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TeachBlue Desk Research REPORT

KA220-SCH - Cooperation partnerships in school education
Project no. 2023-1-PL01-KA220-SCH-000152792

RESEARCH OBJECTIVE

This report aims to provide a comprehensive exploration of Marine and Ocean Literacy (MOL) as it pertains to early childhood education, identifying key concepts and components that are most relevant to this critical developmental stage. It delves into the current landscape of MOL initiatives within early education, analyzing curriculum frameworks, teaching methodologies, and the availability of educational resources.

INTRODUCTION

The oceans cover approximately 70 % of the Earth's surface and play a fundamental role in shaping our climate, providing food and livelihoods, regulating water cycles, and supporting biodiversity. According to **UNESCO, "ocean literacy is the understanding of how the ocean affects us — and how we affect the ocean."** The Ocean Literacy programme of UNESCO-IOC therefore seeks to foster a global understanding of the ocean's influence on humanity and humanity's influence on the ocean, and to build an ocean-literate society capable of conserving and sustainably using the ocean for generations to come. Within this context, the **TeachBlue project is designed to bring these global aspirations into the sphere of early childhood and early primary education.** The underlying assumption is that forming positive attitudes, awareness and responsible behaviours at the earliest possible stage supports long-term ocean stewardship. By introducing concepts of marine and ocean literacy to preschool and early school-aged children, TeachBlue aims to equip educators and learners with the knowledge, values and skills necessary to engage with and protect marine ecosystems.

In the **preschool and early-school context, introducing ocean literacy is especially significant.** Early childhood education provides a unique window: **young children are naturally curious, open to wonder, and eager to explore their environment**. By building on that curiosity with themes related to the ocean — its vastness, its ecosystems, its connection to everyday life — TeachBlue offers an opportunity to **cultivate long-term attitudes of care, inquiry and sustainability.** Moreover, embedding marine and ocean literacy early means that **children grow up recognising the ocean not as a remote or abstract concept, but as a living system that affects their lives, communities and future.**

The aims of the TeachBlue project are therefore threefold:

- **To raise awareness among young learners of the intrinsic links between the ocean, the climate system, human society and the planet's health** — drawing directly on UNESCO's "Why we matter" perspective that "knowing the ocean means understanding our climate, food systems, and our future."
- **To support the integration of marine- and ocean-related themes into early childhood and early school curricula**, through resources, teaching strategies, and age-appropriate materials that reflect the seven essential principles of ocean literacy outlined by UNESCO.
- **To foster a sense of responsibility, action and stewardship among children and their communities** — helping them understand that humans and the ocean are inextricably interconnected, and that collective and individual actions matter.

TeachBlue aligns with UNESCO's mission to "**connect science, education, and community for ocean sustainability"** and places that mission within the classroom and the early education sphere. By doing so, the project seeks to contribute to a generation of children who understand the ocean's role, care about its health, and act in ways that support its sustainable future.

The purpose of conducting the desk research was to **analyze the current state of Marine and Ocean Literacy (MOL) in early childhood education** by reviewing existing literature, educational frameworks, curriculum documents, and official reports.
This phase of the **research aimed to identify the key concepts, principles, and pedagogical approaches relevant to introducing marine and ocean topics to young learners**, as well as to examine **how these themes are currently integrated into early education systems** in different countries. The desk research also sought to **uncover existing gaps, challenges, and limitations in the implementation of MOL**, highlighting areas that require improvement, further investigation, or innovative solutions.
By synthesizing the collected data, the research provided a **foundation for evidence-based recommendations regarding curriculum development, teacher training, and educational practices.** Ultimately, the findings of the desk study were intended to inform the creation of the **TeachBlue Toolkit,** ensuring that it responds to real educational needs and supports the effective inclusion of marine and ocean literacy in early childhood education.

„EARLY CHILDHOOD IS THE MOST IMPORTANT PERIOD FOR THE DEVELOPMENT OF VALUES, ATTITUDES AND BEHAVIOURS THAT LAST THROUGHOUT LIFE."

UNESCO, *Early Childhood Care and Education* (2015)

METHODOLOGY

The desk research phase consisted of a **comprehensive review of existing literature, reports, and educational frameworks related to Marine and Ocean Literacy** (MOL) in early childhood education. The objective of this stage was to **establish a solid theoretical and contextual foundation** for understanding **how marine and ocean-related topics are currently addressed** within early education systems, as well as to identify existing gaps and opportunities for improvement.

The **review covered a wide spectrum of sources, including peer-reviewed journal articles, books, national and international reports, educational frameworks, and official policy documents** concerning preschool and early primary school curricula. Scientific databases such as Google Scholar and Web of Science were used to locate academic publications, while additional sources included **government publications, curriculum guidelines, thematic handbooks, and educational materials addressing oceans and seas for young children**.

The source collection process **focused on materials that provide insight into the presence and treatment of marine and ocean topics** in early childhood education.

Search **queries incorporated a range of relevant keywords**, including but not limited to: “marine literacy in early childhood education,” “ocean literacy preschool education,” “importance of marine education in early years,” “early childhood education on marine ecosystems,” “integrating ocean science in kindergarten,” “teaching ocean conservation to preschoolers,” and “environmental education ocean themes for kids”.
These terms enabled the **identification of studies and resources that address both theoretical foundations and practical implementations of MOL** in early learning environments.

1. INTRODUCTION TO MARINE AND OCEAN LITERACY

1.1. WHAT IS MARINE AND OCEAN LITERACY?

Saving the ocean is nowadays a global issue. Ocean literacy refers to a comprehension of the **ocean's essential role in sustaining and shaping life on Earth** (Unesco, 2024).

It's commonly defined as **"awareness of our personal and shared influence on the ocean, as well as the ocean's influence on our lives and well-being."**

Ocean literacy now **encompasses a wider range of programs and activities across both formal and informal education and communication.** Its aims extend beyond simply **sharing knowledge, emphasizing an emotional connection** to the ocean and promoting behavioural change.

Thus, **ocean literacy is essential for deepening ocean knowledge, fostering meaningful connections in people's lives,** and inspiring citizens and stakeholders to take positive actions for the ocean's well-being (OCT, 2024).

A person who is **ocean-literate recognizes the vital role of the ocean for humanity,** can effectively discuss ocean-related topics, and is capable of making knowledgeable, responsible choices concerning the ocean and its resources.

Marine and ocean literacy are vital for building a society committed to preserving ocean ecosystems.

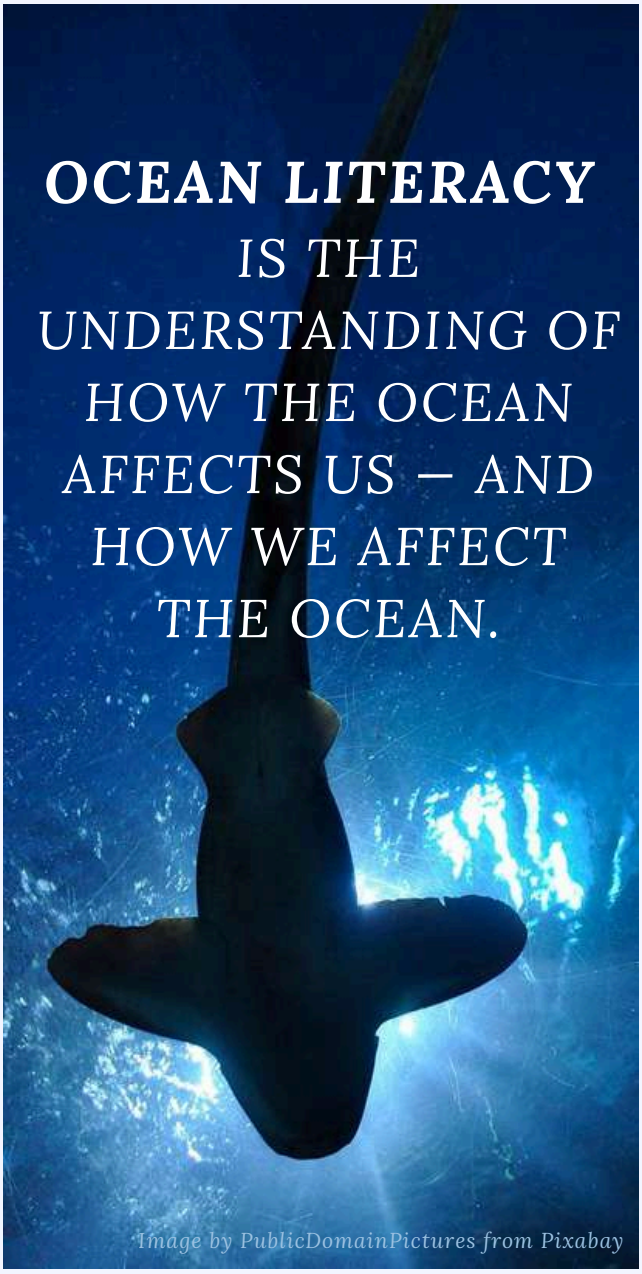


Image by PublicDomainPictures from Pixabay

By **understanding marine systems, individuals can better appreciate the ocean's role in regulating climate, supporting biodiversity, and sustaining life**. UNESCO's Ocean Literacy for All initiative emphasizes the ocean's impact on weather and ecosystems and human impacts on it, such as pollution and overfishing, promoting behaviors that align with global sustainability goals like the United Nations' SDG 14 (Life Below Water) (Unesco, 2021; Unesco, 2020).

Non-formal education programs focused on ocean literacy have demonstrated success in fostering long-term knowledge retention and **positive behavioral changes, particularly when combined with school curricula**.
Such initiatives, including hands-on and community-driven conservation efforts, **significantly raise awareness of ocean issue**s, promoting environmental stewardship (Mokos et al., 2020; Unesco, 2024). Resources like **UNESCO's "Ocean Literacy for All" toolkit and educational frameworks help build understanding** of key ocean principles and encourage sustainable practices, preparing citizens to address future ecological challenges (Unesco, 2024).

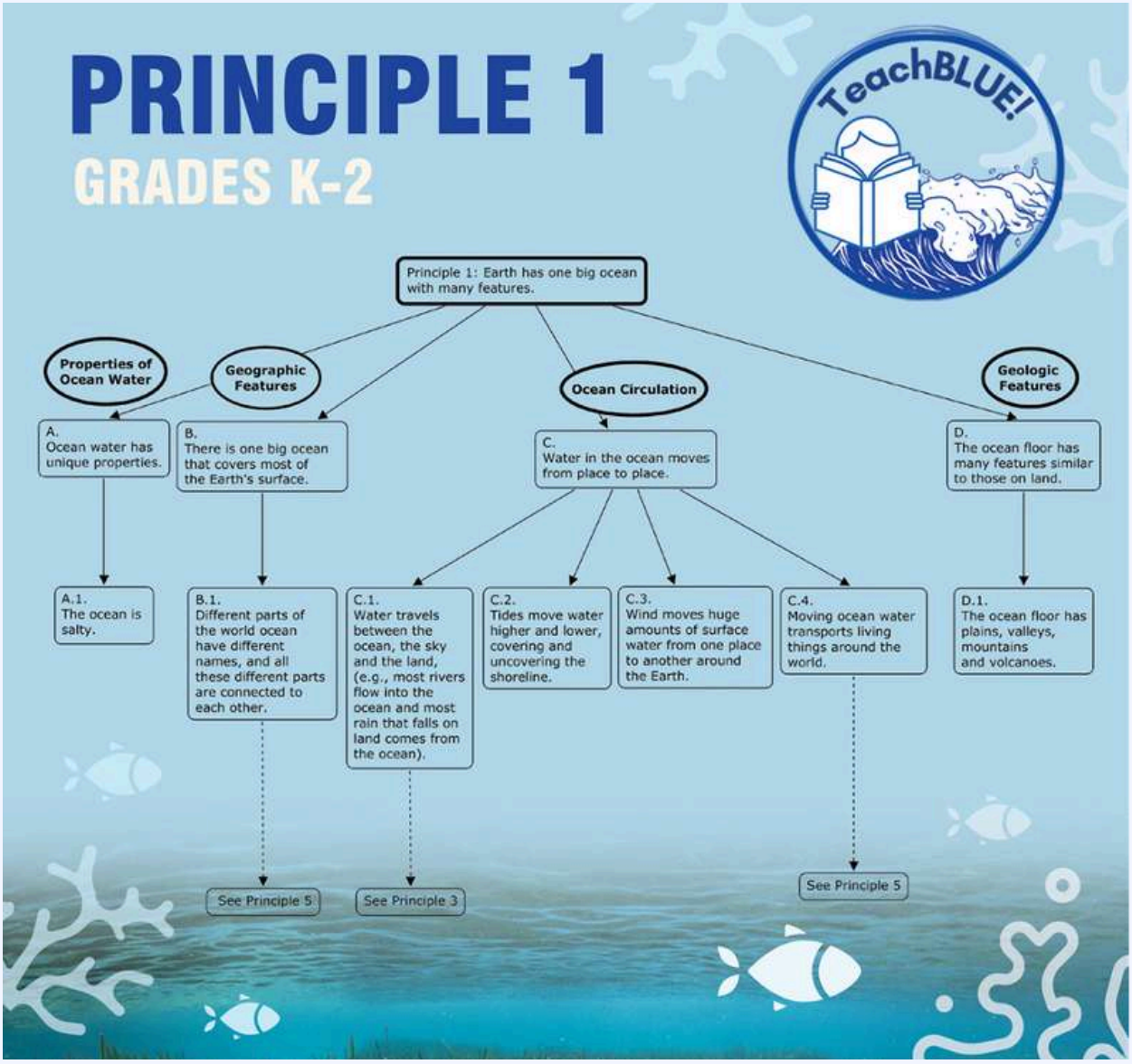
1.2 THE SEVEN ESSENTIAL MARINE AND OCEAN LITERACY CORE PRINCIPLES

The **Seven Essential Principles of Ocean Literacy** offer a **framework for understanding the ocean's impact on life, climate, and biodiversity on Earth, as well as humanity's influence on the ocean.** These principles highlight that Earth's ocean is a single, interconnected system influencing climate, shaping Earth's physical features, and providing essential life-supporting functions (Ocean Literacy, 2015; Ocean First Institute, 2024). They emphasize the ocean's role in making Earth habitable and its extensive, still-unexplored ecosystems.

By **promoting an understanding of these principles**, the framework empowers individuals to make informed, sustainable choices that contribute to ocean conservation and stewardship (Brett, 2024). Ocean literacy involves a **basic understanding of the seven essential principles** that outline how the ocean impacts human life and vice versa. These principles cover topics from the nature of the ocean as a key player in Earth's climate to its vast biodiversity, ecosystems, and role in supporting human needs.

Ocean Literacy Framework includes a guide outlining seven Essential Principles about the ocean that everyone should know, supported by **45 Fundamental Concepts**.
It is accompanied by three key resources: the Ocean Literacy Scope and Sequence for Grades K–12, the alignment of ocean literacy concepts with the Next Generation Science Standards (NGSS), and the International Ocean Literacy Survey (IOLS).
The Scope and Sequence document details what students should understand at different grade levels (K–2, 3–5, 6–8, and 9–12) in order to fully grasp the Essential Principles, showing how ocean-related thinking can develop over time. It was created through a multi-year collaborative process involving more than 150 contributors and was updated in 2021.

Given the design and educational objectives of the project, it is consistent with the **K–2 stage of the Ocean Literacy Framework**.



The ocean is the **defining physical feature** on our planet Earth—covering approximately **70% of the planet's surface**. **There is one ocean with many ocean basins**, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern and Arctic.

Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid-ocean ridges and rift valleys) and vary in size , shape and features due to the movement of Earth's crust (lithosphere). Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.

