inspiring people to become active stewards of the planet. Her books have won several awards, been translated globally and incorporated into curriculum in the US. *The Global Ocean* (Kids Can Press, 2022) is a UNESCO endorsed Ocean Decade Activity, and *One Well: The Story of Water on Earth* (Kids Can Press 2007) was selected as part of the UN's Sustainable Development Goals Book Club in support of SDG 6—Clean Water and Sanitation. *One Well* has also sold over half a million copies worldwide.

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Creative Currents: Art as a Tool for Ocean Literacy

18

Linda Cabot, Susan Tang, Montana Dickerson, and Jeremy Pivor

Abstract

Working at the intersection of Ocean science and arts education since 2011, *Bow Seat*, the world's largest environmental youth program dedicated to the creative arts, provides an innovative space for global youth to connect, create, and communicate for our planet.

In this chapter, we share lessons learned from over a decade of empowering youth through *Bow Seat: Creative Action for Conservation (formerly Bow Seat Ocean Awareness Programs)*, which inspires young people to explore Ocean issues and become environmental advocates through the creative arts. Our award-winning Ocean Awareness Contest, hosted annually, has engaged more than 44,000 students aged 11–18 from over 142 countries and has elevated diverse youth voices and fostered dialogue and participation in Ocean conservation.

Through creative expression, students experience interdisciplinary learning in which conservation topics become personal, experiential, and multisensory as they produce unique images, stories, poems, and media. By sharing the history, methodology, and outcomes of this unique program, we explore the empowering role of the creative arts in introducing students worldwide to complex Ocean challenges. We also highlight the broader implications of our findings, which demonstrate the creative arts' critical role in advancing Ocean Literacy through three key pillars of student impact: building knowledge, fostering empathy and interest, and cultivating youth empowerment.

Keywords

Art for youth empowerment · Artivism (artistic activism) · Art contest · Bow Seat Ocean Awareness Contest · Ocean Literacy (OL) · Teen mental Well-being

18.1 Introduction

The Ocean is vast, mysterious, and has inspired awe and admiration throughout the ages. Mystical and romantic, our glorious blue seas evoke grandeur as they shimmer against golden sunsets and sublime sandy beaches. They remind us of eternity with their expanse, deepness, and unexplored realms. These enormous bodies of water with their wildness often summon in us a sense of

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endless freedom and spirituality. Odes and paintings, limericks and songs, epics and masterpieces, movies and prose have been created over the course of time, celebrating the beauty and magnificence of the Ocean.

The global Ocean is the cornerstone for life on Earth—unfortunately, many people do not realize this. Covering 71% of the Earth's surface and providing half the oxygen we breathe, the Ocean regulates life-affirming climate and water cycles, drives significant global marine economies, and supplies valuable food protein and medicines to the world population.

Humans think of the Ocean as invulnerable and all-powerful, revered for its enormity and immortality, so there is a certain disbelief when one learns that the Ocean is being threatened by human actions. It is hard to fathom that the Ocean ecosystem is vulnerable and susceptible to harm caused by human industrial activities. It is difficult to grasp that something once so powerful is no longer as resilient as we had once thought.

The global Ocean is now overfished and gravely threatened by human-caused pollution effects—oil spills, industrial run-off, plastic and chemical waste, carbon emissions, and even sound and light pollution. Warming Ocean waters from fossil fuel-driven climate change are contributing to changing weather patterns, more severe hurricanes, flooding events, coral reef collapse, destructive sea-level rise, droughts, and changes in the Ocean's biochemistry (The National Aeronautics and Space Administration 2023).

Without more global protections, the Ocean will only degrade further. Ocean health is inextricably linked to the planet's health and to our own. Systematic change is now required beginning with building awareness about problematic ecological issues caused by our dominant economic structures. In a world inundated with information, reaching and actively engaging diverse audiences on critical issues like Ocean health requires innovative approaches.

Creativity and the arts are powerful vehicles for change. Traditional science communication often falls short in connecting with a broader audience, hindered by a lack of accessibility. The consistent unfortunate gloom and doom messaging from these traditional science sources—articles, reports, books, and lectures—can also lead to apathy and feelings of powerlessness (Léger-Goodes et al. 2022).

Artistic environmental communication serves as a universal language that transcends barriers of education, language, and socio-economics. Art tells stories, reframes narratives, and sparks imaginations and joy. Using creativity as an environmental educational tool when teaching difficult knowledge is an exciting and positive way to not only enthusiastically interest young people, but also to enable them.

In 2011, Bow Seat: Creative Action for Conservation (formerly Bow Seat Ocean Awareness Programs) implemented a successful Ocean Literacy program for youth worldwide. Our mission is to empower young people and teach them about Ocean health. When we ask our students to learn about certain Ocean and climate issues and then, in response, create personal and uniquely made artworks, poetry, prose, music, dances, and films, we are asking them to creatively respond with both their thinking mind and their somatic, embodied experience. This type of experiential engagement, where there is space for feelings, and freedom to make unexpected connections, allows students to become critical makers. Being able to communicate on a variety of different and multisensory levels often leads to a deeper, more meaningful learning experience. Learning by doing enhances understanding and gives positive agency to young people, empowering them through the act of creating something unique, original, and impactful. They transform data-driven issues into empathetic concerns, inspiring a cultural shift toward respect and action for our blue planet.

As we'll discuss, the marriage of art and activism—artivism—emerges as a beacon of hope for Ocean conservation, the United Nation's Sustainable Development Goals and Ocean Decade Challenge 10. Creativity becomes a tool not just for raising awareness, but for inspiring positive actions and community building. In the hands of today's youth, armed with knowledge and creativity, artivism is poised to lead the



Fig. 18.1 Illustrating the future. *Note*. By Anika B., 2020, painting, oil on canvas, United States

charge toward a healthier, more sustainable world. As art changes people, these empowered individuals are destined to change the world—one brushstroke, one note, one word at a time (Fig. 18.1).

18.1.1 About Bow Seat

Feeling a deep concern for the health and future of the Ocean, Bow Seat Founder Linda Cabot embarked on a sailing trip with her teenage daughters in 2011 to create a documentary about environmental issues impacting the Gulf of Maine. The act of making this film engaged Linda and her daughters in a unique, authentic, and transformative way—in a manner that textbooks alone could not. Realizing the power of art-making to educate, inspire, and activate younger generations, Linda founded Bow Seat in 2011 to empower youth through imagination and creation, and to motivate them to become active stewards of the Ocean. Bow Seat's founding was also informed by research documenting art's benefits on improving communications and cognition skills as well as encouraging empathy and cultural understanding (Coholic 2011).

18.1.2 About the Ocean Awareness Contest

Bow Seat's flagship initiative, the annual *Ocean Awareness Contest* (referred to as the Contest), began as an essay competition for high school students ages 14–18, and received approximately 70 submissions in its first year. Since then, the Contest has grown significantly in both scope and impact. It now features seven creative arts categories: (1) Visual Art: Handcrafted, (2) Visual Art: Digital, (3) Poetry & Spoken Word, (4) Creative Writing, (5) Film, (6) Performing Arts, and (7) Interactive & Multimedia. These categories are divided into two age divisions: Junior (ages 11–14) and Senior (ages 15–18). Each year, the Contest engages thousands of youth from around the world, inspiring them to explore and respond to a wide variety of issues the Ocean is facing (Fig. 18.2).

18.1.3 Audience

Bow Seat utilizes the Contest to engage youth and educators in formal, informal, and community-based education. Youth find the Ocean Awareness Contest through a variety of



Fig. 18.2 Ocean Awareness Contest timeline. *Note.* Contest themes have evolved since 2012, moving from localized topics around the Gulf of Maine to the global issue of climate change

avenues including online searches, social media, and classroom assignments. Since 2012, the Contest has engaged over 44,000 youth from all 50 U.S. states and 142 countries. Bow Seat has awarded nearly $1,000,000 in scholarships to help further advance teens' creative talents and their passion for the Ocean, as well as to educators from all disciplines who support student participation and encourage them to be creative and active stewards of our blue planet.

Bow Seat expands the reach of student work by showcasing their pieces in our online gallery, and through exhibitions, film screenings, presentations, publications, and social media. This provides a special opportunity to display teens' individual skills and also demonstrates the strength of their collective voices, which brings awareness of Ocean issues to wider audiences. Other community-based organizations also leverage our students' creative pieces through pop-up art shows and campaigns to enhance their own environmental events and messaging.

Bow Seat also works with formal and informal educators in any discipline who want to combine Ocean Literacy and the creative arts in the classroom and beyond. We have directed hands-on workshops on creative advocacy, led summer programs about plastic pollution, and teamed up with students to create watershed murals and storm drain art on campuses and city streets. Bow Seat shares youth creative art pieces as resources for local and global initiatives in environmental and arts education, conservation, and advocacy. From World Oceans Day festivals and international public art campaigns to local beach cleanups and community film screenings, we work with our network of partners to elevate the next wave of creative Ocean leaders.

18.2 Contest Design and Implementation

Each September, Bow Seat launches the new Contest cycle by announcing its theme and accompanying prompt. The annual theme is carefully selected to encourage students to explore and create within a focused area of interest. A prompt is subsequently crafted to succinctly engage students with the chosen theme. For example, the 2023 Contest theme was "Climate Heroes in Action" and the prompt was:

> Research and choose an inspirational scientist, activist, artist, educator, or other hero who is working to solve climate change issues. Create a piece of art, writing, or media that highlights their efforts, organizations, and/or positive impacts. We are familiar with the amazing work of environmental giants like Greta Thunberg and David Attenborough. We challenge you to introduce the Bow Seat community to a Climate Hero whose work we may not know yet—but should.

In addition to the prompt, we provide students with additional context and information to guide them through their brainstorming and creative processes. We curate an online Resource Studio with links to various articles, videos, and other relevant materials, offering students a deeper understanding of the issues associated with the theme, as well as creative resources. For example, the 2023 Resource Studio featured information on the causes and effects of climate change, profiles of climate heroes, and tips for improving artistic techniques.

The Contest closes the following June. Over the summer, Bow Seat mobilizes a team of over 70 judges across three rounds of judging to finalize our Contest winners. Once we've selected our winners, we begin uploading their pieces and reflections to our online Gallery, where they live in perpetuity. Winners are announced to the public in late November, and we continue celebrating our winners on our website and social media pages for the next several months.

18.3 Post-Contest Surveys

Since 2016, Bow Seat has collected both quantitative and qualitative data via online surveys from Contest participants and their adult sponsors. We use these surveys to assess the effectiveness and impact of the Ocean Awareness Contest and to guide our programming, particularly around the selection of the following year's Contest theme. For example, in 2022, following "The Funny Thing About Climate Change" Contest, we

received a lot of responses regarding the anxiety youth were feeling about climate change. In response to this, we developed the following year's Contest theme, "Climate Heroes in Action," to expose youth to the many solutions and hopes that exist worldwide.

18.3.1 Participant Survey

Following the submission of their creative art piece, participants were sent a confirmation email that asked them to complete a voluntary survey to help improve future Contests and shape Bow Seat programming. Participants were assured that their survey answers would not be linked to the judging of their submission.

The survey utilized a variety of question structures including multiple-choice, Likert scale, and open-ended questions related to the Contest's impact on participants. On average, each year, 19% ($N = 719$) of Contest participants responded to the survey. Likert scale questions were quantitatively analyzed using the arithmetic mean given that the values were equally weighted. This analysis also allowed us to compare the changes in mean values for the same question across years. Thematic analysis was used to analyze open-ended answers to uncover recurring themes or patterns in the survey responses within and across survey years. Thematic analysis allowed us to emphasize participants' words and meanings, centering our study on the youth's perspectives and lived experiences.

18.3.2 Adult Sponsor Survey

During Contest submission, the participant must list an adult sponsor and their email, usually their parent or teacher. Bow Seat sent a voluntary survey to all sponsors with the goal of improving the Contest for future years. Sponsors are assured that their responses are confidential and have no impact on the judging of the participant's entry.

Similar to the participant survey, the adult sponsor survey included multiple-choice, Likert scale, and open-ended structures focused on the Contest's impact on students. Sponsor survey responses were analyzed using the same methods applied to the participant data.

18.4 The Alumni Perspective: Evaluating Long-Term Impact

In 2024, Bow Seat sent a voluntary survey to our alumni via a newsletter to assess how to best improve Bow Seat programming for the needs of our community. Survey participants were ensured confidentiality and automatically entered into a raffle for one of five $50 gift cards. 222 alumni responded to the survey, which utilized Likert scale, multiple-choice, open-ended, and single-word answer questions.

Themes in the survey ranged from perspectives gained from Contest participation to Bow Seat's impact on environmental literacy and engagement. Survey responses were analyzed using the same methods as those applied to the Contest participant and adult sponsor surveys.

18.5 Survey Results

18.5.1 Demographics

Data were gathered from 2016 to 2023. In 2020, we began collecting data on race and gender. Table 18.1 describes participant demographics over this 8-year period.

18.5.2 Post-Contest Surveys

Each year from 2016 to 2023, an average of 19% (min: 11%; max: 30%) of participants replied to the student feedback survey. These students reported the following results.

18.5.2.1 Students' Impression of the Contest

Students were asked, "What is your overall impression of the Ocean Awareness Contest? Think about the theme, the information and

Table 18.1 Demographics of ocean awareness contest participants

Demographics	2016	2017	2018	2019	2020	2021	2022	2023
# of Contest Participants	2176	2752	2755	3501	5246	5930	4261	4272
Junior (11-14)	42%	31%	35%	41%	33%	38%	41%	39%
Senior (15-18)	58%	69%	65%	59%	67%	62%	59%	61%
# Male	N/A	N/A	N/A	N/A	23%	27%	27%	27%
# Female	N/A	N/A	N/A	N/A	75%	68%	68%	68%
Non-binary/third gender	N/A	N/A	N/A	N/A	1%	1%	2%	1%
Gender-prefer not to answer	N/A	N/A	N/A	N/A	2%	3%	3%	3%
Black, Latine, and/or Indigenous	N/A	N/A	N/A	N/A	11%	16%	17%	15%
U.S.-based	75%	62%	75%	74%	74%	69%	65%	62%
Based outside the U.S.	25%	38%	25%	26%	26%	30%	35%	38%
# Survey Respondents (% of participants)	238 (11%)	440 (16%)	441 (16%)	1050 (30%)	1364 (26%)	1245 (21%)	682 (16%)	555 (13%)

Note: The number and percentage of participants who responded to our participant survey is noted in the last row

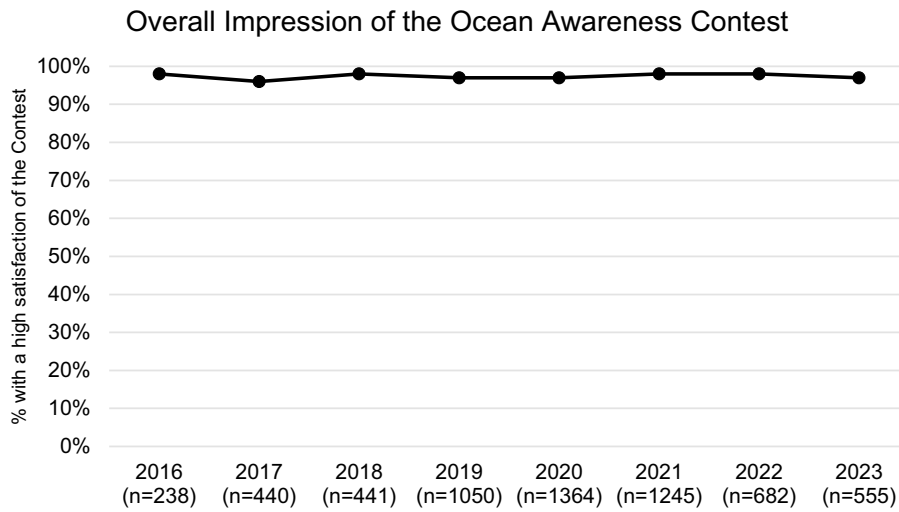


Fig. 18.3 Overall impression of the Ocean awareness contest

resources provided, the submission process, and the overall experience." 1 ("Not so great") to 5 ("Awesome"). Each year, students reported a high satisfaction with the Contest (≥4) (Fig. 18.3).

18.5.2.2 Contest Impact on Students: Knowledge Before and After

Students were asked, "How much did you know about {the Contest issue (e.g. Ocean pollution)} BEFORE participating in the Contest?" 1 ("This was all new to me") to 5 ("I already knew a lot"). An average of 57% of students across the years rated their knowledge of the Contest issue as high (≥4) (Fig. 18.4).

Students were then asked, "How much did the Contest increase your knowledge about {the Contest issue/theme}?" 1 ("Not at all") to 5 ("I learned a lot of new things"). An average of 75% of respondents learned a lot of new information about the Contest issue/theme after participating (≥4) (Fig. 18.5).

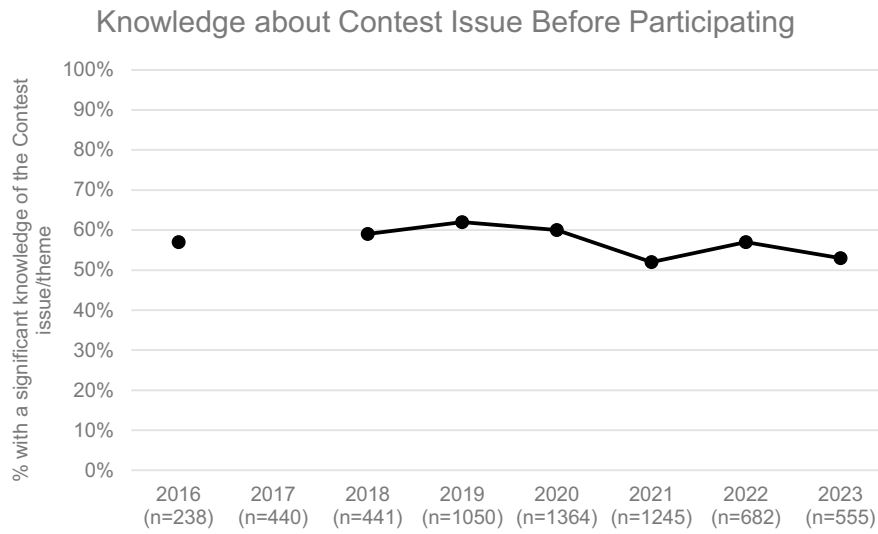


Fig. 18.4 Knowledge about contest issue before participating. *Note.* Students were not asked about their knowledge of the Contest issue in the 2017 survey

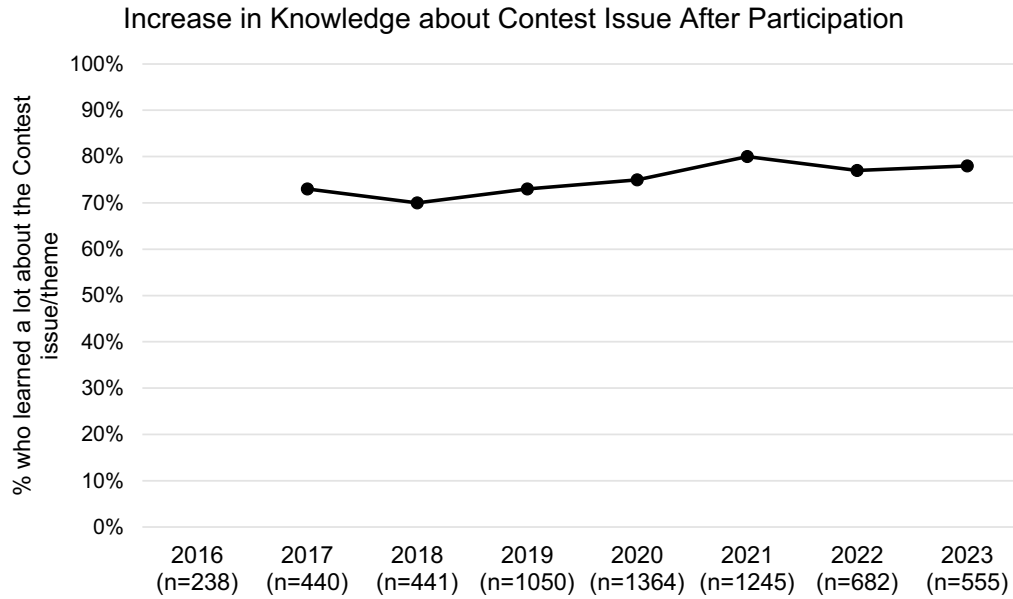


Fig. 18.5 Increase in knowledge about contest issue after participation. *Note*. Students were not asked about the degree to which they increased their knowledge of the Contest issue after participating in the Contest in the 2016 survey

18.5.2.3 Confidence in Creative Skills: Before and After

Students were asked about their confidence in their creative skills including, "How confident were you in your creative skills BEFORE participating in the Contest?" 1 ("Not confident at all") to 5 ("Extremely confident"). Respondents were also asked, "How much did the Contest change your confidence in your creative skills?" 1 ("Not at all") to 5 ("It made me more confident") (Fig. 18.6).

An average of 45% of respondents were confident in their creative skills *before* participating in the Contest (≥4). Additionally, an average of

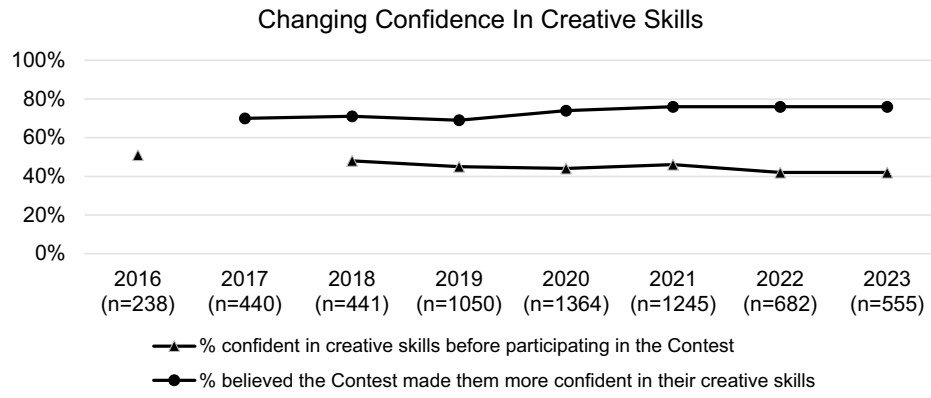


Fig. 18.6 Changing confidence in creative skills. *Note.* Students were not asked about whether they believed the Contest made them more confident in their creative skills in the 2016 survey. Students were not asked about their degree of confidence in their creative skills prior to participating in the Contest in the 2017 survey

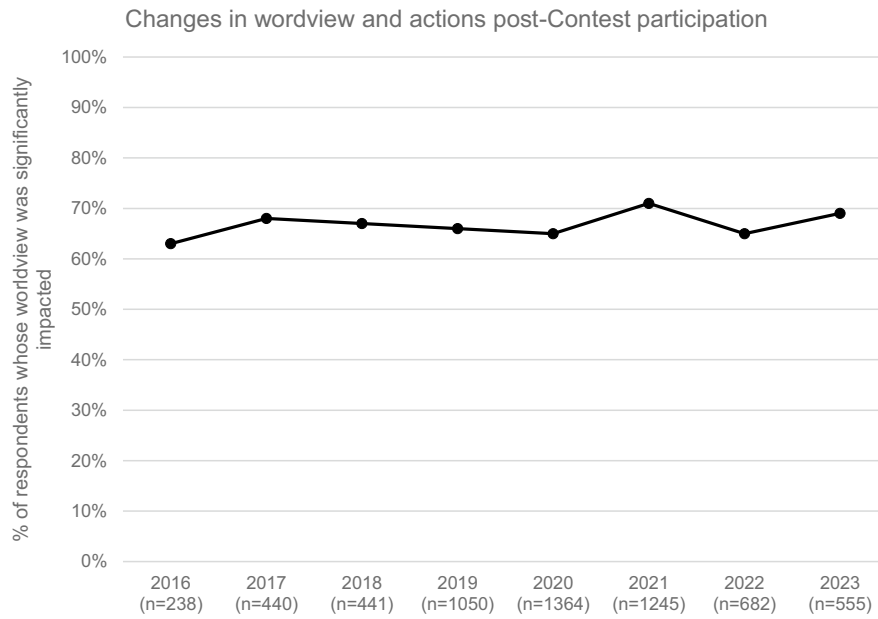


Fig. 18.7 Changes in worldview and actions post-contest participation

73% believed the Contest made them more confident in their creative skills (≥4).

18.5.2.4 Change in Worldview

Students were asked, "Did the Contest change anything about how you see the world or the way you act in it?" 1 ("Not at all") to 5 ("It changed my life"). An average of 67% of students reported the Contest significantly changed their worldview and how they act in it (≥4) (Fig. 18.7).

18.5.2.5 Creativity to Connect to Contest Issues

Students were asked, "How much has creating something helped you personally connect with the {Contest issue/theme}?" 1 ("Not at all") to 5 ("It deepened my personal connection to the issue"). An average of 85% of students reported that creating something deepened their personal connection to the Contest issue/theme (≥4) (Fig. 18.8).

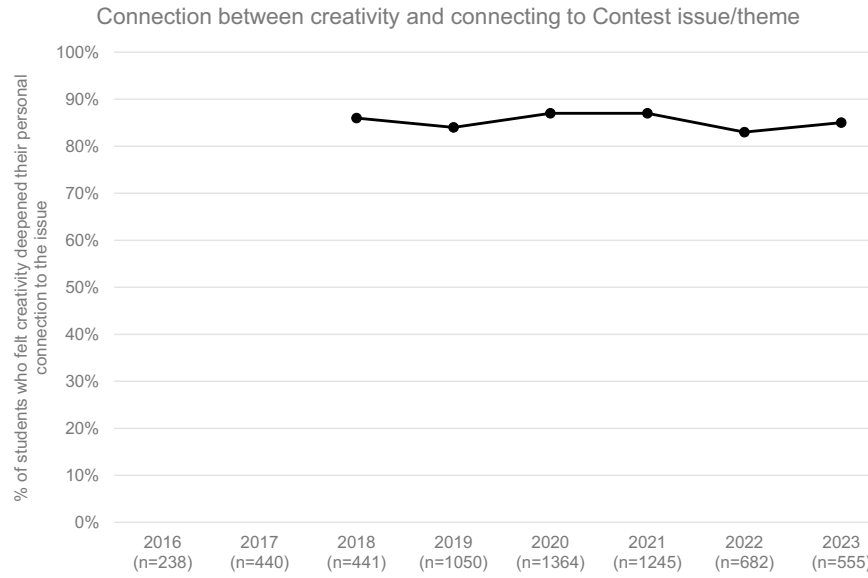


Fig. 18.8 Connection between creativity and connecting to contest issue/theme. *Note.* Participants were first asked about the degree to which creating something helped them connect to the Contest issue/theme in 2018

18.5.2.6 Students' Emotions and Perceptions

Students were also presented with the following prompt, "Learning about climate change or Ocean issues through this Contest made me feel …" They were presented with a range of nine different emotions and had the opportunity to check all that apply (as well as "other").

From 2021 to 2023 more students felt pleasant emotions after participating in the Contest compared to unpleasant feelings (Fig. 18.9).

The survey also provided students with an opportunity to write open-ended responses to the following questions including, "Was there a specific fact or moment that stood out to you when participating in the Contest?", "What did you like about participating in the Ocean Awareness Contest?", and "What would you change about the Contest?" Thematic analysis revealed the following themes with example quotes (Table 18.2):

18.5.2.7 Sponsor Observations

Sponsor feedback supported the aforementioned positive impacts students reported from participating in the Contest (Fig. 18.10).

18.5.2.8 Alumni Feedback

When alumni were asked what excites them most about Bow Seat, the three top categories were driving action (28%) (62/222), providing a platform for creative expression (27%) (60/222), and building community (24%) (54/222). These sentiments were echoed elsewhere in the survey as students described Bow Seat's impact on their lives and education.

- Connections to Environmental Movement: An overwhelming majority of alumni (89%) (197/222) reported that Bow Seat helped connect them with the environmental movement (Fig. 18.11). One participant wrote that Bow Seat connected them with a "community of fellow young creatives equally passionate about taking a stand." We found that a majority of students saw Bow Seat as a launchpad for further activism highlighting its "generational impact."
- Emotional Benefits of Being Creative: Alumni were also asked, "How does being creative make you feel?". The majority of respondents answered peaceful, empowered, free, happy, energized, and curious (Fig. 18.12).

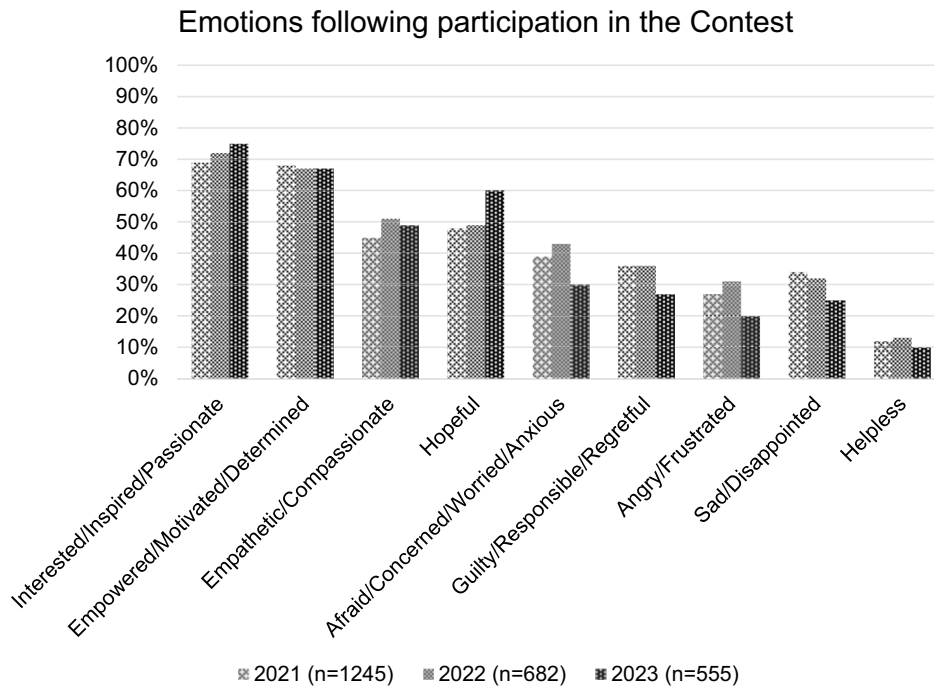


Fig. 18.9 Emotions following participation in the contest. *Note.* While students were asked about their emotions after participating in the Contest in 2018, 2019, and 2020, the choices presented to students were not kept consistent and thus left out of this chapter

- Creative Arts as a Tool for Cross-Disciplinary Engagement: Eighty percent of alumni strongly agreed (≥4) that art makes learning across all subjects more interesting in school, and 86% strongly agreed that the creative arts help them learn about subjects beyond arts courses.