Throughout the ocean **there is one interconnected circulation system powered by wind, tides, the force of Earth's rotation** (Coriolis effect), the Sun, and water density differences. The **shape of ocean basins and adjacent land masses influence the path of circulation**. This 'global ocean conveyor belt' moves water throughout all of the ocean's basins, transporting energy (heat), matter, and organisms around the ocean. **Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.**

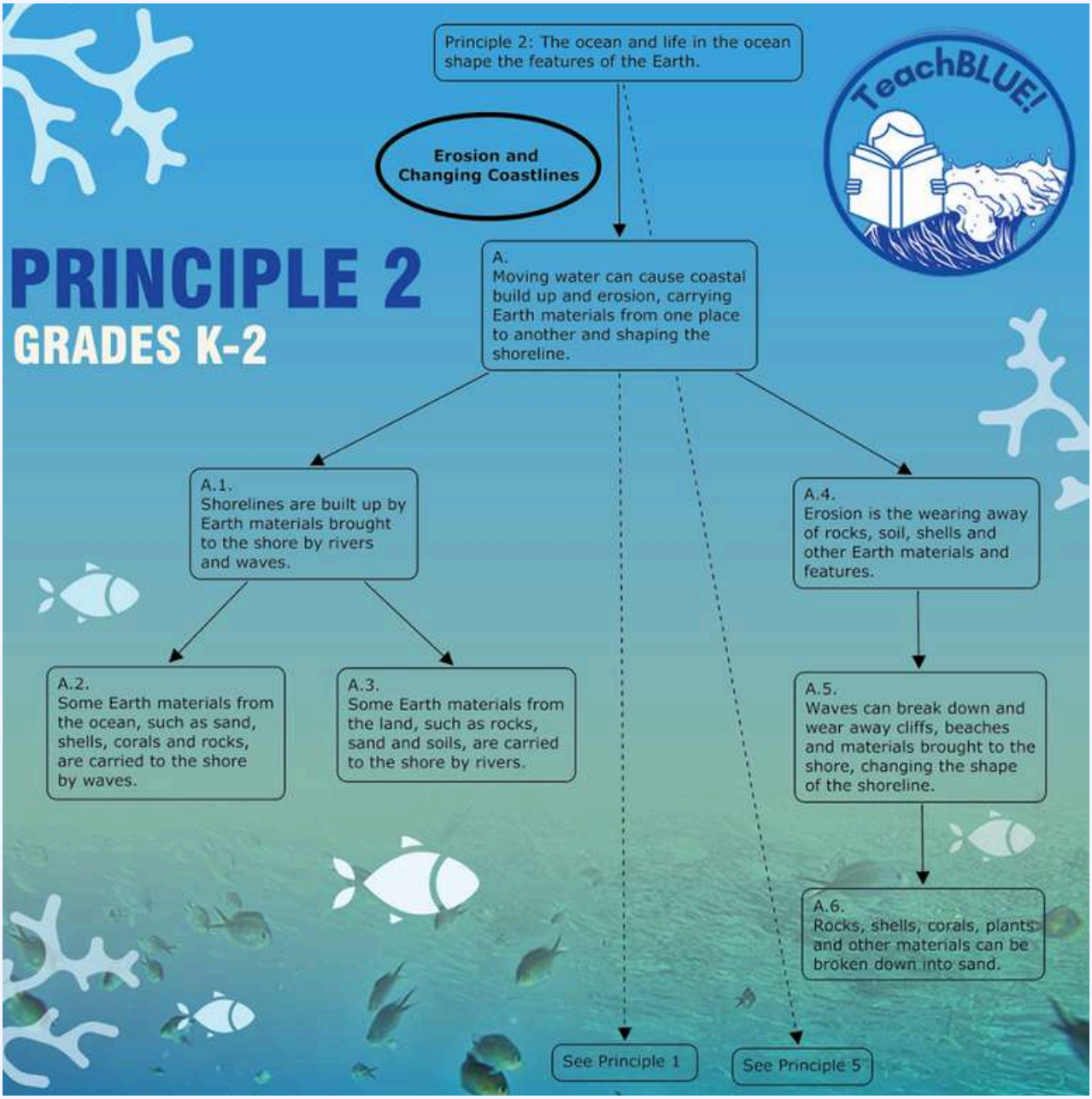
Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow.

It also changes as sea water expands and contracts when ocean water warms and cools. **Most of Earth's water (97%) is in the ocean**. Seawater has unique properties. **It is salty**, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. Balance of **pH is vital for the health of marine ecosystems,** and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.

The ocean is an **integral part of the water cycle** and is connected to all of Earth's water reservoirs via evaporation and precipitation processes.

The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean.

Although the **ocean is large, it is finite and resources are limited.**



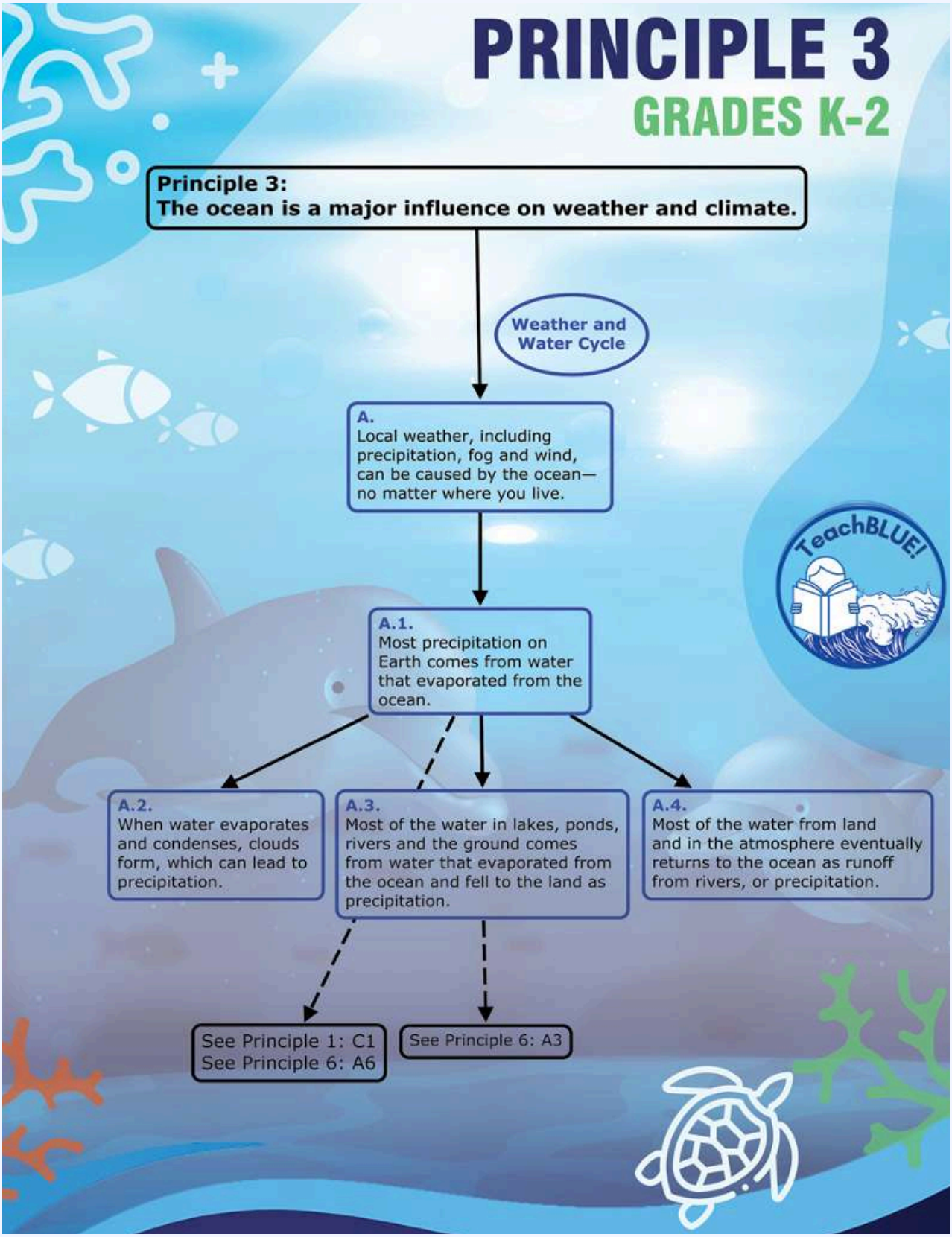
Many earth materials and geochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.

Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

Sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources by surf. Sand is redistributed by waves and coastal currents seasonally.

Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.



The **interaction of oceanic and atmospheric processes controls weather and climate** by dominating Earth's energy, water and carbon systems.

The **ocean moderates global weather and climate** by absorbing most of the **solar radiation reaching Earth**. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation.

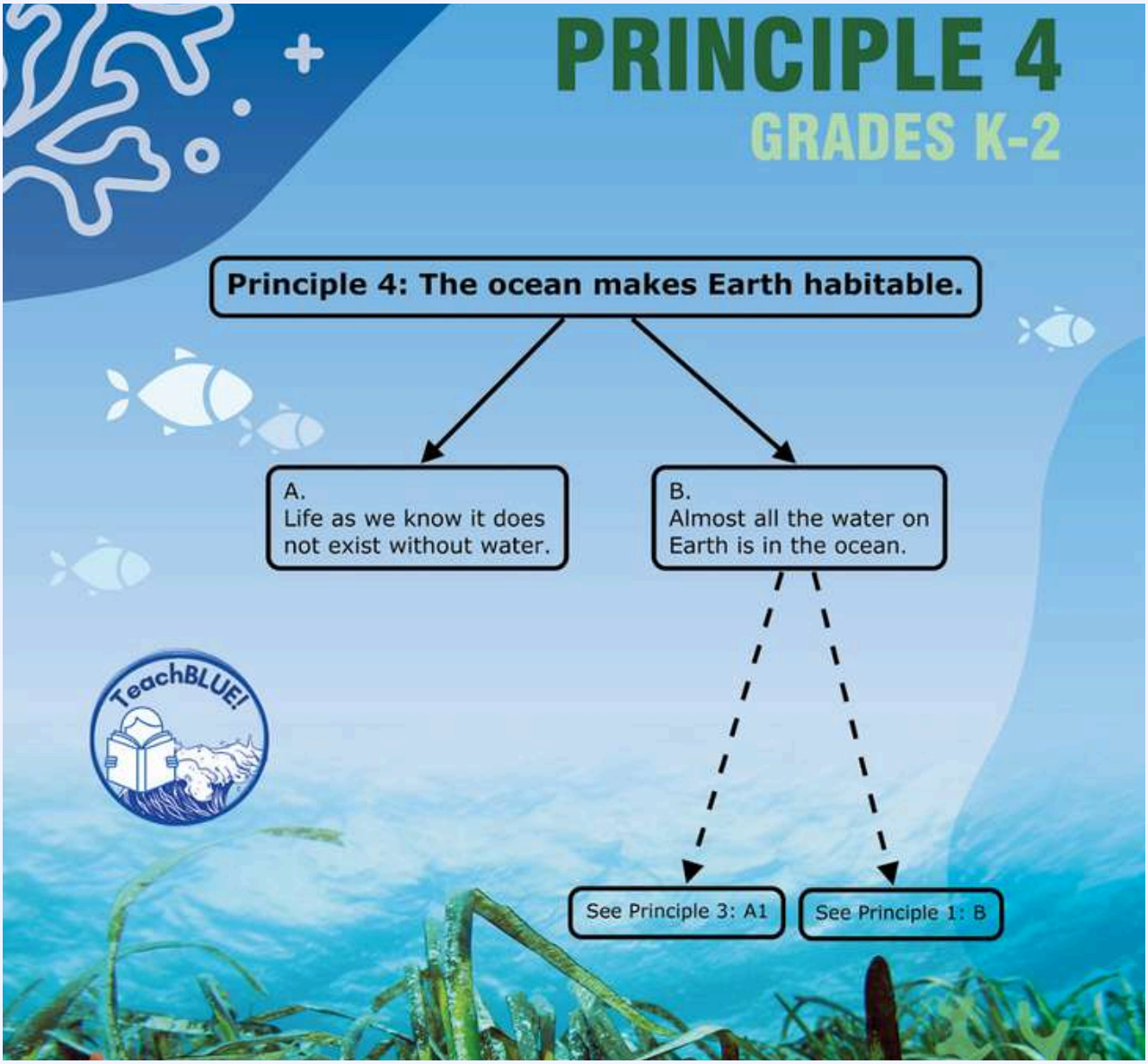
Heat exchange between **the ocean and atmosphere can result in dramatic global and regional water phenomena, impacting patterns of rain and drought**. Significant examples include the El Niño Southern Oscillation and La Niña, which causes important changes in global weather patterns because they alter the sea surface temperature patterns in the Pacific.

Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones. Most rain that falls on land originally evaporated from the tropical ocean.

The ocean dominates Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.

The ocean has had, and will continue to have, a **significant influence on climate change by absorbing, storing, and moving heat, carbon and water.** Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

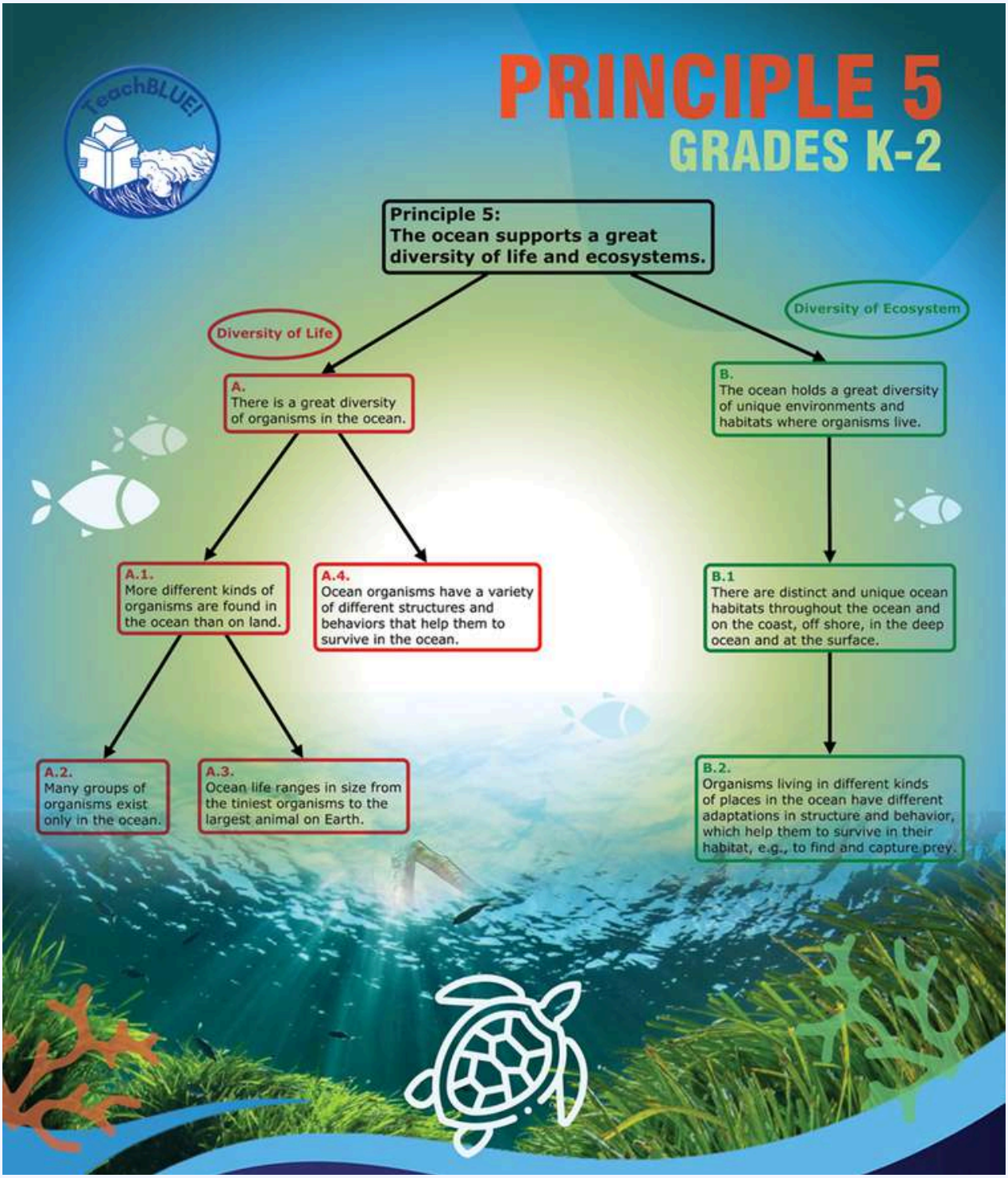
Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. **These interactions have dramatic physical, chemical, biological, economic, and social consequences.**



Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth's atmosphere was necessary **for life to develop and be sustained on land**.

The ocean is the **cradle of life**; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

The ocean **provided and continues to provide water, oxygen and nutrients, and moderates the climate** needed for life to exist on Earth (Essential Principles 1,3, and 5).



Ocean life **ranges in size from the smallest** living things, microbes, **to the largest** animal that has lived on Earth, blue whales.

Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the carbon and oxygen on Earth.

Most of the major groups that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land

Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean.

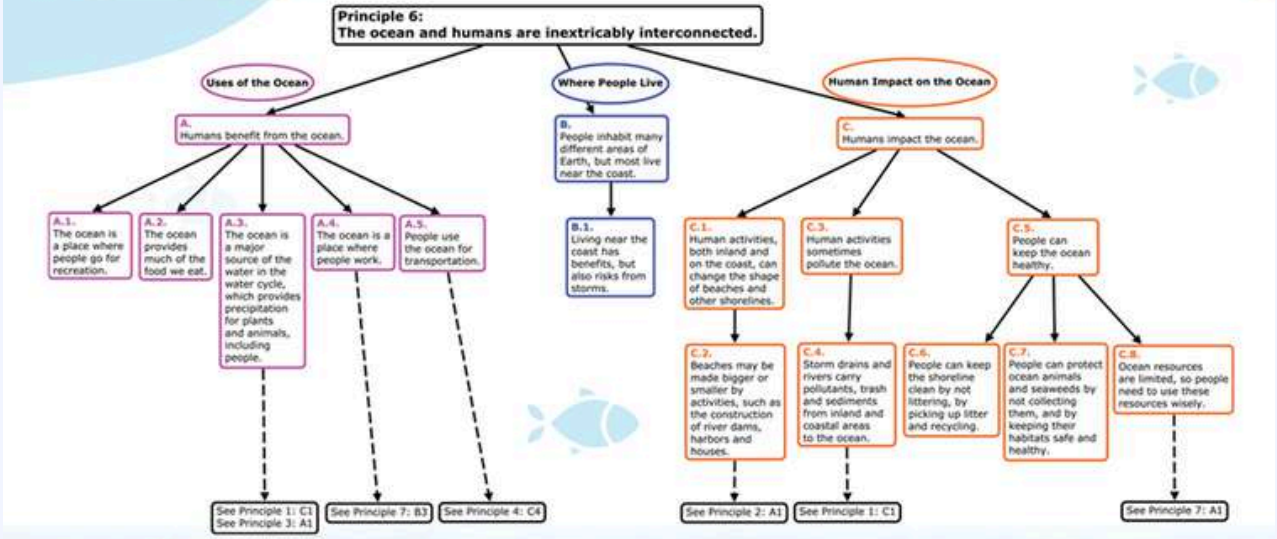
Ocean ecosystems are defined by environmental factors and the community of organisms living there. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, nutrients, pressure, substrate and circulation. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.

There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast: density, pressure, and light levels cause vertical zonation patterns in the open ocean. **Zonation patterns influence organisms' distribution and diversity.**

Estuaries provide important and productive nursery areas for many marine and aquatic species.

PRINCIPLE 6
GRADES K-2



The ocean affects every human life. It **supplies freshwater** (most rain comes from the ocean) and nearly all Earth's **oxygen**. The ocean **moderates Earth's climate, influences our weather, and affects human health**.

The ocean **provides foods, medicines, and mineral and energy resources**. It s**upports jobs and national economies**, serves as a highway for transportation of goods and people, and **plays a role in national security**.

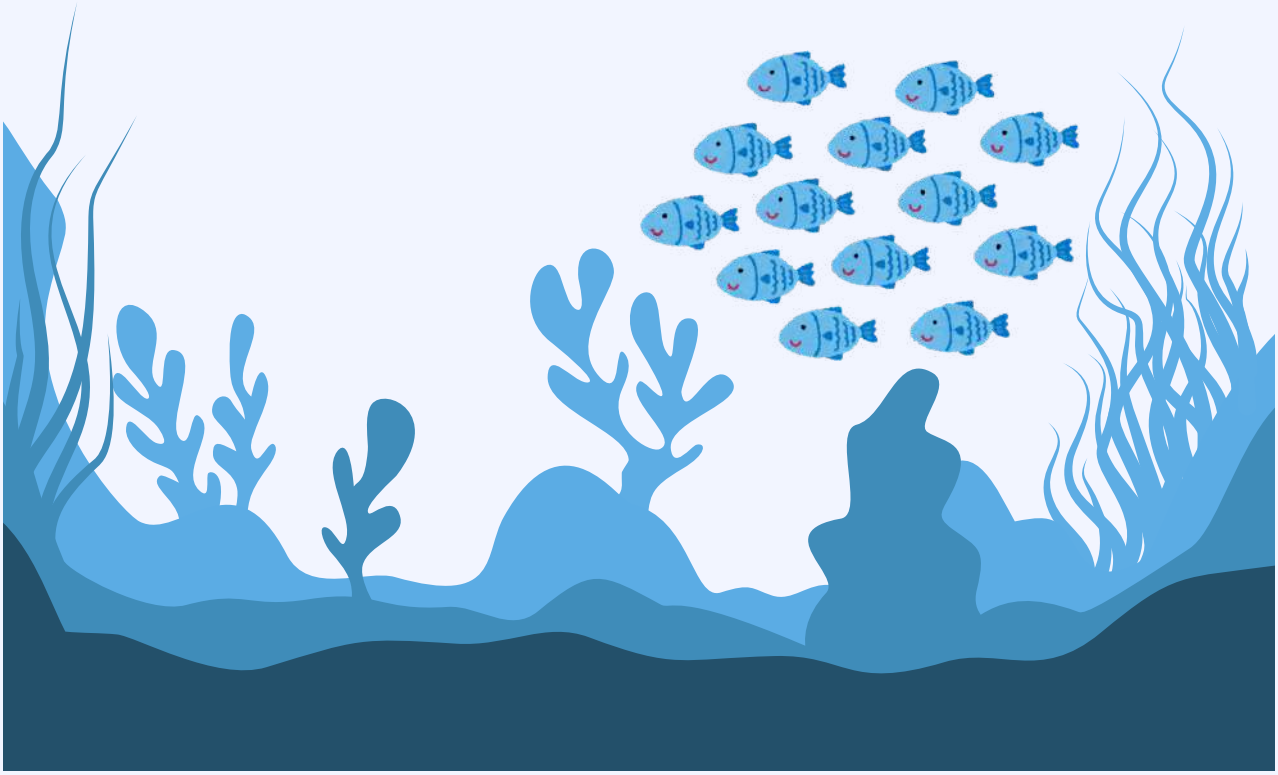
The ocean is a s**ource of inspiration, recreation, rejuvenation and discovery**. It is also an important element in the heritage of many cultures.

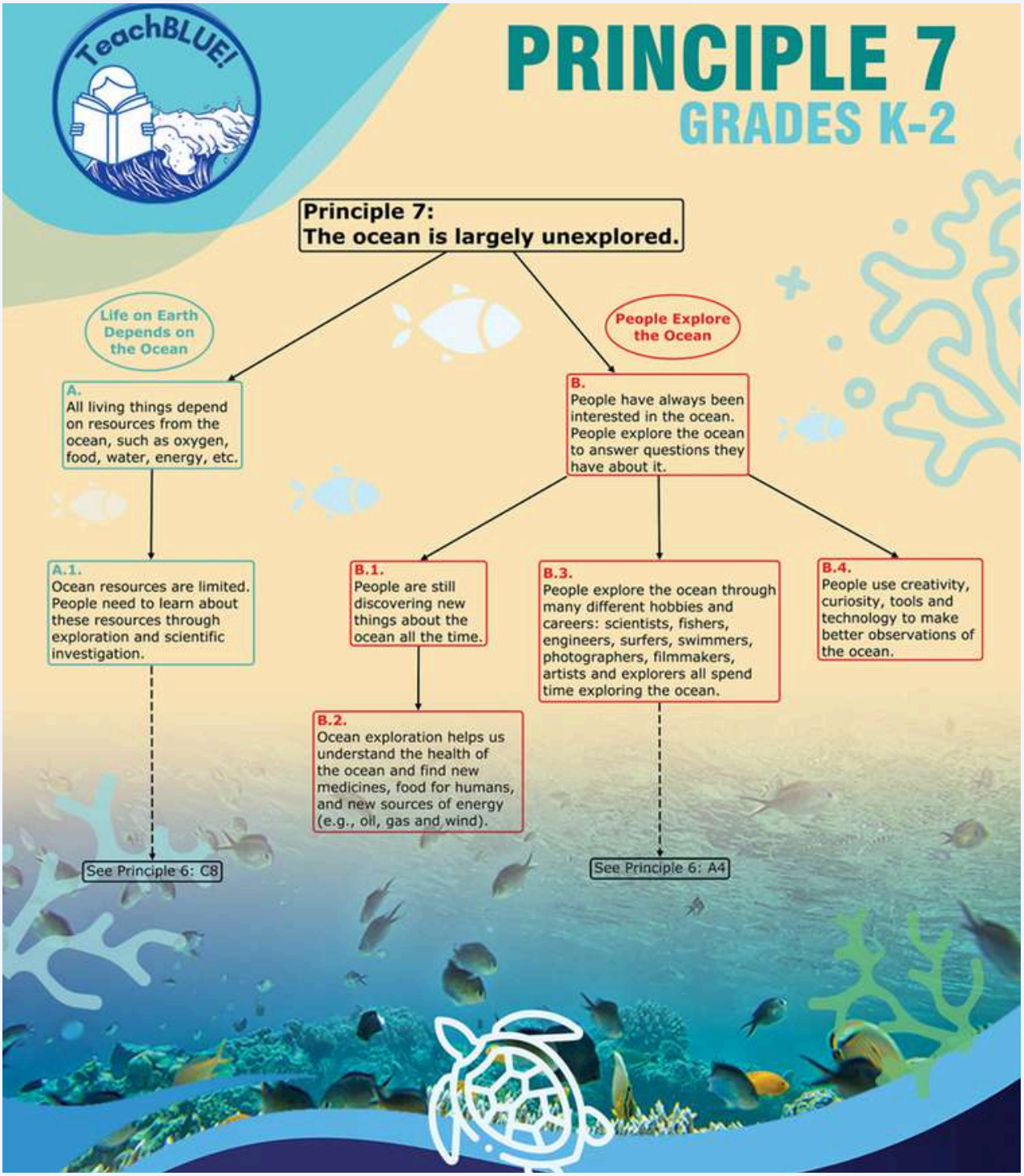
Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. **Human development and activity leads to pollution** (point source, non-point source, and noise pollution), **changes to ocean chemistry** (ocean acidification) **and physical modifications** (changes to beaches, shores and rivers). In addition, **humans have removed most of the large vertebrates from the ocean.**

Changes in ocean temperature and pH due to human activities can affect the **survival of some organisms and impact biological diversity** (coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification).

M**uch of the worlds population lives in coastal areas**. Coastal regions **are susceptible to natural hazards** (tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and **humans must live in ways that sustain the ocean**. Individual and collective actions are needed to effectively manage ocean resources for all.





The ocean is the largest unexplored place on Earth—less than 20% of it has been mapped, observed, and explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation and investigation.

Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes.

Over the last 50 years, **use of ocean resources has increased significantly**, the future **sustainability of ocean resources depends on our understanding of those resources and their potential**.

New technologies, sensors and tools are **expanding our ability to explore the ocean system.** Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and uncrewed submersibles.

Use of mathematical models is an essential part of the ocean systems. **Models help us understand the complexity of the ocean and of its interaction with Earth's interior, atmosphere, climate and land masses.**

Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

1.3 CONNECTION OF MARINE AND OCEAN LITERACY TO GLOBAL GOALS

The **European Commission recognized the significance of ocean literacy in Europe**, prompting it to establish an **expert group to develop an ocean literacy agenda**. The European effort to integrate ocean literacy into broader scientific and educational initiatives, such as Horizon 2020, has led to **dedicated funding and increased awareness** of marine science among the public and policymakers, advancing sustainability goals (EMSEA, 2024; EU4Ocean Coalition, 2024).

Key organizations, like the **European Marine Science Educators Association** (EMSEA), have worked alongside educators and scientists to support this agenda, while global initiatives, such as the **UN Decade of Ocean Science for Sustainable Development (2021–2030)**, further bolster these efforts to foster an ocean-literate society capable of addressing marine environmental challenges.

Marine and ocean literacy initiatives play a **crucial role in fostering sustainable practices, influencing conservation policies, and promoting societal responsibility**. By enhancing awareness of the ocean's connection to climate and biodiversity, these efforts encourage **informed decision-making that prioritizes ocean health, influencing policies worldwide** (Ocean Conservation Trust, 2024; Black, 2023).

On a community level, **ocean literacy builds personal connections** to the marine environment, **fostering civic responsibility** and inspiring behavioral changes that mitigate human impact on ecosystems.
Increased understanding of individual actions on ocean health encourages proactive conservation, supporting marine stewardship for future generations (Unesco, 2021).

1.4 UNDERSTANDING MARINE AND OCEAN LITERACY AND TAKE ACTION TO SUPPORT IT

Marine and ocean literacy play an essential role in advancing environmental protection and sustainability by fostering understanding and responsible stewardship of ocean ecosystems. However, challenges persist, including **limited public access to marine education, a lack of ocean science awareness, and socio-economic barriers** (Unesco, 2024).
Initiatives by organizations like UNESCO and the European Marine Science Educators Association **aim to bridge these gaps, advocating for inclusive marine education and international collaboration to build a more ocean-literate society**.
The **UN Decade of Ocean Science for Sustainable Development** (2021–2030) offers a **promising avenue** to further these efforts, providing resources and uniting global communities in marine conservation and sustainable practices (Ocean Literacy, 2020).

This **State of the Art Report** will encompass a detailed exploration of marine and ocean literacy through several approaches, including **historical perspectives on environmental education, current educational frameworks and policies, and pedagogical approaches**. Additionally, it will address the **role of technology and media in enhancing marine education, present case studies of successful marine literacy programs, and examine barriers and challenges in implementing marine literacy**. Together, these components will provide a well-rounded understanding of the current state and future potential of marine and ocean literacy education.

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2. HISTORICAL PERSPECTIVES ON ENVIRONMENTAL EDUCATION

Environmental Education (EE) has a trajectory of development that reflects the growing awareness of the impacts of human activities on the environment and the need to promote a sustainable relationship with the planet. Over the last few decades, EE has evolved, incorporating different visions and approaches, and reflecting the complexities of current environmental issues. Among these approaches, the naturalist and sociocritical visions stand out as influential and represent two fundamental perspectives that have shaped and continue to influence environmental education. The evolution of EE has also made room for the introduction of ocean literacy, a specific field that broadens the scope of EE to encompass a critical and sustainable understanding of marine ecosystems.

2.1. ORIGINS AND EVOLUTION OF ENVIRONMENTAL EDUCATION

2.1.1. Environmental Education in the 60s and 70s

The earliest roots of Environmental Education can be traced back to the conservation movements of the 19th century, when **environmental degradation began to be perceived** as a threat to ecological balance and human well-being.

However, the concept of EE, as it is known today, **began to be formalised in the 1960s and 1970s,** due to growing concern about environmental degradation and the **impacts of pollution, population growth, depletion of natural resources and loss of biodiversity**. Scientists such as Rachel Carson, (Carson, 1962), significantly influenced public awareness, advocating the need to educate people about pressing environmental issues. In 1972, the **United Nations Conference on the Human Environment** in Stockholm (UNEP, 1972) was a milestone, officially recognising the **importance of education in promoting changes** in the relationship between humans and the environment. The **1977 Tbilisi Declaration** (Unesco, 1978), the result of the **Intergovernmental Conference on Environmental Education**, formalised environmental education, establishing **principles and objectives that influenced global programmes**. This conference consolidated the importance of environmental education in promoting environmental awareness and training as a response to environmental crises.

2.1.2. Transition to Education for Sustainable Development (ESD)

Since the Earth Summit in Rio in 1992 (UNCED, 1992), with the signing of Agenda 21, **environmental education has been integrated into educational policies** in various countries, with the aim of including environmental awareness as a fundamental part of citizens' education. **This global document highlighted education as an essential tool for tackling environmental and economic challenges**, pushing nations to adopt educational practices that encourage sustainable development. There was also a conceptual transition from "**Environmental Education**" **to "Education for Sustainable Development"** (ESD), a change that has been widely criticised by a significant number of environmental education researchers, especially non-Anglophone ones.

With the **United Nations Decade for Education for Sustainable Development** (2005-2014), UNESCO consolidated environmental education within the broader framework of Education for Sustainable Development (ESD). **This transition reflects an attempt to broaden the scope of EE, which now encompasses not only environmental issues, but also interconnected social and economic challenges** (UNESCO, 2004).

2.1.3. The relationship between Environmental Education and Education for Sustainability

The evolution of EE to ESD represents a major change in terms of **methodology and educational objectives.** Initially centred on environmental awareness, **EE has expanded into a more holistic approach, known as ESD, which incorporates the three pillars of sustainability: environmental, social and economic.** This development not only broadens the focus, but also requires learning to be **transformative, stimulating critical skills, systemic thinking and an understanding of global interdependencies.**

ESD therefore differs from traditional environmental education **in seeking not only to inform, but also to transform the way students think and act in relation to natural resources**, including the oceans. This is fundamental in a context where human impact on the planet is at unprecedented levels. **ESD is concerned with a sustainable future, promoting a mindset that aims to balance the needs of economic development with environmental conservation and social justice**, principles that are also fundamental to ocean literacy. However, for some authors (Meira, 2006), the tendency of some sectors to replace environmental education with ESD is critical.