18.6 Discussion

Bow Seat's Contest programming was created to raise global awareness about the Ocean's profound significance and the industrial threats that it faces. Ocean Decade Challenge 10 is an important challenge as our human connection and understanding of the Ocean is often limited and distorted. Having young people realize the true state of Ocean health and its value is the cornerstone of advocacy and change.

We have found through both our quantitative and qualitative analyses that the Contest not only increases knowledge of our Ocean but also helps create empathy and personal connection towards it (Figs. 18.5 and 18.8). Importantly, our Contest program serves as a positive influence for our students where they feel supported to act, can develop a sense of agency and purpose, and are uplifted by a community of their peers. Our three pillars of student impact—**knowledge building, creating empathy and interest,** and **youth empowerment—**all contribute to positively changing young people's relationship with the Ocean and propel students to become Ocean advocates.

18.6.1 Knowledge Building

Every year, Bow Seat selects specific Contest themes so that our students can grasp the differ-

Table 18.2 Themes from participant open-response survey questions from 2016 to 2023

Theme	Quote
Hope	"When I saw everyone who participated… I knew there was hope for the Ocean's future. I knew that us contestants are strong, powerful, and determined to make a difference."
Raising awareness and increasing knowledge	"Even though I already knew about climate change and its effects on the planet and the Ocean, the Contest helped open my eyes even more. It was like I had been near-sighted and had just been given glasses: everything was much clearer now, and I understood and learned a lot during this experience. I'm so grateful to the Contest for helping me discover more!"
Personal attitudes and actions	"I have more self-awareness of things happening around me and what I can do to help out my community. It almost feels like it gave me self-worth."
Community	"I love that it's a community. I love reading past winners' projects, listening to their songs, and looking at their amazing artwork. I feel like everyone here is so incredibly special because they care about serious topics like climate change and Ocean health from such a young age. The Ocean Awareness Contest really brings an entire community together from around the world that encourages passion for our world using beautiful art."
Connecting to the issue	"When I was creating my visual artwork, I thought about what sea life has to go through on an everyday basis."
Empowerment	"I think being able to formulate how you feel into words makes you feel powerful or like you have a voice in this world. It often feels like you are so small and you could never make a difference or be heard, so being able to participate made me see that no matter who you are, you can speak up and make a difference."
Confidence	"When I first thought of the idea, it seemed impossible. But while sitting in class, my ideas just kept building and building until I had a full story outline. It made me believe in my creative ability more."
Program praise	"I have participated in the contest three times, and even though I have not won, writing the pieces always taught me new things, opened my mind to more ideas, allowed me to hone my creativity skills, and, most importantly, strengthened my connection with the Oceans."

Note: Quotes are drawn from participant surveys from 2016 to 2023

ent and ever-changing threats our Ocean is facing. Since only an average of 57% of students know a lot about the Contest theme prior to participation (Fig. 18.4), we ask that students study and learn about the theme before they create their submission. To facilitate this learning, we curate educational resources and share them online in our Bow Seat Resource Studio as well as host webinars and classroom workshops. By asking students to learn about the theme before they create their submission, we find that our students not only explore our resources but often report doing research on their own.

Over the years we have collected thousands of remarkable quotes in our student feedback surveys as demonstrated in Table 18.2. We have included a few below which speak to the significance of student research. We have found that by participating in the Contest, many of our students learn about Ocean conservation and climate change for the first time. In that sense, our Contest Program acts as an incubator or accelerator for conservation learning.

> Before participating, I didn't really care about climate change, global warming, or Ocean pollution. But after doing research, I now feel that these are big problems, and I regret not paying heed to them. It has inspired me to do something for the betterment of our planet.

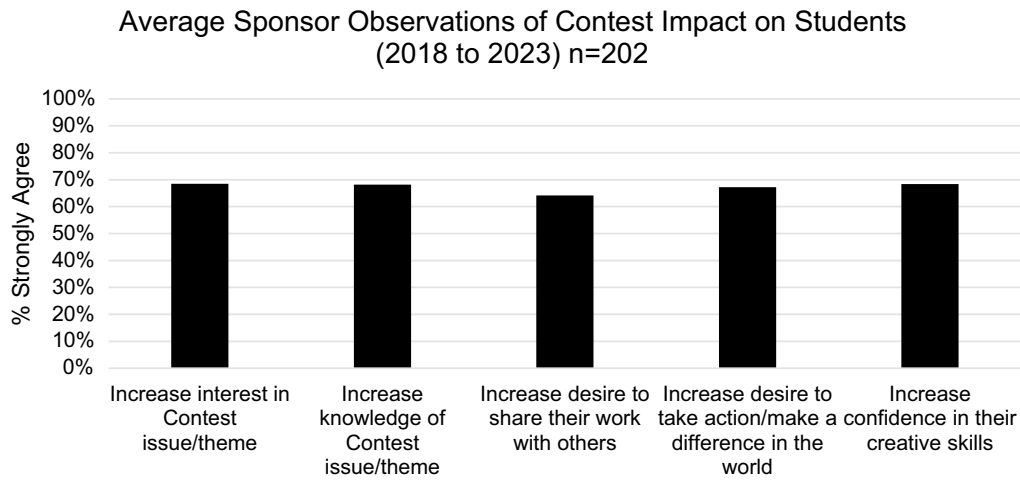


Fig. 18.10 Average sponsor observations of contest impact on students (2018–2023)

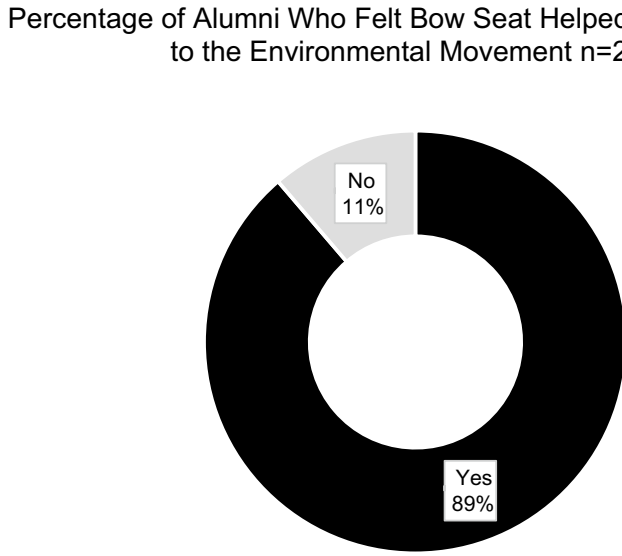


Fig. 18.11 Percentage of alumni who felt bow seat helped connect them to the environmental movement

When researching the piece, I found myself in awe of the different movements toward equality, but also guilt-ridden for my lack of awareness. This Contest brought out a curiosity I had not anticipated.

I enjoyed learning and researching about our Oceans, and I went down (a lot) of rabbit holes. I never fully grasped how diverse and beautiful our Oceans are! And I also never fully grasped how much we have to protect them. I felt like it was my duty to educate others about the issues that our Earth is facing after I learned all of these things.

Independent research allows students to explore their individual interests which, in turn, drives their focus and eventual submission. Regardless of whether students knew nothing or a lot about the issues before the Contest (Fig. 18.4), on average, 75% of participants learned a lot of new information through participating (Fig. 18.5). Additionally, an average of 69% of sponsors noticed increased interest in the Contest issue, and 68% noted increased knowledge about the Contest theme (Fig. 18.10).

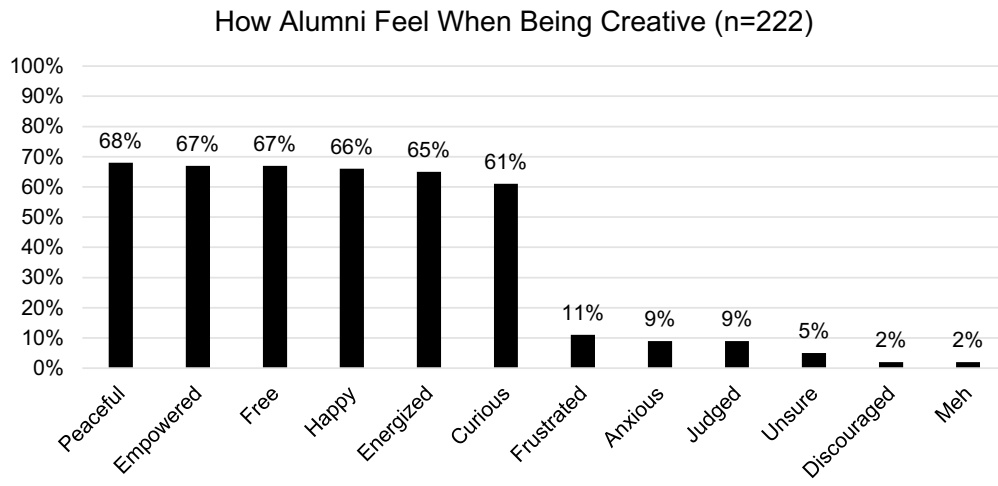


Fig. 18.12 How alumni feel when being creative

Over the Contest's 12 years, students have learned about a wide range of issues and threats that the Ocean is undergoing. Our first two Contests in 2012 and 2013 were about overfishing and marine biodiversity loss. For 4 years from 2014 to 2017, our themes were focused on the harms of marine plastic pollution. During these years our students explored all aspects of plastic pollution, including the problematic issues surrounding microplastics, plastic entanglements, and ingestion for marine animals. As we broadened our theme in 2017 to pollution in general, students learned about issues such as oil spills, agricultural nutrient run-offs, acidification, and even sound and light pollution (Fig. 18.13).

However, since 2019 our Contest themes have shifted from Ocean-specific issues to center around climate change more broadly. Climate change is threatening the Ocean in profound and startling ways that have an enormous impact on both humankind and our entire natural world. It is vital that students understand the connection between climate change and the Ocean, as rising temperatures are rapidly becoming the greatest threat to Ocean ecosystems. Furthermore, by encouraging students to reimagine Ocean issues through different lenses, we were able to expand Ocean Literacy into broader environmental literacy. Our students have researched and explored a variety of these different climate change impacts on the Ocean including sea level rise, acidification, coral bleaching, dead zones, increased storms/flooding impacts, and ecosystem disruptions (Fig. 18.14).

One of our students wrote that after participating in our Contest, they learned things about climate change and the Ocean that were not taught in school (Fig. 18.14).

> The real lesson that you learn from the Contest is the sheer impact of climate change and human influence on the Oceans. This seems obvious, however climate change is still a controversial unit in public schools, let alone all of the fallout that goes along with it. I learned horror stories of Ocean acidification, of how habitats are destroyed by seemingly small degrees in temperature rise, and the disastrous implications of what sounds like a tiny rise in water levels. These subjects are commonplace around Contest entries but overlooked and pushed aside in our education system. So the real lesson I've learned is to do my own research before blindly accepting what I've been handed, not just to leave myself in the dark by being content with the bare bones of what my schools have taught me.

While learning the many threats the Ocean is facing is crucial, Bow Seat recognizes that teaching our students about solutions is paramount to action and positive change. Contests that have included solutions-focused themes are *Climate Heroes in Action* (2023), *Climate Hope: Transforming Crisis* (2020), *Presence of Future* (2019), and *Ocean Pollution: Challenges & Solutions* (2016). Many of our students have researched and created submissions around wind



Fig. 18.13 Collection of student artwork about plastic pollution. *Note.* Clockwise starting from the upper left: *Stop the Madness* by Lily D., 2016, mixed medium on paper, Canada. *Habitats from Habits* by Ishanvi K., 2021, recycled plastics, colored pencil, copic markers, gouache, watercolor, and metallic paint on canvas, United States. *Untitled Art* by Katharine W., 2014, digital art, United States. *Plastic Whale* by Dafne M., 2014, acrylic, watercolor, and recycled plastic on canvas, Peru. *Mermaid's Tears* by Tammy F., 2016, watercolor on paper, Canada

farms, blue tech, sustainable fisheries and aquaculture, marine biologists, and waste and energy reduction (Fig. 18.15).

Our students readily attain Ocean Literacy knowledge because when they develop their unique pieces, they are simultaneously making and thinking, and this hands-on learning becomes personal, emotional, and multidimensional. 85% of our students reported that creating something deepened their personal connection to the Contest issue/theme (Fig. 18.8). This is reflective of how experiential engagement often results in a deeper learning experience where students retain information and feel more deeply engaged by the subject (Somerson and Hermano 2013).

Students also become further invested in the topic through the sense of achievement and pleasant emotions they experience when creating something meaningful, impactful, and original. As we saw in our Alumni Survey, the act of creating results in significantly more pleasant emotions than unpleasant (Fig. 18.12).

18.6.2 Creating Empathy and Interest

Because Bow Seat's Contest engages students in an experiential (learning by doing), creative exercise, they often become emotionally involved with their submission. Harnessing a student's



Fig. 18.14 Collection of student artwork about climate change impacts. *Note.* Clockwise starting from the upper left: *All That's Left* by Gwenan W., 2019, micron pen and ballpoint pen on paper, United States. *Dilemma* by Hongying W., 2022, oil paint on canvas, United States. *Darkening Blue* by Ethan F., 2018, watercolor and ink pen on paper, Canada. *Unusual New Coming* by Roy K., 2021, graphite pencil and acrylic paint on wooden panel, United States

feelings is imperative in creating empathy and interest in the Ocean. Young people who participate in the Contest creatively demonstrate great concern, curiosity, and awe about the Ocean. In the experiential making of their submissions, they often connect emotionally to the subject, and their feelings are expressed through their artworks, songs, poems, prose, and films. As our themes prompt them to respond directly and personally, students have created incredibly moving submissions where they or others are depicted reacting to Ocean conservation topics with compassion, passion, concern, protection, and bereavement (Figs. 18.16 and 18.17).

Anthropomorphism is a powerful artistic device where the artist gives human characteristics to nonhuman elements like animals and nature. We have found that our students often use this device to create sympathy toward what is happening in the Ocean and to render the conservation topics more relatable, approachable, and accessible. This technique can "humanize" their



Fig. 18.15 Collection of student artwork about solutions. *Note.* Clockwise starting from the upper left: *Changing Tides* by Jee Woo P., 2020, digital art, Photoshop and Blender, Republic of Korea. *Passion* by Yerang P., 2023, charcoal on paper, Republic of Korea. *Beautiful Mind in Power* by Sarah P., 2023, colored pencil on paper, Canada. *Beauty and the Deep* by Kaitlyn H., 2020, digital art, United States

artistic message and help the viewer or reader identify with the issue presented. It should be noted that many Indigenous communities have treated nature, trees, plants, animals, and even water bodies as "sentient beings" imbued with aliveness, value, and consciousness independent of human use. This type of Indigenous wisdom where nature is regarded with deep respect and appreciation is a timely lesson for our modern world (Kimmerer 2013) (Fig. 18.18).

We found that after students participated in our Contest, they reported feeling more pleasant emotions (interested, inspired, passionate, empowered, determined, empathetic, and compassionate) than unpleasant ones (helpless, frustrated, angry, and sad) (Figs. 18.9 and 18.12). Allowing and encouraging empathetic and passionate connection to our Ocean is crucial in fostering further advocacy and action. Feeling more deeply connected to an issue inspires prolonged interest and spurs continued commitment to help preserve the health of our Ocean and planet.

18.6.3 Promoting Empowerment

The Contest is designed to empower our students in a number of critical ways. Each year, we have over 125 winners and we extensively celebrate and recognize their efforts and achievements. To date, we have distributed nearly $1,000,000 in



Fig. 18.16 Collection of emotional student artwork. *Note.* Starting from the left: *Above and Below the Water* by Jean C., 2021, digital art, Procreate, United States. *Mother Nature's Embrace* by Yoon Jung N., 2021, colored pencil and marker on paper, Republic of Korea. *The Last Blossom* by Chloe L., 2021, colored pencil and watercolor on paper, United States



Fig. 18.17 Collection of uplifting student artwork. *Note.* Starting from the left: *Resilience* by Ahrin L., 2020, markers, colored pencil, watercolor, and gel pen on paper, Singapore. *Safeguard the Barrier* by Gloria J., 2019, digital art, PaintTool SAI, United States. *Coral Care* by Hannaneh T., 2020, colored pencil and marker on paper, Islamic Republic of Iran

awards to winners worldwide. We showcase their work on social media as well as in our newsletter, which goes out to over 28,000 interested stakeholders. Beyond social media, we also seek out exhibition opportunities with museums, galleries, science centers, and aquariums. Since 2014, we have had over 80 exhibitions featuring our teens' creative advocacy and educating the public on Ocean health.

When our students are acknowledged in this way, they feel that their work is valuable, worthwhile, and impactful. It helps build self-confidence, contributes to teen self-reliance, and gives them a sense of self-agency to become Ocean advocates. Students reported how the Contest increased not only their confidence in their creative skills (Fig. 18.6) but also changed their worldview (Fig. 18.7). Youth are empowered greatly when given a platform to share their voices and concerns with others. Our youth respondents consistently ranked empowerment as the second highest emotion post-Contest



Fig. 18.18 Collection of student artwork featuring anthropomorphism. *Note.* Clockwise starting from the upper left: *Liberty Leading the Soul* by Adam Z., 2023, pastel on paper, People's Republic of China. *We Lose Ourselves* by Sergiy R., 2017, oil paint on canvas, Ukraine. *Will You Ever Hear the Innocent Cry?* by Amy P., 2017, digital art, Photoshop, Canada. *Strangled Seas* by Maxwell S., 2016, colored pencil on paper, United States. *Earth Collaption* by Jada M., 2020, digital art, United States. *A Call for Change* by JieJie Y., 2017, watercolor on paper, United States

(Fig. 18.9), and our thematic analysis found that "empowerment" was one of the central themes in the youth responses (Table 18.2).

> I have more self-awareness of things happening around me and what I can do to help out my community. It almost feels like it gave me self-worth.

> I liked that participating in this Contest prompted me to do research and educate myself. Applying what I learned from my research to an artistic platform made me feel empowered to create positive change in my community.

The primary emotions participants felt following the Contest were interested, inspired, and passionate (Fig. 18.9). The majority (89%) of our alumni respondents credited Bow Seat with spawning a passion to connect their creativity to environmental activism (Fig. 18.11). One student wrote:

> Bow Seat was the first place I meshed my creativity with my activism. I am now in college, double majoring in Environmental Policy and Creative Writing. I attribute much of my decision to go down this path to Bow Seat and their support, creativity, and empowerment for me as a young writer. I just wrote my Creative Writing thesis on water and its ability to reconnect me to life: Bow Seat began what has become a long-term interest in climate writing and Ocean environmentalism.

18.6.4 Building Community

One of the central themes we discovered from youth respondents was how the Contest creates community (Table 18.2). We work to build this community and thus further empower our students by providing opportunities to our Contest alumni. Every year, we organize a Future Blue Youth Council (Council) where alumni receive

financial compensation to work with other alumni from around the globe to develop programs and mentor other youth environmental projects. Our Contest alumni have gone on to do tremendous work for our Ocean. Many of our Council members go on to other youth Ocean boards such as Earth Echo International and the World Ocean Day Youth Advisory Council. Some of our alumni have also become members of The National Geographic Society's Young Explorer Program.

One of our Contest alumni from India, Ajay S., went on to become a Future Blue Youth Council member, which propelled him into the Ocean conservation field. Ajay has now blossomed into a true Ocean hero. He was a World Ocean Day Advisor in 2023 and is now the founder of The Coral Initiative, president of ThinkOcean Society, and a member of the 2024 North American Association of Environmental Education's 30 Under 30. He describes his experience on the Council below.

> Being part of the Future Blue Youth Council was more than just a learning experience; it was an awakening. It was here that I found a sense of belonging and purpose. Seeing young people initiate projects on a small scale and witnessing their growth into impactful movements was both inspiring and enlightening. I learned that real change often starts small, with a single action or idea, but with persistence and collaboration, it can ripple outwards, growing in magnitude and reach.

18.6.5 Supporting Mental Wellbeing

We recognize that there is a global teen mental health crisis that is alarming and needs addressing (Léger-Goodes et al. 2022; United Hospital Fund 2024; World Health Organization 2021). There are many sources of stress that young people are now facing including poverty, country conflict, climate change, and social media. Providing a safe and nurturing community is crucial for teens to feel seen, connected, and heard. One aspect of our Contest programming is to provide a space and platform for teens to feel united and represented. This Contest community has proven to be a source of empowerment where teens are supported in their well-being and need for allied connection.

> When I saw everyone who participated… I knew there was hope for the Ocean's future. I knew that us contestants are strong, powerful, and determined to make a difference.

> My household is often arguing that climate change isn't real; it's hard to advocate for something when you're constantly being told it's stupid. This contest showed me how many others are on the same page as me and where I can find support.

> After submitting, I looked at the website again, waiting for reality to really sink in. Then it did. I was really part of this movement now. I was doing something that mattered. By doing this, I was making my voice heard.

Student participants and alumni reported feeling more pleasant than unpleasant emotions after participating in the Contest (Fig. 18.9) and from being creative (Fig. 18.12), which demonstrates creative making as a means of building youth resiliency. The Contest platform, where one can learn, create, and engage in an uplifting community, can be a source of well-being and positivity for young people. Now more than ever we need to support the next generation as they face an increasingly troubling world.

18.7 Conclusion

UN Ocean Decade Challenge 10 calls for us to strengthen humanity's relationship with the Ocean. Since 2011, Bow Seat has seen how the power of creative expression can increase youth's knowledge, create empathy and interest towards the Ocean, and empower them to become agents of positive change. Bow Seat serves as a beacon of hope for Ocean Literacy by supporting the Sustainable Development Goals and helping to achieve Challenge 10 of the UN Ocean Decade.

The Contest connects students with conservation issues, changing how they see themselves in the world (Fig. 18.7) as well as launching them into the environmental movement (Fig. 18.11). Bow Seat is proud to be a part of a youth movement, where teens from around the world are



Fig. 18.19 Till the last breath. *Note*. By Red W., 2019, digital artwork, United States

learning and taking action to protect our Ocean. While there are many drivers for change, empowering, educating, and engaging young people to advocate for the future that they deserve is perhaps the most vital.

As one of our student's protest paintings says below, *"the Oceans are rising and so are we!"* (Fig. 18.19).

18.7.1 Summary

Key concepts explored in this chapter include:

- The Ocean Awareness Contest, Bow Seat's flagship initiative, exemplifies how creative arts programs can strengthen youth–Ocean relationships through interdisciplinary engagement.

- Art-based environmental programs like Bow Seat foster Ocean Literacy by encouraging young people to explore, understand, and express Ocean and climate issues through personal, multisensory experiences.
- The Contest's evolving themes—from plastic pollution to climate solutions—demonstrate the program's responsiveness to emerging Ocean challenges and its role in shaping youth understanding of complex environmental systems.
- Bow Seat's integration of curated resources, independent research, and creative prompts supports deeper learning by combining scientific content with reflective artistic practice.
- The act of making art enables experiential learning, allowing students to connect cognitively, emotionally, and physically to environmental topics in ways that enhance retention and engagement.
- Student participation in the Contest leads to increased knowledge of Ocean and climate topics, as well as emotional connections that support sustained interest and behavioral change.
- The Contest fosters empathy through creative storytelling, visual symbolism, and emotional resonance, with many students using anthropomorphism and narrative to humanize Ocean issues.
- Survey results demonstrate the Contest's positive impact on mental well-being, as youth report experiencing feelings of hope, empowerment, and belonging through creative expression.
- The Contest promotes youth empowerment by building confidence, fostering agency, and providing a platform for environmental advocacy and leadership.
- Youth feedback and longitudinal surveys confirm that the Contest helps participants reframe their worldviews, inspiring shifts in environmental behavior and identity.
- Through the Future Blue Youth Council and other alumni opportunities, Bow Seat extends its impact by supporting long-term leadership development and real-world conservation action.
- Alumni responses highlight the long-term influence of Bow Seat's programming, with many youth pursuing ongoing environmental work, creative careers, and global activism.
- Artistic contributions from the Contest are used by educators, NGOs, and community organizations worldwide to enhance Ocean advocacy, environmental education, and public engagement.
- By elevating youth voices globally, Bow Seat builds a cross-cultural, inclusive platform that supports equity and participation in the environmental movement.
- Programs like Bow Seat contribute to the goals of the UN Ocean Decade, particularly Challenge 10, by advancing Ocean Literacy and strengthening people's relationship with the Ocean through the arts.
- Programs rooted in artivism can serve not only as pedagogical tools but also as civic strategies for promoting Ocean Literacy, environmental justice, and sustainable change.

18.7.2 Recommended Resources

The following resources provide further insights and support on this topic:

- Bow Seat: Creative Action for Conservation. (2024). https://bowseat.org
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United Hospital Fund (2024) The ripple effects of the adolescent behavioral health crisis: Recent trends and impacts on American adolescents, families, and society. https://uhfnyc.org/publications/publication/the-ripple-effects-of-the-adolescent-behavioral-health-crisis/

World Health Organization (2021, November 17) Mental health of adolescents. https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health

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[1]Linda Cabot: Co-conceptualization; Writing—Introduction, Discussion and Conclusion of Original Draft, Review, and Editing; Graphics: Selected/Curated Art; and Methodology—Data Analysis.

[2]Susan Tang: Co-conceptualization; Writing—Original Draft, Review, and Editing; and Graphics—Design and Curation.

[3]Montana Dickerson: Co-conceptualization; Writing—Review and Editing; and Methodology—Data Collection and Analysis.

[4]*Jeremy Pivor: Co-conceptualization; Writing—Original Draft, Review, and Editing; Methodology—Design, Data Collection, Data Visualization, and Analysis; and Project Administration—Coordination.

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Susan Tang is the current Contest Program Director at Bow Seat: Creative Action for Conservation. Born and raised in Boston, MA, Susan's passion for environmentalism is grounded in the idea that urban and natural landscapes are deeply interconnected. Susan graduated from Brown University in 2023 with a B.S. in Environmental Science and Urban Studies before returning to Boston, where they are currently based. Before joining Bow Seat, Susan served as a Public Art Fellow at the Rose Kennedy Greenway Conservancy, a public park in Downtown Boston.



Montana Dickerson is currently an undergraduate at Yale, working on a double major in Ethics, Politics, and Economics along with Urban Studies. Her studies focus on how public policy and design can reinforce or challenge systems of oppression. At Bow Seat, Montana learned about different strategies for creative engagement and honed her data analysis skills. Before Bow Seat, she interned in the House of Representatives under Speaker Emerita Nancy Pelosi and with the Center for Employment Opportunities, helping justice-impacted individuals reintegrate into the workforce. This semester, Montana is working with the Connecticut Office of the Secretary of State doing community outreach and engagement.



Jeremy Pivor is the Partnerships and Youth Engagement Director at Bow Seat where he strives to develop meaningful partnerships and organizes Bow Seat's True Blue Fellowship. He has worked for over a decade in environmental conservation, international climate change diplomacy, and public health around the world. Before joining Bow Seat, Jeremy served as Senior Program Coordinator at the Planetary Health Alliance, where he worked to build a global Planetary Health community. Jeremy received an MS from the University of California, Berkeley School of Public Health's Joint Medical Program, and a BA in Environmental Biology from Washington University in St. Louis.

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19 Expanding Ocean Literacy with Storytelling Through Collaborative Quilts

Laura Guertin

Abstract

When one hears the term "quilt", one visualizes stitched layers of fabric used as an object of comfort, warmth, and decoration. Yet some quilts are specifically generated for science communication, education, and outreach. While quilting is historically known as a predominantly solo activity in the fiber arts, the practice of collaborative quilting is increasing across audiences of varying ages and skill levels. This points to the potential for quilts constructed by groups of people, versus individuals, to be shared across a wider audience. Participants are able to share the story of quilt construction as well as the story behind the quilt. Ocean-themed quilts shared in the present as well as handed down through generations can represent stories to improve the oceanographic content knowledge of those that interact with the quilts. This activity of quilt dissemination aligns with the goals of Ocean Decade Challenge 10 by using storytelling and artistic expression to communicate Ocean science and broaden public engagement with Ocean research. This chapter provides examples of quilts generated collaboratively by scientists and by university students, the outcomes of the quilting activities, and how to carry out a similar effort to improve Ocean Literacy of non-scientists. Questions still remain about the measured effectiveness of an increased understanding and long-term retention of Ocean science communicated via quilts.

Keywords

Collaborative quilting · Coastal Oceanography · Ocean Literacy (OL) · Science quilting · Science communication · Science storytelling

19.1 Introduction

The term "quilting" has been applied as a metaphor for collecting patches, or personal stories, and stitching them together to see cultural connections and shared experiences (Sermijn et al. 2008; Saukko 2000). Traditionally, quilts are defined as a type of blanket made of three or more layers of fabric, with the middle layer composed of a thicker padding or batting. These layers are then stitched together by hand or by sewing machine. Quilts are recognized as a symbol of comfort and support for all ages, gifted or handed down in families across generations, and

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displayed and/or collected for decades long after the quilter has passed.

Quilting is known as a historically-gendered practice completed by individual women. Quilting parties or quilting bees have been known to exist for centuries and still exist today. Although the original mission of these quilting bees was partly for women to gather to pool resources and work together on one quilt, most of these sessions provided women the opportunity to focus on community, socialization, organization, and independence (Robertson 2014). Quilting activities have grown over time from activism-themed abolitionist causes in the nineteenth century to a movement that is increasingly collaborative and fosters community-building. In the past as well as the present, quilts are created to generate awareness and education around economic themes, environmental topics, and more.

Some high-profile women have led collaborative quilting projects. For example, while on the International Space Station in 2013, astronaut Karen Nyberg hosted a virtual quilting bee for global participants to construct a quilt square. Participants were then encouraged to submit their quilt squares to an international quilt festival for the construction of a star-themed quilt (Boone 2013). Nyberg successfully mobilized quilters worldwide to produce 2400 quilt blocks from more than 30 different countries (Kuta 2022). Another example comes from 2016 Olympic rower Grace Latz, who went to Paris prior to the 2024 Summer Olympic Games to create a quilt with local senior citizens from upcycled sports fabrics (Quilting Digest 2024). By shifting the quilting activity from solo to collaborative, everyone that contributes to a quilt has the potential to share their story of participation as well as the final product across their circles of family and friends. In this way, the story of the creation of the quilt, as well as the focus of the quilt itself, can impact a wider section of the population than the creative efforts of one person.

This chapter describes the journey of the author, trained in the field of marine geology and geophysics, and how I began using quilts as a tool for Ocean science storytelling. We begin when I first started stitching about human solutions being carried out in the environmentally challenging coastal zone of southern Louisiana (United States). We then shift to how I brought together scientists from an Ocean expedition to collaboratively contribute to a quilt sharing stories of science at sea. Next, I describe how I have integrated storytelling and collaborative quilting activities into an undergraduate (ages 18+) introductory-level university course on coastal Oceanography. Finally, I end with a discussion around the challenges of measuring and documenting the impact of an Ocean-themed creative art display.

19.2 Storytelling Via Quilts

Quilting has the potential to serve as a powerful medium to engage individuals with science, partially because a quilt is recognized as a familiar, comforting handmade object. A quilt is more than an object that lays across a bed or hangs on a wall. In addition to being a piece of creative art that is visually appealing, a narrative may be included as part of the quilt design. This stitched story allows the quilt to serve an additional function—as a tool for communication and education. For example, Jackson (2023) discusses how quilts have been used for visualizing data, ranging from directions for those escaping along the Underground Railroad in the United States in the early to mid-1800s, to the recordings of daily high and low temperatures for a location. Robertson (2014) highlights the extension of quilting practice, utilizing traditional quilting processes such as patching and appliqué to draw together knowledge, facts, images and artifacts into quilted wholes with activist or political narratives. Pope (2021) specifically focused her discussion on quilts to sharing science-themed subjects.

By adding a science narrative to the quilt design, science becomes accessible to those that view the quilt. A science-themed quilt can bring in new audiences to engage and talk about science that perhaps scientists have not been able to attract before, such as quilting guilds, friendship circles, and library patrons. The Vision 2030 White Paper for The Ocean Decade Challenge 10 defines that success for this Challenge will

include "science communication through multiple approaches including… storytelling, and the arts" as well as "increased public perceptions of Ocean research" (Glithero et al. 2024, p. 6). Here, I describe how I began using quilts as a tool for storytelling in Ocean science, first as an individual quilter, and then how I have expanded to having groups contribute to the construction of quilts. With more individuals involved with the construction of Ocean-themed quilts, the more opportunities there are for sharing those science stories and increasing the Ocean Literacy of those who view and hear about the quilts.

19.2.1 My Journey

My own journey into quilting science stories began in 2018. I was invited to an event at the Louisiana Universities Marine Science Consortium (LUMCON) called OCEANDOTCOMM. This event brought scientists and science communicators together at the W. J. DeFelice Marine Center in Chauvin, Louisiana (United States), for a week of lectures and field excursions on the theme of Coastal Optimism. Despite the media consistently reporting on how the southern Louisiana coast is constantly facing sea-level rise, subsidence of land, loss of vegetation, and more, this event challenged all participants to learn about efforts towards adaptation and resilience. We were each asked to find a way to tell the stories of success along the coast, to elevate the efforts of local residents, scientists, educators, non-profits, and elected officials. In essence, we were challenged to find ways to increase the Ocean Literacy of those outside of southern Louisiana on how local efforts are addressing environmental challenges. But it was more than just broadening the content knowledge of the coastal zone to those outside of Louisiana. Although the United Nations Decade of Ocean Science for Sustainable Development did not officially begin until 2021, the OCEANDOTCOMM event was highly focused on Challenge 10—restore humanity's relationship with the Ocean.

I was impacted greatly through meetings with community members, being led through the physical spaces where they work and live, and hearing from experts on the past, present, and future impacts that climate change and human activity are sure to bring to their location. I spent time reflecting about how I could get audiences engaged in learning these stories of success alongside the challenges. Instead of turning to communication methods I am most comfortable and familiar, such as writing an article or blog post, I decided to connect one of my hobbies in the creative arts to coastal science storytelling. And that hobby is quilting.

I began quilting almost a decade prior to the OCEANDOTCOMM event, and all of my quilts up to that point consisted of fun fabrics and patterns that were given as gifts to family members and friends. But OCEANDOTCOMM started me on a journey into a new purpose for quilting, using my quilts now as a science communication tool. I selected stories from my time along the southern Louisiana coast and generated nine quilts for a quilt collection titled *Stitching Hope for the Louisiana Coast*. These quilts share stories that range from the utilization of discarded Christmas trees for reducing shoreline erosion, to flood gate protection for wetlands. This quilt collection showcases Recommendation #2 in the Vision 2030 White Paper for Ocean Decade Challenge 10—the need for regional expertise to ensure how people are connected to the Ocean. In this instance, meeting with regional partners allowed me to learn and communicate their actions and activities in mitigating human/coastal connections.

I have shown this collection in a range of venues, from science museums and community centers to an art gallery in an arboretum. The reaction people have to these quilts is always positive. I am struck by how quickly people are drawn to the quilts when the quilts are hanging as a group, and how viewers are quick to offer their own quilt story or connection to quilting (if they are a quilter themselves, they have a family member that made them a quilt, etc.). If I am standing alongside the quilts, I am often asked additional questions beyond the signage next to the quilt. And there are so many photos, including selfies, that people take with the

quilts. I actively encourage viewers to share the images and stories that they have learned about the quilts with someone else, so that their science connection is communicated to an even wider audience.

19.3 Collaborative Quilts with Scientists

I first began involving other individuals with my quilting activities when I sailed for 2 months on the scientific drilling vessel *JOIDES Resolution* for the International Ocean Discovery Program (IODP) Expedition 390 (South Atlantic Transect I) in 2022. Part of my duties as an Onboard Outreach Officer were authoring blog entries, posting on social media, and conducting ship-to-shore live video connections for classrooms and community groups. These live internet connections allowed those on land to hear from scientists and to learn more about how we conduct science at sea. But I was also committed to continuing the conversations with audiences post-expedition around not just our scientific objectives but the process of how scientists learn about our Ocean. I planned on generating a quilt collection to share these stories, based upon the reactions and success I was still having in sharing the quilts and stories of the Louisiana coast. Two of the quilts from Expedition 390, one that I began on the ship and one that was made 2 years after sailing, involved the efforts of scientists, technicians, and students, and are presented here.

19.3.1 Team Effort Quilt

As I prepared to join *JOIDES Resolution* (JR) for my expedition, I was already thinking of how I could quilt stories of the deep-sea material we were coring. This was a very different physical environment from the Louisiana coast, but the connection to and impact of humans on the Ocean is just as important for all individuals to have an awareness of. Although there were no sewing machines on the ship, I developed the idea those interested on board the JR help contribute to a quilt through their own drawings on blank fabric squares.

Included in my packing list for this expedition were white fabric squares pre-cut to 7 in. by 7 in. (18 cm by 18 cm) and fabric markers. This size square was determined by the size container in which I had to pack the fabric and markers. Towards the end of the expedition, I invited the scientists and technicians on board the JR to the ship's conference room to draw on a fabric square. The topic for them to draw was open, as long as the theme of their square related to the science of the expedition and/or life at sea. Nineteen people from 10 different countries drew images on the squares reflecting a snapshot of their time on the JR, from seeing a whale for the first time, to sketches of the instrumentation they ran on the deep-sea material collected.

In the middle of the quilt, I placed the winning design of our expedition's logo contest. The border around and between the white fabric squares is Three Cats Shweshwe, a Da Gama Textile manufactured in South Africa. I wanted to use a South African fabric on the quilt, as the expedition first spent a week in hotel quarantine in Cape Town to ensure all scientists and crew members were free from COVID. Then, the JR departed from and returned to Cape Town, South Africa. I completed sewing the squares together with Shweshwe borders after the expedition.

The individual pieces of this quilt each have their own story, ranging from the objects drawn by those on the ship to the actual fabric used in its construction. Images and the final quilt description were shared with the entire group of scientists that sailed. The quilt, along with the story of the quilt and the story of the expedition itself, has been shared and displayed at scientific conferences, libraries, quilting guilds, and more. This one quilt, with its multiple contributors from individuals from different nations across the globe, has been able to serve as a communication tool to tell stories of how humans study the Ocean and information about the Ocean itself (Fig. 19.1).



Fig. 19.1 Collaborative quilt titled *Team Effort* from the scientists and technicians that sailed on board *JOIDES Resolution* for Expedition 390 in 2022. Quilt measures 55 in. (140 cm) tall by 36 in. (91 cm) wide and was completed in 2023

19.3.2 *Takk, JOIDES Resolution* Quilt

Two years after I sailed on *JOIDES Resolution*, the scientists that sailed onboard and that worked in parallel onshore for Expedition 390 gathered with the scientists from Expedition 393 (South Atlantic Transect II) that sailed for 2 months immediately following Expedition 390. It is common for scientists that sail on the JR to come together and meet years after sailing, as it takes time for samples to be shipped back to research laboratories and for analyses to be completed. The scientists and student researchers working on deep-sea material collected during both expeditions came together for a meeting in Reykjavík, Iceland, in May 2024.

The timing of this post-expedition science meeting was bittersweet, as while we were gathered to share our early results from samples gathered by and on *JOIDES Resolution*, the JR was about to depart on its final expedition from across the three international marine research collaborations it sailed—the Ocean Drilling Program (ODP, 1983-2003), the Integrated Ocean Drilling Program (IODP, 2003-2013), and the International Ocean Discovery Program (IODP, 2013-2024). In addition to the 194 expeditions and the >360,000 m of core recovered during JR's time at sea, numerous significant scientific discoveries have been made and will continue to be made from archived core material that advance our knowledge of Earth's history, processes, and structure. These discoveries and more would not be possible without the dedication and tireless efforts of the technicians and crew that have worked aboard *JOIDES Resolution*. Without their time and expertise, these scientific advancements would remain mysteries in the deep sea. And although the ship is a critical part of conducting science at sea, the JR and those that work on board are completely invisible to those that have learned from and utilized the sample data.

I had remaining blank white fabric squares from the *Team Effort* quilt, and I brought those along with fabric markers to Iceland. Of those gathered for the post-expedition meeting, 20 individuals from five different countries took a moment to express appreciation to the ship and those that have worked to provide the material and measurements. After the Iceland meeting, I went home and constructed the quilt in a layout of thank-you notes, appearing as if the notes are on the inside of an envelope. The envelope fabric is again the Da Gama Textile called Three Cats Shweshwe, as both Expeditions 390 and 393 departed from and returned to Cape Town, South Africa. The yarn stitched between the fabrics is Lopi Léttlopi, an Icelandic wool yarn. The post-expedition meeting for 390 and 393 was held in Reykjavík, Iceland, so this yarn is a nod to where the scientists came together to share their current scientific results. The colors of the yarn represent the Ocean (blue), sediment layer (yellow), and basaltic crust (dark gray)—all areas through which JR extended its drilling operations. I titled the quilt *Takk, JOIDES Resolution* as the Post-Expedition Meeting was held in Iceland, and takk is the Icelandic word for thank you (Fig. 19.2).

The scientists and technicians that have sailed on and worked with samples collected by *JOIDES Resolution* certainly have a high degree of Ocean Literacy. Even though each expedition has specific objectives defined, Ocean Literacy Principle #7 (The Ocean is largely unexplored) is front and center at the beginning and an outcome of any time spent at sea. Although involving scientists in the creation of collaborative quilts does not increase their own Ocean Literacy, the resulting quilts have the potential to increase the Ocean Literacy of those that take the time to learn the stories behind the quilt itself and what the fabric pieces are highlighting.

19.4 Case Study: Quilting Coastal Stories with Students

As I have shared my quilts at venues ranging from scientific conferences to museums and public outreach events, more and more individuals were asking me if I ever had my students generate quilts. I had always kept my quilting separate from the active learning taking place in my classroom. But after much reflection, I decided to embrace the integration of quilting with one of my courses. Although there has been an increas-



Fig. 19.2 Collaborative quilt titled *Takk, JOIDES Resolution* from the onboard and onshore scientists from Expeditions 390 and 393. Quilt measures 70 in. (178 cm) tall by 68 in. (173 cm) wide and was completed in 2024

ing trend of collaborative quilting with youth groups (Thomas and Stornaiuolo 2016), quilting in university courses (students aged 18+) either is not widely practiced or not widely reported. One example of a student collaborative quilt occurred in a university course on Women in Science, where students made squares in honor of female scientists (Pope 2021).

Moving forward with the addition of quilting to my course, I reminded myself that I have always had storytelling as a required activity in all my courses, as I want my students to be able to share their science knowledge with others once the course concludes (see Joubert et al. 2019, for the public communication of science). By adding quilting to the storytelling assignment, this would allow students to expand their dissemination in a creative way and potentially reach a wider audience beyond our own classmates.

19.4.1 Scaffolding Instruction for Student-Generated Quilts

Each fall semester, I teach two sections of an introductory-level university course for non-science majors titled Coastal Processes, Hazards, and Society. Each section of the course enrolls approximately 20 students that range from their first semester to their final semester of university studies. The course satisfies general education requirements for natural science and social science. At the conclusion of the course, students will have been provided with a global perspective of coastal landscapes, the processes responsible for landscape formation, diversity, and change over time, as well as societal responses to current changes in coastal zones around the world. In addition to increasing the overall Ocean Literacy of students, the course directly addresses Ocean Decade Challenge 10: Restoring Society's Relationship with the Ocean (Glithero et al. 2024) and additional Ocean Decade Challenges.

19.4.1.1 Storytelling Instruction

The overarching goal I establish for my coastal Oceanography course is for students to successfully understand and evaluate national and global coastal science issues and to communicate this information via storytelling techniques. In the fall semester of 2023, students were instructed in the And-But-Therefore (ABT) storytelling approach defined by Olson (2015). This narrative structure starts by constructing the story foundation with details (And), introduces a transition that drives the story forward (But), and ends when a resolution or understanding is reached (Therefore). Students are provided with several short assignments early in the semester that involve reading articles and viewing videos where they construct an ABT story for the content presented. After having these opportunities to practice writing with the ABT format, students are then assigned to write their own ABT on a specific topic.

19.4.1.2 Introduction to Project Drawdown

In the fall semester of 2023, the student-authored ABT stories focused on the coastal and Ocean sinks sectors defined by Project Drawdown. Project Drawdown is a U.S.-based nonprofit, non-partisan organization of scientists that model ways to reverse the increasing trend of greenhouse gases in the atmosphere with attention to time, safety, and equity (see the Recommended Resources section for more information). The 93 technologies and practices defined by Drawdown look at reducing greenhouse gas emissions and increasing the sinks across groupings called sectors. The coastal and Ocean sinks sector for Project Drawdown has modeled five areas of action that center on ecosystem protection, ecosystem restoration, and agricultural practices. These climate change solutions in the coastal zone address Ocean Literacy Principles #3 (The Ocean is a major influence on weather and climate) and #6 (The Ocean and humans are inextricably interconnected), as well as Ocean Decade Challenges #2 (Protect and restore ecosystems and biodiversity), #4 (Develop a sustainable, resilient, and equitable Ocean economy), #5 (Unlock Ocean-based solutions to climate change), and #10 (Restore society's relationship with the Ocean).

Students were allowed to spend class time exploring online to learn about Project Drawdown's five defined coastal and Ocean sinks: coastal wetland protection; coastal wetland restoration; improved fisheries; macroalgae protection and restoration; and seaweed farming. Given the enrollment of 20 students per course section, I limited each coastal sink to a maximum of four students, enabling each group to develop their own original ABT story. The assignment required students to write a minimum of 500 words and incorporate at least three sources published within the past 5 years to ensure the information was current and relevant.

The required story components had scaffolded deadlines. First, students selected their topic,

then students submitted at least three sources they would use in APA formatting, next they uploaded a bulleted list for each of the And/But/Therefore sections of their narrative, and finally students turned in the final story with references and a title. Students were provided with the rubric that would be used to grade their submission based upon the relevance and accuracy of the story content, the accuracy of the ABT story format, and how current and reliable the sources were. I had informed the students ahead of time that I would post their stories online in an ArcGIS StoryMap so they could disseminate the stories across all the Drawdown coastal and Ocean sinks with others beyond their classmates.

19.4.1.3 Stitching the Pieces Together

The final project component was completed after students submitted their Project Drawdown stories to me. One day in class, I introduced the idea of each person contributing an individual square to a collaborative quilt. First, I provided everyone with a blank sheet of paper and had them draw a 7-in. by 7-in. (18-cm by 18-cm) square on the paper. Then, students were instructed to sketch out a drawing that represented the content of the ABT story they had just completed. Next, I distributed the fabric squares and fabric markers for students to draw an image to match their story from their sketch they completed on paper. Students took photos of their completed square and uploaded the image to our online course management system. I then took the images and added them to the matching ABT story in the ArcGIS StoryMap.

Unfortunately, there are no sewing machines available on my campus, so I was not able to engage students in the actual sewing of the quilt. I volunteered the time at home to sew together the fabric squares, with each row in the quilt representing one of the defined coastal sinks. I brought the completed quilts to class before the end of the semester and displayed them to the students. The student reaction was very positive, with students pointing out to each other where their sketched square was in the quilt, and many photos were taken.

To ensure that the completed work of the students was shared beyond our classroom walls, I worked with my university library to have the quilts on display for 2 weeks during National Quilting Month (March) and across National Quilting Day, an annual celebration on the third Saturday of March coordinated by The Quilt Alliance and the National Quilt Museum in the United States. The quilt display included signage describing the background of the quilts, in addition to QR codes to the ArcGIS StoryMaps that contained the stories for each square. I have also brought these student-generated quilts, focusing on coastal solutions to global warming, to presentations I have given at museums, libraries, and educator conferences, so that others may be inspired by the student work and consider how they can generate their own Ocean-themed collaborative quilts (Figs. 19.3 and 19.4).

19.4.2 Continuing the Collaborative Coastal Quilts

The coastal Oceanography course at Penn State Brandywine (Pennsylvania, United States) is continuing to train students in science storytelling and the generation of collaborative quilts. To ensure there is not a duplication of quilted topics from year-to-year, in addition to broadening the educational value of new quilts, the theme for the quilts changes each fall semester. For example, in the year after the coastal climate solution quilts were created, the course shifted from using Project Drawdown as a foundation to Elizabeth Kolbert's book, *H Is for Hope: Climate Change from A to Z*. The book is a collection of 26 essays Kolbert authored for *The New Yorker* related to the past, present, and future of climate change. In each section of my Oceanography course in the Fall of 2024, students were assigned a letter of the alphabet and a topic relating to coastal science and issues (topics were determined by myself to ensure that students expanded their own learning and did not select more familiar subjects such as fish or marine mammals). The storytelling instruc-



Fig. 19.3 Collaborative quilt made by undergraduate students in a coastal Oceanography course. The quilt measures 44 in. (112 cm) tall by 37 in. (94 cm) wide and was completed in 2023



Fig. 19.4 Another collaborative quilt made by undergraduate students in another coastal Oceanography course. The quilt measures 44 in. (112 cm) tall by 37 in. (94 cm) wide and was completed in 2023

tion utilized the COMPASS Message Box template (listed in the Recommended Resources section) instead of And-But-Therefore to encourage students to expand their research and write a more complete story on their topic. The stories were again added to an ArcGIS StoryMap, and after story submission, the students completed the final step of drawing on fabric squares with markers. These quilts will be on display again at the campus library and at community events.

19.5 Conclusion: Ocean Literacy From Quilts—Is It Measurable?

As stated previously, each individual that participates in the generation of a quilt has contributed not only to the finished product, but now has a story to share about their creative efforts in addition to the story the quilt is showcasing. Although I have suggested that expanding the network of quilters can increase the reach of stories about Ocean science, research still needs to be carried out to quantitatively answer the question: does an artistic display of science, such as through an individual Ocean-themed quilt, improve the Ocean Literacy of the person viewing or engaging with the object? The Vision 2030 White Paper for Challenge 10 states that by 2030, successful attainment of fulfilling the critical science and knowledge gaps will be completed through science communication methods such as storytelling and the arts, but are the pathways in place to measure this attainment?

In her book *Slow Looking: The Art and Practice of Learning Through Observation*, Shari Tishman (2017) discusses that learning through observation can be accomplished by taking one's time to observe through any of the senses, not just visual, to ultimately gain knowledge about the world. With its foundation in the area of museum studies, the scholarship behind *Slow Looking* is shown to have wide educational benefits, allowing for critical thinking to develop from accumulated observations over time spent with material. This leads to the question—are individuals taking the time to engage with storytelling and the creative arts for effective learning?

Studies completed in art museums document that overall visitor behavior is not demonstrating *Slow Looking*, or moving beyond first impressions. Studies completed at two different museums 15 years apart measured the amount of time as well as how visitors spent their time viewing art. Results show that while visitors have consistently spent a similar median viewing time—17.0 s (Smith and Smith 2001) and 21.0 s (Smith et al. 2017)—how they engage with the art during that time has changed. The 2017 study documented that individuals quickly "consumed" the work without actually engaging in its content; instead, visitors in front of art pieces spent their time taking selfies with the artwork. Smith et al. (2017) summarize that an art museum visit is not characterized by long looks at a few works of art, but rather by brief looks at many works of art, with few works getting viewers to spend even 1 min at a piece.

It is a challenge to measure if an improved understanding and long-term retention of science content can come from exposure to a scientific topic, or from the integration and display of a science story, through art (Bowen and Kisida 2022; Feinstein et al. 2013; Hardiman et al. 2019). With visitors potentially having an internal reaction instead of a visibly external reaction to any one piece of art, Martella et al. (2017) suggest that efforts would be better spent studying visitor behaviors within entire collections and exhibits rather than individual pieces. Additional research is required in this area to determine whether content and increased Ocean Literacy can be achieved through fiber arts, including a collection of quilted Ocean science stories versus an individual Ocean-themed quilt, to move us closer to accomplishing the goals and recommendations laid out in the UN Ocean Decade Vision 2030 White Paper for Challenge 10. By expanding these artistic and educational collaborations, we can amplify the public's connection to Ocean research and foster meaningful engagement toward restoring our relationship with the Ocean.

19.5.1 Summary

Key concepts explored in this chapter include:

- The design and construction of a quilt can be used for education and communication, including sharing data sets, political and social messaging, and stories of climate solutions in the coastal zone.
- By shifting the quilting process from individual to collaborative, there is an expanded opportunity for the sharing of not only the story of creating to the quilt but the story behind the quilt itself.
- Scaffolded activities can be embedded into an introductory-level Oceanography course for non-STEM majors to enhance the ability of undergraduate students to use varying storytelling techniques to increase the Ocean Literacy of others.
- Quantitative studies are still required to measure the actual increase in Ocean Literacy from viewing a quilt and learning the science story behind it, as studies in museums report limited viewing time and reading of signage with art pieces.
- Using quilts as a storytelling medium for science communication has the potential to increase public perceptions of Ocean research, highlight regional expertise, and move our global community closer to reaching success for UN Ocean Decade Challenge 10.

19.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

Science Storytelling and Communication

- COMPASS Message Box for science communication—https://www.compasssciencomm.org/leadership-development/the-message-box/
- *The Narrative Gym: Introducing the ABT Framework For Messaging and Communication*, by Randy Olson (2020), Independently published, ISBN-13: 979-8550151402.
- Project Drawdown: https://drawdown.org/

Climate Change Resources

- *H Is for Hope: Climate Change from A to Z*, by Elizabeth Kolbert (2024), Penguin Random House, ISBN: 9781984863522.
- Project Drawdown, researching solutions to reduce atmospheric greenhouse gas concentrations—https://drawdown.org/

Fiber Arts, in General and Science-Themed

- Quilt Alliance—National Quilting Day—https://quiltalliance.org/nationalquiltingday/
- *Knit the Sky: Cultivate Your Creativity with a Playful Way of Knitting*, by Lea Redmond (2015), Storey Publishing, LLC, ISBN-13: 978-1612123332.
- The Tempestry Project, fiber art with temperature data—https://www.tempestryproject.com/
- The Women in Science Quilt Project video documentary (2019), 18 min, in Vimeo—https://vimeo.com/265770339/a68ecf6924
- Laura Guertin's collaborative science quilts (full descriptions and image gallery):
  - *Team Effort*—https://www.sciodquilts.studio/quilts/team-effort
  - *Takk, JOIDES Resolution*—https://www.sciodquilts.studio/quilts/takk-jr
  - *Coastal Climate Solutions*—https://journeysofdrg.org/2023/11/28/sciquilt-coastal-climate-solutions/
- Laura Guertin's coastal Oceanography student stories with quilt images:
  - *Coastal Climate Solutions*, Section 1—https://arcg.is/nv4az
  - *Coastal Climate Solutions*, Section 2—https://arcg.is/1XCa4e1
- Laura Guertin's interview for the Springer Nature podcast *My Sediments Exactly*, Empowering Science Communication through

Storytelling, One Quilt at a Time—https://www.buzzsprout.com/2361040/15627564-empowering-science-communication-through-storytelling-one-quilt-at-a-time-an-interview-with-prof-laura-guertin-penn-state-brandywine-university

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"*Tramares, Weaving Reefs*": A Science-Art Mesophotic Project

20

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Abstract

"*Tramares, Weaving Reefs*" ("*Tramares, tejiendo arrecifes*" in Spanish) is a collaborative science-art project, in which more than a hundred people, predominantly women aged over 60, from small coastal communities in central Chile meticulously crafted 600+ distinct woven art pieces blending ecology, geometry, and knitting to depict marine life inhabiting Chile's twilight reefs. The resulting artwork has been showcased in 12 exhibitions across Chile and internationally, receiving more than 100,000 visitors. It has inspired crochet artists and enthusiasts in other communities and has become a powerful tool for communicating biodiversity and opening conversations on conservation.

One of the distinctive elements of the "*Tramares, Weaving Reefs*" project is its focus on local species, particularly those living in the virtually unknown, semi-deep rocky reefs that have recently begun to be explored off the productive Chilean coast. Descending to depths below 30 m light quickly fades and becomes scarce. This is the mesophotic or twilight zone, where there is barely enough light for photosynthesis.

In this chapter, you will find information about the twilight zone and details of the "*Tramares, Weaving Reefs*' project, including its story, results, and evolution. Additionally, you can find photographs and recommendations for those interested in embarking on similar endeavors.

Keywords

Ocean Literacy (OL) · Twilight zone · Animal forest · Crochet · Senior citizen · Science-art

20.1 Introduction

What is the twilight zone in the Ocean? Are there corals and sponges in the cold twilight coastal waters, like those we think of in tropical waters? What connection could there be between crochet and the Ocean's twilight zone? How can older people contribute to the Ocean Literacy of their communities? These are some of the questions answered throughout this chapter, which focuses on "*Tramares, Weaving Reefs,*" a science and art

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project that originated in Chile in 2023 in the coastal town of Las Cruces in the central region of the country.

The chapter begins with a brief introduction to the Twilight Zone reef, the variety of organisms that inhabit it, the unique environmental challenges they face, and how little we know about these ecosystems. It also shares some of the initial findings from the first exploratory research being conducted in Chile on these semi-deep or mesophotic reefs, led by the Millennium Nucleus for Ecology and Conservation of Temperate Mesophotic Reef Ecosystems (NUTME).

After establishing the geographical context, the chapter is dedicated to the creation process and exhibitions of the collaborative project "*Tramares, Weaving Reefs*." This project consisted of a series of workshops centered on weaving, ecology, and geometry, that culminated in the production of a large, knitted reef composed of over 600 individual crochet pieces.

At the end of the chapter, we discuss how the artwork not only sparked conversations and has been raising awareness about mesophotic reefs but also is inspiring other projects to combine science and art. Finally, we highlight a series of lessons learned from the process and provide recommendations for those looking to embark on similar adventures.

20.2 Twilight Reefs

20.2.1 What Are Mesophotic Reefs and Animal Forests?

As we dive deeper into the Ocean, it becomes increasingly darker. Sunlight fades with depth, and in some regions like central Chile, light becomes scarce even below just 30 m, requiring artificial illumination (like a flashlight or spotlight) to see in full color. This is the mesophotic or twilight zone, typically extending from 30 m down to over 150 m (Pyle and Copus 2019), where light is barely enough to support photosynthesis (the process by which algae obtain energy and produce oxygen). We say "typically" because this range can vary depending on location, seasonality, and other factors that affect light penetration (Cerrano et al. 2019). In the mesophotic zone, there are areas with sandy bottoms and others with rocky or other hard bottom substrates, known as mesophotic reefs, which are the focus of this chapter.

Due to the lack of light, large algae such as kelp, that depend on light for photosynthesis, are often replaced by communities of animals. Corals, sponges, and other marine invertebrates can create complex three-dimensional habitats that provide shelter, food, and space for others, acting as ecosystem engineers (Figs. 20.1 and 20.2). These communities, dominated by animals that filter organic matter and small organisms from the water, are also known as "animal forests," a term that highlights their structural and functional similarity to terrestrial forests (Rossi et al. 2017).

It is important to note that "animal forests" include a wide range of marine ecosystems. This term includes everything from shallow-water tropical coral reefs to oyster beds, mussel banks, and other unique 3D habitats created by the animals. Of all these, the "animal forests" in the twilight or mesophotic zone remain especially unexplored.

20.2.2 Relevance of the Unknown Mesophotic Reefs

We live on a blue planet in which sustainable use of Ocean resources is closely linked to human health and livelihoods. Despite this, the Ocean remains unexplored, and our understanding of the processes that regulate marine diversity and resilience to human and natural stressors is minimal in many habitats.



Fig. 20.1 Tropical mesophotic landscape at Galapagos Archipelago (60 m depth). Photo by Alejandro Pérez-Matus



Fig. 20.2 Forest of cold-water corals (gorgonians) at a temperate mesophotic reef in Chile (45 m depth). Photo by Alejandro Pérez-Matus

The twilight zone of the Ocean, which harbor unique mesophotic ecosystems often a few hundred meters away from the shore, is especially unexplored and frequently overlooked in conservation plans. Remarkably, we know more about the deep Ocean or even the surface of Mars than we do about these reefs found just beyond the well-studied shallow reefs (1–30 m) (Duarte 2014). The lack of scientific knowledge of mesophotic reef distribution, biodiversity, and ecological processes restricts our ability to make well-informed decisions for managing and conserving these ecosystems (Eyal and Pinheiro 2020).

Yet, we know these reefs face increased human impacts, such as fishing pressure, and are

often left unprotected at the edge of current management areas. Thus, expanding Marine Protected Areas (MPAs) to include mesophotic reefs is crucial and may help safeguard their biodiversity and ecological functions. Moreover, MPAs could also help maintain linkages between mesophotic and shallow waters, and therefore critical ecological processes. This proactive approach can ensure a more comprehensive conservation strategy that addresses the full spectrum of marine ecosystems (Mantas et al. 2024).