ESD should focus on critical issues and not just on adapting to a current neoliberal global economic model. Although ESD **is widely promoted by international organisations such as the UN,** there is a risk, according to the same author, that its implementation will become a more moderate and less critical discourse than EE, by f**ocusing on adaptation rather than the transformation of current unsustainable systems**. Environmental Education can be understood from different perspectives, each approaching environmental issues with different emphases. Cartea and Caride (2004) mainly emphasise the naturalist and sociocritical views of EE, which represent complementary approaches, but also have significant differences in terms of research objectives and methodologies.

2.1.4. The Sociocritical Vision of Environmental Education

As EE **has evolved, it has incorporated a sociocritical perspective** that recognises environmental issues as intrinsically linked to social, economic and political factors. This approach argues that environmental education should not only promote the appreciation of nature, but also **encourage critical reflection and the transformation of social structures that contribute to environmental degradation** (Meira, 2000).

The sociocritical perspective thus aims to **raise critical awareness**, promoting the analysis of the causes of environmental problems and collective and individual responsibility for resolving them.

After the Tbilisi Conference, this sociocritical vision was consolidated as **an essential component of environmental education, integrating it into discussions on social justice and sustainability.** By developing critical thinking skills, **this approach empowers students to become agents of change**, challenging the economic and social systems that lead to exploitation and environmental degradation. In this way, the socio-critical perspective transcends a simplistic view of environmental problems, **promoting an understanding of the underlying causes**, such as overconsumption and economic inequality. In the sociocritical view, **environmental education is a tool for social transformation** that aims to question the structures and systems of power that contribute to environmental degradation. Meira and Caride (2004) argue that environmental education should promote critical awareness, enabling students to reflect on the origins of environmental problems and get involved in actions for systemic change. This perspective incorporates elements of **critical pedagogy**, such as encouraging collective action and questioning unsustainable practices, creating a "socio-environmental rationality" that links human development to sustainability.

In short, **the naturalist and sociocritical perspectives offer complementary but distinct approaches to environmental education.** While the naturalist view focuses on awakening appreciation for the environment, the sociocritical perspective encourages transformative action and critical understanding of the underlying causes of the environmental crisis. **Effective Environmental Education must integrate these two perspectives**, promoting both a connection with nature and critical reflection and active citizenship, with the aim of tackling environmental challenges in a holistic and inclusive way. In terms of research methodologies, EE has expanded to include interpretive, critical and post-structuralist methodologies, reflecting a more complex view of environmental problems. This **methodological evolution has allowed EE to address not only environmental issues, but also social, political and cultural factors.** Gough (2012) highlights the importance of approaches such as action research and participatory methods that involve communities, stressing the need to go beyond mere behavioural change to broader social transformation.

2.2. OCEAN LITERACY AS AN EXTENSION OF ENVIRONMENTAL EDUCATION

Ocean literacy has emerged as an essential field for understanding and protecting marine ecosystems, .approaching the oceans from an educational and scientific perspective.

This concept **refers to understanding ocean systems and the fundamental role that oceans play for life on Earth**, including their importance in regulating the climate, sustaining biodiversity and providing livelihoods for millions of people.

Several organisations, such as UNESCO, have **emphasised the inclusion of ocean literacy in school curricula as a means of raising awareness among future generations** about the importance of the oceans and promoting sustainable practices. Initiatives such as the Blue Schools programme (Costa, 2012) or Conhecer o Oceano (Ciência Viva, n.d.) seek to provide students with a **critical understanding of the relationship between human society and the marine environment.**

These programmes **encourage students to explore topics such as marine pollution, global warming and the conservation of ocean biodiversity** (Costa, 2012). In addition to promoting scientific and naturalistic knowledge, ocean literacy is closely linked to socio-critical thinking, as it encourages its targets to reflect on social justice, conscious consumption and public policies that directly impact the health of oceans and coastal communities. At the level of formal education, **critical thinking is fundamental for students to understand the complexity of ocean issues and become advocates for practices and policies that protect these essential ecosystems.**

2.2.1 The Importance of Including Environmental Education and Ocean Literacy in School Curricula

The combination of the naturalist and socio-critical visions, together with ocean literacy, allows **environmental education in the school context to be a powerful tool for forming aware and committed citizens**. Activities that promote an emotional connection with the environment, such as observing fauna and flora, are essential for raising students' initial awareness. On the other hand, the inclusion of the socio-critical perspective and ocean literacy facilitates a **critical understanding of the relationship between society and the environment**, encouraging students to engage in active citizenship practices, which contributes to building fairer and more sustainable societies.

2.2.2 Global Initiatives in Ocean Literacy

Initiatives such as the **UN Decade of the Ocean (2021-2030)** aim to expand research, education and awareness of the oceans, promoting international collaboration aimed at protecting and restoring marine ecosystems.

Several nations, **especially those with large coastal areas, have also adopted educational policies and community projects to increase ocean literacy**. These initiatives aim not only to train citizens in science and conservation, but also to **promote sustainable practices** that can mitigate the effects of climate change and over-exploitation of the oceans.

2.2.3. Challenges and future prospects

The European Commission's 2022 Report on "**Education for Environmental Sustainability**" presents ideas that broaden the historical perspectives of environmental education. Below are some important additional ideas on the subject, as discussed in the report.

Integrating Sustainability Skills at All Educational Levels

The report emphasises **the need for a comprehensive curriculum** that incorporates sustainability skills from the earliest school years right through to higher education. **Skills include critical thinking, ethical values, collaboration and understanding environmental impact, promoting continuous and transversal training** at all stages of education.

United Nations Decade of Ocean Science 2021-2030

Education as a Tool for Social Transformation

Education for environmental sustainability is presented as a means of **encouraging long-term behavioural and social change**. The report argues that training should go **beyond an informative approach** to **adopt a transformative perspective**, where students develop the capacity to act and influence environmental policies and sustainable practices within their communities.

Partnerships and Inter-institutional Collaboration

Collaboration between **schools, universities, companies and non-governmental organisations is essential** for the success of Education for Sustainability. The report emphasises that **these partnerships promote innovative practices and facilitate the development of sustainable projects** that involve local communities, creating positive impact on a large scale.

"Whole Institution" Approach to Sustainability

For environmental education to be effective, it is **essential that all parts of the educational institution** - from the administration to the teaching staff and students - **are aligned with the principles of sustainability**. The report argues that a systemic approach, where sustainability is lived in the school environment, contributes to the internalisation of sustainable behaviours in students.

Connection with the Sustainable Development Goals (SDGs)

The report also links environmental education to the UN SDGs, particularly **SDG 4** (Quality Education), **SDG 13** (Climate Action) and **SDG 15** (Life on Land). This connection broadens the scope of **environmental education to include the promotion of a green economy, reduction of inequalities and environmental conservation,** reflecting a global and integrated approach to sustainability.

Environmental education and ocean literacy are essential tools for promoting a more environmentally aware and responsible society. By expanding the goals of EE to ESD and including themes such as ocean literacy, education can play a transformative role in building a sustainable future. As we face complex and interdependent environmental challenges, education must adapt to prepare individuals capable of making informed decisions and valuing the preservation of marine resources.

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3. CURRENT EDUCATIONAL FRAMEWORKS AND POLICIES

3.1 EDUCATIONAL STRUCTURE IN THE PROJECT PARTNER COUNTRIES

In the project partner countries, the **education system looks slightly different in terms of the starting time of education and national guidelines defining the knowledge, skills and social competences** that students acquire.

The **Greek** educational system is mainly divided **in three different levels: primary, secondary and tertiary**, with an additional post-secondary level providing **vocational training**. **Compulsory education** in Greece lasts for ten years, **from 5 to 15.** Within this, primary education is divided into **preschool education** (ages 4-6) and **primary education**, lasting six years (ages 6 to 12). Preschool education starts when pupils are 4 years old and attendance is compulsory for all 5-year-old children. Primary education lasts six years and concerns children between the ages of 6 to 12 years. Thus, early childhood education, which is the focus of the present of the present study, concerns the preschool education (ages 4-6) and the first two grades of primary education (ages 6-8).

In **Portugal**, **compulsory education starts at age 6 and continues until 18 years (12th grade)**, covering three main stages: **early childhood educatio**n (ages 2-5), **basic education** (ages 6-14) divided **into three cycles, and secondary education** (ages 15-17). Preschool education starts when pupils are 4 years old and **attendance is compulsory for all 5-year-old children.** Primary education lasts six years and concerns children between the ages of 6 to 12 years. Thus, early childhood education, which is the focus of the present of the present study, concerns the preschool education (ages 4-6) and the first two grades of primary education (ages 6-8).

In **Cyprus**, compulsory education begins at age 5 and continues until age 15, covering three main stages: **pre-primary education (ages 3-5), primary education (ages 6-11), and secondary education (ages 12-18) divided into two cycles**. Pre-primary education starts at age three, with attendance being **compulsory for all children from the age of 4 years and 8 months.** Primary education lasts six years and serves children between the **ages of 6 to 11.** Secondary education is divided into **lower secondary** (Gymnasium, ages 12-15) and **upper secondary** (Lyceum or Technical Schools, ages 16-18), with lower secondary being mandatory.

Early childhood education, which is the focus of the present study, encompasses pre-primary education (ages 3-6) and the initial years of primary education (ages 6-8).

In **Poland**, the education system begins with **preschool education** (**age 3-6**), through school education - **primary school** (**age 7-15**), **secondary school** (age 16-19), and ends with **studies and doctoral school**. **Primary school education lasts eight years** and is divided into two educational stages: **stage I** covering grades I-III of primary school - early school education; (age 7-9). **Stage II** covering grades IV-VIII of primary school (age 10-14). In Poland, the **Polish Qualifications Framework** (PQF) is in force, which is a reference system for qualifications awarded in Poland. The PQF has 8 levels. Each is described using general characteristics of the scope, as well as the degree of complexity of knowledge, skills and social competences required of people with qualifications at a given level. The PQF includes **characteristics typical of qualifications awarded in general education, vocational education and higher education.** Education at the primary school level is at level 1. Within the framework of knowledge, the student knows and understands elementary facts and concepts and the relationship between selected natural, social and human thought phenomena (https://prk.men.gov.pl/polska-rama-kwalifikacji-prk/).

3.2. ENTITIES RESPONSIBLE FOR EDUCATION AT NATIONAL LEVEL

The **administration of Greek** primary and secondary education is conducted at central, regional and local level by the **Ministry of Education, Research and Religious Affairs,** the Regional Education Directorates, the Directorates of Education (Prefectures) and the School Units, respectively. However, **the Ministry of Education, Research and Religious Affairs holds supervisory control over primary and secondary schools** by defining the content of the curricula, recruiting and appointing staff and controlling funding. The Ministry, also, retains the **full responsibility of the textbooks used**, and it provides students in all grades with only one free of charge textbook, along with a workbook, per course, which is common across the country for both public and private schools.

The administration of primary and secondary education **in Portugal** operates at central, regional, and local levels, managed by **the Ministry of Education**, the Regional Education Directorates, Municipalities and local school units (named “Agrupamentos”), respectively. However, the Ministry of Education maintains overarching control over primary and secondary schools by defining curriculum content, recruiting, and appointing teachers and managing funding.

Additionally, the Ministry is responsible for **selecting the textbooks used, ensuring that students across the country, in both public and private schools, receive standardized textbooks** and workbooks free of charge for each subject.

The integration of marine and ocean-related topics into early childhood curricula **in Cyprus** occurs at multiple levels. At national level **the Ministry of Education** incorporates Marine and Ocean Literacy concepts into the **national curriculum,** ensuring that environmental education, including marine topics, is a part of early childhood education (UNESCO, 2020). Advocate for policies that prioritize Marine and Ocean Literacy in educational frameworks, ensuring consistent teaching across schools. Secure funding to develop high-quality materials, support teacher training, and create experiential learning opportunities (UNESCO, 2020). **At state level** - state-level initiatives **focus on implementing national guidelines and developing specific programs tailored to Cyprus's marine ecosystems**. Partnerships with marine research institutes help create relevant educational materials (Ryan, 2021). At local level schools collaborate with l**ocal marine organizations** to provide experiential learning opportunities. Events like SeaWeek engage students in activities that emphasize the importance of marine conservation (Reid & Strathairn, 2024).

The **Ministry of National Education** is responsible for conducting Poland's policy in the area of education and upbringing. This ministry is responsible for **matters related to pre-school education, general, special and vocational education, establishing curricula, textbooks and teaching aids**, as well as developing external examinations.

3.3. EARLY CHILDHOOD EDUCATION CURRICULA AND THEIR RELATIONSHIP TO MARINE AND OCEAN LITERACY

For the purpose of the present research, the **Curricula for the preschool education and the ones for the first two grades of primary education were studied**. Content analysis was implemented on both **textual and visual (pictorial) material** to assess the information regarding the **presence of ocean literacy elements in the curricula and the textbooks under study.**

GREECE. In preschool education, the physiognomy/orientation of the kindergarten is determined by the Curriculum for the Preschool Education (Institute of Educational Policy, 2022), which is an integrated system of work. **The curriculum forms the common framework for the organization of learning in kindergarten.** The learning content is organized by the teachers o**n the basis of what the children are intended to learn**, and there are no school textbooks or educational material provided by the Ministry of Education, available to be used in class.

The **learning objectives and indicative activities** presented in the curriculum do not constitute a binding framework for kindergarten teachers, or "material" that must be covered. What matters is that the **kindergarten teachers' choices respond to the children's characteristics and the classroom conditions.** Since 2021, **Skills Workshops** are also included in the **Kindergarten timetable**. In the first two grades of the primary education, the basic subjects are the following: **Modern Greek Language, Mathematics, Study of the Environment, Physical Education, Music,Art, Theater, Skills Workshops**. The subject **Study of the Environment** is the **most closely related to ocean literacy** and it is orientated by the Curriculum for the Study of the Environment (Institute of Educational Policy, 2021). **It consists of two separate books, a student reading book and a workbook.** Study of the Environment recommends a single domain of learning with an **interdisciplinary character**, as elements from the natural, social, religious, cultural, historical, and economic environment are incorporated (Institute of Educational Policy, 2014). **The Skills Workshop**s (Institute of Educational Policy, 2021) are an **innovative didactic and educational activity**, which after its pilot application in 2021 has been integrated into the compulsory timetable of kindergartens, primary and secondary schools, public and private.

This is an **action which aims to strengthen the cultivation of soft skills, life and technology and science skills.** The teachers responsible for teaching the Skills Workshops are invited to design the Skills Cultivation Programs within 4 Thematic Modules, among which the 2nd Module entitled "**I take care of the environment**". Within the framework of this subject, there are also projects offered by institutions, NGO's, museums, which teachers can implement in order to serve the needs of Skills Workshops. For the purpose of the present study, we studied only the 2nd Module of the Skills Workshop, as well as we looked for the projects which were the most closely related to ocean literacy. The **Curriculum for the Environment and Education for Sustainable Development** (Institute of Educational Policy, 2011) runs both preschool and primary education and puts forward the principles and values of Education for Sustainable Development for the inculcation of these principles and values in the Curricula of other didactic learning areas. It is accompanied by a **Guide for the Environment and Education for Sustainable Development** (Institute of Educational Policy, 2011).

Table 1. Topics concerning ocean literacy in Greek Curricula

Source	Topics concerning ocean literacy in preschool education	Topics concerning ocean literacy in primary education (1st and 2nd grade)
Curriculum for the Preschool Education	• positive attitude and responsible action towards the environment • one experiment concerning whether sea freezes	
Curriculum for the "Study of the Environment" **Textbooks for the "Study of the Environment"**		• coasts and the sea • islands • human interventions on the coasts • biogeochemical features of the sea • water cycle
Curriculum for the "Environment and Education for Sustainable Development" **Guide for the "Environment and Education for Sustainable Development"**		• water cycle • water pollution • saving water

Source	Topics concerning ocean literacy in preschool education	Topics concerning ocean literacy in primary education (1st and 2nd grade)
Skills Workshops*	• Sea without plastic • Mediterranean, the sea that unites cultures **Projects offered by institutions to be optionally implemented by teachers:** • Discovering Gyaros, a Marine Ecosystem in the Heart of the Cyclades (World Wide Fund for Nature WWF Greece • Water... Explorers! (Quality Net Foundation) • The Lake's Water, the Sea's Salt... the Lagoon's Palace! (K.P.E. Messolonghi) • Niretta the Caretta (Mediterranean Association for the Rescue of Sea Turtles) • The Rain that Became a Flood. The Rain Gauge! (Rhodes Butterfly Environment and Sustainability Education Center) • Children's HELMEPA - Our Friend the Sea (HELMEPA - Hellenic Marine Environment Protection Association) • Children's HELMEPA - Our Friend the Sea (HELMEPA - Hellenic Marine Environment Protection Association) • Where Do You Go Boating in Such Weather? - The Maritime Tradition of the Aegean (Culture Agency I.M.D. (Magneton Kivotos, for the Rescue of the Cultural Reserve)	

*All topics of Skills Workshops concern both pre-school and the first two grades of primary education

In Portugal the primary goal of promoting Ocean Literacy within early childhood education is to **empower future generations to protect marine environments by understanding the ocean's ecosystems, resources, and their own impact.** This educational scope includes the study of pedagogical practices that **incorporate ocean themes in childhood activities** and assessing the effectiveness of these approaches to foster environmental awareness. Below you can read about Key Concepts and Components of Marine and Ocean Literacy in Early Childhood Education in Portugal. In "**The Ocean Literacy for All: A Toolkit**", (UNESCO,2017) references to Portugal primarily highlight the country's early adoption and integration of ocean literacy principles and leadership in Ocean Literacy Translation and Adaptation to schools. **Portugal was one of the first European countries to implement an ocean literacy framework**. In 2011, led by Ciencia Viva (the Portuguese National Agency for Scientific and Technological Culture), **Portugal translated the Ocean Literacy Essential Principles and Fundamental Concepts into Portuguese** under the project "Conhecer o Oceano" ("Knowing the Sea"). This adaptation aimed to **make ocean literacy principles accessible within the Portuguese educational context**. This early adoption has established a model for integrating ocean literacy into national curricula, influencing other regions in Europe and beyond.

"**The New Blue Curriculum: A Toolkit for Policy-Makers**" (UNESCO, 2022), references Portugal in the following contexts related to ocean literacy: **Blue Schools Network**: Portugal's Escola Azul (**Blue School**). Network is highlighted as an exemplary **initiative aimed at preparing ocean-literate citizens.** The program is spearheaded by the Portuguese Ministry of the Sea and developed by the Directorate-General for Maritime Policy. **It connects schools with local communities, industries, NGOs, municipalities, and the marine sector** to implement ocean literacy into the formal curriculum, emphasizing Portugal's commitment to fostering ocean literacy at all educational levels (UNESCO, 2017;2022).

European and All-Atlantic Networks (https://escolaazul.pt/en): the document notes **Portugal's participation** in broader European Union initiatives, such as the **European Network of Blue Schools**, promoted by the **EU Directorate-General for Maritime Affairs and Fisheries**. Portugal also engages in the **All-Atlantic Blue Schools Network**, part of the All-Atlantic Ocean Research Alliance, reflecting its commitment to advancing ocean literacy at both national and international levels. **Portugal's role in ocean literacy reflects a proactive approach in Europe,** setting a foundation for regional adaptations and promoting environmental stewardship from an early age (UNESCO, 2022).

The **REASE network** (Barracosa et al., 2019) highlighted **Ocean Literacy** (OL) as an educational approach to **raise awareness about coastal Ecosystem Services** (ES) in Portugal. It emphasized several key points: **the essential role of coastal ecosystems in supporting biodiversity, carbon sequestration, and providing services such as food and water purification**. The REASE initiative, based in the **Algarve**, **integrated these themes to educate the public, especially students, about their reliance on and impact on marine environments.** REASE developed formal and informal OL education programs, engaging K-12 students and the general public. This included **activities like teacher training, field trips, and hands-on projects**, such as the "**Blue Carbon**" initiative that involved students in carbon mapping of local coastal ecosystems. REASE was seen as a model for increasing OL, encouraging other regions in Portugal to implement similar programs. Recent educational reforms, like the **Project for Autonomy and Curriculum Flexibility** (PACF), allowed Portuguese schools to customize curricula, potentially opening avenues for OL integration. The REASE project formally ended in 2017 but continued through the **SeagHorse** and **Blue Forests** Education projects. Both projects focused on **carbon-sequestering marine plants**, targeting children across all school levels and their teachers in the case of SeagHorse, and specifically teachers in the case of Blue Forests Education.

Many researchers also highlight the importance of creating and sharing **web-based repositories** that **promote Ocean Literacy by engaging teachers across different educational levels** (Costa et al, 2024). To this end, a free-access, English-Portuguese-language-ocean-themed repository (Blue Forests Learning Platform) was developed under the **Blue Forest Education Project** (2024) (https://ccmar.ualg.pt/en/project/boosting-blue-forests-education-and-capacity-building) coordinated, as REASE, by **CCMAR**. This **repository provides a collection of educational resources and activities tailored for educators and stakeholders**. It includes downloadable resources on marine topics and elements, developed in Portuguese/English. Costa et al, 2024 study, aimed to explore the current state of OL in **Azorean schools**, examining teachers' perspectives on OL, **assessing the integration of ocean topics into regular teaching practices**, and evaluating how Azorean schools are preparing students to become environmentally responsible citizens, particularly in alignment with **SDG 14** (Life Below Water). In the Azores, as in other parts of Europe, the **design and implementation of educational programs specifically focused on Ocean Literacy (OL) remain a challenge.** Addressing this requires close collaboration between schools, universities, research institutes, and Ministries of Education. A broader cooperation among curriculum developers, textbook authors, marine educators, and marine scientists is essential to incorporate OL topics into national curricula on a global scale.

In **Portuguese preschool education**, the physiognomy/orientation of the kindergarten is determined by the Curriculum for the Preschool Education (Orientações Curriculares para a Educação Pré-Escolar, 2016), which is an integrated system of work.

The following entry points can be considered for ocean literacy topics within the pre-school education:

Content area: Personal and social training

- Topic: respect and appreciation of the natural and social environment and the landscape heritage

Content area: Knowledge of the world

- Topic: science approach
- Topic: knowledge of the physical and natural world.

I**n the first two grades** of the primary education (grades 1 and 2), the **basic subjects are the following**: Portuguese, Mathematics, Study of the Environment, Physical Education, Music, Art, English and Citizen and Development. The subject **Study of the Environment** is the most closely related to ocean literacy and it is orientated by the **Curriculum for the Study of the Environment** (https://www.dge.mec.pt/aprendizagens-essenciais-ensino-basico).

The **Curriculum of Citizen and Development** (DGE, 2018) runs both preschool and primary education and puts forward the principles and values of Education for Sustainable Development for the inculcation of these principles and values in the Curricula of other didactic learning areas.

It is accompanied by a strategy (Estatégia Nacional de Educação para a Cidadania, DGE 2018).

The following entry points can be considered for ocean literacy topics within cycle 1 (school years 1 to 2):

Subject: Citizenship and Development

- Topic: Sustainable development
- Topic: Environmental education

The integration of marine and ocean-related topics into early childhood curricula in Portugal occurs at multiple levels:

National level - **Project for Autonomy and Curriculum Flexibility** (PACF). The incorporation of ocean literacy into Portugal's educational curriculum is **supported by legislative measures such as the Project for Autonomy and Curriculum Flexibility**, allowing schools to **adapt curricula to local contexts, including ocean literacy themes.** Despite the ocean's omnipresence in a country like Portugal, it might be expected that ocean-related themes would be a prominent part of official curricula and daily teaching activities. However, the prevailing perception suggests otherwise, **as marine and ocean topics are relatively underrepresented in the formal education** (Fauville et al, 2012). According to OECD (2018) the principal obstacles to the inclusion of Ocean Literacy in Portuguese curricula are the **excessive fragmentation of curricula into many disciplines, the size of the current programs and the reduced practice of interdisciplinary projects** and problem-based learning.

However, the **recent legislation** (DL55/2018) allowed schools to **integrate innovative methodologies and practices** representing an opportunity to explore the Ocean Literacy in Portuguese schools. Ultimately, "ocean-literate individuals take action, and through active participation in OL experiences, attach emotion and values to the ocean and its resources" (Barracosa et al., 2019). **PACF provides schools with the necessary conditions to adjust the national curricular program with local contents**. Schools may thus integrate innovative methodologies and practices to promote better learning. This project includes the **National Education Strategy for Citizenship** to introduce citizenship education in the schools. This strategy has created **mandatory teaching areas, such as environmental education, sustainability, human rights, and health.** In addition, it promotes partnerships with NGOs and other institutions. PACF recommends developing **curricula according to the local contexts, associated with active methodologies such as project-based learning methodologies.** This recent legislation represents an opportunity to introduce and explore the theme of coastal ES and OL in the Portuguese school curriculum. Ocean literacy provides a way for students and teachers to work with their communities, and to change behaviors to reduce negative impacts on the ocean and its resources, ensuring that a healthy ocean will be available for future generations.

Furthermore, the **Organization for Economic Co-operation and Development** (OECD) Learning Framework 2030 (OECD, 2018b) acknowledges that the concept of "competency" implies more than just the acquisition of knowledge and skills; it involves the mobilization of knowledge, skills, attitudes and values to meet complex demands (like the concept of ES). One of the recommendations of OECD's Skills Strategy Diagnosis for Portugal is "**adjusting decision-making power to meet local needs**."

Portuguese National Ocean Strategy (ENM) 2021–2030.

As part of Portugal's national commitment to ocean sustainability, the government's **strategy includes a focus on ocean literacy for all ages, with funding for educational materials, teacher training, and community outreach**. This strategy has led to the development of accessible, age-appropriate teaching materials focused on marine conservation, sustainability, and environmental responsibility, used widely in kindergartens and primary schools.

In Cyprus, initiatives to incorporate MOL into early childhood education are **emerging as part of a broader effort to align with international educational frameworks**. These initiatives aim to instill foundational environmental values and scientific curiosity in young learners.

Inquiry-based learning, which encourages children to explore and investigate ocean-related questions, has proven **effective in engaging and educating young minds**. For example, **ocean-themed picture books** are utilized to convey complex marine science concepts in an accessible manner, enhancing children's understanding through visual and textual elements (Springer, 2021). Marine and Ocean Literacy in early childhood education in Cyprus focuses **on fostering an understanding of marine ecosystems, human impact, and the ocean-climate interaction**. Children learn about the **diverse marine species and habitats around Cyprus, food webs, and the importance of each species through interactive activities and ocean-themed picture books**. They are introduced to the effects of pollution and the importance of sustainable practices, such as **recycling and conserving water, to protect the marine environment** (Springer, 2021; UNESCO, 2020).

Basic concepts of **how the ocean influences weather and climate are taught, along with simple explanations of climate change and its impact on marine life**. Educators incorporate Cyprus's rich maritime heritage into lessons, helping children connect with their cultural identity and understand the local economy's reliance on the sea (UNESCO, 2020).

Marine and Ocean Literacy initiatives in early childhood education in Cyprus are **gradually developing, aiming to align with international standards and educational frameworks.** These initiatives include integrating MOL concepts into curriculum frameworks, adopting **diverse teaching approaches, and utilizing various educational resources**. In Cyprus, MOL is gradually being integrated into early childhood education. The national curriculum includes elements of environmental education that cover basic marine science concepts. Initiatives like the **Sea4All project** provide educational kits and online resources to help teachers introduce marine topics interactively. **Experiential learning activities, such as beach clean-ups and visits to aquariums, are also being incorporated to enhance practical understanding** (Alves et al., 2021). Overall, while MOL initiatives in early childhood education in Cyprus are still evolving, significant strides are being made to integrate these concepts into the curriculum, adopt effective teaching approaches, and utilize engaging educational resources. Continued efforts in these areas will help foster a generation that values and protects marine environments.

In Poland, the education of children and youth is based on the **Regulations of the Minister of National Education**: **Regulation of the Minister of National Education of 14 February 2017** on the core **curriculum of preschool education and the core curriculum of general education for primary school**, including for students with moderate or significant intellectual disabilities, general education for vocational school of the first degree, general education for a special school preparing for work and general education for a post-secondary school (Journal of Laws 2017, item 356) and **Regulation of the Minister of Education of 28 June 2024** amending the regulation on **the core curriculum of preschool education and the core curriculum of general education for primary school**, including for students with moderate or significant intellectual disabilities, general education for vocational school of the first degree, general education for special school preparing for work and general education for post-secondary schools (Journal of Laws 2024, item 996). The Polish core curriculum for preschool education **indicates the purpose of preschool education, preventive and educational tasks of the preschool, preschool department organized in primary school and other forms of preschool education, and the effects of implementing tasks in the form of goals achieved by children at the end of preschool education.**

The purpose of preschool education is to **support the overall development of the child**. This support is implemented through the process of **care, upbringing and teaching - learning**, which allows the child to discover their own abilities, the meaning of action and to gather experiences on the path leading to truth, goodness and beauty. As a result of such support, the **child achieves maturity to start learning at the first stage of education**. The purpose of early school education is to support the overall development of the child. The process of upbringing and education conducted in grades I-III of primary school allows the child to discover their own abilities, the meaning of action and to gather experiences on the path leading to truth, goodness and beauty. **Education at this stage is focused on meeting the natural developmental needs** of the student. The school respects the subjectivity of the student in the process of building individual knowledge and transitioning from childhood to adolescence. As a result of such support, the child achieves maturity to start learning at the second stage of education. The programs also describe the achievements that a child should achieve by the end of a specific stage of education. Achievements of a child at the end of the education stage. In preschool education, within the area of cognitive development of a child, the child is prepared to start school.

They can **use concepts related to natural phenomena**, e.g. rainbow, **rain, storm**, falling leaves from trees, seasonal migration of birds, flowering trees, **freezing water, related to the life of animals**, plants, people in the natural environment, using **natural resources**, e.g. mushrooms, fruits, herbs.

In turn, **the general goals** of the student's development in early school education, achieved at the end of early school education, are the source of detailed goals, described in the form of effects. The student is to achieve them by **carrying out tasks that require multidirectional activity**. The scope of this activity is determined by the educational effects listed in the core curriculum, **assigned to individual scientific disciplines.** The educational process at this stage is integrated, not subject-based. As **part of environmental education** in the field of understanding the natural environment, the student: **recognizes popular species of plants and animals in their environment**, including farm animals, as well as protected species, recognizes and distinguishes the features of ecosystems, such as: **meadow, lake, river, sea, field, pond, forest, commercial forest, identifies the components and functions of the ecosystem** using a selected example, e.g. forest, forest layers, clearings, peat bogs, dead tree in the forest.

The school **takes care of educating children and young people in the spirit of acceptance and respect for other people, shapes the attitude of respect for the natural environment**, including disseminating knowledge about the principles of sustainable development, motivates to act for the **protection of the environment and develops interest in ecology**. Additionally, as part of regional language education - Kashubian language - education includes **knowledge and understanding of very simple elements of the surrounding natural and geographical world**, very simple content of material, spiritual culture and Kashubian tradition, and the ability to function in the Kashubian community (acquired during lessons, trips to the local and regional environment and workshops and educational projects). The student has basic information about, among others, the treasures of Kashubia in fairy tales (e.g. **amber**) and **the sea and land in legends and proverbs**.

In Polish early primary education (Grades 1–3), the concept of Ocean and Marine Literacy **is not explicitly included in the national curriculum**, nor does the f**ramework formally refer to the seven internationally recognized Principles of Ocean Literacy** (UNESCO/NOAA). **Ocean-related content appears only indirectly**, mainly **within broader themes of environmental and science education, such as the water cycle, weather phenomena, biodiversity, and responsible behavior toward nature**.

As a result, **the implementation of Ocean Literacy in Poland at this educational stage is mostly bottom-up and driven by regional or non-governmental initiatives rather than by national policy**. This makes Poland's approach significantly less systematized than that of countries with a strong "**blue education" agenda, such as Portugal, which has introduced the nationwide Blue School** (Escola Azul) **program supported by its Ministry of Education** and r**ecognized by UNESCO-IOC as a model framework for integrating Ocean Literacy across formal education.**

Although the Polish core curriculum for Grades 1–3 **includes environmental topics, it does not mention the ocean directly,** nor does it provide any formal reference to Ocean Literacy principles. **Teachers may**, however, **incorporate these ideas voluntarily within the integrated structure of early education**, which combines natural, social, and linguistic learning areas. The general learning objectives in the Polish curriculum — especially those related to understanding nature, the environment, and the interdependence between humans and the natural world — **offer enough flexibility to include marine and oceanic content creatively.**

Even though Ocean Literacy principles are not mandated in Poland, **many typical classroom activities for Grades 1–3 can be mapped to these ideas**. For example, lessons using **maps and globes to connect rivers and seas to the "one global ocean"** relate to Principle 1 (Earth has one big ocean).

Experiments with **evaporation, condensation, and wind** connect to Principle 3 (The ocean influences weather and climate). Lessons on the **water cycle and oxygen production from phytoplankton** correspond to Principle 4 (The ocean makes Earth habitable), while **studies of Baltic sea animals and food chains** illustrate Principle 5 (The ocean supports a great diversity of life). **Campaigns on reducing plastic waste or investigating litter in local rivers** can embody Principle 6 (the ocean and humans are interconnected), and **discussions about marine exploration** or underwater robots address Principle 7 (The ocean is largely unexplored).