Worldwide, the great majority of existing studies on mesophotic ecosystems are from tropical regions, with only about 20% from temperate seas and only an extreme few of these focus on highly productive coasts. Similarly in Chile, the few previous mesophotic studies have focused on specific species or environments, such as those from subtropical Easter Island, the echinoderms of seamounts, oceanic islands, or Chilean fjords (Campoy et al. 2023).

Evidence suggests that mesophotic ecosystems may have more geographically endemic species than shallow reefs. Although these deeper ecosystems might also serve as refuges for some shallow species, they are increasingly recognized as unique ecosystems in their own right (Pyle and Copus 2019). Thus, as global pressures and stressors intensify, mesophotic reefs have been highlighted as potential buffer zones and refuge areas for shallow marine organisms exploited by fisheries (Rocha et al. 2018). The assumption was that environmental conditions in mesophotic reefs were more stable, less affected by climate change, and relatively insulated from a myriad of anthropogenic disturbances impacting shallow habitats. However, the generality of these tenets must be assessed across regions and stressors. Indeed, environmental disturbances at mesophotic depths now appear at least as strong as those in shallow/surface waters in the southeastern Pacific and coastal Chile (De la Maza et al. 2024), In addition to climate change and overfishing, another threat for mesophotic reefs is plastic pollution. Marine debris has been found in the twilight zone and remote unexpected places. These findings highlight the importance of community involvement and awareness in addressing mesophotic reef threats (Fig. 20.3).

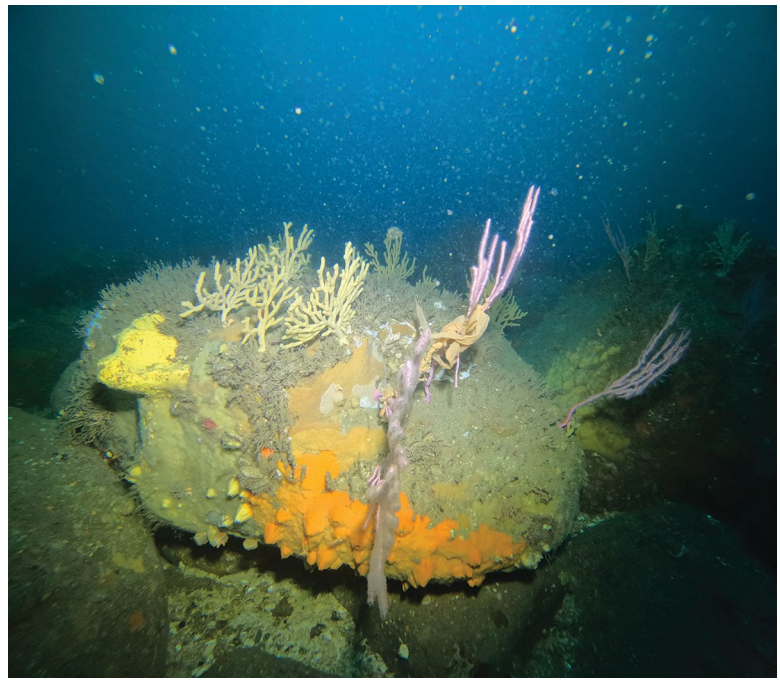


Fig. 20.3 A plastic bag entangled in a cold-water coral at a temperate mesophotic reef in Chile (53 m depth). Photo by Alejandro Pérez-Matus



Fig. 20.4 Technical diver (rebreather) doing a fish survey at a temperate mesophotic reef in Chile (60 m depth). Photo by Alejandro Pérez-Matus

20.2.3 Exploring the Mesophotic Reefs in Chilean Waters

In 2021, driven by the lack of information on temperate mesophotic reefs and the absence of ecological studies in Chilean mesophotic habitats, the Millennium Nucleus for the Ecology and Conservation of Temperate Mesophotic Reef Ecosystems (NUTME) was established with support from Chile's National Research and Development Agency (ANID).

Since its inception, NUTME has led pioneering efforts to explore and document mesophotic reefs. The team developed technical diving capacity for mesophotic depths (Fig. 20.4), employing simple to cutting-edge tools such as towed underwater videos (TUVs), baited remote underwater cameras (BRUVs), autonomous reef monitoring structures (ARMS, Fig. 20.5), and environmental DNA (eDNA) to expand knowledge of these ecosystems. These methods revealed new species records, ecological patterns, and the broad connectivity between shallow and mesophotic communities.

NUTME's research also highlighted the harsh environmental conditions of mesophotic zones, including frequent exposure to low-oxygen waters, raising questions about species adaptations and the global extent of such challenges.

Collaboration with artisanal fishers has been vital to mapping mesophotic reefs, combining scientific research with local knowledge, and fostering ties between science and coastal communities. Education is another key pillar, exemplified by initiatives like "*Tramares, weaving reefs*," which share discoveries to inspire conservation and appreciation for mesophotic ecosystems.

20.3 *Tramares, Weaving Reefs:* The Project

"Tramares, Weaving Reefs" (*Tramares, tejiendo arrecife*s in Spanish) originated from a project initiated during the pandemic by the Faculty of Mathematics at the Catholic University of Chile. This project, called "Hyperbolic Reef", focused on tropical coral reefs geometry and included contributions from researchers at NUTME who shared ideas of the importance of these environments. The initial concept led to the creation of a



Fig. 20.5 Artificial Reef Monitoring Structure installed in a temperate mesophotic reef in Chile (30 m depth). Photo by Ana Navarro Campoy

knitted tropical reef, which served later as inspiration for our adaptation to Chile's unique twilight reefs.

Leveraging the extensive knowledge and expertise of NUTME, the team adapted the concept to reflect the distinctive mesophotic ecosystems off the Chilean coast. The project involved nearly a hundred people, predominantly women over 60, from small coastal communities in central Chile. These participants, who live in close proximity to the mesophotic reefs—60 m deep reefs can be located only a few hundred meters offshore—engaged in a series of free workshops combining weaving, ecology, and geometry. Together, they crafted over 600 individual crochet pieces, which were assembled into a large, knitted reef (Fig. 20.6). The resulting artwork has been exhibited nationally and internationally, attracting over 100,000 visitors within a year.

This section details the history of the "Tramares" project, outlining its source of inspiration, goals, and the main outcomes achieved. It covers both the artistic creation and exhibition of the piece, as well as the insights and experiences gained by the participants throughout the process.

20.3.1 Inspiration and Objectives

"*Tramares, weaving reefs*" began in 2022, as a way to share findings and generate interest in the unknown mesophotic reefs of Chile. The project, spearheaded by the Millennium Nucleus NUTME, in collaboration with the Faculty of Mathematics at the Catholic University of Chile and supported by the Vice-Chancellor's Office for Research at the same university, was inspired by the "Hyperbolic Reef" project and its international predecessor "Coral Crochet Reef Project", which sparked creative processes in various countries, mostly in the Northern Hemisphere. Motivated by the desire to find less conventional ways to communicate science and engage with communities, the outreach team of the NUTME decided to create an experience that combines art and science, specifically aimed at older adults from the communities surrounding the research center.

Why specifically develop a project for people aged 65 and older? There are three main reasons: (1) they are a growing age group, exceeding 23% of the population for the cities where the project has its main operations (among the highest proportion



Fig. 20.6 *"Tramares, weaving reefs"* at the National Museum of Natural History, in Chile. Photo by Celeste Kroeger Campodónico

nationwide, National Institute of Statistics INE 2020), (2) they are a group commonly overlooked, at least in Chile, when targeting scientific outreach activities, and (3) they often have available time and enjoy new challenges. Moreover, in the specific case of women, knitting is a common hobby (crochet, weaving on a loom, or knitting with needles), regardless of their socioeconomic status, tying-in with their local culture.

The general objectives were to foster curiosity and creativity, along with the ability to observe, work as a team, and communicate, through an invitation to learn and share knowledge about the biodiversity of temperate mesophotic reefs. At the same time, the design of the experience aimed to contribute to the positive aging of older adults in our region, enhancing their sense of well-being.

"*Tramares, weaving reefs*" also aligns with the international Ocean Literacy movement that started in the early 2000s in the United States of America and then expanded to the world seeking to strengthen the understanding of the Ocean's influence on us, and our influence on the Ocean. In particular, the project is focused on three of the seven Essential Principles defined by the wide-ranging, collaborative, and decentralized effort Ocean Literacy Campaign, which is pushed by hundreds of scientists and educators to create a more Ocean-literate society. Those are: (1) the

Ocean supports a great diversity of life and ecosystems (Essential Principle 5); (2) the Ocean and humans are inextricably interconnected (Essential Principle 6), and (3) the Ocean is largely unexplored (Essential Principle 7) (NOAA 2024).

20.4 Let's Get to Work! Planning, Implementing, and Evaluating the Project

20.4.1 Looking for Strategic Partners

After defining the objectives of "*Tramares, Weaving Reefs*" and securing a small, but exclusive grant ("Proyección al Medio Externo") from the Chilean National Agency of Research & Development (ANID), NUTME defined a plan to seek for strategic alliances.

We sought to team up with individuals from different disciplines, combining marine biology, visual arts, knitting, mathematics, education, and diving, to incorporate and integrate diverse perspectives and experiences from the beginning (Fig. 20.7). Undoubtedly, this was a key decision for the success of the project. A very concrete and simple example that illustrates the benefit of involving all these viewpoints is the selection process for the yarns to be used. When the team visited the "Costuritas" warehouse, the company that made a significant donation of materials (450 balls of yarn, 120 crochet hooks, needles, scissors, and sewing threads), to select the supplies for the workshops, each member took on different roles: while a researcher and diver ensured that the colors were representative of what is found in Chile's mesophotic reefs a visual artist focused on making sure the combination of colors and textures worked well aesthetically. In parallel, the knitting teacher made sure that the thickness and other properties of the chosen yarns were suitable for the intended knitting patterns.

Institutional support was also crucial, particularly from the municipalities through their social initiatives such as "Centro Diurno Comunitario para el Adulto Mayor" and "Centro Diurno de Personas Mayores" in El Quisco and El Tabo, respectively. Through the coordinators of these programs, older adults who regularly participate in their activities were invited to participate in a series of knitting workshops, regardless of their prior knitting experience. The coordinators also arranged transportation for all participants, ensuring they could easily travel from their homes to the workshop location (Fig. 20.7).



Fig. 20.7 Members of the multidisciplinary team interacting with biological samples of cold-water corals for the first time. Photo by Celeste Kroeger Campodónico

20.4.2 Creating Knitting Patterns and Inspirational Material

The first big challenge was choosing which local and mesophotic species we would represent and then creating the unique knitting patterns that captured their key shapes, forms, sizes, and colors!

The goal was to select species characteristic of mesophotic animal forests that, once knitted, would showcase both the diversity and beauty of these ecosystems, while also conveying some of the relationships between them. For example, a pattern was created for hermit crabs and another for cold-water corals (gorgonians), and during the assembly, care was taken to place the crabs on the corals, just as they were observed during the exploratory dives of the NUTME.

The role of the weaving instructor was essential. In several cases, she used only photos of the marine organisms and then relied on feedback from the team's marine biologists to develop the knitting patterns. She not only adapted and created patterns for marine organisms (Figs. 20.8 and 20.9) but also designed some to represent textures, like rough rocks and rocks covered by sponges. The unique patterns were compiled into a digital magazine, available for viewing and free download (see Sect. 20.6.2).



Fig. 20.8 Knitted patterns for two crocheted sea stars and marine sponge. Photo by Celeste Kroeger Campodónico



Fig. 20.9 Detail of a knitted cold-water coral (gorgonian). Photo by Celeste Kroeger Campodónico



Fig. 20.10 Workshop with knitters from El Quisco, creating their first pieces. Photo by Celeste Kroeger Campodónico

Simultaneously, we designed the project's graphic identity with the help of two undergraduate students and their professor and planned the science art workshops. To bring mesophotic reefs closer to the participants and inspire them, a 4-min documentary on temperate mesophotic reefs was developed before the workshops. It focused on the species that inhabit these ecosystems, incorporating both underwater footage and animations.

20.4.3 Knitting Workshops

Four cycles of workshops were held at the Coastal Marine Research Station (ECIM) of the Catholic University of Chile (Figs. 20.10–20.13). Each cycle consisted of two sessions. In each cycle, just over 20 people participated, the majority of whom were women over 60 years old (Table 20.1). It was decided to limit the maximum of participants to ensure a personal experience with each attendee. In



Fig. 20.11 Knitters learning a second and more advanced pattern, for creating marine sponges of the genus *Axinella*. Photo by Municipalidad de El Quisco



Fig. 20.12 Close-up of a knitter creating an anemone. Photo by Celeste Kroeger Campodónico



Fig. 20.13 Knitters of El Tabo, after their first workshop. Photo by Mariana Milos Montes

Table 20.1 Knitters of "*Tramares, weaving reefs*" from all workshops led by the teacher Sandra Cerda

Knitters of "*Tramares, weaving reefs*"		
Adelina Pincheira, Adriana Martinez, Adriana Reyes, Ainara Aguilar, Alejandra Guerrero, Alexandra Guzmán Suazo, Alice Facques, Amalia Becerra, Amanda García Marin, Amelia Clavijo, Ana María Avanzacs, Ana María López, Ana Miranda, Ana Quevedo, Andrea Ramirez, Beatriz Salgado, Belda Sepúlveda, Belén Carvajal Verdejo, Benita Rojas, Blanca Carrasco, Blanca Fuenzalida, Blanca Galaz, Bristela Clarys, Caro Belén, Carola Tobar Perez, Carolina Cabello, Caroline Allaud, Catalina Gómez Rojas, Cecilia Gómez Del Valle, Cecilia Latorre, Celeste Kroeger Campodónico, Celina Garica, Celinda Gonzalez, Claudia Godoy, Corina Farías González, Drina González Pinto, Edelmira Zuñiga, Edesia Olivares Silva, Edith Campos, Edith Perez, Elena Fuentes, Elena Riquelme, Eliana Retamal Nash, Eliana Tobar, Elizabeth Melo Rojas, Elizabeth Parada Espillico,	Elsa Hernández Gatica, Ema del Carmen Lorca, Emérita Garrido Jara, Emilia Finke, Emperatriz Escobar, Eugenia Linsambarth Salgado, Evelyn Elgueta, Fernanda Yañez León, Fidelina Camus, Flor Pino Astudillo, Florentina Sanhueza, Francisca Herrera Cortés, Gina Marchant Moreno, Gladys Reyes, Gloria Cortez Baez, Gloria Núñez, Graciela Aravena García, Haydeé Gómez, Hector Silva, Ignacia Jara León, Inés Hurtado, Ingrid Danae, Isabel Herrera Morales, Isabel Izunza, Jaqueline Honores, Javiera Madariaga Gómez, Jose Vargas, Juan Perez Valdez, Juana López, Juana Massó, Juanita Gonzalez, Katherine Cornejo, Laura Gomez Del Valle, Leonor Salinas, Leslie Zuñiga Rodriguez, Leticia Muñoz, Lidia Tapia Diaz, Lila Vera, Liliana Cabezas, Liliana Leiva, Luisa Muzzi, Magali Moreno, Marcela Araya, Margarita Olguin Urbina,	María Angélica Vargas, María Antigual, Maria Clavijo García, María Elena Navarrete, María José Calderón, María Macarena Gutiérrez Gebacier, Maria Navarro, María Sagredo, María Teresa Briceño, María Teresa Lopez Vera, Mariela Gatica Leal, Marinet Peña, Maureen Fuentes Usen, Millaray Rocco Villalobos, Miriam Fernández, Mirta Barra, Mónica Rojas González, Nicole Moreno, Olga Fernández, Olga Ortiz, Patricia González, Patricia Rojas Salinas, Paula Miranda, Paulina Saldivia, Pilar Vigue, Rafaela Fuentes, Raquel Aburto Alarcón, Rosa Cepeda, Ruth Cortes, Sandra Cerda, Sarina Lincoln, Sergio Benavides, Susana Silva, Teresa Aranguiz, Valentina Alonso Rivera, Valeria Cáceres Beltrán, Valska Silva, Verónica Urrutia, Verónica Gil Abarca, Violeta Campodónico.

total, nearly a hundred people took part, primarily women from the central Chilean coastal towns of El Tabo and El Quisco. Some of the scientists from the research station also joined in the knitting.

In the first session, participants were introduced to concepts, images, and stories to inspire them, drawing from both the world of geometry and the life of temperate mesophotic reefs. Key to this introduction was the use of the short documentary, photographs, and even biological samples. The documentary allowed participants to engage with aspects not captured in photos, such as sounds, animal movements, and even the textures of the organisms living in these remote ecosystems. This first session also introduced participants to crochet, working with a predefined pattern, and a few exercises to take care of their hands. For beginners, the teacher had simpler tasks and crochet patterns prepared.

For the second workshop session, the participants returned with their completed or partially finished creations, along with their questions. The initial part of the workshop was dedicated to addressing these questions, but the majority of time was spent learning a second crochet pattern, discussing and helping one another with any difficulties in stitching, sharing experiences, and, importantly, enjoying the process. At the end of the second session, participants were asked to complete a brief feedback survey.

In all the sessions, the invitation was to crochet as many organisms as they wished, always inspired by the inhabitants of Chilean temperate mesophotic reefs. To support this, additional patterns were shared with those who were interested in continuing to crochet at home or in other community spaces. Participants were also invited to donate their crocheted pieces to help build the large collaborative reef. After taking part, everyone generously contributed their creations, bringing this collective project to life.

What unfolded during the workshops was undoubtedly more than just knitting. A space was created for sharing life experiences and getting to know other women. Each person brought their knowledge and experiences to the project, fostering a collaborative environment. The participants, while not necessarily coming from scientific or artistic backgrounds, were eager to get involved, motivated by their interests and concerns.

20.4.4 Results: Knitted Pieces and Self-Perceived Learning

The final artwork product is a hand-woven mesophotic reef, composed of over 600 knitted pieces. From a single anemone, the reef quickly grew to 98 of them (Fig. 20.14), thanks to the collective effort of so many women involved in the project.

A significant portion of the pieces were knitted during the workshops held at the ECIM research station, but not all of them. Participants often finished their work at home and later



Fig. 20.14 A colony of anemones created by the collective effort of the participants. Photo by Celeste Kroeger Campodónico

brought the pieces to the station. Some knitters, from the "Centro Diurno Comunitario para el Adulto Mayor", even gathered in their neighborhoods to teach others the patterns and then donated the extra pieces, showing great motivation, initiative, commitment, and an impressive capacity for organization.

Gauging participant satisfaction was measured through an anonymous survey which was completed by 73 out of the 91 invited participants. It included four multiple-choice and open-ended questions: (1) How satisfied are you with the activity? (with 5 being very satisfied and 1 very dissatisfied), (2) Which of these skills do you feel were encouraged by this activity? (you can select more than one), (3) Did you learn something new in this activity? What would you highlight?, and (4) Is there anything you would change to improve this activity?

On average, participants rated the experience 4.9 out of 5. Regarding self-perceived learning, the women highlighted creativity, teamwork, and other aspects not included in the options, such as increased tolerance for frustration.

In response to the open-ended question about new skills, the knitters emphasized both knitting-related skills (how to create 3D shapes, how to hold the crochet hook, how to read knitting patterns, etc.) and knowledge related to the sciences (the wonders of the deep sea in their region, what goes on at the research center where the workshops were held, the connection between geometry and marine animals, among others). Additionally, they noted improved communication with peers, increased patience and creativity, better concentration, and confidence in their ability to replicate the knitting patterns in other contexts. They also appreciated the opportunity to see their work exhibited.

In their recommendations for changes to the experience, participants unanimously expressed a desire for more workshops and longer sessions. Two participants also suggested having more than one instructor or having assistants in the classroom.

In addition to the participant surveys, internal project evaluation sessions were held to identify key learnings and discuss possible improvements. Some of these essential insights are presented in the final section of this chapter.

20.5 The Reef Expands

20.5.1 From a Hundred Knitted Pieces to One Crochet Artwork

Once the hundreds of knitted pieces were collected, the creative work of assembling them began. The leadership of the visual artist was crucial in this process. She, along with a group of volunteers and young assistants, carefully added each piece, one by one, in a highly collaborative and interdisciplinary effort (Table 20.2).

Among those involved in the initial assembly were art students and a group of knitters who participated in the previous project "Hyperbolic Reef". A key role was played by the scientific-technical diving team from the Millennium Nucleus NUTME, contributing their first-hand knowledge of mesophotic reefs, and offering insights based on their direct observations of these ecosystems.

Table 20.2 List of people who participated in assembling "*Tramares, weaving reefs*" at different times of the project, led by Mariana Milos Montes and Celeste Kroeger Campodónico

Participants in the assembly of the artwork "*Tramares, Weaving Reefs*"		
Alejandra Santiago, Alicia Leiva, Amanda Kroeger, Bárbara Barrera, Beatriz Salgado, Catalina Ruz, Celeste Kroeger Campodónico, Constanza Allende, Constanza Salgado, Elizabeth Anriquez,	Ema Pérez, Emilia Martinic, Fernanda Vargas, Francesca Search, Graciela Hidalgo, Javiera Rivera, Laura Milos, Magdalena Araya, Magdalena Guichard, Mariana Milos, Mirtala Parragué,	Myriam Carrasco, Norma Riveros, Pascual Kroeger, Ricardo Calderón, Rodrigo Alarcón, Valentina Nadeau, Valentina Romagnoli, Verónica Rojas, Violeta Campodónico.



Fig. 20.15 Ema Lorca, lead knitter, giving some words at the inaugural act of "*Tramares, weaving reefs*". Photo by Celeste Kroeger Campodónico

Two months after the workshops, the artwork was ready for its first exhibition. It was decided to create a piece that would be easy to transport, durable, and adaptable to different spaces, with the aim of broadening its exhibition potential. The knitted pieces were mounted on a textile, and a foldable wooden frame was built to support the fabric. Padding was added between the frame and the textile, which could be easily inserted and removed. The artwork was divided into three sections (two measuring 210 cm × 120 cm, and one measuring 120 cm × 120 cm), which can be arranged in various ways depending on the space hosting the exhibit.

The first unveiling of *Tramares, Weaving Reefs* took place at the Cultural Center in the provincial capital of San Antonio, Chile. More than 60 people, most of them knitters from the coastal towns of El Tabo and El Quisco, attended, with their transportation once again facilitated by the local municipalities. The ceremony was very emotional, with special efforts to ensure that key participants which created the artwork were also central to this milestone (Fig. 20.15). Afterwards, the reef began its journey to different public spaces and cultural centers within the central coast and to other regions of the country.

The artwork is still growing, as the workshops are still ongoing, even at the time of this chapter's publication. Thus, with each new exhibition, more pieces are added to the reef. Volunteers from the ECIM Marine Research Station help incorporate these new contributions.

20.5.2 "*Tramares, weaving reefs*" on Tour

Since the first exhibition of "*Tramares, weaving reefs*", in one year, the collaborative mesophotic reef artwork has been exhibited 12 times, both nationally and internationally, visited by more than 100,000 people, and has attracted attention from various media outlets (Table 20.3).

The initial exhibitions took place in cultural centers near the communities where the project was created. Soon after, it became part of Science Festivals and Art and Science Festivals in different regions of Chile. Later, it was featured at scientific and marine education conferences in Costa Rica and the United States of America.

Each exhibition has been uniquely adapted to the space where it was hosted. Depending on the location, the use of space and lighting has varied.

Table 20.3 National and international exhibitions of "*Tramares, weaving reefs*" between July 2023 and March 2025

Exhibitions 2023–2025			
Location	Region/Country	Year	Visitors
San Antonio Cultural Center	San Antonio, Valparaíso, Chile	2023	3,000
Camilo Mori Cultral Center	El Quisco, Valparaíso, Chile	2023	250
Natural History Museum of Concepción	Concepción, Biobío, Chile	2023	6,451
Science Festival of Maipú	Maipú, Metropolitana, Chile	2023	7,000
Biological Sciences Faculty, Ponticia Universidad Católica de Chile	Santiago, Metropolitana, Chile	2023	200
Coastal Marine Research Station, Ponticia Universidad Católica de Chile	Las Cruces, Valparaíso, Chile	2023	500
Nicanor Parra Cultral Center	Las Cruces, Valparaíso, Chile	2024	300
Puerto de Ideas Festival	Antofagasta, Chile	2024	12,200
National Universidad de Costa Rica	Heredia, San José, Costa Rica	2024	975
University of Boston	Boston, Massachusetts, United States of America	2024	350
National Museum of Natural History	Quinta Normal, Metropolitana, Chile	2024	64,522
Fonck Museum	Viña del Mar, Valparaíso, Chile	2025	5,557

In some cases, the rooms have been darkened or illuminated, while others were outdoors (Fig. 20.16). The arrangement of the knitted units that make up the artwork has also shifted, along with the accompanying elements. For example, sometimes marine organism photographs or biological samples have been displayed, helping to connect the knitted representations with the species that inhabit mesophotic reefs. This flexibility, built into the design, has yielded excellent results, allowing the project to bypass limitations presented by smaller or less resourceful venues.

Through the numerous exhibitions of "*Tramares, weaving reefs*," the project team has found the artwork serves as a powerful conversation-starter about marine biodiversity and conservation. People are drawn to the piece for different reasons. For some, the crochet evokes family traditions, others are captivated by marine life or simply by the artwork's unique shapes and vibrant colors. From there, fascinating conversations naturally unfold.

20.5.3 Inspiring Others

Just as "*Tramares, weaving reefs*" found inspiration in other interdisciplinary projects, it too has stirred sensitivities and inspired new initiatives, some similar and others quite different.

One example is the project "Tejer Litoral: Mar y Crochet" driven by professionals from the Municipality of El Tabo, who participated in "*Tramares, weaving reefs*" in 2023. They decided to represent another ecosystem crucial to their coastal territory: kelp forests. Another initiative is "Die Ostsee: eine gewobene Welt", ("The Baltic Sea: A Woven World" in English), based in Germany, which has adapted some of the patterns from "*Tramares, weaving reefs*" to suit the biodiversity of the Baltic Sea.

Additionally, a group of design professors from the Catholic University of Chile proposed a reinterpretation of the project featured in this chapter, called "Tramares Biobasado". This new project focused on exploring how to create new materials for knitting, made from gels (sugars) found in the cell walls of brown algae. They developed materials of different colors, thicknesses, and elasticities, testing them by knitting the patterns of "*Tramares, weaving reefs*" while also inventing new ways to represent the same species that inhabit mesophotic reefs.



Fig. 20.16 Same artwork, different sets up according to the available space and its environmental conditions. Photos by Celeste Kroeger Campodónico

20.6 Conclusion

"*Tramares, weaving reefs*" began as a way to share findings and generate interest in the mesophotic reefs of Chile. We met our goals, sparking curiosity and communicating discoveries. However, we also achieved unexpected outcomes fostering community engagement, cross-disciplinary collaboration, and inspiring other initiatives. The project integrated diverse strategies for Ocean Literacy applied across multiple groups and settings, effectively bridging the gap between science, art, and the public.

Sharing with the public the marine life inhabiting coastal ecosystems, where light quickly fades and becomes scarce, was the foundation for designing the initiative "*Tramares, Weaving Reefs*." The twilight or mesophotic zone of the coastal Ocean is dominated by "animal forests" that provide habitats for a diversity of invertebrates and fish. Remarkably, we know little about these ecosystems and even less about those in temperate regions like Chile. Since 2021, the Millennium Nucleus for the Ecology and Conservation of Temperate Mesophotic Reef Ecosystems (NUTME) has been exploring mesophotic reefs along the coast of central Chile.

"*Tramares, Weaving Reefs*" shifted the main focus of our educational program. While our outreach efforts had primarily concentrated on schoolchildren, we decided to pivot and focus on older adults, who make up an important portion of the local population and often have limited learning opportunities. In this endeavor, we aimed to offer them a space to discover mesophotic reefs.

Collaboration is a key concept in this project. We teamed up with individuals from diverse disciplines, including marine biology, visual arts, knitting, mathematics, education, and diving, to incorporate and integrate a wide range of perspectives and experiences from the very beginning. The collaboration with Costuritas warehouse, the company that made a significant donation of materials, was crucial. Partnerships with local organizations were also essential, enabling the project to surpass its original objectives, particularly by expanding the number of exhibitions and workshops, which in turn increased visitor engagement.

More than 60 older adults participated in workshops designed to share scientific knowledge about mesophotic reefs and inspire them to engage in the process of knitting marine life. These workshops provided safe spaces for sharing life experiences and strengthening social bonds, extending beyond just knitting. Over 600 crochet pieces were created and assembled into traveling reefs, which were exhibited at 12 locations, attracting more than 100,000 visitors. On average, participants rated the experience 4.9 out of 5. In terms of self-perceived learning, participants (mostly women) highlighted creativity, teamwork, tolerance, and frustration management. They unanimously expressed a desire for more activities and were extremely proud of their contribution to bringing mesophotic reefs to the surface, helping to share scientific discoveries. Many participants eagerly showed their work to loved ones and invited other community members to get involved.

This project not only sparked curiosity but also fostered community engagement, and cross-disciplinary collaboration, and inspired other initiatives. Ocean Literacy can take many avenues to effectively bridge the gap between science and the public. We hope that this chapter facilitates and inspires other groups to create mesophotic crocheted reefs.

20.6.1 Summary

Key concepts explored in this chapter include:

- The mesophotic crocheted reef served as an excellent multi-faceted entry point for discussions about marine biodiversity, Ocean threats, and conservation, with people from varied demographic and socioeconomic backgrounds that composed the public of exhibition visitors.
- Every phase of the project was enriched by the engagement of an interdisciplinary and multigenerational team that included experts in visual arts, knitting, science, diving, mathematics, design, and local businesses. From

concept development to workshop planning to assembling and exhibiting the crocheted reef, the integration of diverse expertise enhanced everyone's learning and creativity.
- Sharing photos, videos, and biological samples from ongoing studies and explorations of the mesophotic reefs and organisms "neighbors" living directly adjacent to workshop participants offered personal relevance and motivation, as well as a pride for sharing newfound local knowledge.
- Holding workshops in comfortable, semi-private and inviting local venues provided safe spaces for sharing life experiences and strengthening social bonds. Discussions in the knitting circle expanded far beyond just knitting.
- Hosting new workshops alongside each exhibition ensured the reef's continuous growth. It is crucial to have a plan in place to support the integration of new pieces into the artwork and to manage its storage effectively, as well as to incorporate new lessons and challenges along the way.
- Each of the knitters felt ownership of the resulting, larger textile artwork. They brought their loved ones to the exhibitions proudly showing their work. This sense of ownership also encouraged them to teach others what they had learned and invite them to join the project.
- Collaborative efforts with local organizations allowed the project to exceed its original objectives, particularly in expanding the number of exhibitions and thereby increasing visitor engagement.
- Holding workshops once a week provides enough time for the knitters to make progress, reflect on their learning, and return with questions to the next workshop, while also maintaining continuity.
- The interest and commitment of the knitters were very high, and they would have appreciated longer workshop cycles (either longer sessions or more sessions). It is advisable to plan several sessions per participant.
- Older participants preferred reading knitting instructions from printed patterns during workshops. These resources need to be printed to reach their full potential. Tutorial videos were also welcomed.
- When creating the artwork, it is important to consider how it will be displayed. The format chosen for "*Tramares, weaving reefs*" allowed it to travel fully packed in a small car for national trips, or only part of it in a suitcase for international journeys. You never know how far the exhibition can reach!