In practice, **several institutions and initiatives in Poland promote Ocean Literacy** in ways that reach early primary education. **The Gdynia Aquarium of the National Marine Fisheries Research Institute** (NMFRI) plays a leading role, providing **educational resources** such as the "**Ocean Literacy – Understand Your Ocean" platform**, the "**Oceanic Non-Textbook**", teacher training, and participation in the EMSEA-Baltic network. The P**omeranian Marine Education Program and local city initiatives**, for example in Gdańsk, **organize field trips, workshops, and projects about Baltic heritage and ecology**, many of which are adapted for younger pupils.

Poland also **participates in the UNESCO Baltic Sea Project** (ASPnet), a long-standing regional network of schools engaged in environmental and **scientific projects concerning the Baltic Sea**. Some primary schools involve their youngest learners in simplified observation and awareness activities related to local water bodies and marine ecosystems. Furthermore, international initiatives such as **eTwinning** and **EU4Ocean / EMSEA provide teachers with ready-to-use lesson plans and materials aligned with the Ocean Literacy** framework, allowing for greater alignment with European standards.

Compared **to leading "blue education" nations**, Poland's **efforts remain fragmented**. Portugal's Blue School network, for example, integrates Ocean Literacy systematically through ministerial endorsement, dedicated funding, and a national certification system for schools. In contrast, **Poland relies on the initiative of individual educators, local authorities, and scientific institutions**. Nevertheless, Polish schools can join the **EU4Ocean / Network of European Blue Schools**, which provides European-level recognition and support for Ocean Literacy projects, offering a framework that bridges national gaps.

Despite the absence of a coherent national strategy, **Poland has strong regional promoters and growing engagement in European networks.**

For early primary education, this presents an excellent opportunity: by aligning existing environmental and science lessons with the seven Ocean Literacy principles, teachers can introduce children to the idea that the ocean is essential to life on Earth and deeply connected to their everyday environment, even far from the coast. In this sense, **Poland is not significantly behind in awareness but still at an early stage of systematic implementation**. Strengthening teacher training, integrating Ocean Literacy into the official curriculum, and promoting participation in European initiatives could help Polish early education move toward a more structured and sustainable approach to blue education.

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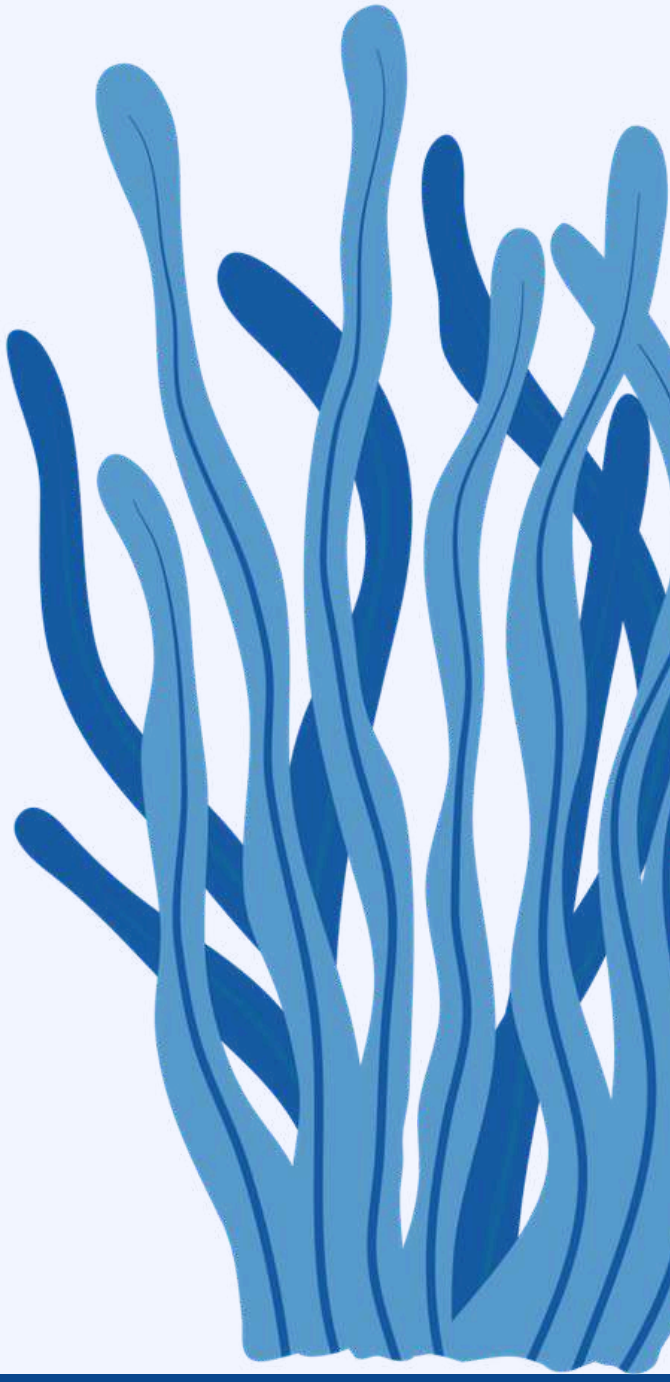


4. PEDAGOGICAL APPROACHES TO MARINE AND OCEAN LITERACY

4.1. PEDAGOGICAL STRATEGIES

Pedagogical strategies for enhancing marine and ocean literacy emphasize experiential learning, innovative digital tools, and interdisciplinary integration. McCauley et al. (2021) highlight the use of **educational e-books and gaming pedagogy** as transformative methods **to foster engagement in ocean literacy**, addressing the challenge of maintaining student interest in the digital age (McCauley et al., 2021). Similarly, Linsky (2012) underscores the value of immersive professional development programs, such as **Hawaii's Project ISLE**, which combine **cultural, ecological, and scientific** insights to deepen teachers' understanding and ability to incorporate ocean literacy into classrooms (Linsky, 2012). These approaches not only **build foundational knowledge** but also **emphasize real-world applications** and **cultural connections** to foster a **comprehensive educational experience.** Further, Constantinou and Fazal (2007) explore integrating **information literacy** into maritime curricula, emphasizing **course-embedded lectures and assessment**-driven learning outcomes as vital for fostering **critical thinking and problem-solving** skills within the maritime domain (Constantinou & Fazal, 2007).

This aligns with **critical literacy** frameworks that address broader **sociocultural and environmental challenges**, as discussed by Luke (1997), who advocates for a literacy approach that empowers marginalized communities through **inclusive pedagogy** (Luke, 1997). Freitas et al. (2022) used the Australian public school system as a case study to investigate the marine science teaching practices (teacher-led learning, lectures or activities conducted by marine science experts, classroom inquiry-learning activities, digital learning activities, literature-children books, excursions, marine science group projects) of primary school teachers (Foundation – Grade 6), through an online survey. All the participants (87.4%) **selected at least two different methods,** for a total of 367 cases. The **most commonly used approaches** included **teacher-led learning, use of children's literature** and **classroom inquiry-learning activities**. These three approaches were also considered **very effective most commonly by teachers**. The teaching method that was considered to be **extremely effective** by most respondents was the **use of excursions**, but only 43 (34.7%) of teachers employed this method.

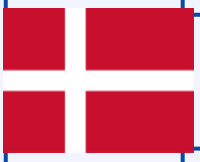
The category least employed by teachers was **marine science group projects**, but proportionally, **was considered most effective by its users**, more than 90% of teachers using this method considered it is **very or extremely effective in raising children's engagement in marine science** topics. Kidman (2023) presented a baseline research understanding of marine science education to provide an entry point for conversations among educators of marine education in Southeast Asia, particularly Indonesia. In particular, the author presented a rapid review of 149 research papers located in a systematic search of the ERIC via ProQuest that followed the PRISMA exclusion process. The findings were presented as **eight themes**

- Learning potential of marine education,
- Knowledge acquisition,
- Skill acquisition,
- Attitudinal gains,
- Planning approaches,
- Teaching methods,
- Teaching method frequencies.
- Assessment approach

Three differing teaching methods (pedagogy approaches) used by teachers, university academics, and informal education providers were reported in the literature corpus: **Fieldwork and inquiry processes**, **Classroom activities** (simulations and taxonomic activities, guest speakers, debating, storybooks, group problem-based scenarios, digital opportunities) and **Teacher centred.**
Although this typology indicates a primarily interactive learning experience is available in marine education, the frequency analysis indicated it is very teacher-centred. Literature review revealed 27 articles concerning pedagogical approaches used to enhance ocean literacy in early childhood and broadly in primary education

Table 2. Articles referring to interventions concerning ocean literacy in early childhood and primary education

Australia				
Age	**Study aim**	**Educational actions**	**Pedagogical approaches**	**Reference**
Primary school	A combination of marine science, traditional knowledge, education and community engagement to enhance ocean literacy	Marine science project based on, classroom activities, place-based education, field trips	Marine Science project	Davey & Breidahl (2019) (in Payne et al., 2019)

	**Brazil**			
6th-grade level	Raise ocean awareness using marine invertebrates	Marine science project: Teacher-led learning, Training by researchers, Lab activities, Field trip, workshops	Marine Science project	Costa et al. (2022)
8-15	Promoting the principles, concepts, and dimensions of Ocean Literacy	Marine Science project (lecture lesson, hands-on lesson, field trip, shared reading)		Pazoto et al. (2023)
	**Croatia**			
Primary School	Marine food web, overfishing, ocean acidification	Lecture and hands-on lesson, role game, artwork, experiment	Teacher-led learning, Classroom/laboratory inquiry-learning activities	Mokos et al. (2020)
	**Denmark**			
10-11	Nursing grounds for fish	Pupils create and deploy nursing grounds for fish, designing and building them, and tracking them using 360 cameras and exploration in VR	Excursion digital learning activities	Chappell & Hetherington (2024)

Greece				
9-11	Ocean acidification	Teacher-led learning, classroom inquiry based activities, experiments	Teacher-led learning, Classroom/laboratory inquiry-learning activities	Boubonari et al. (2023)
10-16	Coastal lagoons	Marine Science project (Teacher-led learning, classroom inquiry learning activities, digital-learning activities, field trip)	Marine Science project	Kevrekidis et al. (2024)
Spain				
11-18	Marine Litter	Hands-on field and laboratory activities	Classroom/laboratory inquiry-learning activities, excursion	Gravina et al. (2019) (in Bettencourt et al., 2021)
11-14	Accessing the Ocean	Pupils learn some key ideas in ocean literacy through an aquarium visit and broader research, then draw on creative approaches within VR and AR spaces to communicate their ideas	Excursion, digital learning activities	Chappell & Hetherington (2024)
7-11	Shoal the Fish	Pupils learn about the ocean and fish behaviour, drawing on their own questions and reflective conversations and dialogue. They create a game using AR	Classroom/laboratory inquiry-learning activities, digital learning activities	

Ireland				
Primary school	Understand and engage in ocean literacy	Saltwater aquaria in the classroom, seashore safaris, marine projects and marine workshops, Field observations	Marine Science project	Joyce et al. (2019) (in Payne et al., 2019)
Italy				
8-10	Marine Litter	Explainer video, brainstorming and serious game	Digital learning activities	Rossano et al. (2017) (in Bettencourt et al. 2021)
		Discussion, explainer, video and serious game		
11-18		Hands-on field and laboratory activities	Classroom/laboratory inquiry-learning activities, excursion	Gravina et al. (2019) (in Bettencourt et al., 2021)
8-10	Marine litter, biodiversity of the Apulian and the Mediterranean Sea	Game-based learning: Explainer video, serious game	Digital learning activities	Rossano &Calvano (2020)
New Zeland				
5-8	Marine conservation with a goal to enhance the ecological literacy (ecoliteracy)	Mixed Reality approach in the classroom, outside the classroom, and between the two settings	Digital learning activities	Eames & Aguayo (2019)

Poland				
K-18	Raise awareness of the connection between humans and the ocean	Long-term marine science project:laboratory lessons, field activities, as well as activities on board	Marine Science project	Niedoszytko et al. (2019) (in Payne et al., 2019)
Portugal				
9-11	Scientific knowledge and skills related to Ocean Literacy in the context of climate change	Museum activities: Theoretical teaching by experts, Field trip, biodiversity mapping platform	Lectures by scientists/ experts, excursion	Boaventura et al. (2021)
3rd grade	Ocean sustainability	Visits to the local fish market and hands-on activities of fish biological sampling	Excursion, Classroom/ laboratory inquiry-learning activities	Aurelio et al. (2022)
11-18	Marine Litter	Hands-on field and laboratory activities	Classroom/ laboratory inquiry-learning activities, excursion	Gravina et al. (2019) (in Bettencourt et al., 2021)
Romania				
11-18	Marine Litter	Educational films incorporated in workshops	Digital learning activities	Ashley et al. (2019) (in Bettencourt et al. 2021)

 **Taiwan**				
Primary school	Students' knowledge of the marine environment: sharks and molluscs	Teacher-led learning, hands-on activities, integrated resources	Teacher-led learning, Classroom/ laboratory inquiry-learning activities	Lee et al. (2019) (in Payne et al., 2019)
 **Tasmania**				
8-11	Marine Litter	Beach clean-up, found object art, participation in science experiments and tours to local waste management facilities	Classroom/ laboratory inquiry-learning activities, excursion	Emery et al. (2020) (in Bettencourt et al. 2021)
 **USA**				
2nd grade to high school	Marine Litter	Field trip and educational program	Excursion	Torres et al. (2019) (in Bettencourt et al., 2021)
 **United Kingdom**				
8-13	Marine Litter	Educational films incorporated in workshops	Digital learning activities	Ashley et al. (2019) (in Bettencourt et al. 2021)

9-10	Ocean Adaptations	Pupils learn in response to their own questions about how organisms are adapted to survive in the ocean, based on inter disciplinary stimulus. The VR space maintains connection with the aquarium stimulus and the ocean experts from the aquarium	Marine Science project	Kevrekidis et al. (2024)
	Plastic Pollution	Pupils learn about the problem of ocean plastics using transdisciplinary creative pedagogies and digital technologies, whilst developing the potential for activism	Digital learning activities	Chappell & Hetherington (2024)

The **six pedagogical approaches** found in the above-mentioned interventions are **teacher-led learning, lectures by experts, classroom/laboratory inquiry-learning activities, digital learning activities, excursions and marine science projects**, and they are consistent with the six approaches described in Freitas et al. (2022). Specifically, the most used approaches are **digital learning activities**, which are applied in 12 out of 27 interventions (44%), **excursions** in 8 (30%), **classroom/laboratory inquiry-learning activitie**s and **marine science projects** in 7 (26%).

4.2. PEDAGOGICAL MODELS

Mc Cauley et al. (2021) recounted the design of **two educational initiatives** that address the advancement of ocean literacy: **educational e-book design and gaming pedagogy.** Boyd and Hirst (2018) describe the **Beach Kindy** approach, which utilizes the **natural environment of the coastline, at sites that demonstrate the biodiversity of the planet**. Water, for example, is recognized not only as an effective medium and tool for education for sustainable development but also its immense capacity to support holistic, interconnected areas within early childhood education (Boyd and Hirst, 2018). Schio & Reis (2024) proposed a pedagogical model which has been designed to go beyond theoretical concepts, **offering schools a practical and objective way to foster ocean citizenship** in basic education, with this being an innovative aspect of the research on ocean literacy.
The proposed pedagogical model encompasses the main tools highlighted in the New **BLUE CURRICULUM-A TOOLKIT FOR POLICY-MAKERS** as essential to supporting teachers in implementing a blue curriculum, specifically: **(1)** lesson plans containing up-to-date resources about the ocean for teachers to present content in the classroom; **(2)** field trips, excursions and immersive experiences; **(3)** experiments designed to introduce science-based ocean processes to students; **(4)** documentaries, media and audiovisual materials; **(5)** digital tools; and (**6)** art.

The toolkit emphasizes **ocean citizenship as a key element to be fostered throughout the curriculum framework, encouraging student agency to act, interact and participate as active citizens**. Thus, employing this pedagogical model to foster ocean citizenship in basic education will provide **multiple educational tools for educators and students,** which can underpin the implementation of a blue curriculum in schools.

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5. ROLE OF TECHNOLOGY AND MEDIA IN MARINE EDUCATION

Marine education is essential for fostering environmental awareness and sustainable practices from a young age. Early childhood, a formative period for cognitive and emotional development, presents a unique opportunity to instil values of marine conservation. However, traditional educational methods often fail to adequately engage young learners or convey the complexity of marine ecosystems. **Technology and media offer innovative tools to bridge this gap**, providing interactive and immersive experiences that enhance learning. This chapter examines the role of technology and media in marine education for early childhood, drawing on educational theories, practical applications, and resources from organisations such as UNESCO.

It concludes with recommendations for educators and policymakers on **optimising digital tools for marine education**.

Marine ecosystems cover over 70% of the Earth's surface and are integral to maintaining global biodiversity and ecological balance. Despite their importance, **awareness and education about marine environments are often overlooked in early childhood curricula**. Introducing marine education during early childhood not only fosters curiosity but also instils a lifelong commitment to environmental stewardship.

Traditional educational approaches face challenges such as limited access to marine environments and abstract concepts that are difficult for young learners to grasp.

The **integration of technology and media** into educational frameworks **provides innovative solutions to these barriers**. **Interactive platforms, multimedia tools, and virtual reality applications can make marine education accessible, engaging, and effective.** Organisations such as UNESCO have recognized this potential, advocating for the use of technology in education to achieve the Sustainable Development Goals (SDGs), particularly in environmental education.

The foundation of early childhood education is deeply rooted in constructivist theories, which emphasise active learning through exploration, interaction, and the direct experience of the learner. These principles are particularly relevant in marine education, as they align with the cognitive and developmental needs of young learners, fostering curiosity and comprehension of complex systems.

5.1. CONSTRUCTIVIST THEORIES IN EARLY EDUCATION

Jean Piaget's stages of cognitive development provide a comprehensive framework for understanding how children acquire knowledge through interaction with their environment. Piaget emphasised that **young learners construct their understanding by engaging in activities that challenge their existing knowledge frameworks.**

This active, experience-driven process is especially important in introducing **abstract concepts** like marine biodiversity and ecosystems to early learners, as it allows them to make tangible connections to otherwise distant or inaccessible subjects (Piaget, 1954). **Lev Vygotsky's concept** of scaffolding complements Piaget's theories by **highlighting the importance of guided learning**. Vygotsky posited that children's learning is enhanced when they are supported by more knowledgeable individuals, such as educators or technology-mediated tools, within their "zone of proximal development" (Vygotsky, 1978). In marine education, **interactive technologies such as virtual reality (VR)**, **augmented reality (AR)**, and **educational apps** serve as scaffolding tools, providing children with tailored learning experiences that **progressively build their understanding of marine environments.**

5.2. MULTIPLE INTELLIGENCES AND LEARNING STYLES

Howard Gardner's theory of multiple intelligences further underscores the importance of diversifying instructional approaches to cater to different learning styles. Gardner identified s**everal intelligences, including visual-spatial, naturalistic, and linguistic**, which are particularly relevant in marine education (Gardner, 1983). For instance:

- **Visual-Spatial intelligence** is engaged through multimedia content like videos, animations, and 3D models of marine habitats.

- **Naturalistic intelligence** is stimulated by virtual aquariums and AR applications that allow children to interact with realistic representations of marine life.
- **Linguistic intelligence** is fostered through digital storytelling platforms and interactive games that teach vocabulary and concepts related to ocean literacy.

Thus, integrating constructivist theories and multiple intelligences into technology-supported marine education not only enhances cognitive development but also **nurtures a deeper connection to and understanding of the natural world in early learners.**

5.3. TECHNOLOGY AND MEDIA IN EARLY CHILDHOOD EDUCATION

Technology and media are increasingly recognized as **valuable tools in early childhood education**. Interactive whiteboards, tablets, educational games, and storytelling apps have been shown to improve engagement, retention, and comprehension in young learners. In the context of marine education, these tools can simulate underwater ecosystems, enabling children to explore marine biodiversity without geographical or logistical constraints.

5.4. ROLE OF EMERGING TECHNOLOGIES IN COGNITIVE DEVELOPMENT

Technology's ability to integrate sensory engagement with structured learning objectives has transformed early childhood education into a **dynamic field**. For children aged 3–8, the period of **rapid brain development demands tools that align with their curiosity and energy**. Emerging technologies like **artificial intelligence (AI) and machine learning are now complementing traditional educational** methods, tailoring content to individual learning styles.

For example, adaptive learning platforms analyse a child's responses to educational activities and adjust the difficulty level accordingly. This personalised approach ensures that children neither feel overwhelmed nor under-challenged, promoting steady cognitive growth. AI-powered virtual assistants embedded in apps can answer children's questions in real-time, mimicking a teacher's role and encouraging inquiry-based learning.

5.5. KEY TECHNOLOGIES IN MARINE EDUCATION

Marine education presents unique challenges, particularly in early childhood, as young learners often lack direct access to marine environments. Key technological tools, such as **augmented reality (AR), virtual reality (VR), gamification, multimedia content, and educational apps**, address these barriers by creating immersive, engaging, and educational experiences.

These tools not only simplify complex concepts but also **foster emotional connections to marine life, cultivating pro-environmental behaviours from an early age.**

5.6. MULTIMEDIA CONTENT

Videos, animations, and documentaries are powerful tools for early learners, offering a **visual narrative of marine life** and conservation efforts. These formats are particularly effective for introducing complex ecological concepts in a simple, age-appropriate manner.

- **Documentary clips**: short, engaging videos highlight marine biodiversity and conservation challenges, fostering emotional connections to marine environments.
- **Animated stories:** animation simplifies scientific processes, such as the water cycle or the food web, helping children grasp these ideas intuitively.

Multimedia content also supports **inclusive education by catering to various learning styles**, including auditory, visual, and kinesthetic learners.

5.7. AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR)

AR and VR have revolutionised early childhood education by offering immersive learning environments.

These technologies enable children to **explore marine ecosystems without leaving the classroom,** fostering curiosity and understanding.

- **AR Applications**: augmented reality overlays **digital images onto the real world**, allowing children to interact with 3D models of marine creatures. For example, apps like "**Ocean AR**" allow students to virtually observe sea turtles swimming through their living rooms or classrooms.
- **VR Simulations**: virtual reality takes immersion a step further, **enabling children to "dive" into coral reefs or explore shipwrecks**. Platforms like Google Expeditions provide 360° underwater experiences, helping children visualise complex ecosystems and processes.

These tools **enhance spatial awareness, stimulate curiosity, and offer a tactile way to learn abstract concepts,** making marine education more engaging and accessible.

5.8. GAMIFICATION IN MARINE EDUCATION

Gamification **integrates game mechanics into educational activities**, making learning engaging and enjoyable. It has proven effective in maintaining children's attention while reinforcing important concepts.

- **Pollution cleanup games**: Interactive platforms teach children about the effects of pollution by **assigning tasks such as cleaning virtual oceans**. By completing these activities, children learn the importance of reducing waste and preserving marine habitats.
- **Marine conservation challenges**: Games that **simulate real-world scenarios**, such as balancing predator-prey dynamics, teach young learners about biodiversity and ecosystem management.

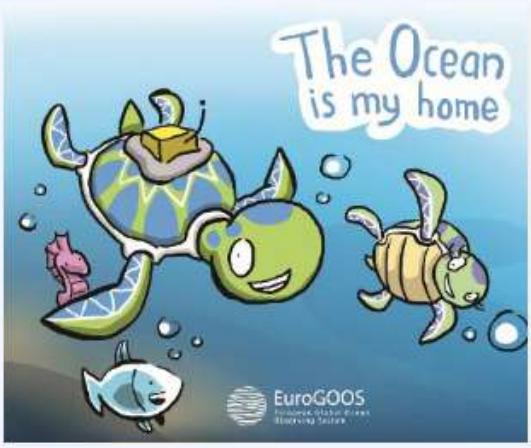
Through **gamified experiences, children develop problem-solving skills** and empathy toward marine life, nurturing a sense of responsibility for environmental stewardship.

5.9. EDUCATIONAL APPS FOR YOUNG EXPLORERS

Educational apps combine interactive elements with rich content, creating a versatile learning platform for young children. Designed with age-appropriate interfaces, these apps encourage exploration and active participation.

- **Ocean explorers**: this **app gamifies marine education with quizzes and interactive maps**, allowing children to learn about aquatic ecosystems while "travelling" to different marine habitats.
- **Marine life encyclopaedia**: with colourful visuals and engaging facts, this app introduces children to various marine species, fostering both knowledge and curiosity.

These apps often **incorporate adaptive learning technologies, tailoring content to each child's pace and interests,** thus promoting sustained engagement and comprehension.



5.10. INTEGRATING KEY TECHNOLOGIES INTO BROADER EARLY CHILDHOOD EDUCATION

When combined, **these technologies create a multifaceted approach to marine education**, offering opportunities for collaborative, inclusive, and impactful learning:

1. **Collaborative learning with AR/VR:** children can use AR and VR tools collectively, exploring marine environments together and engaging in discussions about their observations.
2. **Gamified group activities:** games that require teamwork, such as solving marine conservation puzzles, foster collaboration and social skills.
3. **Multimedia-assisted storytelling**: teachers can integrate animations and videos into lessons to support storytelling, enhancing emotional engagement with marine themes.
4. **App-based projects:** children can work on app-guided projects, such as creating their own marine conservation plans, combining creativity with learning.

5.11. IMPACT ON KNOWLEDGE, BEHAVIOUR, AND EMOTIONAL ENGAGEMENT

Research underscores the effectiveness of these technologies in **fostering pro-environmental attitudes among young learners**. By making marine education interactive and immersive, these tools not only improve knowledge retention but also **encourage emotional connections to marine ecosystems.**

EXAMPLES:

1. **Children exposed to VR simulations of coral bleaching demonstrate higher empathy levels and a greater willingness to participate in conservation efforts**. A study by Bailenson et al. (2018) found that immersive VR experiences significantly impact children's empathy for environmental issues. The study demonstrated that when children virtually witnessed the degradation of coral reefs, they reported stronger emotional connections to marine life and a greater commitment to adopting eco-friendly behaviours.
2. **Gamified activities significantly enhance understanding of concepts such as pollution, biodiversity, and ecological balance.** Research by Hamari et al. (2016) indicates that gamification promotes active learning and enhances retention by blending educational objectives with engaging game mechanics. Marine-themed games, such as pollution cleanup challenges, were shown to improve children's understanding of human impacts on marine ecosystems and foster problem-solving skills.

This **combination of cognitive, emotional, and behavioural outcomes underscores the transformative potential of integrating technology into marine education.** By leveraging the emotional engagement and interactive learning afforded by these tools, educators can create meaningful and lasting impacts on young learners' attitudes and behaviours toward marine conservation.

5.12. INTEGRATING KEY TECHNOLOGIES INTO BROADER EARLY CHILDHOOD EDUCATION

Marine education **is essential for fostering awareness about ocean conservation and promoting sustainability** from a young age. However, the integration of marine education into early childhood curricula presents several challenges, **which technology and media are uniquely positioned to address.**

One of the primary barriers is **accessibility**. For many children, **direct interaction with marine environments is limited** due to geographical, financial, or logistical constraints. **Technology provides an innovative solution by enabling virtual access to these ecosystems**. Augmented reality (AR) and virtual reality (VR) platforms, for example, allow children to explore coral reefs or interact with marine species in a controlled, immersive setting, overcoming physical and economic barriers.

Another challenge lies in the **complexity of marine ecosystems**, which are often perceived as **abstract and difficult for young learners** to comprehend. Digital tools, such as **educational apps and gamified learning modules, simplify these concepts** through interactive and engaging formats. For instance, **gamification breaks down complex ideas,** such as food chains or biodiversity, into manageable activities that encourage active participation and critical thinking.

Finally, **the lack of prioritisation of marine education** within early childhood curricula **limits its inclusion**. Marine literacy is **rarely featured as a core component of educational programs**. Here, technology and media can play a pivotal role by embedding marine themes within existing frameworks. **Digital storytelling, multimedia resources, and apps** like "Ocean Explorers" **integrate seamlessly into broader curricula, making marine education more appealing and feasible for educators.**

UNESCO's Ocean Literacy Framework highlights the importance of addressing these barriers through early and sustained engagement with marine education. It advocates for the strategic **use of digital tools to make marine literacy more accessible, relatable, and impactful**. By leveraging these technologies, educators can bridge gaps in traditional methods, fostering a generation of learners who are both informed about and connected to the marine environment.

The integration of advanced technologies such as augmented reality, virtual reality, gamification, multimedia content, and educational apps into early childhood education has redefined the scope of marine literacy.

By fostering knowledge, emotional connection, and pro-environmental behaviours, these **technologies lay the groundwork for a generation dedicated to ocean conservation and sustainability.**

Future advancements in educational technology **promise to further expand these possibilities, ensuring that marine education becomes increasingly inclusive and impactful**. Continued research, innovation, and collaboration among educators, policymakers, and technologists will be vital to maintaining this momentum, guaranteeing that marine education remains an integral part of early childhood learning in an evolving global context.

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6. CASE STUDIES OF EFFECTIVE MARINE LITERACY PROGRAMS

As shown in the research on the inclusion of Ocean Literacy-related issues in the project partner countries, **a major barrier to including these topics in ecological or nature education is the lack of easily accessible educational materials and recommended lesson plans** that could be used by early childhood teachers.

In **Greek** national desk research the review revealed 14 reports which concern ocean literacy, and are addressed at a range of age groups. Specifically, 11 reports are addressed to early childhood education, i.e. 2 of the reports to the preschool age (4-6), and 9 to the first two grades of primary education (6-8) (Table 3).

Table 3. Educational material concerning ocean literacy

Authors	Title	Age group	Description
NCC EPE, Greek Ornithological Society	In search of the natural treasures of Andros Special Protection Zone	6-12	Experiential activities, aiming to connect children emotionally with the marine environment of Andros
Association U Marinu – France CDE Petra Patrimonia – France Helenic Centre for Marine Research – Greece Consell Insular de Mallorca – Spain Istituto Giuseppe Garibaldi – Italy MEDORO – Italy OsnovnaškolaPučišća– Croatia	MED-EDUC: Pedagogical Guide for teachers	11-17	Classroom activities about issues concerning the Mediterranean

Nonprofit organization: Agents of the Planet	Save the sea from plastics	7-9	Program on marine litter pollution
WWF	Exploring Yaros, a unique ecosystem in Cyclades	5-12	A series of short activities, to help students study a rich marine ecosystem
WWF	Adopt a beach	9-18	Classroom activities so as students to realize the seriousness of the problem of plastic pollution, as well as "adopting" a beach, to actively participate in the control and follow-up setting of the coastal pollution of their area
MIO-ECSDE-MEdIES	Garbage in the foam-Mylopotamos	9-12	Information and motivation of action to reduce and better manage marine litter and especially single-use plastics
Department of Primary Education, University of the Aegean	BIODIVERSITY/ SEA: Dolphin	6-9	A multimedia application with informational material, educational activities for the teacher and electronic games for the student. Information about NGOs dealing with the dolphin as well as links to relevant websites
Department of Primary Education, University of the Aegean	BIODIVERSITY/ SEA: Whale	7-9	A multimedia application with information about the species of whales and their threats, pictures, videos, recorded sounds, stories and educational activities

Department of Primary Education, University of the Aegean	BIODIVERSITY/SEA Seal Monachus	6-12	Website with games, photos, information and educational activities for the Mediterranean seal
Department of Primary Education, University of the Aegean	SEA/BIODIVERSITY Mediterranean Sea	6-12	Animals and plants, coastal ecosystems, cultures, history of the Mediterranean, threats for its ecological balance and protection of it
Department of Primary Education, University of the Aegean	SEA/BIODIVERSITY Traveling with the fishermen	6-12	Students search for, collect and record stories of their island, related to fishing and the marine environment. Information on the causes of the crisis in the fishing industry and ways to deal with them, the state of the oceans today, and the effects that certain fishing methods have on the marine ecosystem
Department of Primary Education, University of the Aegean	SEA/BIODIVERSITY Overfishing	10-12	The issue of overfishing in Greek seas with information about overfishing, exercises and games
Education Centre for the Environment and Sustainability of Ermoupolis	*Posidonia oceanica*	4-12	Information and experiential activities concerning the seagrass and its protection
Lab of Environmental Research and Education, Department of Primary Education, Democritus University of Thrace	Exploring the coastal lagoons	10-16	A guide for teachers to carry out field research with their students in an estuarine environment, collecting biological samples under a specific research practice, aiming to collect flora and fauna of the specific ecosystems, observing the avifauna, measuring physical and chemical parameters

Other activities in which children in early childhood education can participate are **events organized on the occasion of various awareness days, whether ecological or related specifically to the oceans and seas**. The United Nations observes designated days, weeks, years, and decades, each with a theme, or topic. By creating special observances, the United Nations **promotes international awareness and action** on these issues. Each international day offers many actors the opportunity to organize activities related to the theme of the day. Organizations and offices of the United Nations system, and most importantly, governments, civil society, the public and private sectors, schools, universities and, more generally, citizens, make an international day a springboard for awareness-raising actions.