20.6.2 Recommended Resources

The following resources provide further insights and support on this topic:

- "*Tramares, weaving reefs*" webpage and magazine: www.tramares.nutme.cl
- Millennium Nucleus NUTME webpage: www.nutme.cl
- Video "Explorando al límite de la luz": https://www.youtube.com/watch?v=M_hOQhw94zM
- "Coral Crochet Reef" project webpage: https://crochetcoralreef.org
- "Hyperbolic Reef" magazine: https://www.mat.uc.cl/revista-arrecife.html
- "Patagonia Crochet" webpage: https://www.proyectosub.org.ar/crochet

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Evie Ann Wieters Buchanan, PhD, is a marine ecologist. Her research integrates diverse scales and tools, from organismal ecophysiology to large-scale biogeographic comparisons, to address ecological and conservation challenges. She has advanced understanding of how physical changes and human activities interact to influence biodiversity, ecosystem functioning, and resilience. Emphasizing fieldwork and experimental approaches, her work spans Chile, South Africa, the US, and Argentina, with a focus on temperate and subtropical systems like Rapa Nui. Her collaborations bridge ecology, spatial modeling, Oceanography, and population genetics, addressing key issues such as foundation species, indirect effects, and responses of macroalgae and invertebrates to extreme environmental stressors.



Miriam Ethel Fernández Bergia, PhD, is a marine ecologist and professor at the Catholic University of Chile is dedicated to the management and conservation of coastal ecosystems. She has worked closely with local fishers to understand their responses to management practices and the conditions required for collaboration in conservation plans across continental Chile and Oceanic islands. Fisher's knowledge plays a critical role in her research, contributing to scientific discoveries, such as identifying the distribution of mesophotic reefs in Chile. Her research also focuses on both physical and human-driven processes (e.g., temperature, oxygen) that affect reproductive patterns in species with varying life history strategies.



Alejandro Pérez-Matus, PhD, is a community ecologist. His research focuses on temperate and semitropical subtidal marine environments of the South Pacific. He studies the impact of human activities, such as fishing, and environmental variability, like upwelling, on species-rich communities dominated by macroalgae and corals. His work investigates the behavioral and ecological responses of associated species to these changes. He also explores functional traits in coastal fish to predict ecosystem changes. Through scientific diving, his research includes the discovery of new species and behavioral phenomena, with ongoing projects on fish movement, human impacts, and mesophotic reef biodiversity.

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Land or Sea: Diving into the Ocean from Land

21

Begoña Vendrell-Simón, Josep-Maria Gili, Janire Salazar, and Jordi Corbera

Abstract

There is an urgent need for Ocean Literacy (OL) to empower citizens to understand how the functioning of our planet is linked to their lives, enabling informed decisions about habits and lifestyles. Efforts worldwide aim to inspire interest in and promote the conservation of the Ocean, transforming how people view and relate to it.

We propose playing with similarities and analogies as powerful tools for communicating and learning about the Ocean in an engaging, dialogical way that fosters social exchange and discussion in a positive learning environment. This approach may help construct a more Ocean-centered worldview. Analogies can provide understanding and insight into the Ocean by bridging the more familiar terrestrial world with the lesser-known and less visible marine domain, thereby enhancing OL. We present the *Land or Sea* game as a tool to facilitate this shift in perspective. Results from five case studies show highly positive evaluations. The game effectively enhances imaginative access to marine environments and fosters knowledge, awareness, interest, creativity, curiosity, and observational skills. A holistic understanding of the Ocean may be key to restoring humanity's relationship with it—and, by extension, with the natural world as a whole.

Keywords

Analogical thinking · Game-based learning · Margalef's legacy · Nature connection · Ocean consciousness · Outdoor and place-

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based education · Ocean Literacy (OL) · Observational skills · Quality education · Social-emotional learning

21.1 Introduction

> There is a pervading feeling of beauty in the contemplation of nature. (Margalef 1997, p. 3)

The Ocean remains largely inaccessible to many people, even in coastal regions where citizens often live with their backs to the sea. This inaccessibility stems from several factors: the Ocean is not a natural habitat for human life, it is difficult to access beyond the shoreline, and its vastness and depth keep much of it a mystery, even to scientists. Furthermore, the absence of Ocean education in formal curricula (e.g., Gotensparre et al. 2017) has widened the gap between humans and the Ocean, especially in a world with limited education *in* nature. Despite this widespread disconnection, the Ocean exerts a profound influence on human lives—and all life forms—and human actions significantly impact it. So how can we turn more eyes to the Ocean and make it more visible, particularly in landlocked areas when it too often remains 'unseen'?

Ocean Literacy (OL) in educational contexts should focus on building a positive bond with the Ocean, largely achievable through direct experiences like outdoor and place-based learning (see O'Brien et al. 2023). These perspectives encourage a deeper connection with nature. They go beyond simple observation to foster curiosity and a more holistic understanding of ecosystems. The nature-based approach to learning motivates a shift from a purely exploitative view to a more thoughtful, naturalistic, and less disruptive interaction with marine ecosystems.

Analogies, similarities and metaphors are common everyday tools for explaining unfamiliar or abstract ideas in familiar terms. They tap into human imagination, enhancing conceptual understanding and serving as powerful communication tools. By using familiar land-based examples, individuals may better grasp more complex or less visible Ocean concepts, sparking a sense of wonder (Carson 1965/2019) and inspiring care for the natural world, even in its unknown aspects. If humanity's hope lies in learning from nature (by studying and understanding it), perhaps we should expand our view from landscapes to seascapes as well. The *Land or Sea* educational game presented in this chapter advocates for a mindful engagement with nature, urging humanity to learn about and from ecological systems to support a sustainable future coexistence with the environment. The proposal, which may serve marine educators, researchers and the general public worldwide, was inspired by the teachings of the renowned ecologist and pioneering thinker Ramon Margalef (Figs. 21.1 and 21.2).

21.2 The *Land or Sea* Game in a Clamshell

The *Land or Sea* game originated in 2011 from playful discussions among researchers at Institut de Ciències del Mar (ICM-CSIC) about uncovering similarities between land and sea, inspired both by Margalef's ideas and personal experiences as scientists delivering education and outreach in contexts where marine examples were often overlooked. A list of land-sea pairs was compiled. Then, collaborating closely with a biologist and artist, simple, naturalistic drawings were selected to represent these concepts. The goal was to create a purely visual game with clear, straightforward illustrations that could evoke familiar landscapes, seascapes, or experienced (lived, read, seen) situations. Initially, it focused on biological and ecological comparisons, but the scope soon expanded to include geology, physical oceanography, technology, and human impacts. The first target was to identify 100 similarities or analogies between land and sea. This goal was soon surpassed. To date, 133 scientifically verified pairs have been published, with currently over 100 pending proposals, as new ideas have continuously emerged from a variety of players (scientists, colleagues, educators, amateur naturalists, students) (Fig. 21.3).



Fig. 21.1 Natural mirrors. *Note.* Ramon Margalef proposed in his lessons and extensive writings that land and sea ecosystems mirror each other in many ways. Looking closely at land ecosystems can reveal similarities with the Ocean. Photo (iceberg) by Armin Rose; photo (underwater) by Marta Masdeu

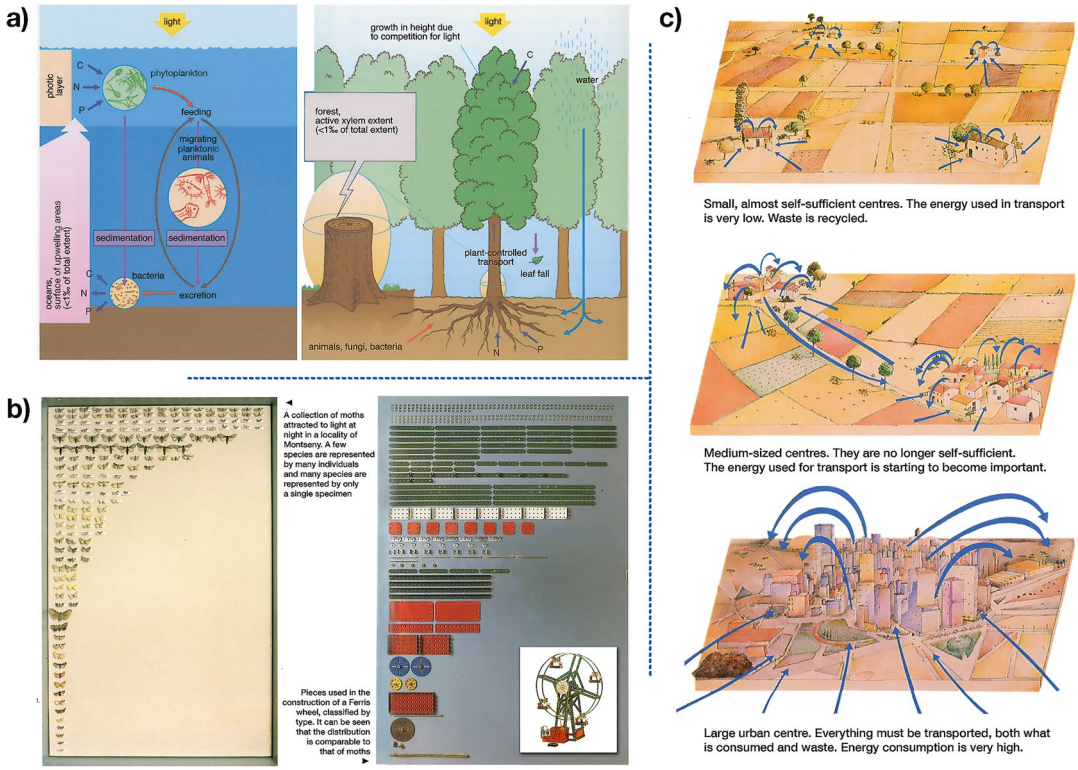


Fig. 21.2 R. Margalef's comparisons between ecosystems. *Note.* Examples of pictorial images of Margalef's works comparing land and water ecosystems or biological and human-made systems; a) is modified from Folch, R. (Coord.). (1993). Biosfera, 1: Planeta viu. Enciclopèdia Catalana; b) and c) are modified from Margalef, R. (1985). L'ecologia. Catalog for an exhibition at the Zoology Museum. Diputació de Barcelona



Fig. 21.3 First completed version of the game's land-sea pairs. *Note.* The first 133 land sea pairs were prepared for the launch of the *Land or Sea* game. The complete game, along with a didactic guide, species list and illustrated album, is available online in three languages at the *El mar a fons* website and at the Digital CSIC repository. Both resources were physically printed and copies are available at the CESIRE Educational Resource Center (Barcelona) and in public libraries throughout Catalonia. Drawings by Jordi Corbera

During playtests, it was observed that some similarities required more basic ecosystem knowledge. To address this, pairs were categorised into four difficulty levels to enhance usability: structural or morphological parallels generally belong to the easiest levels, while ecological processes, life cycles, and concepts regarding microscopic or geological scales were assigned to higher difficulty levels, as they proved more challenging in trials with diverse age groups and backgrounds. The clarity of the images was also tested, leading to corrections and updates when needed. A didactic guide was elaborated, including concise descriptions and explanations for all the land-sea pairs. Overall, game design followed several methodical steps and pedagogical considerations, as seen in game literature (Fig. 21.4).

In terms of content, the game covers six major subthemes and aligns with all seven OL principles (Cava et al. 2005), particularly Principles 1, 5 and 6 (Table 21.1), along with many of their associated concepts (Table 21.1).

The final game includes a set of cards with terrestrial (green background) or marine (blue background) illustrations. It can be played either cooperatively or competitively, with the main objective of matching all land-sea pairs. The game remains open-ended, evolving based on participant feedback, and accommodating various rules. Basic gameplay involves the following steps:

1) Players gather in small groups, with all cards face-down.
2) Each group selects an equal number of land cards.
3) At the same time, all groups turn up the land cards and think of corresponding marine examples (with a time limit, when used competitively).
4) Sea cards are then turned up.
5) Groups try to match all their land cards with the now visible sea cards (time-limited if played in competitive mode).
6) Each group explains their matches, using the game's guide to verify accuracy. Judges may be educators or members of other groups.
7) Game ending:
   - Cooperative mode: All groups work together to match pairs, revising as needed.
   - Competitive mode: The group with the highest number of correct matches within the time limit wins.
8) All participants are invited to suggest new land-sea pairs or alternative examples for existing pairs in the game.

Land or Sea's storytelling potential also inspired an illustrated album, primarily aimed at teens, featuring a story about two friends who embark on a challenge. It highlights the role of women in science and incorporates information on scale and technology.

Since its creation in 2011, the game has engaged over 25,000 participants of all ages (from four-year-old children onwards) in different formal and informal educational contexts such as science fairs and festivals, museums, environmental entities, schools, teacher training courses, and workshops (Figure 21.5). Typically, it has been played as a standalone activity; however, it has also been used in informal contexts preceded by a workshop on marine forests or in formal educational contexts as part of larger didactic activities or projects, both as the spark that may trigger further research and teaching on marine topics, or as a synthesis after performing activities regarding marine aspects. Feedback from players through these years has yielded new land-sea pairs and the addition of a species list to the game.

Over the years, informal feedback from participants of different ages and backgrounds has been very positive, though not formally documented. Recently, evaluations were conducted in spring and summer of 2024 in four primary schools and one marine education centre, focusing on students aged 10–12. Although the sample size is relatively small (143 students and 13 educators) and assessments varied slightly across sites, many evaluative items were consistent. Feedback was gathered via anonymised paper (students) and online (educators) questionnaires, with informed consent obtained from all participants. The questionnaires collected basic demographic data and included a mix of three-point and five-point Likert scale questions for evaluat-

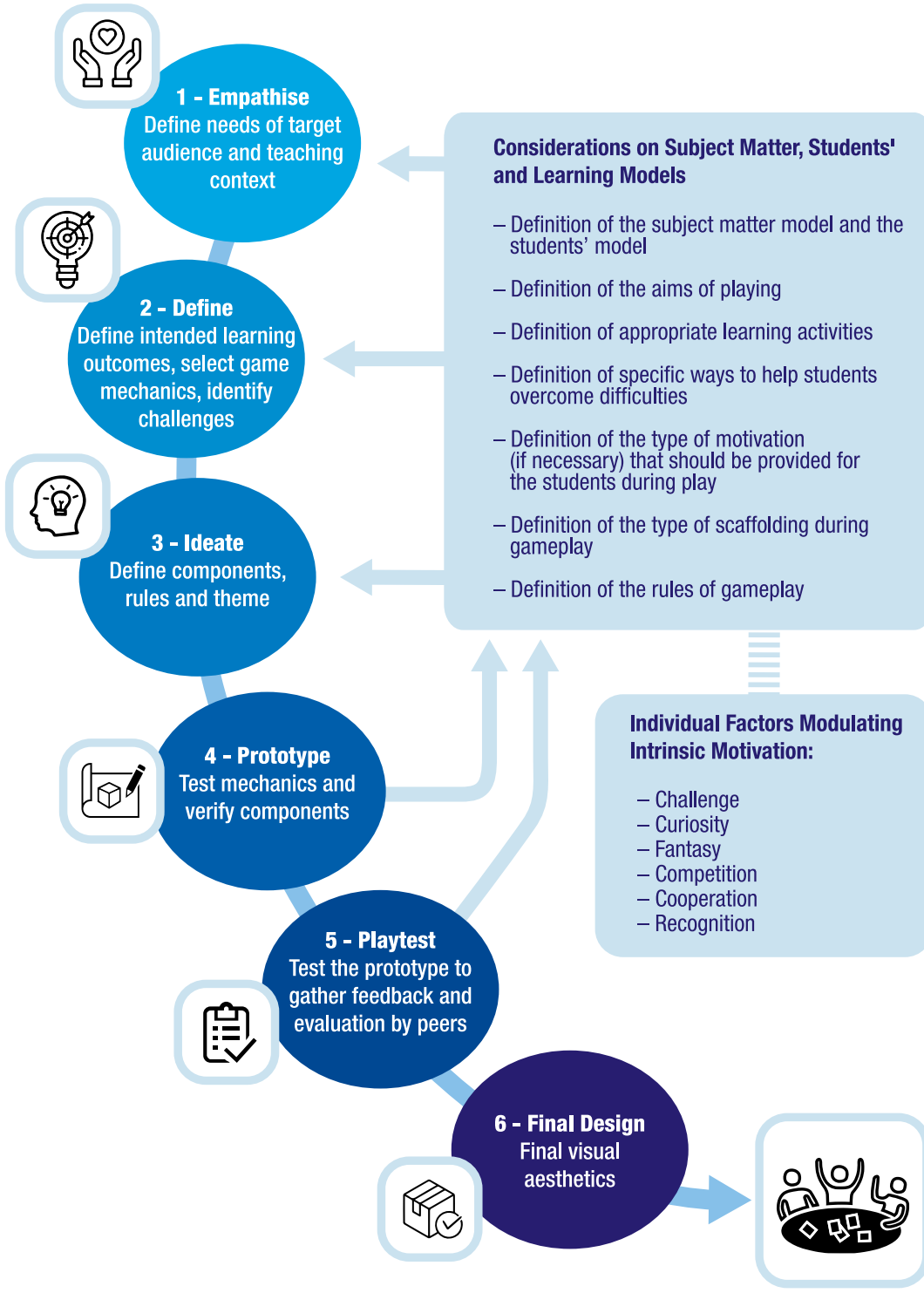


Fig. 21.4 Game design process. *Note.* Game design followed a framework similar to that currently proposed by Cardinot et al. (2022). Figure corresponds to a modified conceptualization of their six-step game design framework. Integration of learning considerations by Kordaki (2015) were embedded in the three first design steps. Intrinsic motivation factors were taken into account during all steps of game development

Table 21.1 Main general topics and OL principles covered by the current set of cards in the *Land or Sea* game

OL principles (as part of the knowledge dimension of OL)	Number of examples in the game	Thematic group
1. The Earth has one big Ocean with many features	17 (25)	Geology and oceanography Ecosystems
2. The Ocean and life in the ocean shape the features of the Earth	5 (14)	Geology and oceanography Ecosystems
3. The Ocean is a major influence on weather and climate	8 (18)	Geology and oceanography Ecosystems Functioning of organisms
4. The Ocean makes Earth habitable	8 (6)	Ecosystems Functioning of organisms Structure or type of organisms
5. The Ocean supports a great diversity of life and ecosystems	102 (83)	Geology and oceanography Relationships among organisms Ecosystems Functioning of organisms Structure or type of organisms
6. The Ocean and humans are inextricably interconnected	14 (48)	Humans and the Ocean Relationships among organisms Functioning of organisms
7. The Ocean is largely unexplored	4 (11)	Humans and the Ocean

Note. This table lists currently published and unpublished but being worked on (in parentheses) numbers of land-sea pairs that cover each of the seven OL principles. Note that one pair may cover more than one principle. The land-sea pairs are arbitrarily grouped into six major subthemes to ease coverage of all topics when distributing cards for small group play: Human species and the Ocean, Geological structures/processes and physical oceanography (geology and oceanography), Structural/morphological/typological similarities among organisms (structural or type of organisms), Relationships between organisms, Functioning of living organisms and Ecosystems

ing several aspects of OL and the game, multiple choice items, and open-ended questions. All participants used cards with mixed-difficulty levels, playing in small groups with land cards first, and concluding by explaining their matches as outlined in the game rules. Each session lasted about 1.5 h (including group formation, game introduction, gameplay, result sharing, and assessment).

In this chapter, we present key findings from these case studies, focusing on the game's effectiveness in fostering engagement with the Ocean, sparking curiosity and communication, enhancing OL, and retrieving and integrating theoretical and experiential knowledge.

21.3 What Do We "Sea"? Main Results of Assessments in Five Case Studies

In an initial assessment of 96 students, their alignment with OL principles and self-reported marine knowledge were evaluated. Results showed limited agreement with certain OL principles (Fig. 21.6a). For example, 36.46% of students disagreed with the statement "The Earth has one Ocean with many features," a result consistent with trends in global OL surveys (e.g., O'Halloran and Silver 2022). Alarmingly, only 35.11% of students acknowledged the connection between humans and the Ocean, while 42.55% were uncertain (aligning with findings by Salazar et al. (2024) in a group of small-scale fishers).

Some students responded to seven items designed to explore additional aspects of OL. Remarkably, more than 98% of respondents agreed that knowledge is essential for Ocean protection, recognised the importance of individual actions, and 90% reported missing the sea when they had not been there for a long time (Fig. 21.6b). Feelings experienced when near the sea were mostly positive (Fig. 21.7).

Game assessments revealed notable outcomes: after playing, 83.70% of students expressed increased interest in learning about the Ocean, 81.32% reported they would observe more actively during future sea experiences, 68.89% expressed a desire to share Ocean knowledge, and 64.44% felt their perspective on the Ocean had changed. Eight students spontaneously noted that the game was helpful for learning about the Ocean. Additionally, some individuals and



Fig. 21.5 Different educational settings where the game has been used. *Note.* The *Land or Sea* game, developed as part of the *El mar a fons* educational project, was introduced at the EGU GIFT workshop in Vienna in 2011. Since then, it has been used in different educational settings, including classrooms, Forest School sessions, science fairs, museums, a Seas and Ocean Ghymkhana, and a Marine Forests workshop (where the public experiences a simulated Ocean immersion alongside parallel land--based examples explained by scientists). Photos by the authors

groups of students asked new questions about marine topics after playing, and one student expressed that she felt very eager to know more about the sea and was filled with curiosity.

A comparison of descriptive words about the Ocean before and after the game revealed interesting changes in word choices. Initially, students provided 429 words, which narrowed to 108 words from 40 voluntary students after gameplay. The latter responses were enriched with game-specific terms and deeper emotional insights (Fig. 21.8).

In two of the classes, small groups of about five students each identified 17 new land-sea similarities during gameplay. Students provided explanations that led to further comparisons; when given land cards, they generated new analogies or noted interesting aspects to match with imagined marine examples. Additionally, 11 examples expanding upon existing pairs were proposed. Students demonstrated considerable memory retrieval, reflection, intuition and creative thinking: overall, students produced 108 accurate explanations by the end of the game.

After gameplay, students were asked to suggest new land-sea pairs. This activity, often completed quickly and with ease, sparked group discussions focused on personal experiences. Many suggestions matched existing game pairs identified by other groups, which boosted students' confidence. The proposals included entirely new analogies as well as examples related to already covered topics, with some reflecting environmental or emotional themes, such as "woodlands and the sea are relaxing" and "both are affected by climate change". Several suggestions also addressed less commonly explored geological aspects (Table 21.2).

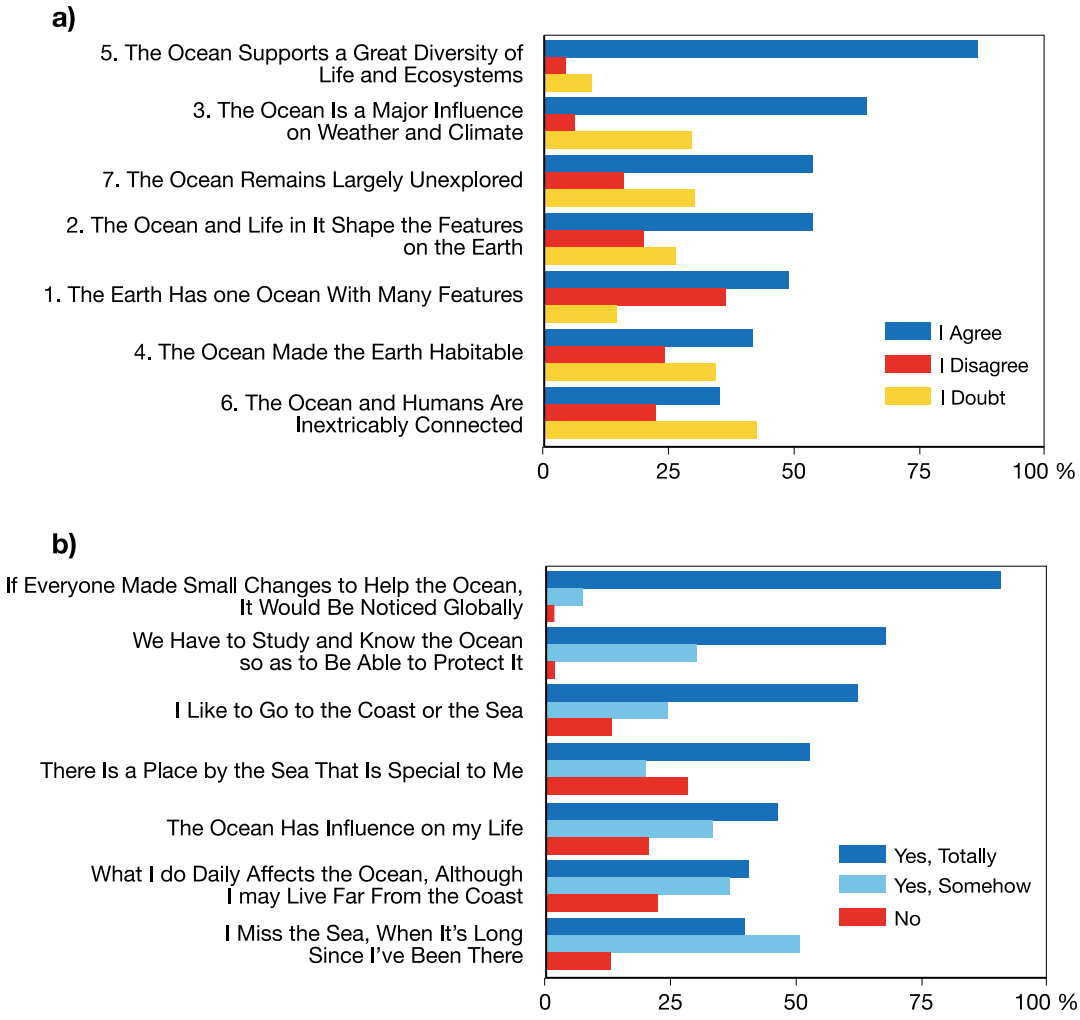


Fig. 21.6 Brief student assessment on OL aspects. *Note.* a) Students' agreement with OL principles, ranked by highest to lowest agreement. b) Students' agreement on perceptions, awareness, and attitudes, ranked by highest to lowest agreement

However, despite accurate comparisons, 37 examples included errors or lacked sufficient explanations (Table 21.3).

Regarding educator insights, teachers were asked about the game and their personal and professional perspectives on OL. They reported moderate knowledge of marine topics, mostly gained through self-study and personal experiences (e.g., books, travel, holidays at sea, friends, news, talks and water sports), followed by peer learning. While many recognised a need for training in marine topics, only a few had received such training in the past 5 years; however, more than half were offered some form of marine training in the last year. Most educators strongly agreed with OL principles, with the least agreement on OL1. Their descriptions of the Ocean were more varied than students' and included feelings and memories. Identified barriers to marine education included economic and logistical challenges, difficulty accessing marine environments, concerns for student safety, and limited

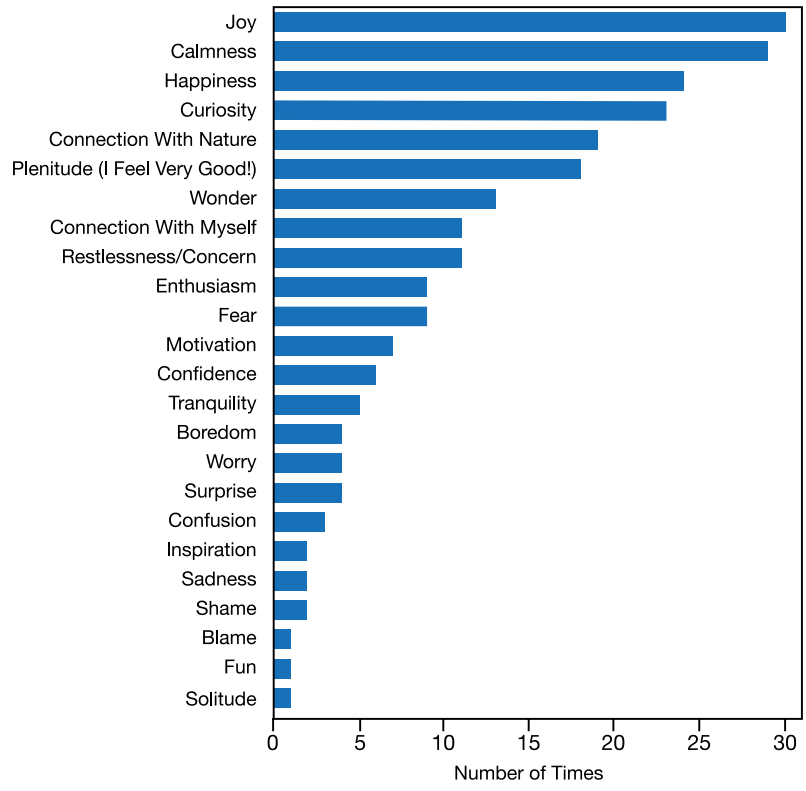
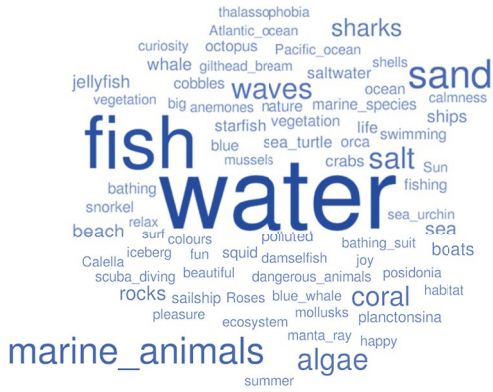


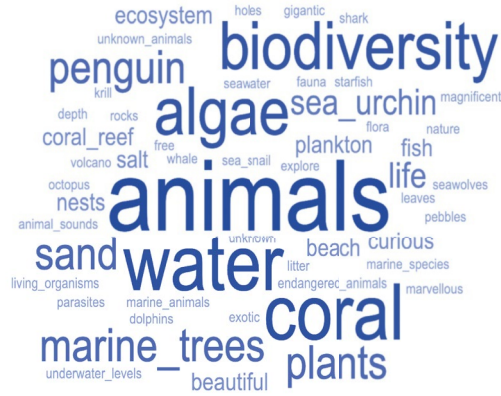
Fig. 21.7 Emotions felt by students in marine environments. *Note.* Students' top emotional responses to being near the sea included joy, calmness, and happiness, which together accounted for about 35% of choices. When curiosity, connection, plenitude and wonder are included, the total rises to over 70%. Negative emotions, such as concern and fear, accounted for only 8.4%. "Very little rage" was categorized under "calmness"

teaching materials. Enablers included field and classroom training and opportunities for interaction with scientists.

Educators rated the game highly for increasing marine knowledge and recognised its educational value, illustration quality, flexibility, didactic possibilities, online availability, and potential for player-driven updates (Fig. 21.9a). Nearly all teachers strongly agreed that the game 'makes you see the Ocean with different eyes' and 'inspires a desire to learn more about the Ocean'. Additional strengths noted were its playfulness as an effective learning tool, its similarity-based methodology to stimulate thought, and its ability to unveil the unknown (the Ocean). One teacher specifically outlined its ability to foster curiosity, and another the way it encourages reflection on personal understanding of the Ocean and the broader world. Suggestions for improvement included making the game physically less cumbersome, offering more teaching resources, and enhancing accessibility for young children by using puzzle-style pairs for self-guided play. Some educators noted that certain images are challenging for younger children and may require prior knowledge.

All teachers who used the game expressed intentions to incorporate more marine examples in future lessons, and expressed willingness to use the game again and recommend it to colleagues across educational levels with adaptations as needed. They found the game effective for teaching all topics proposed, particularly biodiversity, inter-organism relationships, ecosystems, and human impact (Fig. 21.9b). Most had used the game previously to teach ecology or marine biology, with three educators also using it to teach geology. They were impressed by how readily students identified land-sea similarities after gameplay and were surprised by the number of analogies between land and sea.





PRE

$N_{children}$: 143
N_{words}: 429
Different Words: 74 (17.24%)

- 8 with focus on locality: particular places (Roses, Calella) or memories/experiences-related ("planctonsina", summer) or local species (Mediterranean chromis, posidonia, damselfish, gilthead bream) + sea repeatedly [a]
- 3 planetary views (nature, habitat, ecosystem)
- life repeated 3 times
- 2 ocean basins (Pacific, Atlantic) + 1 polar (iceberg)
- 5 different water sports (snorkel, scuba-diving, sailing, swimming, surf) [b]
- 8 positive (beautiful, relax, pleasure, curiosity, happy, calmness, joy, fun) + 1 negative (thalassophobia) emotions/perceptions [c]

POST

$N_{children}$: 40
N_{words}: 108
Different Words: 54 (50%)

- at least 18 directly game-related (33.33%) ("marine trees", penguin, plants, nest, plankton, endangered animals, whale, sea snail, dolphins, starfish, holes, leaves, seawolves, litter, underwater levels, parasites, animal sounds, volcano)
- 9 related to the unknown or implying vastness, discovery and beauty (16.67%) (exotic, explore, unknown, magnificent, marvellous, curious, beautiful, unknown animals, gigantic)

Fig. 21.8 Descriptive vocabulary related to the Ocean. *Note.* (up) Word Clouds Displaying Vocabulary Changes Pre- and Post-Playing *Land or Sea*. The word clouds show students' descriptive vocabulary for the Ocean before (left) and after (right) playing *Land or Sea*. Post-game results indicate that approximately 50% of the words differed, potentially reflecting vocabulary changes influenced by the gameplay experience. (down) Main metrics and observations on vocabulary use related to the Ocean pre- and post-playing. [a] These words indicate sense of place and personal connection to the Ocean. Ten children attending an environmental education camp at the coast or sea referenced two of the three local species in their vocabulary. [b] Water sports may significantly enhance connection with the Ocean and Ocean Literacy. For example, two children who mentioned "snorkeling" were participating in the environmental camp where snorkeling is a primary activity. [c] A subgroup of 46 children who did not participate in the post-game word review started a transdisciplinary week focused on the sea. Initial positive emotional words belonged to this group

Table 21.2 Summary of new analogies or similarities proposed by participants

New analogies proposed by participants during spring–summer 2024 trials			
	Before playing (N = 46)	While playing (N = 67)	After playing (N = 143)
New land-sea pairs	17	12	25
Other examples to existing pairs	0	7	9
Already existing pairs	11	56	15
Qualitative information on new analogies			
Initial game step (once land cards are provided)			
Snake/worm—eel (similar shape)			
Honeycomb—fish egg laying, crab holes in the sand, or rock erosion[a] (similar aspect)			
Zebra—black and white striped fish (e.g. pilot fish) (similar aspect)			
Vague proposal on life cycles (similar functioning)			
Bird flying—fish swimming (focusing on similar functions)			
Dandelion seeds—ephyrae (juvenile jellyfish) (similar aspect)			
Geyser or volcano—animal exhaling (similar aspect)			
Plant ('grass') moving with wind—anemone with tentacles moving with current (similar aspect)			
Soil—sand (similar support for organisms; similar aspect)			
Cows eating grass—fish eating algae (similar aspect and functioning)			
Tiger—shark (two top predators) (similar ecological function)			
Carnivorous plant—'piranha' teeth (similar shape)			
Animals that hide or live in rocks or rocky habitats in both systems (similar function; somehow similar aspect)			
'Tails' (of bird and of fish) (similar part of the body)			
People on land—people at sea (same organism)			
Palm trees moved by wind—octopus swimming (and shooting ink) (similar shape)			
Stick insect—"razor clam" (similar shape)			
Before or after playing (spontaneous new examples)			
Both systems are affected by climate change (similarly human-related)			
There are microplastics in both systems (similarly human-related)			
Soil—sand (similar support for organisms; similar aspect)			
Woodlands and the sea are relaxing (similar human perception)			
Lungs—gills (breathing but in different ways) (similar function)			
Rocks (types) in both land and sea (same type)			
There are animals that use lungs to breathe both on land and sea (similar function/structure)			
"Both have the water cycle" (similar functioning)			
There is oxygen in the air and in seawater (and organisms must take it from these different fluids)[b] (more functional)			
"There are both very much inhabited" (concept of habitat or living space for organisms) (same type and functioning)			
There is oxygen production in both systems[c] (similar process)			
"Waters of rivers-waters of the sea" (assuming 'different types') (variations in composition depending on site)			
There are rocky habitats in both systems (similar types of habitats)			
People on land—people at sea (same organism)			
Exploring land—exploring the sea (punctuating different degree of exploration) (similarly human-related)			
Nettle—sea urchin (they both prickle) (similar shape and function)			
High diversity hotspots on land and in the sea (similar aspects on diversity)			
Cucumber—sea cucumber (similar name and shape)			
Different landscapes—different seascapes (varied land or seascapes in both cases)			
Geyser—whale exhaling (similar aspect)			
There are dangers in both systems (similar human perceptions)			
Oviparous animals (e.g., insects/birds-fish) (functioning)			
Leaves—"sort of leaves from algae" (similar structure/function)			

(continued)

Table 21.2 (continued)

Cow—black and white fish or seacow (sea slug) (similar colours, similar name)
It rains in both systems (but with a noticed difference: there is more rain globally on the sea) (similar process)
Wave-like dunes in the desert—waves at sea (similar shape)
They both receive sunlight, "but in different ways" (similar process)
Parrot—octopus (they both have a beak) (similar name and shape/function)
Horse—seahorse (both "are" horses)
Moss—some algae (similar aspect)
Pink dolphin (river)—pink flamingo (marshes)[d] (similar aspect)
Jellyfish—hat-shaped or similarly shaped flowers (similar shape)
Mediterranean fanworm—palm tree (similar aspect)
"There are plants with leaves in both systems" (similar structure)
Cabbage—green coral (similar shape and aspect)
"In both places, there is carbon dioxide" (similar chemicals)
Tomato—beadlet anemone (named 'sea tomato' in Catalan) (similar colour and name)

Note. This table summarises the 54 new analogies or examples of land-sea similarities generated by students (and one educator, who contributed an example on microplastics) before, during, or after playing *Land or Sea*. Duplicate ideas within each subgroup are excluded, although repetitions across groups may be present. General suggestions such as "there are animals or living organisms in both systems", were common but are not counted in these totals. Broader concepts like "pollution in both systems" were also excluded as too general; however, these suggestions may inspire more specific analogies related to chemical pollution or eutrophication. Most new examples focused on biology and ecology, though some addressed geological, physicochemical, and human-related perceptions or activities. Many examples related to surface or structural similarities. The 16 examples proposed for existing pairs (e.g., carnivores, with examples beyond those illustrated) suggest the potential to explore local examples or specific ecosystems worldwide (such as polar ecosystems, tropical areas, and caves)

[a] This example likely refers to alveolar erosion

[b] This group proposed a breathing analogy, but focusing on oxygen availability and intake, noting that "organisms require oxygen, but marine organisms extract it from water, whereas land organisms obtain it from air"

[c] Although oxygen production could align with the photosynthesis pair, students highlighted the concept of oxygen production, rather than the metabolic process itself

[d] Here, marshes are integrated within broader coastal (marine) ecosystems

21.4 Discussing Main Findings

21.4.1 On the Use of Analogies to Dive into the Ocean

> In everyday life we learn so many things by comparing and contrasting. The use of analogies and metaphors is important in science itself and their use in teaching science seems a natural extension […] (P. Fensham, in Aubusson, Harrison, & Ritchie et al. 2006, Foreword).

School curricula worldwide often focus on terrestrial environments, leaving students more familiar with land than sea, which can hinder OL (Marrero and Mensah 2010; Gotensparre et al. 2017; Fauville et al. 2018). To address this, along with the challenge of easing access to the Ocean, especially for those living far from it, the *Land or Sea* game effectively challenges traditional perspectives: By leveraging people's knowledge of terrestrial ecosystems, the game enhances understanding and mental imagery of the Ocean. As terrestrial beings, we cannot enter the marine environment without the aid of technology—a technology currently accessible to only a handful of people. However, analogies and similarities between land and sea can help us explore the Ocean indirectly but effectively, without the need to physically immerse ourselves in it. Following Margalef's principles, we can use land-sea similarities to build a solid foundation for OL, both theoretically and experientially (Fig. 21.10).

Table 21.3 Misconceptions, errors, and notable doubts observed during assessments that educators should address

Errors/misconceptions/doubts	Remarks for educators
There are only protists in the sea, not on land	Protists are found in both environments. Educators should explain what they are, the different types, and how they live
There is no gravity inside the sea	Gravity exists in the sea as well. The differences in how gravity acts on land and at sea should be explained
There is nothing like plankton on land	Although not referred to as 'plankton', suspended invertebrates can be considered as 'aerial plankton'
We know more about the sea than about land	This statement should be linked to OL Principle 7. It also opens the possibility of a new analogy, exploring both land and sea
There is less oxygen at sea, although both places contain oxygen	Global primary production should be addressed, along with the differences between 'oxygen in the sea' and on land
Is there a land equivalent to ghost fishing?	They inquired about the possibility, which should be further explored
One environment receives sunlight directly (land), while the other does not (sea)	This suggests that explanations are needed on how sunlight reaches the planet's surface, as well as an exploration of the similarities and differences in how sunlight interacts with land and sea ecosystems
At sea, animals breathe through gills (not all), while on land, they breathe through lungs	This indicates the need for reflection (as noted on two occasions, that in the sea there are animals that breathe through different mechanisms—such as lungs or others), but there is no similar reflection on land (e.g., invertebrates). This should be further explored
There is a temperature difference between woodlands and the sea (the sea is always warmer)	This misconception should be addressed by exploring temperature variations on both land and sea. It could also lead to a discussion of similar conditions in both land and sea, particularly in polar or tropical systems
Land has a greater variety and quantity of vegetation than the sea, although both have a lot of vegetation	Interestingly, several students pointed out that while there are similarities, many land plants have rigid stems, whereas stems in the sea are not lignified (similar function, but different structure). Students tend to assimilate 'vegetation' with all plants and algae. The focus should be on the differences in primary producers at sea, which include mostly microscopic algae and cyanobacteria, as well as seaweeds and seagrasses
The tree and the turtle are both influenced by temperature	The focus should be on how environmental temperature influences the behaviour of organisms
Both images show caterpillars	Both are types of worms. It is common for students to confuse caterpillars with worms. In Catalonia, the term 'worm' is colloquially used (incorrectly) to refer to various organisms
Portuguese Man o'War and roots: both have tentacles	There is a clear structural similarity detected, but the identification is incorrect (it is a 'titiwan,' not roots)
Map of land and map of the sea	The images on the cards are not maps. This remark could lead to the proposal of new land-sea pairings (e.g., bathymetric map and height map)
Marine and terrestrial moles: they both have the same shape	The correct term should be 'holes,' not 'moles.' Additionally, there are no marine moles
Elephant seals mating and goats mating	The images show male mountain goats and elephant seals fighting, not mating
Microbes and bees: both suck	It's not a microbe, and microbes do not 'suck'
A tree and a 'marine tree' both have trunks	The structure is similar, but they are not actual trees; the marine organisms in question belong to the animal kingdom
Agriculture and aquaculture both involve the cultivation of plants	On land, plants are involved, whereas at sea, it is algae

(continued)

Table 21.3 (continued)

Errors/misconceptions/doubts	Remarks for educators
Desert and dead whale: both are dry	It is interesting to note that whales cannot dry out in the water. What happens to organisms when they die? The similarity lies in the role of whale carcasses, which serve as spots for life, similar to an oasis
They are unable to identify lichens	The topic of lichens should be addressed: What are lichens?
Dolphins prey on whales	Dolphins do not attack or prey on whales
Just as buffaloes have organisms living on them, so do whales	The organisms living on whales do not serve the same purpose as the birds that live on buffaloes; both aspects should be clarified
Sharks eating whale	Clarification is needed on what whale carcasses are and how they decompose
Carnivorous plants exist both on land and at sea	There are no carnivorous plants in the sea; instead, similar structures for capturing prey are adopted by animals, such as some invertebrates
They do not recognise a firefly	This has occurred several times, with one instance involving a comparison to a shrimp. Different groups of organisms should be clearly differentiated and properly addressed
Underwater tornadoes	Tornadoes cannot occur underwater
The idea of jellyfish having nests (related to the dandelion--jellyfish analogy)	Although dandelion seeds may structurally resemble small ephyrae, jellyfish do not leave 'nests' to drift into the Ocean. Further knowledge about life cycles should be introduced
A feather resembles the leaf of an algae	Apart from an initial misinterpretation of a drawing, algae do not have leaves. The differences between the protist and plant kingdoms should be emphasised
Flying fish and birds	Although students grasped the idea, flying fish cannot truly fly; they can only glide
Plankton are often compared to insects. However, a question arises when considering new pairings: Are there any insects in the sea?	The definition of an insect and the differences between groups of organisms on land and at sea could be conveyed. Additionally, the definition of plankton and the variety of organisms it includes should be clarified
Fish seek shelter in caves and birds use nests	It highlights a lack of knowledge regarding fish biology and behaviour, as well as the potential for studying the diversity of fish species and their habitats
Pairing hurricanes with deep-water currents	The circulation of water in the Ocean should be addressed, with an emphasis on correcting misconceptions about water movement being limited to depth or circulating uniformly throughout the entire Ocean
Pairing a polar bear with a seal	Polar bears are considered marine mammals, not terrestrial ones. This opens possibilities for exploring polar habitats and the broader category of marine mammals
There are no "fruits" at sea	This could lead to an investigation into seagrasses
Trees are taller than marine vegetation	This could open the possibility of studying macroalgae (e.g., kelp forests)
Assimilating all small organisms to microbes or bacteria	Addressing the microscopic world would be appropriate, considering the variety of small organisms, belonging to different kingdoms and serving different functions

Note. This table compiles possible misconceptions or errors detected during assessments. Some observations in explanations included examples where students identified only superficial similarities despite correct pairing. For example, students matched "octopus" and "frog" based on their "dotted colours" rather than their shared characteristics of being venomous species. Other issues involved misidentifying "swarming grasshoppers" as "grasshoppers" due to Catalan name differences or failing to recognise a "whale carcass" as an "oasis" (for its ecological function). Additional errors included labeling hypersaline lakes as "dead rivers," confusing "sea fleas" with "sea lice," prioritising visible invertebrates over plankton, and mistaking vultures for hawks

Analogies have long been essential in science, helping to clarify complex models and theories (Oppenheimer 1956). They are equally effective in education, particularly in science education, promoting relational thinking that enhances meaningful learning (Haglund 2013). Through analogical thinking, students engage in cognitive processes like those of scientists. When used

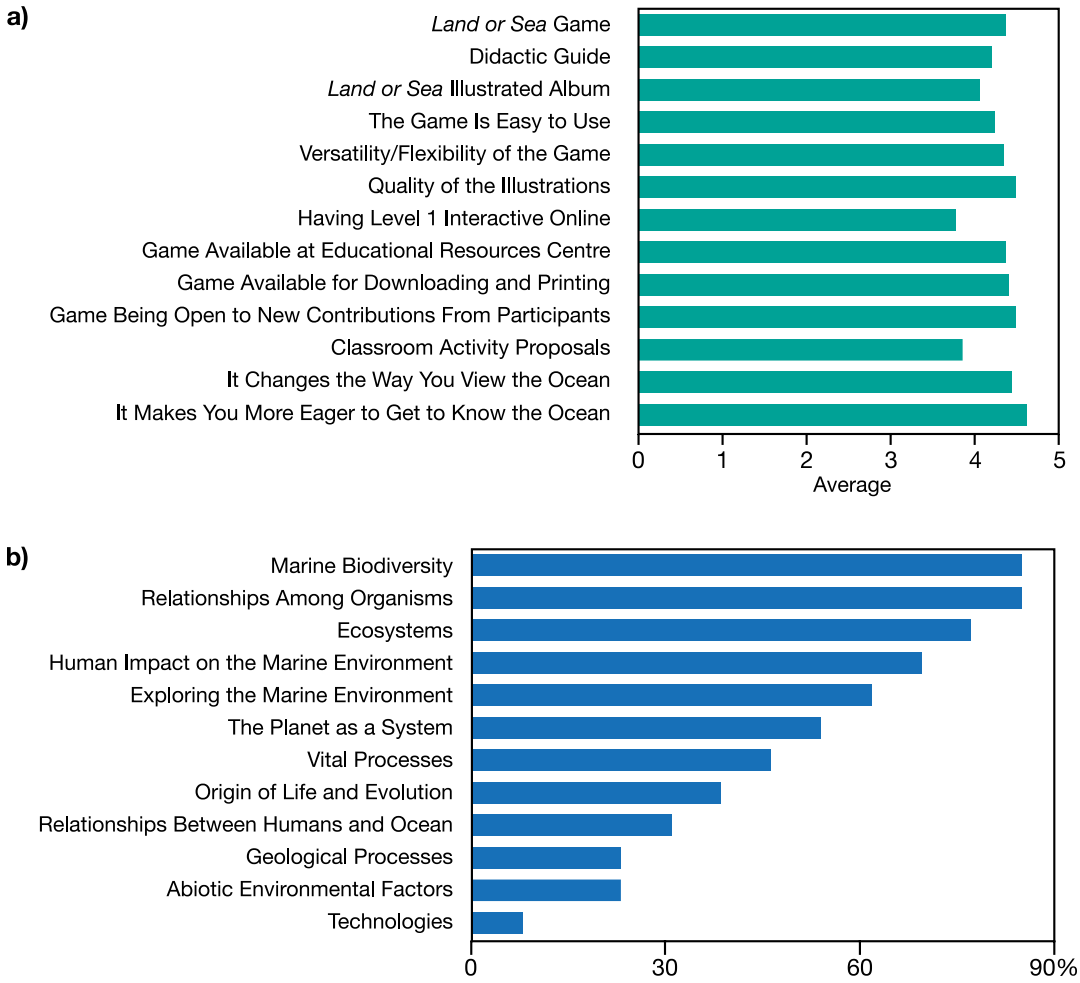


Fig. 21.9 Assessments by educators. *Note.* a) Assessments given by 13 educators evaluating the game using a five-point Likert scale on aspects such as educational value, illustration quality, flexibility, online availability, and the game's ability to engage players with new perspectives on the Ocean. b) Primary topics chosen by educators for teaching through the *Land or Sea* game in formal educational settings

appropriately, analogies help students connect familiar knowledge with new concepts, facilitating a constructivist approach to learning. Teachers can leverage this by guiding students to apply known information to new contexts.

Analogies are, therefore, crucial for human thought, creativity, and cognitive learning, providing the grounds for higher-level thinking and lateral mental leaps that reveal new patterns (Lakoff and Johnson 1980). Analogical reasoning enables us to notice and articulate similarities across diverse contexts by focusing on shared features or relationships (as the familiar source provides information to interpret the unfamiliar target) (Gentner and Maravilla 2018). Their value resides in the mental inquiry they trigger: the cognitive engagement they inspire, the knowledge they generate, and the communicative aspects they enhance.

Creating analogies fosters active learning: Analogies evoke rich mental images, fostering insight, understanding, and critical thinking by enabling students to view concepts from new perspectives. This process can bring the "invisible"—in this case, the Ocean—into focus, advancing OL. Once commonalities between land and sea are identified, students can explore further inferences, applying and amplifying



Fig. 21.10 A comparison of land and sea forests. *Note.* We can shift from a general contemplation of natural systems to an analytical gaze, observing common patterns and similarities across seemingly disparate systems, such as land and sea forests. In the lower drawing, "forest layers" are compared, highlighting differences such as scale and the fact that many underwater forests are dominated by animals, which provide structure and habitat, instead of trees. Drawings from various sources by Jordi Corbera, with the collaboration of Mikel Zabala, in the upper-right panel

knowledge from familiar domains to new ones. This process of structural alignment has two potential benefits: it helps students grasp abstract principles shared by both analogs, and it invites inference and hypothesis-making, which can enhance understanding of unfamiliar concepts (Wilbers and Duit 2006). Students can also generate their own analogies by using relational thinking to see likeness, transferring knowledge across domains and using induction to generate knowledge in the new context. For instance, children might explain the structure or functioning of a marine animal by projecting their understanding of prototypical familiar animals onto the new

organism (Carey 1985, as cited in Harrison and Treagust 2006).

Surface similarities make analogies easier to identify, as seen while using the game (matching is more eye-catching for structural similarities, which are usually the first to be found while playing). However, process analogies promote deeper understanding or the ability to transfer knowledge to new situations. Both surface and process analogies, therefore, play relevant roles: while the former aids recognition, the latter fosters deep learning. As learning is a process of self-construction of knowledge, analogies may be regarded as useful tools for restructuring knowledge frameworks and introducing new knowledge. However, for an analogy to be effective, it must challenge thinking while resonating with individual or collective experiences (sources being familiar to students, grounded in life experiences) (Harrison and Treagust 2006). Students should be encouraged to think like naturalists, using their practical observations and experiences of the terrestrial world as the starting point for fruitful relational thinking for envisioning the Ocean. Results of this study show that once the first land-sea pairs are thought of during play, the spark of analogical reasoning makes the Ocean cognitively present. This shift of focus towards the Ocean enhances a certain 'snowball effect': Pairing is smoother and quicker once marine cards are introduced, as experiences and knowledge (mental imagery and memory) are mobilised while children discuss in small groups. As one educator stated, "It strikes the facility with which students come up with pairings!"

While analogies between source and target are only partial, their relevance lies in their ability to help reawaken a primitive attachment to the world, bringing students closer to those lesser-known domains (the Ocean). However, as stated in our results, analogical thinking has limitations. Students might create unintended analogies, fail to see connections, or take analogies too literally, which can reveal errors in understanding scientific concepts or could even lead to unwanted misconceptions (Haglund 2013). The errors or misrepresentations we found in the present study highlight the pivotal role that attentive educators play in guiding the analogical process by asking questions, clarifying similarities, enriching self-generated analogies, moving from more descriptive to more explanatory insights, and providing accurate examples to readdress or avoid errors and misrepresentations. Playing the game may be valuable to educators for further refining scientific knowledge and addressing educational gaps and prior ideas, with the teacher's role in scaffolding remaining crucial. Nonetheless, errors and clarifications may also provide new learning opportunities, as some of the examples given by students and not initially intended as analogies may inspire new ideas.

As noted, analogical retrieval involves applying knowledge from one context to another, which may be difficult but is at the core of whatever educational endeavour. A key challenge for students is learning to recognise opportunities to apply previously learned information, skills, or experiences to new situations. Analogies are more engaging when they build on students' experiences, but unfamiliar analogies may cause frustration. This may be challenging when working with the Ocean. However, personal observations suggest that group play fosters collaboration and engagement, mitigating this frustration. Also, presenting land examples first aims to ease recognition and recall. However, it simultaneously highlights gaps in marine knowledge or memories, emphasising a basic need for OL. Although the familiar analogue (land) informs the student about the unfamiliar (Ocean) concept, some pairs may require a bit more of imagination or prior knowledge. The question still arises: If students have limited prior experience or knowledge of Ocean topics, what can they build on? If previous knowledge is revealed scarce during play, educators should address gaps and maintain focus until sea cards come into play. Studies suggest that simultaneous versus sequential presentation of both source and target (land and sea) images enhances analogical reasoning (Christie and Gentner 2010). In the present case, the versatility of the game would allow for this mode of playing, if needed.

Additionally, drawings serve as effective tools for communication and reasoning, aiding both

abstract and concrete concept visualisation. Visual evocation underlies analogical thinking, addressing pictorial aspects of cognition and mental imagery. Visual analogies are highly suggestive: they prompt participants to discover connections themselves by aiding quick recognition and long-term recall, as they facilitate initial relational thinking and comparisons. This makes the game more accessible for younger children, for instance, who learn more kinaesthetically and aesthetically. The game directly offers images with the intention of helping intuitive pairing once the Ocean has been cognitively made more present. Overall, pairing stimulates questioning about the drawings and encourages verbalising thoughts, as well as sharing sea and land personal experiences, life events, and knowledge sources, sometimes introducing more examples and thus enhancing the learning experience. Once pairs are internalised, the game can also be adapted into a memory game to reinforce visual connections between pairs. Educators can also use it in storytelling by creating narratives from selected similarities and encouraging students to craft parallel stories.

Some of the final pairs usually matched with previous reasoned guesses by students. If marine examples don't match initial thoughts, participants must readjust their knowledge. Ambiguous pairs can be clarified with the help of educators by offering hints, questions, or introducing specific observations and group discussions. Making cross-connections between land and sea fosters a desire to learn more about both environments, broadens perspectives, and facilitates not only knowledge sharing but also knowledge production through the creation of new examples (see Table 21.2). There are always favourite or surprising pairs (mostly expressed at unexpected similarities), as many as the tastes of participants with varied knowledge, interests, and preferences. In this sense, assessments reveal no clear trend or subtopic preference, but qualitative comments usually refer to the unknown, indicating that the purpose of learning is met. The game effectively invites the exchange of experiences on the Ocean by stimulating curiosity, communication, emotional engagement, and social interaction, regardless of age or background.

The game could excel in connecting local ecosystems with broader marine concepts, enhancing players' sense of place and their connection to the Ocean (Plankis and Marrero 2012; Wu and Lee 2015). Observations and feedback during gameplay reveal the growing importance of including local examples, particularly when clarifying similarities. Although the game was initially designed for being played anywhere in the world, the local perspective now gains relevance. The game has the advantage that for every example provided, many similar ones can be found in most cases, turning attention to local ecosystems and thus hopefully widening the sense of place to the Ocean. This approach to locality aligns with place-based education, linking personal experiences to the game and strengthening deeper local knowledge and emotional links to land and sea.

21.5 On Learning About the Ocean Through Play

> Play is the answer to how anything new comes about. (Piaget, n.d.)

Communicating marine science to the public can be challenging, but marine research institutions, such as the ICM-CSIC, are addressing this through various methods, including educational games like *Land or Sea*. Game-Based Learning (GBL) incorporates game principles into educational environments, enhancing student engagement, motivation and learning outcomes (Madani et al. 2017) through active, playful, and meaningful experiences. The concept of learning through play dates back to Ancient Greece, where Plato advocated for *paideia* as a powerful educational approach. Games, as structured forms of play, have historically served as tools for networking, training, and education, fostering social interaction, deep thinking, and problem-solving abilities (Prensky 2001). From a Piagetian perspective, play is essential for development, contributing to cognitive, emotional, creative, and social skills.

Games are particularly effective because they integrate cognitive and emotional learning experiences, which are crucial for meaningful education (Novak 2010). As playing is associated with fun and pleasure, it makes learning more appealing and enhances intrinsic motivation. This can lead to a state of "flow" (Csikszentmihalyi 1990), where players are deeply absorbed, focused, and engaged, making the learning experience both pleasurable and effective. Solely integrating game elements into educational contexts (gamification) has been used to shift attitudes and enhance motivation towards learning (Leitão et al. 2022).

Gaming has been described as the 'multimodal literacy par excellence', because it integrates textual, visual, auditory, gestural, spatial, intellectual, and communicational aspects to convey complex information and address real-world issues (Staudt et al. 2018). While digital games and gamification are popular in GBL, traditional analog games also offer significant benefits. They provide a flexible, open-ended approach to learning that encourages observation, conversation, and rapid retention, especially when played without the distractions of competition (Treher 2011; Greenhalgh 2016).

Educators often express concern that students spend little time on independent thinking, peer discussion, or active learning. Games address this by reinforcing learned information and encouraging the application of concepts in different contexts (Odenweller et al. 1998). They offer a student-centred approach that engages learners in critical thinking and problem-solving, while providing continuous feedback and motivating them to expand their knowledge. This perspective shifts the focus from simply transmitting knowledge to viewing learning as an evolving process where mistakes are valuable learning opportunities. Games are therefore embodied learning experiences that can significantly enhance teaching strategies (Madani et al. 2017). They accommodate different learning styles, build communication skills, aid memory, reinforce key information, reduce learning time, and promote collaboration. Games also teach social skills, transform thoughts, strengthen bonds, and foster shared experiences when played with family or friends, making learning more relevant and enjoyable (Kordaki, 2015; Botes, 2024). Classrooms act as social environments where teamwork and social interaction can promote learning.

Environmental education, including OL, can be effectively conveyed through games, as they use positive content, personal experiences, and interactions to trigger curiosity, reflection, and wonder about nature. This can foster socio-emotional connections to the game topic, leading to greater personal responsibility and attitudinal change, thereby promoting environmental stewardship and Ocean citizenship (Koenigstein et al. 2020; Leitão 2020; O'Brien et al. 2023). Games such as *Land or Sea* can also address current barriers in formal education (Fauville et al. 2018; Vendrell-Simón et al. 2024), such as fragmented knowledge across subjects (as in sustainability, environmental and Ocean education) or lack of outdoor learning. However, learning does not rely solely on playing; it must be supported by educators who guide the learning process, deliver accurate knowledge, and use analogies and dissimilarities to clarify concepts and deepen understanding (Ritchie et al. 2006).

Based on the self-reported outcomes from students and educators, the game seems to have successfully stimulated curiosity, increased interest in observing nature, encouraged communication about Ocean topics, and prompted deeper field observations and potential new perspectives. Additionally, the game raised questions about the Ocean, indicating that it effectively enhances students' interest and motivation. While *Land or Sea* was designed to be cooperative (being the goal to match all pairs), it can be made more challenging by adding time constraints, increasing card difficulty, or introducing other competitive elements like scoring and question rounds. While gamification can be applied, it may also shift the focus away from educational goals toward winning. It is important to note that games like *Land or Sea* can be motivating without competition, as knowledge alone (whether explicit or intuitive) and social interaction already promote experiential and theoretical exchange. This

enhances inspiration, understanding, and discussion about the Ocean.

Overall, the joyful playing experience may bring the Ocean to the forefront while potentially engaging participants as Ocean ambassadors in their communities. Results from this study suggest an optimistic starting point for building Ocean awareness, fostering positive connections to the Ocean, and enabling future change, as also noted by Koenigstein et al. (2020).

21.6 OL, Sustainability Goals and Ocean Decade Challenges

OL, as a component of scientific literacy, emphasises Education for Sustainability by developing learning, inquiry, and transfer skills that enable the application of knowledge across various contexts. Analogical reasoning, a core cognitive process in everyday life, teaching, learning and research, is essential for understanding and transferring knowledge by drawing connections between different areas. By evoking location-based memories through play, analogies may bring emotions to the forefront, positively influencing learning. Duit (1991) demonstrated that analogies provoke students' interest, acting as powerful agents of conceptual change. They facilitate understanding by establishing relationships between theoretical concepts and students' real-life experiences, helping visualise more abstract ideas. Consequently, analogies become powerful motivational tools, as they relate to student engagement in learning, alongside factors such as interest, teacher-student relationships, the perceived value of the knowledge conveyed, self-efficacy, and the social environment-elements that are of great relevance (Harrison 2006).

OL is connected to the United Nations Sustainable Development Goals (SDGs) through its role in promoting understanding, responsible behaviour, and informed management of marine environments. The *Land or Sea* game addresses several SDGs, but is most directly linked to SDG14 (Life Below Water), SDG13 (Climate Action), SDG15 (Life on Land), SDG12 (Responsible Consumption and Production), SDG3 (Health and Wellbeing), SDG4 (Quality Education) and SDG17 (Partnership for the Goals). By educating people about the Ocean, OL enhances stewardship and informed decision-making. Through shared understanding and coordinated actions, OL supports global partnerships and helps address Ocean-related challenges, thereby enhancing collective efforts to achieve the SDGs. The *Land or Sea* proposal aligns with these goals and the Ocean Decade's challenges by helping restore people's connection with the Ocean. Ultimately, it may drive actions that promote Ocean (and planetary) health, build empathy, facilitate access to the Ocean, raise awareness of ecosystem services, and foster marine citizenship. It promotes a place-based education that is globally informed, relational, experiential, and social, applicable in both formal and informal environments while embracing different knowledge systems. Incorporating games like *Land or Sea* into diverse educational settings helps visualise complex topics, integrate multiple perspectives, and contribute to quality education. The game could serve as a starting point for societal change (Treher 2011) by encouraging a more positive, motivational, and wonder-filled approach to connecting with, understanding, and engaging with the Ocean.

21.7 Food for Thought

> One image may be worth 1,000 words. Popular saying

Land or Sea aims to instil a positive bond with the Ocean, making it more accessible and present in people's minds. To achieve this, the game has focused more on naturalistic than on impactful aspects. The intentional choice to first deepen understanding and appreciation of the Ocean sets the stage for introducing critical issues later. Currently, new land-sea pairs are being developed, aligned with OL Principle 6 (Table 21.1), to address both positive and negative dimensions of humanity's relationship with the Ocean. Impactful images may evoke emotions, raise



Fig. 21.11 Imagining how bottom-trawling might look on land. *Note.* Presenting an imagined land analogy to industrial bottom trawling often shocks students by making hidden issues more visible. This can trigger questioning and reflection: "Would we do to land what we are doing to the Ocean?" Land-sea analogies could therefore be used provocatively to encourage communication and foster care for the Ocean. Drawing by Jordi Corbera

awareness, and further stimulate motivation and action. Using the game in this way can prompt self-reflection on everyday actions affecting the Ocean and raise ethical questions, such as, "Why do we harm the Ocean in ways we wouldn't harm the land?" By revealing what is less visible compared to land, it may potentially upheave shame and enable future behaviour change. The game should therefore serve as a tool for reflection and perspective-taking and may provide images of predicted future environmental scenarios involving both land and Ocean (Fig. 21.11).

This update, which focuses on humanity's relationship with the Ocean, also aims to integrate historical and cultural perspectives. Fortunately, not all human groups are disconnected from the Ocean, and some communities maintain deep bonds with it, even expressing their identities through it. By including these cultural perspectives and embracing diverse ways of knowing the Ocean, the educational experience can undoubtedly be enhanced.

Land or Sea has shown that once players are engaged, they are motivated to explore marine topics in greater depth. The game thus serves as a gateway for introducing marine subjects across various curricular areas, facilitating cross-curricular integration. Additionally, the analogies in the game can reveal unexpected insights, new knowledge, and emotional responses, challeng-

ing students' prior knowledge and contributing to the development of emOceans (McKinley et al. 2023). Indeed, playing the game addresses various dimensions of OL beyond knowledge, including awareness, attitudes, communication, emotions, access and experience as defined by McKinley et al. (2023). It may also encourage further behaviour change and activism.

The use of analogies, which involves transferring attributes from a source to a target based on prior knowledge, highlights the relevant role of prior experience in relating and retrieving information from long-term memory. As memory often evokes reality and emotions, this process may be enriched by previous direct interaction with nature. Immersion in nature is frequently associated to positive emotions, making such memories more rewarding and lasting. Engaging with natural environments awakens a sense of wonder (Carson 1965/2019). In this context, outdoor education and direct contact with nature—whether in forests, rivers, seas, or coasts—help students and citizens observe, establish connections between different natural systems, and explore relational similarities while sensorily immersed in Nature. By playing in natural settings, whether by the sea or on land, individuals are immersed in a space that nurtures this connection. Links with the Ocean can be cultivated through analogical thinking, drawing parallels between observations of land ecosystems and marine ones. Direct engagement with nature fosters curiosity, observation, questioning, awe, and a sense of care and belonging, emphasising the importance of recognising commonalities across our world, whether intuitively or explicitly. This can significantly enrich the *Land or Sea* experience and positively impact OL.

Making the Ocean more visible by drawing parallels to familiar land ecosystems, processes, and landscapes should help shift perspectives and foster recognition of the Ocean's central role in planetary functioning and One Health. *Land or Sea* encourages this perspective change, through a playful lens, similar to M.C. Escher's *Sky and Water I* visual metaphor, where fish and birds merge and blend across the continuum of air and water, nurturing a sense of unity and connection between land and sea (Fig. 21.12).



Fig. 21.12 The land and sea continuum. *Note.* The image on the left shows Margalef at S'Albufera, Menorca (photo by Pere Montserrat. Used under CC BY-NC 4.0). On the right is the *Land or Sea* game logo

21.8 Conclusion

In this chapter, we have advocated for using analogical thinking in a playful, social context to deepen learning about the Ocean, foster a personal connection with it, and promote conceptual change. Playing *Land or Sea* sparks creativity, aesthetic appreciation, and a greater awareness and understanding of marine concepts, while encouraging the formation of a bond with the Ocean. The game has not only proved to expand knowledge but also to stimulate curiosity, prompting questions, reflection, and deeper reasoning. It makes the Ocean feel more accessible and meaningful by appealing to imagination and personal experiences. The *Land or Sea* approach not only introduces the Ocean into educational settings but may also inspire students to study and explore marine ecosystems further. Additionally, it can draw attention to local ecosystems and different knowledge systems and cultures, broadening students' sense of place and belonging by including the Ocean. One teacher's comment summarises the game's impact: "Truth is, I've discovered another way of looking at the world!"

We propose that the core philosophy behind *Land or Sea*-combining analogical thinking with GBL to enhance understanding of the Ocean-can effectively contribute to making it more accessible through imagination and enjoyable learning, thereby positively enhancing OL. Through this approach, we aim to shift from Ocean ignorance to Ocean consciousness, fostering a deeper connection and sense of responsibility towards the Ocean.

With *Land or Sea,* we hope to inspire a broader, more holistic view of the planet by highlighting natural patterns and similarities that can illuminate the still largely unknown Ocean. We believe this is crucial to changing our view of the Ocean and transforming our relationship with it, ultimately promoting a necessary planetary perspective on (human) life.

21.8.1 Summary

Key concepts explored in this chapter include:

- The Ocean remains largely inaccessible to many, even in coastal regions. This inaccessibility is partly due to the challenges of accessing the Ocean beyond the shoreline, its vastness and depth, and the lack of outdoor education and of Ocean-related content in formal curricula. Ocean Literacy (OL) should focus on building (positive) connections with the Ocean.
- Ramon Margalef, a pioneer in modern ecology, used analogies between land and water ecosystems to teach ecology. Inspired by Margalef, the *Land or Sea* game was created. The game aims to make the Ocean more accessible and understandable through analogical thinking and game-based learning, helping to 'see' and connect with the Ocean through imagination and observation.
- Visual analogies in the game facilitate quick recognition and long-term recall, making it engaging for diverse age groups. The game is flexible, open-ended, and adaptable for different uses, allowing participants to suggest new pairs and encouraging creativity, collaboration, and understanding.
- Personal memories can evoke emotions that positively influence learning, making abstract ideas more concrete and enhancing student engagement and motivation in relation to the Ocean. The game can link local ecosystems with broader marine concepts, thus enhancing players' sense of place and emotional connection to the Ocean, in line with place-based education.
- The game promotes cognitive functions like analogical reasoning, helping players apply knowledge across different contexts and thereby broadening their understanding of marine environments.

- Assessments with students demonstrated increased interest in learning about the Ocean, with many participants expressing a desire to share Ocean knowledge and observe the Ocean with greater attention.
- Educators praised the game's educational value, flexibility, visual appeal, and its ability to stimulate curiosity and reflection, as well as its openness to new contributions. Many planned to use it in future classes and would recommend it to colleagues.
- However, educators must support the game with guidance, reflection, and accurate knowledge delivery. It should be used to clarify concepts, integrate multiple perspectives, and promote deep learning.
- The game serves as a gateway for introducing marine topics across various subjects, facilitating cross-curricular integration and expanding students' knowledge. It also addresses multiple Sustainable Development Goals (SDGs), promoting stewardship and informed decision-making.
- *Land or Sea* aims to contribute to restoring humanity's relationship with the Ocean. By drawing parallels between land and sea ecosystems, the game helps shift perspectives from Ocean ignorance to Ocean consciousness, encouraging a deeper understanding of the Ocean's role in planetary functioning and promoting a holistic, nature-immersed and thought-provoking approach to learning and a more integrated view of the planet.

21.8.2 Recommended Resources

The following resources provide further insights and support on this topic:

- **The Land or Sea Game and Illustrated Album**
  - El Mar a Fons. (n.d.). *Land or Sea game*. Retrieved from https://elmarafons.icm.csic.es/?lang=es
  - Digital CSIC. (n.d.). *Land or Sea game repository*. Retrieved from https://digital.csic.es/handle/10261/360444
  - Digital CSIC. (n.d.). *Land or Sea game repository*. Retrieved from https://digital.csic.es/handle/10261/167506

- **Supplementary Reading on Ramon Margalef**
  - Margalef, R. (1992a). *Ecología*. Ediciones Planeta.
  - Margalef, R. (1992b). *Planeta azul, planeta verde*. Prensa Científica, S.A.
  - Margalef, R. (1996). *Widening vistas: Toward an ecology tailored to our problems*. Fundación César Manrique.
  - Reales, L. (Coord.). (2006). *Margalef, The biosphere biologist*. Generalitat de Catalunya, Departament de Medi Ambient.
  - Ros, J. (2001). Ramon Margalef: Master of ecologists and environmentalists. In *Eleven referents on environmental thinking* (pp. 149–154). Generalitat de Catalunya, Departament de Medi Ambient.
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22

Seaweed, Science, and Society: A Collaborative Model for Ocean Literacy, Community Building, and Blue Innovation

Sarah P. Taylor, Carlos Rius Errando, Sam Chandler, Jack Ching, and Jadis Blurton

Abstract

This chapter explores *Seaweed, Science and Society*, a distinctive school-based approach that blends marine science education, community collaboration, and blue-economy innovation. Developed through The Harbour School's Marine Science Program in Hong Kong, the Seaweed Initiative brings together students, educators, scientists, and local fishers to cultivate seaweed in urban coastal waters. The program offers students authentic field experiences, from raft design and deployment to biodiversity monitoring and carbon sequestration research, while encouraging creative thinking in transforming harvests into products such as food, cosmetics, and animal feed. Framed within the rapid global expansion of seaweed aquaculture, which has grown from 10.6 million tonnes in 2000 to 36.5 million tonnes in 2022, and with Asia contributing more than 97% of production, the chapter highlights the potential of Integrated Multi-Trophic Aquaculture (IMTA) as a sustainable pathway for future food systems. By combining scientific research, traditional ecological knowledge, and student-led innovation, the Seaweed Initiative demonstrates how schools can contribute directly to the UN Ocean Decade's objectives. It offers an adaptable model for fostering Ocean Literacy, empowering youth, and strengthening community resilience while advancing nature-based solutions that link environmental restoration with sustainable economic opportunities.

Keywords

Aquariums · Biodiversity · Blue innovation · Carbon sequestration · IMTA (Integrated Multi-Trophic Aquaculture) · Marine science · Ocean challenges · Ocean Decade · Ocean Literacy (OL) · PBL (project-based learning) · Seaweed · STEAM (Science, Technology, Engineering, Arts, and Mathematics) · Sustainability · Sustainable development goals (SDGs)

22.1 Introduction

The Harbour School in Hong Kong has elevated project-based learning (PBL) through its innovative Seaweed Initiative. Now in its third year, the program brings together students from multiple grade levels to collaborate with experts in designing and implementing seaweed farms in Hong Kong's less-than-pristine coastal waters.

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The project fosters Ocean Literacy by immersing students in real-world applications of applied ecology and pollution mitigation. These student-built farms yield substantial amounts of seaweed, which are then dried and transformed into usable products such as soup packets, pet food, and skincare items.

Each year, the high school chemistry and global project development teams explore new sustainable ventures for utilizing the harvest, while biology students investigate the farms' carbon sequestration potential, biodiversity, and biomass production. The initiative also integrates The Harbour School's design-thinking makerspace program, where students apply principles of Ocean physics to create, test, and deploy seaweed farming structures. By combining scientific research, innovation, and hands-on design, the project provides a powerful model for linking education with environmental stewardship and blue-economy opportunities.

22.1.1 The Importance of Seaweed in East Asia

Seaweed cultivation, the deliberate farming of marine macroalgae, has emerged as one of the fastest-growing sectors of global aquaculture. From modest coastal harvests, it has grown to supply food, including hydrocolloids such as agar and carrageenan, animal feed ingredients, biostimulants, and increasingly, feedstocks for bio-based materials and carbon-mitigation strategies. Global production increased from 10.6 million tonnes in 2000 to approximately 35 million tonnes in 2020, and by 2022 farmed algae reached 36.5 million tonnes (Huang et al. 2022; FAO 2024; Buschmann et al. 2017).

This growth is concentrated in Asia, which accounts for over 97% of global seaweed production. China and Indonesia together produce more than half, with the Philippines, South Korea, Japan, and Malaysia also playing key roles. In 2019, Asia generated around 34.5 million tonnes, nearly 99% of global output. Globally, the majority of seaweed is cultivated rather than harvested from the wild—more than 96% in recent years, showing a strong transition to aquaculture-based production (Huang et al. 2022).

Seaweed farming employs diverse techniques and targets different species. Tropical smallholder farms predominantly use rope-and-stake methods for carrageenan-bearing reds (e.g., Kappaphycus, Eucheuma) and Gracilaria (agar). Temperate regions favor kelps (e.g., Saccharina japonica) and nori (Porphyra, Pyropia) via longlines and rafts. These practices have expanded into value chains that now include food, cosmetics, fertilizers, bioplastics, and feed additives, while research in genetics, husbandry, and processing continues to grow (Chopin and Tacon 2021; Huang et al. 2022).

A major innovation shaping the sector's future is Integrated Multi-Trophic Aquaculture (IMTA). IMTA pairs fed species (finfish, shrimp) with extractive species (seaweeds, shellfish, sea cucumbers), allowing nutrient recycling, improved ecosystem function, and co-producing marketable biomass. Although much of this work remains in the pilot stages, trials in Asia and Europe show strong potential. South Korea has tested offshore kelp–bivalve–finfish systems, China has combined seaweed with abalone, scallops, and fish, and the Philippines has piloted seaweed–sea cucumber or mussel projects. Together these examples demonstrate both environmental and socio-economic benefits (Duarte et al. 2017).

In Asia, seaweed farming underpins livelihoods and economies. Indonesia, the Philippines, China, South Korea, Japan, and Malaysia lead production. China's kelp and nori industries, alongside Indonesia's carrageenan sector, continue to drive global tonnage, but the heavy concentration of farming also increases risks. These include disease outbreaks, limited genetic diversity, and market volatility (Huang et al. 2022).

To address these challenges, researchers and industries are exploring IMTA and hybrid systems. Pilot studies and meta-analyses report promising results, but many remain experimental. Continued progress will depend on standardizing best practices, improving post-harvest processing, ensuring equitable benefit sharing, and building governance frameworks that support both environmental and social equity. Thoughtfully designed seaweed farming incorporating IMTA concepts offers a unique convergence of ecosystem restoration, blue innovation, and community-centered development (Duarte et al. 2017).

22.2 The Harbour School

The Harbour School (THS) is a K–12 international school established in Hong Kong in 2007. Starting with only seven students, no campus, and very limited resources, THS has grown over the past 16 years into a world-class institution at the forefront of an educational revolution. Having placed among the top schools worldwide in global competitions and won numerous local awards, THS is now recognized as a leader in the current paradigm shift in education. At THS, particular attention is given to experiential techniques that emphasize authentic production, design thinking, and real-world application.

THS started a Marine Science Program (MSP) in 2018 with the aim and objective to enhance the local and regional educational programs with marine science to improve Hong Kong's Ocean Literacy. The MSP includes both a 50-foot sailboat (The Black Dolphin) and a state-of-the-art Marine Science Center (MSC) with life support systems for marine fish and invertebrates. The school's 50-foot wooden ketch is used as an outdoor classroom for the ultimate immersion in Ocean sciences. The school has employed multiple marine biologists to create a marine science curriculum for the whole school K–12.

THS has invested more than USD 700,000 in the Marine Science Program, enhancing not only the school but also the wider community. The school is open to non-students for educational camps, professional development for teachers and marine science internships for young professionals. The MSC acts as a beacon in Hong Kong, setting an example by immersing itself in the marine science community and environmental groups to assist, educate, advise and contribute to solutions for current environmental marine issues (Fig. 22.1).



Fig. 22.1 The Harbour School, Hong Kong SAR

22.2.1 The Marine Science Center

The Marine Science Center (MSC) is a combined aquarium and laboratory dedicated to education and outreach. Its facilities feature a diverse range of aquariums from interactive touch pools and eel displays to moon jelly tanks, vibrant coral systems, and advanced research aquaria supported by high-tech life support systems. The MSC integrates marine science directly into the school curriculum offering students in Hong Kong hands-on learning experiences that connect local marine ecosystems to regional and global contexts. Through its programs the MSC inspires curiosity, builds scientific understanding and nurtures a deeper appreciation for the marine environment.

MSC activities are organized into lessons, modules, and units that serve students year-round, from kindergarten (age 4) through high school (age 18). Lower and upper primary students participate in "intensive weeks" stepping out of their regular schedules for 1–2-week projects at the MSC. Middle school students engage in co-planned biology and chemistry units taking on 2-week projects involving marine field research. In high school the MSC offers term-based credit-bearing science courses such as Introduction to Marine Science, Applied Marine Science, Applied Ecology, Oceanography, Marine Science Research Skills, and Introduction to Aquaculture (IMTAs). High school students can also apply for internships gaining real-world experience by assisting MSC aquarists with animal care and tank maintenance (Fig. 22.2a and 22.b).

22.2.2 The Black Dolphin

The Black Dolphin is a 50-foot wooden ketch built in 1944 from solid Burmese teak, a material prized for its durability and resistance to the marine environment. It serves as an immersive outdoor classroom for students across all grade levels. Its ketch rig allows for manageable sails, its shallow five-foot-four-inch draft enables access to coves and beaches, and its unobstructed flush deck makes it ideal for hands-on learning in marine science, navigation, ecology, storytelling, geography, and more. The Black Dolphin is integral to THS's experiential learning model and strengthens the school's marine literacy curriculum across disciplines.

Today the vessel regularly sails the waters of Hong Kong visiting areas such as Sai Kung, Lantau Island, and remote outlying islands. These trips provide opportunities for group lessons, fieldwork, scientific inquiry, creative exploration,



Fig. 22.2a and 22.2b Interactive touch pool in the Marine Science Center at The Harbour School



Fig. 22.2a and 22.2b (continued)

and skill building all while fostering a deeper connection with and stewardship for the Ocean (Fig. 22.3).

22.3 The Seaweed Initiative

One of The Harbour School's flagship student projects is the Seaweed Initiative. This unique programme showcases how a secondary school in Hong Kong can contribute meaningfully to global sustainability goals by using *Ulva lactuca* (commonly known as sea lettuce) as a focal point for interdisciplinary, community-based learning.

At its core, the Seaweed Initiative is a student-led seaweed farming project that combines environmental science, engineering and community engagement. It was designed to offer hands-on, real-world experiences in marine ecology while addressing several pressing issues facing our



Fig. 22.3 The Black Dolphin



Fig. 22.4 Students in the MSC with the seaweed tank

Ocean today. The initiative aligns with the broader mission of the UN Ocean Decade by fostering Ocean stewardship among youth and encouraging innovative, nature-based solutions to climate and biodiversity challenges (IOC-UNESCO n.d.; Santoro et al. 2017).

The project is built on collaboration. Educators, students, marine scientists, and local fish farmers work together to design, test, and refine each stage of the seaweed farming process. Students begin by learning the scientific foundations of seaweed biology and the ecological role of marine vegetation. They then apply this knowledge by designing and building floating seaweed rafts, using mostly recycled and repurposed materials. These rafts are deployed into coastal waters using the school's Black Dolphin Sailboat, giving students direct exposure to fieldwork and the operational aspects of marine farming (Fig. 22.4).



Fig. 22.5 Students working in the Foundry makerspace at The Harbour School

22.3.1 Design and Construction

THS's makerspace, the Foundry, is a multipurpose workshop for creating everything from woodworking projects to 3D prints. Students in grades five (ages 10–11) and eight (ages 13–14) study marine science with MSC teachers, then use this knowledge to design rope structures to sustain sea lettuce in southern Hong Kong waters. Guided by the boat captain and makerspace team, they learn about buoyancy in the Ocean and the challenges of long-term exposure to marine conditions.

High school students (ages 14–18) study at the MSC for a full term (consisting of 12 weeks), and some classes go for the full school year depending on the class. The students learn about Ocean current patterns, water quality data, and topography to identify suitable farm locations. They then meet with the Grade 5 and Grade 8 teams to present these sites and finalize calculations for ropes, anchors, and signage. Over time, farm designs have evolved as each new cohort examines past builds and makes improvements. The variety of designs provides more data for the high school class to analyse, including factors like durability, recruitment and biodiversity (Fig. 22.5).

22.3.2 Deployment and Monitoring

The structures, ropes, anchors, and buoys are deployed by the Black Dolphin Sailboat Team. Students use a smaller boat to approach the shore and work in assigned roles such as leader, technician, observer, and labourer. Together they position the structure, set anchors, take water measurements, and document each step (Fig. 22.6).

Once in place, the seaweed rafts serve as living laboratories. Students conduct a range of scientific experiments focused on measuring biomass growth, assessing nutrient uptake and monitoring carbon sequestration. They also carry out biodiversity surveys and record the presence of juvenile fish, crustaceans and other marine life that quickly begin to inhabit the seaweed structures. These early ecological outcomes highlight how even small-scale, student-led interventions can support marine ecosystems in a short period of time (Fig. 22.7).

22.3.3 Harvest and Processing

Each month student teams visit their seaweed farming structures to harvest seaweed by collecting



Fig. 22.6 Students on their way to deploy cultivation structures



Fig. 22.7 Students deploying a floating seaweed raft

it in buckets and taking water quality measurements. They also assess the integrity of the structures to ensure that no waste material is at risk of being lost to the sea. Back at the MSC, seaweed is examined for the abundance of life it supports. Students sort the animals found in the harvest, calculate biodiversity, and compare results between farms. These investigations reveal that the placement of the structures has a direct influence on biodiversity (Fig. 22.8).

Similar patterns are observed when students dry the seaweed, measure and record average blade size, and calculate biomass. After the seaweed has been examined, measured, and weighed, the seaweed undergoes a curing process in which it is dried in the sun. This natural bleaching effect provides a biosecure preparation of the seaweed for human use and reflects a common practice in Hong Kong and across Asia. The dried seaweed is then provided to the school's Global Development Programme class, where students have, over the years, developed a wide range of creative and practical uses for the product (Figs. 22.9 and 22.10).



Fig. 22.8 Biodiversity survey of seaweed harvests

22.3.4 Retrieval and Project Conclusion

In Hong Kong, seaweed only grows naturally during the colder months, from October to March. At the end of the season, student teams return to the field for the final harvest and to retrieve the cultivation structures, which are then recycled or repurposed for future use. This cyclical process is central to the Social Impact and Sustainability Program (SISP), a structured educational framework that provides supplementary developmental activities aligned with the United Nations' 17 Sustainable Development Goals (SDGs). By embedding principles of sustainability and resource efficiency, SISP not only reinforces ecological responsibility but also gives students firsthand experience in closing ecological loops while contributing to broader global priorities.

One of the most powerful outcomes of the Seaweed Initiative is the way it transforms students into environmental communicators and advocates. For example, one secondary student expanded his independent research project into a school-wide awareness campaign, educating his peers about the ecological importance of seaweed. His work illustrates how the initiative cultivates leadership, agency, and a strong sense of responsibility among young people.

The initiative also thrives through its partnerships with local fish farmers. These community collaborators contribute traditional ecological knowledge, offering practical insights into local marine systems. Students, in turn, validate and expand upon this knowledge through field-based experimentation. This reciprocal exchange enhances the scientific value of the project while fostering meaningful connections across generations, professions and cultures.

In addition to cultivation and harvest, students conduct research experiments on water quality throughout the seaweed season and into the following months before summer. They measure dissolved oxygen, ammonia, nitrogen, and phosphate levels to assess the role of seaweed in nutrient cycling and ecosystem health. Using small, individualized tanks, students have opportunities to observe nutrient uptake processes directly, deepening their understanding of the critical functions that seaweed plays in maintaining marine balance.

22.4 The Harbour School STEAM Curriculum

The Marine Science Center (MSC) at The Harbour School serves as the cornerstone of the school's Marine Science Program, offering a distinctive K–12 Ocean education model that integrates fieldwork, classroom learning, and community engagement through intentionally designed Science, Technology, Engineering, Arts, and Mathematics (STEAM) experiences. Unlike programs that offer occasional excursions



Fig. 22.9 Students drying and measuring seaweed biomass

or isolated units, the MSC embeds marine science throughout the academic year, ensuring sustained and meaningful student engagement. Resident marine biologists, along with the captain and crew of the Black Dolphin, work side-by-side with teachers from all subject areas to design curriculum modules that merge science with math, engineering, history, and the arts. This collaborative, co-teaching model allows a unit on sound waves to be connected to marine echoloca-



Fig. 22.10 Seaweed drying racks made by students

tion, a lesson on electricity to be reinforced through the study of electric fish, and history classes to explore maritime trade and navigation aboard the school's research vessel. By integrating Ocean topics into diverse subjects, the MSC transforms marine science into a living context that enriches all aspects of the curriculum.

The curriculum is distinguished by its emphasis on authentic, project-based inquiry. Students of all grade levels are invited to participate in real-world restoration and conservation projects that make measurable contributions to local ecosystems. One of the most visible examples is the artificial reef program. During dedicated STEAM weeks, and throughout the year, students design reef modules using sustainable materials to replicate the structural complexity of natural reefs. These modules have supported oyster reefs in over-harvested mudflats, coral recruitment in stressed reef zones, and new habitats for juvenile fish. The work does not end at deployment. Students monitor their creations through biodiversity surveys, water quality testing, and behavioral observations of fish using the structures for feeding, spawning, and protection. These projects highlight the interconnectedness of marine ecosystems while also demonstrating the role humans can play in restoring balance to degraded environments.

Oyster reef restoration provides another avenue for experiential learning. By reusing discarded shells, students create substrates for oyster spat, directly contributing to population recovery in areas historically impacted by over-harvesting.

Field data collected before and after deployment reveal changes in biodiversity and water quality, giving students firsthand evidence of the ecological services oysters provide as natural filters and habitat builders. Similarly, mangrove projects immerse students in one of the most critical yet vulnerable coastal ecosystems.

Using GPS mapping, drone surveys, and tree health assessments, students build a comprehensive picture of mangrove forests while also engaging in hands-on cleanups and sediment monitoring. These efforts not only contribute to shoreline resilience but also connect students to broader discussions of climate change mitigation through carbon sequestration. By combining field data with applied action, students gain a deep appreciation of how ecosystems support human communities and global environmental health.

The curriculum is not limited to ecological restoration. It also extends into controlled experimentation and innovation. Using the MSC's high-tech aquaria and smaller experimental tanks, students investigate water chemistry, nutrient cycling, and species behavior under different conditions. For example, they examine how seaweed absorbs nitrogen and phosphates, directly observing the mechanisms behind nutrient uptake that improve water quality. Fish recruitment experiments allow students to test the effectiveness of different reef designs in attracting species, while coral settlement studies help students understand the delicate requirements for reef growth.

These projects mirror professional marine science practices, giving students skills in data collection, experimental design, and long-term monitoring. Importantly, the MSC emphasizes iteration and repetition while students revisit and refine their projects across months or even years, fostering persistence and reinforcing learning through cycles of trial and discovery.

The Marine Science Center's commitment to interdisciplinary learning extends powerfully into the arts, exemplified by the annual Arts Interim week focused on Marine Macro Photography. This immersive program transforms middle school students into underwater visual scientists and artists, utilizing the Center's unique aquarium facilities. Guided by instructors, students master the technical aspects of underwater photography using specialized cameras. They learn to manage challenging conditions such as light refraction, water movement, and the precise "close-focus" requirements of macro work, where the lens must capture small subjects—like seaweed, invertebrates, or textures—at very short distances. These conditions make the process technically demanding, as even slight shifts can blur an image. In this way, students develop not only artistic expression but also the technical precision required for underwater macro photography.

The week culminates in a significant, tangible outcome: each student curates a collection of their best macro images. These striking photographs, capturing the hidden beauty and complexity of marine habitats, are professionally printed and displayed as a permanent exhibition within the Marine Science Center. This project exemplifies the MSC model by merging rigorous science education with artistic expression and technical skill development, resulting in authentic, student-generated contributions that enrich the Center's environment and serve as an enduring testament to their learning and perspective. Like the reef modules and mangrove data, this photographic work represents a meaningful and lasting student contribution directly connected to the marine world.

The MSC's influence extends far beyond student learning. Recognized with the 2022 International School Award for "Best in Teaching and Learning," The Harbour School has become a leader in marine education innovation. Building on guidance from the National Science Teaching Association (NSTA) and the National Marine Educators Association (NMEA) White Paper on Ocean Literacy and Science Education (2025), the MSC develops K–12 curriculum frameworks that integrate Ocean Literacy and can be adapted by other schools. It also provides professional development programs for teachers who wish to bring marine science into their own classrooms. In doing so, the Harbour School initiative reflects the expected outcomes of the Ocean Decade by

advancing inclusive education, fostering Ocean Literacy across generations, and building bridges between science, policy, and society. This vision resonates with UNESCO's Vision 2030 Challenge 10 White Paper, which calls for restoring humanity's relationship with the Ocean through education, inclusion, innovation, and action (Glithero et al. 2024). The MSC embodies these priorities by serving as a living laboratory that empowers students, integrates traditional and scientific knowledge, and fosters a lasting culture of Ocean Literacy.

Through its emphasis on authentic engagement and cross-sector collaboration, the program demonstrates how local, school-based initiatives can contribute to the global goals of creating a healthy, resilient, and sustainably managed Ocean. These initiatives position the Marine Science Program at The Harbour School as a global pioneer in Ocean Literacy, inspiring future generations of scientists, educators, and environmental leaders.

22.5 Programmatic Impact

The Seaweed Project has generated measurable ecological, social, and educational impacts that set it apart from traditional classroom-based programs. Ecologically, biodiversity monitoring revealed notable increases in juvenile fish, crustaceans, and invertebrates within the first season of raft deployment. Student teams documented an average 20% increase in observed biodiversity across different sites, lending strong support to published findings that seaweed aquaculture enhances habitat complexity and ecosystem services (Duarte et al. 2017). These outcomes show that even small-scale student-led projects can provide meaningful contributions to ecosystem restoration while also serving as valuable research case studies.

The educational outcomes are equally significant. More than 80% of students reported an improved understanding of Ocean systems and a greater motivation to participate in conservation projects. Unlike many short-term or field trip-based Ocean Literacy initiatives, the Seaweed Project offers repeated, year-long engagement across grade levels. This sustained exposure reinforces learning through continuity and long-term involvement, supporting the development of lasting Ocean Literacy. Students not only learn scientific concepts but also develop the perseverance, data-collection skills, and problem-solving abilities that authentic science requires.

The project also fosters social impact through intergenerational collaboration. Local fishers contribute traditional ecological knowledge that students validate with systematic data collection. This reciprocal exchange builds social ties while highlighting the value of combining scientific and traditional knowledge systems. Such collaboration strengthens community resilience and demonstrates how schools can function as hubs of citizen science. Educational partnerships spanning the entire community—scientists, NGOs, conservation groups, local fishers, and other community leaders—extend the reach of The Harbour School's Marine Science programming, creating a reciprocal exchange of knowledge that benefits both students and society at large. Programs that engage all civil society actors promote co-design, collaboration, and partnerships, offering multiple entry points for diverse interests and driving action to advance Ocean Literacy by transforming knowledge into meaningful engagement and lasting societal change (Kennedy et al. 2024, p. 7).

Compared to other Ocean Literacy programs, which are often time-limited, externally facilitated, or reliant on external summer camps, the Seaweed Project's model is embedded directly into the K–12 curriculum. This integration ensures that student participation is not an isolated event but part of a continuous, school-wide culture of Ocean engagement. In this way, the project illustrates how sustained, student-led inquiry can surpass the outcomes of many conventional outreach models, where students may be passive observers rather than active contributors.

The Harbour School's Marine Science Program (MSP) broadens the impact of the Seaweed Project by integrating experiential marine learning across the curriculum. Rather

than relying on occasional external activities, MSP integrates aquaria, fieldwork and sailing expeditions into students' daily academic experience. The Black Dolphin sailboat and the MSP provide platforms for consistent and repeated engagement, reinforcing the principle that authentic science requires persistence and context diversity. The MSP design highlights the value of providing repeated and varied experiences that build knowledge and nurture a deeper emotional connection to the Ocean.

MSP students routinely conduct water quality testing, biodiversity surveys, and ecological monitoring across multiple environments, linking marine biology with chemistry, engineering, and environmental policy. The program has demonstrated measurable outcomes in standardized science assessments and has increased student participation in regional and international competitions. Beyond academic performance, the program's alumni have pursued marine science degrees and conservation careers, illustrating its long-term legacy. In comparison to other school-based models worldwide, few have achieved this level of integration across grade levels, disciplines, and community engagement. Where other programs may rely heavily on visits by short-term facilitators, The Harbour School has developed a self-sustaining, embedded system that places students at the center of knowledge creation.

The Marine Science Program also emphasizes the ethical dimensions of human–animal relationships. Students learn to view marine species as sentient beings rather than simply as food or resources. Through animal care in aquaria, biodiversity monitoring, and participation in habitat restoration, students build empathy while reflecting on personal choices surrounding consumption and sustainability. As a member of the Southeast Asian Zoos and Aquariums Association (SEAZA), the program maintains rigorous standards of animal welfare, aligning practical student learning with broader conservation ethics.

Each visit to the Marine Science Center or expedition on the Black Dolphin deepens students' understanding of marine systems. Hands-on, project-based learning transforms abstract concepts into concrete experiences. Activities such as seaweed raft deployment, mangrove mapping, and reef recruitment monitoring provide opportunities for authentic data collection and critical analyses. These practices strengthen Ocean Literacy, empowering students to make informed and responsible decisions about conservation.

The program functions as a living laboratory that nurtures curiosity and innovation. The Marine Science Center houses high-tech aquaria for controlled research, while the Black Dolphin serves as a mobile field lab for in-situ data collection. Students show measurable improvements in science performance, demonstrating the benefits of applying theory in real-world contexts. These experiences inspire future scientists, engineers, environmental leaders, and active global citizens, cultivating transferable skills such as critical thinking, data analysis, and collaborative problem-solving (Fig. 22.11).

The Harbour School extends its impact beyond the classroom by actively engaging the wider community in marine education and conservation. For example, students partner with Ocean Park through the Clean Waterways Carnival, where they showcase their seaweed project to raise awareness about sustainable aquaculture and water quality. In addition, their field-based initiatives—such as mangrove monitoring and reef restoration—invite community stakeholders to participate directly in citizen science. Together, these efforts demonstrate how Harbour School empowers students not only to learn about the Ocean, but also to share their knowledge and inspire action across the broader community (Fig. 22.12).



Fig. 22.11 Students seeding ropes to start a new seaweed monitoring site at a local fish farm



Fig. 22.12 Working with Ocean Park for a Clean Water Ways Carnival to show the community our seaweed project

22.6 Conclusion

This chapter explored how The Harbour School's Seaweed Initiative and Marine Science Program integrate education, community engagement, and ecological restoration into a unified model for Ocean Literacy. Through seaweed farming, experiential learning, and interdisciplinary projects, students gain scientific knowledge, develop ethical perspectives on sustainability and contribute to meaningful environmental outcomes. The program's design demonstrates that schools can serve as living laboratories where students actively shape solutions to global challenges while cultivating a lasting sense of stewardship for the Ocean.

22.6.1 Summary

Key concepts explored in this chapter include:

- The Seaweed Project as a model for Ocean Literacy development. The chapter demonstrates how cultivating *Ulva lactuca* (sea lettuce) provides a tangible way for students to explore marine ecology, biodiversity, and carbon sequestration while linking classroom learning to real-world environmental issues.
- Experiential learning through education. By combining the Marine Science Center, the Black Dolphin sailboat and the school's makerspace, The Harbour School embeds project-based and inquiry-driven learning into its curriculum, allowing students from kindergarten through high school to participate in authentic marine science research.
- Integration of community and traditional knowledge. Collaborations with local fishers and community members enrich the program by combining practical ecological knowledge with student-led scientific investigations, creating a reciprocal exchange of insights across generations. The community also benefits as traditional knowledge is validated and preserved, local voices are elevated in environmental decision-making, and sustainable practices are reinforced in ways that support both livelihoods and ecosystem health.
- Sustainability and the blue economy. Students engage with the broader economic and ecological potential of seaweed farming, from product innovation to Integrated Multi-Trophic Aquaculture (IMTA), situating their work within global discussions of sustainable aquaculture and climate change mitigation.
- Impact of the Marine Science Program. Beyond seaweed farming, projects such as artificial reef construction, mangrove mapping and oyster restoration broaden student understanding of ecosystem services while cultivating ethical perspectives on animal welfare and conservation.
- Alignment with global initiatives. The program directly supports the UN Ocean Decade's call for transformative Ocean science, particularly through contributions to Challenge 2 (sustainable Ocean economy) and Challenge 10 (restoring humanity's relationship with the Ocean).
- Youth empowerment and leadership. Perhaps the most significant outcome is the transformation of students into environmental leaders and advocates who not only acquire scientific skills but also develop agency, creativity, and a sense of responsibility for Ocean stewardship.

22.6.2 Recommended Resources

The following resources provide further insights and support on this topic:

- The Harbour School: ths.edu.hk
- The Harbour School Hong Kong Teaching & Learning Initiative: https://www.youtube.com/watch?v=wy4C-KQ2eFA
- The Harbour School on Facebook: https://www.facebook.com/TheHarbourSchoolHongKong/
- Marine Science Center Hong Kong on Instagram: https://www.instagram.com/marinesciencecenterhk/#

Acknowledgements The success of The Harbour School's Marine Science Program and the Seaweed Initiative has been made possible through the dedication and expertise of several individuals whose contributions continue to shape the school's vision for innovative, hands-on education.

Craig Blurton brings more than 25 years of experience in experiential learning and curriculum development. A former director of NASA's GLOBE Program, Craig has been a driving force in designing innovative K–12 programs that integrate field-based science with hands-on design. At The Harbour School, he has supported the growth of the Marine Science Program and mentored students in project-based initiatives, ensuring that science learning is both rigorous and meaningful.

Dan Blurton, as Managing Director of The Harbour School, has advanced the school's emphasis on inquiry-

based and student-centered learning. With a strong background in business development and organizational leadership, he has created sustainable frameworks that promote the long-term retention of scientific concepts through repeated, meaningful engagement. His vision ensures that The Harbour School remains at the forefront of educational innovation, preparing students to become critical thinkers and problem solvers.

Maxine Cutracci, a marine educator and conservation advocate, played an integral role in the development of the Marine Science Center's curriculum and programs during her time at The Harbour School. She continues her work through community outreach initiatives and environmental awareness campaigns, while also pursuing her PhD in fish genetics. Maxine's contributions bridge the gap between scientific research and public engagement, inspiring young people to take active roles in conservation.

Jay Stanley, a professional mariner and environmental educator, has served as captain of the Black Dolphin. His leadership at sea has been central to integrating sailing and navigation skills into the Marine Science Program. By providing students with authentic maritime experience and safety training, Jay has helped ensure that the program extends beyond the classroom, fostering both confidence and stewardship in young learners.

Together, these individuals have strengthened The Harbour School's commitment to blending science, education and community engagement in ways that prepare students to meet the environmental challenges of the future.

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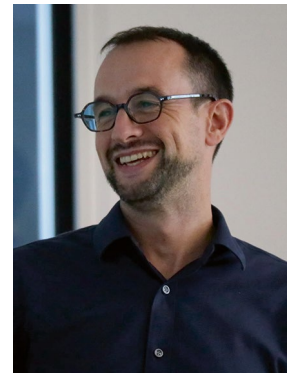
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Sarah Taylor is a marine biologist, aquarist and educator, she moved to Hong Kong in November 2017 to manage the Marine Science Center. Sarah was born and raised in North Carolina, USA, in a small beach town called Surf City. Being raised on the Ocean ignited her passion for marine sciences. She gained her associate's degree in marine technology and BSc in Ocean Science. During her studies she worked with SEN children and adults where she learned about teaching practices for different kinds of children. She lived and worked in Cambodia as Survey Director for a Marine Conservation Cambodia where she oversaw volunteer operations and educated the volunteers on scientific diving, while also teaching the locals English and learning Khmer. Before moving to Hong Kong Sarah returned to her hometown of Surf City where she worked as the Director of Operations for a marine science summer camp.







Carlos Rius, born in Barcelona, Spain, is a marine biologist specializing in coastal marine ecosystems and seaweed communities. He holds a bachelor's degree in biology, with a final year at the University of the Azores focused on coastal marine biotopes, and a master's degree in Nature Management from the University of Copenhagen. His research experience spans marine ecology of coastal seas, temperate macroinvertebrates, and kelp forest ecology in the South Pacific. He has contributed to international projects on Marine Protected Areas in Portugal and Spain, emphasizing ecology and conservation of coastal biotopes. An experienced diver, Carlos combines scientific expertise with hands-on fieldwork, having also worked at a diving center on Spain's southeast coast.

Sam Chandler and Jack Ching, students at THS High School, have distinguished themselves through exceptional leadership and service within both their school and the broader community. Their experiences range from representing their peers in Model United Nations conferences to initiating sustainable income projects that support orphans in the Philippines. At the Marine Science Center (MSC), Sam (currently in 11th-grade) and Jack (currently in 12th-grade) serve as interns, conducting research on seaweed and corals. Notably, Sam's eighth-grade class was the first cohort to establish the seaweed research project, which he and Jack have since advanced through public education initiatives highlighting the ecological significance of seaweed. By presenting their findings to diverse audiences, they continue to inspire and empower the next generation to engage meaningfully in environmental stewardship.



Jadis Blurton, PhD, is an educator, psychologist, and school leader with over 40 years of experience in education, child psychology, and educational psychology. She is the founder and Clinical Director of the Blurton Family Development Center in Hong Kong and recipient of the American Chamber of Commerce Ira Dan Kaye Award for Community Service (2009). A former university lecturer and practicing clinical psychologist, Dr. Blurton holds a Ph.D. in Cognitive Developmental Psychology, master's degrees in special education (gifted) and Psychology, and credentials as a Qualified Teacher in Hong Kong, Certified Montessori Teacher (AMS), Licensed Clinical Psychologist (U.S.), and Registered Psychologist (Hong Kong). She has advised numerous international schools and spoken globally on gifted education, progressive learning, child and family development, and special educational needs.

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Ocean Literacy at the Crossroads of Community, the Sustainable Blue Economy, and the Arts: Insights, Innovations, and Future Pathways

Teresa J. Kennedy

As Volume II draws to a close, several key insights emerge from the diverse contributions gathered under the themes of community engagement, the Sustainable Blue Economy, and the transformative power of the Arts. Ocean Literacy has evolved into a dynamic, participatory practice that thrives when local cultures, creative expression, and economic considerations intersect. By weaving together case studies and real-world examples from coastal, inland, and island contexts, this volume demonstrates that community-rooted initiatives, whether through collaborative textile arts, environmental theater, or youth-led citizen and participatory science, can foster deeper connections to the Ocean and generate tangible benefits for both people and ecosystems.

The chapters on community-driven strategies underscore the importance of culturally tailored approaches. Recommendations include implementing the ESRA methodology (Explore, Feel, Reconnect, Act) to leverage experiential learning and emotional resonance in cultivating lasting stewardship among underserved coastal populations. Other chapters introduce complementary frameworks, such as the Seven Principles for Community Engagement and Cultural Ecosystem Services approaches, which together provide adaptable, context-sensitive tools for advancing Ocean Literacy. By blending art, enterprise, and community engagement, initiatives not only empower local livelihoods but also nurture cultural identity. Similarly, several contributions emphasized the importance of recognizing and honoring local knowledge systems, not only to strengthen community ownership but also to enrich global Ocean science with diverse and context-sensitive perspectives. Initiatives such as these challenge the notion that Ocean Literacy follows a one-size-fits-all pedagogy and instead, highlight that effective Ocean Literacy emerges when programs resonate with participants' lived experiences and values.

The volume's focus on the Sustainable Blue Economy reframes economic development as an opportunity rather than a threat to Ocean health. Chapters examining market-driven disinterest in marine stewardship demonstrate that aligning community livelihoods with sustainable practices can yield both ecological and socioeconomic dividends. From artisanal fisheries co-management in West Africa to seaweed ventures in Southeast Asia, these case studies reveal models where conservation incentives dovetail with income-generation strategies, while simultaneously drawing on creative expression and collective identity to strengthen participation and sustain impact. By spotlighting enterprises that prioritize circular economy principles and equitable benefit-sharing, Volume II offers a blueprint

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for reconciling economic growth with the long-term resilience of oceanic systems.

The Arts emerge throughout this volume as a remarkably powerful and multifaceted vehicle for Ocean engagement. Whether through murals that transform urban walls into stories of coral resilience, interactive theater that animates the hidden lives of plankton, or public installations that invite tactile exploration of Ocean currents, creative projects bridge the gap between abstract scientific concepts and visceral human experience. The Arts not only captivate diverse audiences but also create safe spaces for reflection, dialogue, and collective action. They affirm that Ocean Literacy is as much about emotion and imagination as it is about data and policy.

Taken together, the chapters in Volume II affirm that community empowerment, economic innovation, and creative expression are interdependent pillars of a holistic Ocean Literacy framework. When communities are invited as co-creators to design curricula, develop enterprises, or craft art, the resulting ownership fuels sustained engagement and advocacy. At the same time, integrating sustainability into economic ventures ensures that Ocean health and human well-being advance in tandem. Finally, infusing the Arts into these processes amplifies their reach, fostering empathy and inspiring action in ways that conventional science communication cannot. In this way, Ocean Literacy contributes not only to the objectives of the Ocean Decade, but also to the achievement of Sustainable Development Goal 14: Life Below Water, along with the many interconnected Sustainable Development Goals (SDGs) that depend on a healthy Ocean. Volume II offers a compelling testament to the power of community, economy, and the Arts as catalysts for Ocean Literacy. It challenges educators, policymakers, artists, business leaders, and entrepreneurs to imagine new possibilities, envisioning a world where every individual recognizes their intrinsic connection to the Ocean and feels empowered to contribute to its health and vitality. As the Ocean Decade progresses, the insights gathered here will help guide stakeholders toward more inclusive, resilient, and creative pathways, ensuring that Ocean Literacy becomes not merely an aspiration, but a lived, collective reality.

Moreover, the combined contributions from Volumes I and II underscore the urgency of centering equity, diversity, and inclusion in all Ocean Literacy endeavors. Through community-based methodologies and creative modalities the authors provide tested strategies for scaling Ocean Literacy initiatives at regional, national, and international levels. Whether working with youth from underserved coastal neighborhoods, marginalized fishing communities, or students living far from the shore, practitioners must ensure that programs address systemic barriers and amplify underrepresented voices.

Looking ahead to Volume III: *Accelerating Communication, Technology, and Global Initiatives*, the journey continues with examples of cutting-edge tools, digital platforms, and global collaborations shaping Ocean Literacy in the twenty-first century. As emerging digital platforms, data visualization tools, and transboundary partnerships reshape the landscape of Ocean engagement, the scientific rigor and educational applications established in Volume I, together with the human-centered principles highlighted throughout Volume II, including authentic collaboration, cultural relevance, and imaginative storytelling, will remain indispensable. Onward to Volume III.

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Volume II: Acronym List

The following acronyms related to Ocean Literacy were included in this volume.

Acronym	Full Name
AAAS	American Association for the Advancement of Science [USA]
AAG	American Association of Geographers [USA]
AAPA	American Association of Physical Anthropologists [USA]
ABT	And-But-Therefore (storytelling framework)
ADAR	Adenosine Deaminase Acting on RNA
AFS	American Fisheries Society [USA]
AMOC	Atlantic Meridional Overturning Circulation
ANID	Agencia Nacional de Investigación y Desarrollo [Chile]
ASLO	Association for the Sciences of Limnology and Oceanography
Bappenas	Ministry of National Development Planning [Indonesia]
BAU	Business As Usual
BE	Blue Economy
BILLFISH–WIO	Billfish Western Indian Ocean project
BLM	Black Lives Matter
CC	Creative Commons
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCAT	Coastal Communities Adapting Together
CCC	Climate Crisis Commission (IUCN)
CCMPA	Canadian Council of Marine Protected Areas
CEANIM-ESPOLC	Centro de Investigación Marina y Acuícola de la Escuela Superior Politécnica del Litoral [Ecuador]
CEC	Commission on Education and Communication (IUCN)
CIDP	County Integrated Development Plan
CITES	Convention on International Trade in Endangered Species
COLC	Canadian Ocean Literacy Coalition
COLS	Canadian Ocean Literacy Survey
COMPASS	Communication Partnership for Science and the Sea
CONVEMAR/UNCLOS	United Nations Convention on the Law of the Sea
COP	Conference of the Parties
COP28	28th Conference of the Parties
COVID-19	Coronavirus Disease 2019
CRC	Convention on the Rights of the Child
CSIC	Consejo Superior de Investigaciones Científicas [Spain]
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive (EU)
CTC	Centro de Turismo Comunitario [Ecuador]
DEFRA	Department for Environment, Food and Rural Affairs [UK]
DG MARE	Directorate-General for Maritime Affairs and Fisheries (EU)
DNA	Deoxyribonucleic Acid (molecule that carries genetic information for the development and functioning of an organism)
DOSI	Deep Ocean Stewardship Initiative
E&O	Education and Outreach
EC	European Commission
ECIM	Estación Costera de Investigaciones Marinas [Chile]
EcoClubs (FADO)	Environmental education clubs by Fundación Amiguitos del Océano [Ecuador]

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Acronym	Full Name
ECOP(s)	Early Career Ocean Professional(s)
EEZ	Exclusive Economic Zone
EGU	European Geosciences Union
EMSEA	European Marine Science Educators Association
ENEA	Estrategia Nacional de Educación Ambiental [Chile]
ESD	Education for Sustainable Development
ESG	Environmental, Social, and Governance
ESRA	Explore, Feel, Reconnect and Act
ESRS	European Sustainability Reporting Standards
EU	European Union
EU4Ocean	European Union for Ocean Coalition
EV	Exploration Vessel
FADO	Fundación Amiguitos del Océano [Chile]
FAO	Food and Agriculture Organization of the United Nations
FCT	Fundação para a Ciência e a Tecnologia [Portugal]
FDA	Food and Drug Administration [USA]
G20	Group of Twenty
GAO	Government Accountability Office [USA]
GDP	Gross Domestic Product
GES	Good Environmental Status Descriptors
GHG	Greenhouse Gas
GIFT	Geosciences Information for Teachers
GLOBE	Global Learning and Observations to Benefit the Environment (NASA, NOAA, NSF, US Dept. of State Program)
GLOBEC	Global Ocean Ecosystem Dynamics
GPS	Global Positioning System
GRI	Global Reporting Initiative
GRRIP	Grounding RRI Practices project
Gt	Gigatonne
Hypersea Theory	Theory on life migrating from Ocean to land
IAP2	International Association for Public Participation
IB PYP/PYP	International Baccalaureate Primary Years Programme
ICAO	International Civil Aviation Organization (United Nations)
ICASE	International Council of Associations for Science Education
ICHN	Institució Catalana d'Història Natural
ICM/ ICM-CSIC	Institut de Ciències del Mar—Consejo Superior de Investigaciones Científicas [Spain]
ICoRSA	International Consortium of Research Staff Associations
ICS	International Chamber of Shipping
IMPAC5	Fifth International Marine Protected Areas Congress
IMTA/IMTAs	Integrated Multi-Trophic Aquaculture
INE	Instituto Nacional de Estadísticas
IOC	Intergovernmental Oceanographic Commission
IOC-UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization
IOC-AFRICA	IOC Sub-Commission for Africa
IODP	International Ocean Discovery Program
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISPRA	Italian Institute for Environmental Protection and Research
IUCN	International Union for Conservation of Nature
JEDI	Justice, Equity, Diversity, Inclusion
JOIDES Resolution (JR)	Joint Oceanographic Institutions for Deep Earth Sampling
K–6	Kindergarten through fifth grade (ages 5 through 12)
K–12/p–12	Kindergarten through 12th Grade/ Preschool through 12th Grade (typically ages 5 through 18)
KICC	Kenyatta International Conference Centre
KICD	Kenya Institute of Curriculum Development
KMFRI	Kenya Marine & Fisheries Research Institute
LERS	Large-Scale Ecosystem Restoration Section
LL(s)	Living Lab(s)
MAATE	Ministerio del Ambiente, Agua y Transición Ecológica [Ecuador]
MaB	Man and the Biosphere Programme
MATES	Marine Technology Skilling Strategy
MEOPAR	Marine Environmental Observation, Prediction and Response Network

Acronym	Full Name
MOC	Making Oceans Count (reference to all Ocean basins)
MPA(s)	Marine Protected Area(s)
MSC	Marine Science Center
MSCI ACWI IMI Index	Morgan Stanley Capital International All Country World Investable Market Index
MSP	Marine Science Program; Marine Spatial Planning (context-specific)
MUP	Multi-Use Platform
MUSICA	Multiple Use of Space for Clean Island Autonomy
NASA	National Aeronautics and Space Administration [USA]
NBS	Nature-Based Solutions
NGO/NGOs	Non-Governmental Organization(s)
NGO(s)–UNESCO	NGOs in Official Partnership with UNESCO
NMEA	National Marine Educators Association [USA]
NOAA	National Oceanic and Atmospheric Administration [USA]
NSTA	National Science Teaching Association [USA]
NUTME	Núcleo Milenio para la Ecología y Conservación de Arrecifes Mesofóticos Templados
O20	Ocean Engagement Group (of G20)
OBIS	Ocean Biodiversity Information System
OD	Ocean Decade (United Nations Decade of Ocean Science for Sustainable Development)
ODC(s)	Ocean Decade Challenge(s)
ODO(s)	Ocean Decade Outcome(s)
OECD	Organisation for Economic Co-operation and Development
OECM	Other Effective Area-Based Conservation Measures
OL	Ocean Literacy
OLP(s)	Ocean Literacy Principle(s)
OLPCC	Ocean Literacy Program for Coastal Communities
OLR	Ocean Literacy Research
OLRC	Ocean Literacy Research Community
OLWA	Ocean Literacy With All Programme (IOC)
ONG(s)	Organisation(s) Non-Gouvernementale(s) (French) [equivalent of NGO(s) in English]
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment
OSR	Ocean State Report
OSS	Ocean and Society Survey
PBL	Project-Based Learning
PCK	Pedagogical Content Knowledge
PHAROS	Marine Biodiversity Restoration in the Atlantic and the Arctic project
PPP	Public–Private Partnership
PWC	PricewaterhouseCoopers
QH	Quadruple Helix
R&I	Research and Innovation
RELATO	*Red de Educación Latinoamericana para el Océano* (Latin American Education Network for the Ocean)
REMAPE	El Pelado Marine Reserve
RESBIOS	Responsible Research and Innovation grounding practices in Biosciences
RNA	Ribonucleic Acid (a polymeric molecule that is *essential for most biological functions)*
RPO/RPOs	Research Performing Organization(s)
RRI	Responsible Research and Innovation
RRING	Responsible Research and Innovation Networked Globally
RSTC	Recreational Scuba Training Council
SAT	Self-Assessment Tool
SBEC	Sustainable Blue Economy Conference
SCOR	Scientific Committee on Oceanic Research of the International Science Council
SCUBA	Self-Contained Underwater Breathing Apparatus
SDG/SDGs	Sustainable Development Goal(s)
SDG 4	Sustainable Development Goal 4 Quality Education
SDG 5	Sustainable Development Goal 5 Gender Equity
SDG 9	Sustainable Development Goal 9 Industry, Innovation, and Infrastructure
SDG 11	Sustainable Development Goal 1 Sustainable Cities and Communities
SDG 13	Sustainable Development Goal 13 Climate Change
SDG14	Sustainable Development Goal 14 Life Below Water
SDG 17	Sustainable Development Goal 17 Partnerships for the Goals
SEAZA	Southeast Asian Zoos and Aquariums Association
SER	Society for Ecological Restoration
SIDS	Small Island Developing State(s)

Acronym	Full Name
SLO	Student Learning Objectives
SISP	Social Impact and Sustainability Program
SME	Small and Medium Enterprise
SMMR	Sustainable Management of Marine Resources
STEAM	Science, Technology, Engineering, Arts, Mathematics
STEM	Science, Technology, Engineering, and Mathematics
TEK	Traditional Ecological Knowledge
TCPES	Theory of Change for Public Engagement with Science
TLS	Teaching and Learning Sequence
TNFD	Task force for Nature-related Financial Disclosures (UK market-led, science-based, and government-back initiative)
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-IOC	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Oceanographic Commission
UNFCCC	United Nations Framework Convention on Climate Change
UNOC3	United Nations Ocean Conference (third edition)
VC	Venture Capital
WIOMSA	Western Indian Ocean Marine Science Association
WP	Work Package
WTTC	World Travel & Tourism Council
WWF	World Wildlife Fund