The international days of action and awareness concerning the environment and in particular Marine and Ocean environment were recorded, based on the international Days Calendar of the United Nations, which is shown below:

United Nations | World Wetlands Day
2 February

United Nations | World Seagrass Day
1 March

United Nations | World Water Day
22 March

United Nations | International Day for Biological Diversity
22 May

United Nations | International Day for the Fight against Illegal, Unreported and Unregulated Fishing
5 June

United Nations | World Oceans Day
8 June

Research carried out in the **European calendar** of actions and awareness shown this calendar is in line with the United Nations International Days calendar with most of them having common days. European Ocean Day is celebrated every year on 20 May since 2008, at the initiative of the European Union, to highlight the important role that the oceans and seas play in the daily lives of EU citizens and in the European effort for sustainable development.

EMD
EUROPEAN MARITIME DAY

An investigation was carried out on the publication of **Circulars of the Ministry of Education, Religion and Sports**, to the **School Units of Primary Education** for the school years 2022 – 2023 & 2023 – 2024, that focus on actions that need to be developed about common themes, trends, and challenges in Marine and Ocean Literacy education of the early childhood education (Table 4.).

Table 4. Analysis of Ministry of Education, Religion and Sports Circulars on Marine and Ocean Literacy Actions in Early Childhood Education (School Years 2022/2023–2023/2024)

Action	Description
Circular Φ11/66547/Δ7/ 01.06.2022 / To School Units of Primary Education and K.E.P.E.A.	World Environment Day/ The theme of the World Environment Day Celebration titled: I care and I love the Environment, I am informed, I participate and I act, it focuses on raising awareness and informing the educational community on issues of Environmental Education and Sustainable Development. The main thematic axis is the "Environment and Climate Change"
Circular Φ11/944/Δ7/ 04.01.2023 / To School Units of Primary Education and K.E.P.E.A.	Educational visits and training activities at the Centers for Education for the Environment and Sustainability (K.E.P.E.A.) during the school year 2022-2023 / http://www.minedu.gov.gr/ypapegan/ypour-apof
Circular Φ11/11511/Δ7/ 02.02.2024 / To School Units of Primary Education and K.E.P.E.A.	Educational visits and training activities at the Centers for Education for the Environment and Sustainability (K.E.P.E.A.) during the school year 2023-2024 / http://www.minedu.gov.gr/ypapegan/ypour-apof
Circular 60277/Δ7/ 03.06.2024 / To School Units of Primary Education and K.E.P.E.A.	World Environment Day/ The theme of the World Environment Day Celebration titled: I care and I love the Environment, I am informed, I participate and I act, it focuses on raising awareness and informing the educational community on issues of Environmental Education and Sustainable Development. The main thematic axis is the "Environment and Climate Change"

OL initiatives in Portugal include such programmes: **Kit do Mar** – Preschool and 1st Cycle Worksheets. Developed by the Directorate-General for Maritime Policy (DGPM), this **set of worksheets offers activities tailored for preschool and the 1st cycle**, covering topics such as **marine biodiversity, pollution, and the importance of the sea in art and history.**

Escola Azul Program (UNESCO, 2020; Costa et al., 2021). Launched by the Portuguese Ministry of the Sea, Escola Azul is **an educational program that provides resources and guidance for schools** to integrate ocean themes across various educational levels, including pre-school. This program **encourages schools to create ocean literacy projects** that are interactive and community-centered, **often involving activities such as visits to local marine areas, art projects related to marine life, and storytelling sessions** that introduce ocean stewardship concepts. Through such **hands-on, interdisciplinary approaches**, children learn about ocean ecosystems, the impact of pollution, and their role in conserving marine environments. By fostering early engagement, the program helps build a foundation for lifelong environmental responsibility among young learners.

Oceano Azul Foundation's "Educating for a Blue Generation". This initiative collaborates with **Oceanário de Lisboa** and aims to develop ocean literacy across Portugal, focusing initially on primary education but also influencing pre-school methodologies. The foundation **provides teachers with specialized training and curriculum materials** that cover essential ocean concepts. For example, materials introduce children to the **biodiversity of the ocean, the idea of ecosystems, and the importance of marine conservation**. Activities are designed to be age-appropriate, often using storytelling, simple games, and visual aids to convey concepts in a way that young children can understand and connect with emotionally.

"Show Me the Sea!" – Lesson Plan for Preschool. This educational resource, available on "Casa das Ciências platform", is inspired by the principles of ocean literacy and incorporates learning goals for the preschool level, promoting understanding of marine life diversity.

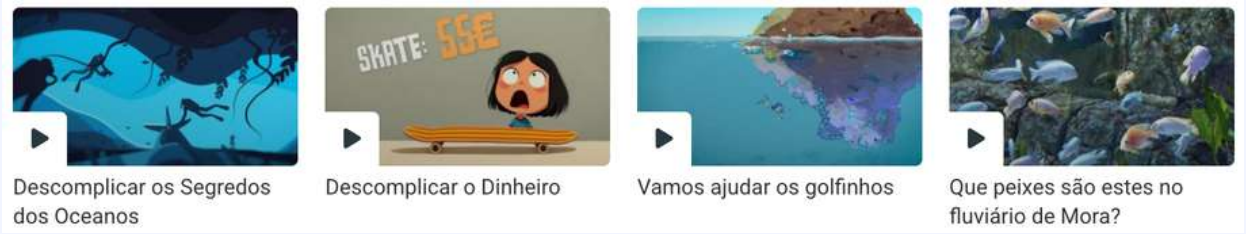
The **REASE initiative** supports both formal and informal education in Portugal, **encouraging students to participate in outdoor activities** that demonstrate the importance of ecosystem services like carbon sequestration and biodiversity maintenance. This project involves partnerships with educational institutions and municipalities in the Algarve, training teachers to facilitate ocean-related learning experiences. Such locally developed content has made a significant impact by enabling translations into national languages and utilizing existing resources through national or regional channels.

During the COVID-19 pandemic and the consequent need for remote learning, the **Portuguese Government developed an educational platform called "Estudo em Casa".** This platform is designed to cater to all grade levels, excluding preschool education. Within the curriculum for primary education (1st cycle), the **platform includes numerous references to the sea and the study of oceans, fostering environmental awareness and encouraging students** to explore marine ecosystems.

Estudo do Meio e Cidadania - 1.º ano , aula 33 - 01 mar 2021 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 1.º ano , aula 29 - 08 fev 2021 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 1.º ano , aula 31 - 22 fev 2021 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 1.º ano , aula 63 - 23 jun 2021 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 1.º ano , aula 33 - 01 mar 2021 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 1.º ano , aula 47 - 28 abr 2021 - Estudo Em Casa - RTP

Second Year
Estudo do Meio e Cidadania - 2.º ano , aula 11 - 23 nov 2020 - Estudo Em Casa - RTP
Estudo do Meio e Cidadania - 2.º ano , aula 28 - 04 fev 2021 - Estudo Em Casa - RT

In addition to "Estudo em Casa," the public television channel RTP Ensina offers a wide array of educational resources for students. Among these, there is a significant focus on **ocean-related topics, providing videos, interactive content, and educational materials** that help deepen students' understanding of the oceans. A search for "oceanos" on RTP Ensina reveals an impressive collection of resources aimed at enriching students' knowledge and raising awareness about the importance of ocean conservation. These initiatives highlight the commitment to integrating environmental education into the academic framework, ensuring students develop a strong connection to marine science and sustainability.



Marine and Ocean Literacy initiatives in **Cyprus** use **various pedagogical strategies** that have proven effective in engaging young learners and fostering a connection to marine environments.

Inquiry-Based Learning: this approach **encourages curiosity and critical thinking** by allowing children to explore marine topics through **guided questions and investigations**. It has proven effective in engaging young learners and fostering a deeper understanding of marine science (Ahmad-Kamil et al., 2022).

Experiential Learning Activities like **beach clean-ups and aquarium visits provide hands-on experiences** that help children connect theoretical knowledge with real-world applications. These activities are effective in building a sense of responsibility towards marine conservation (Alves et al., 2021).

Educational Resources: utilizing multimedia tools, interactive digital content, and ocean-themed picture books makes learning about the ocean engaging and accessible for young children. These resources simplify complex concepts and cater to diverse learning styles (Ahmad-Kamil et al., 2022).

Community and Stakeholder Engagement enhances MOL initiatives through collaborations with local marine organizations and experts, providing unique insights and hands-on learning opportunities (Reid & Strathairn, 2024).

These strategies collectively promote a deep understanding and appreciation of marine environments, fostering a more ocean-literate generation.

In **Polish institutions**, educational forms for children of preschool and early school age were **available only in zoos or aquariums.**
In Poland, there are many events available for preschool and early primary school children. These initiatives are presented below.

The event **"Inhabitants of the Coral Corner"** is designed for children in grades 1–3 and **introduces them to the world of coral reef environments**. During laboratory-based classes, participants learn what corals are, what conditions are necessary for the proper development of coral reefs, and which animals inhabit them. The activities combine an educator's narrative with photos and short films, and an important part of the session involves hands-on work with real animal specimens, including coral skeletons, starfish, and seahorses.

The event "**Expedition to the Bottom of the Ocean"** is intended for children in grades 1–3 and introduces them to life in the deepest parts of seas and oceans. During the laboratory classes, participants learn which bivalves, snails, fish, cephalopods, crustaceans, and echinoderms inhabit the ocean floor, as well as how natural resources such as oil and natural gas are used in daily life. The activities combine the **educator's narrative with photos** of animals living on the seabed, and an important part of the lesson involves **hands-on work with real specimens, including bivalve and snail shells, as well as starfish, sea urchin, and crustacean skeletons.**

The event "**Our Baltic for the Younger Ones**" is aimed at **children from kindergarten age through grade 3** and focuses on the Baltic Sea. During a multimedia presentation, participants learn about **marine organisms** whose traces and remains can be found on the beach, as well as about the inhabitants of the Baltic coastal zone, including species capable of camouflaging themselves. Children discover which bird is considered the king of the Polish coast, why mussels bury themselves in the sand, and how many legs a shrimp has. **The educator's story is enriched with the presentation of various specimens**, including those displayed through a digital microscope.

The event "**Visiting the Clownfish**" is designed for children aged 6 to 11 (grades 0–4) and introduces them to the **world of coral reefs** through a multimedia presentation held in a cinema hall. Participants learn what coral reefs are, what conditions are necessary for their proper development, and which animals inhabit these unique ecosystems. The presentation is enriched with **demonstrations of various specimens**, some shown using a digital microscope, adding a hands-on and engaging element to the educator's story.

The event "**Animals of the Gdynia Aquarium**" is intended for children in grades 0–3 and offers participants the opportunity to learn about the animals exhibited at the Gdynia Aquarium directly from its educators. It serves as an excellent introduction to a visit, enriching the overall experience of touring the aquarium. **The lecture, accompanied by a multimedia presentation**, includes photos and videos that showcase the everyday lives of the animals under the aquarium's care.

The event "**Arctic and Antarctic**" is aimed at children in grades 0–3 and introduces them to the two **polar regions at opposite ends of the Earth**. Participants learn about the extreme conditions found there, as well as unusual natural phenomena such as the aurora borealis and the formation of icebergs. The **multimedia lecture is enriched with unique nature photographs and selected specimens from Antarctica,** helping children better understand these fascinating, icy environments.

The event "**Unusual Sea Animals**" is designed for children in grades 0–3 and introduces them to fascinating marine species whose appearance or behavior may be surprising. Participants discover which **shark is completely harmless, which fish can change sex, whether a snail can be dangerous**, and many other intriguing facts about ocean life. The educator's presentation is enhanced by a display of **unique specimens, adding a hands-on and engaging element to the session.**

The event "**Biodiversity of the Bay of Puck**" is intended for children in grades 1–3 and introduces them to the unique ecosystem of the Bay of Puck. This body of water, known for having the **highest biodiversity along the Polish coast**, provides excellent conditions for life both on the seabed and in the water column due to its shallow depth and limited influence from open sea waters. **The presentation is enriched with unique landscape photographs and nature films** that showcase the bay's most distinctive features.

The event "**Underwater Fish Life**" is aimed at children in grades 1–3 and introduces them to the fascinating world of fish through a multimedia presentation. Participants learn what distinguishes fish from other aquatic animals, how to tell a fish from a whale, and why fish play such an important role in aquatic ecosystems. The classes explain that not all fish share the same type of skeleton, explore their feeding habits and habitat preferences, and show how these features reflect their adaptations to different environments.

Children also take a close **look at shark eggs and discover that not all fish hatch from eggs**. The presentation is enriched with engaging facts and the display of various specimens viewed through a digital microscope.

The event "**Underwater Life of Whales**" is designed for children in grades 1–3 and **introduces them to cetaceans,** a group of marine mammals often mistakenly associated with fish. During this multimedia presentation, participants learn where the misleading name comes from, what adaptations whales have developed for life in the water, and how these animals have influenced fashion and global industry. The session takes children on a **journey to discover where whales can be found and what these ocean giants eat**. The classes are enriched with unique specimens, including Antarctic krill, baleen, and a fragment of a whale skeleton, offering an engaging and educational experience.

The event "**Meeting with the Baltic Sea**" is intended for children in grades 1–3 and combines laboratory workshops with field activities. During the indoor part, participants **learn basic facts about the Baltic Sea, discover which animals can be found on the beach, and explore the species living in coastal waters**. The classes alternate between theoretical instruction and hands-on examination of prepared biological materials using magnifying glasses, allowing children to independently study organisms such as mussels and Baltic shrimp. **Educational worksheets** support the learning process.

The second part of the workshop takes place **outdoors at the marina in Gdynia, where participants spend an hour catching coastal animals using landing nets**. They also learn how to measure water transparency with a Secchi disk, gaining practical insight into marine research methods.

The event "**Birds of the Polish Coast**" is designed for children in grades 2–3 and introduces them to the **avifauna of the Polish Baltic shoreline**. During the lecture, participants learn about the characteristics of coastal bird species, their diversity, and various methods of identifying water birds. The second part of the activity is an **ornithological walk** along the seashore, during which each child uses binoculars to independently observe birds and identify them together with the instructor. The classes are supported by **educational materials, including a worksheet** and an identification key based on the presentation.

The event "**We Live on the Baltic Sea**" is intended for preschool children and focuses on **introducing them to the Baltic Sea and its inhabitants**. During the meeting, the educator talks about **Baltic crustaceans, fish, coastal birds, and marine mammals**, explaining **what makes the Baltic unique** and how it differs from rivers and lakes. Children learn about various species and their behaviors, supported by a multimedia presentation.

The session also **includes interactive elements such as role-playing to imitate animal movements, building a model of the sea together, and completing an educational worksheet**. The meeting concludes with a colorful quiz that checks the preschoolers' newly gained knowledge. Species presented during the class include the swan, duck, seagull, crab, shrimp, jellyfish, herring, cod, seal, and porpoise.

The event "**Colorful Life on the Coral Reef**" is designed for preschool children and introduces them to the vibrant world of coral reef animals. The **educator's storytelling is combined with short videos** showing organisms in their natural habitats, helping children understand what makes this environment so unique. Together with the educator, participants **create a coral reef ecosystem using magnetic animal images.** They solve riddles with the help of plush animals and take part in a fun math-based guessing game related to organism structure. The classes also include an **educational worksheet, and the meeting ends with a colorful quiz that checks what the children have learned.** Animals discussed during the session include the clownfish, starfish, seahorse, octopus, sharks, and sea turtle.

The event "**Extraordinary Inhabitants of the Ocean**" is intended for preschool children and focuses on **remarkable ocean animals whose names or appearances resemble everyday objects**. The meeting begins with an imaginative activity in which children "pack" items needed for a cruise across unknown seas and oceans. During this journey, they learn about **animals living in open waters, on the ocean floor, and among coastal coral reefs**. The **educator's story** is supported by a short **multimedia presentation**, helping children visualize these unusual creatures. Afterwards, the participants reinforce what they have learned through a **game** in which they search for animals whose names relate to familiar objects. Children also complete an educational worksheet. Species discussed during the class include the bottlenose dolphin, sea cucumber, manta ray, sponge, and sawfish.

The event "**Baltic Sea Up Close**" is intended for children in grades 1–3 and takes place **online in the form of a multimedia presentation**. Participants learn which **animals can be found on the beach and in the coastal waters of the Baltic Sea**. The **educator's story** is enriched with a **display of Baltic flora and fauna**, including specimens shown through a digital microscope, allowing children to observe marine life in greater detail.

The event "**Inhabitants of the Coral Reef**" is designed for children in grades 1–3 and is conducted online as a **multimedia presentation**. Participants learn fundamental information about **corals and discover a wide variety of animals that inhabit coral reefs**. The presentation is enriched with **demonstrations of real specimens,** some shown using a digital microscope, allowing children to explore reef life up close.

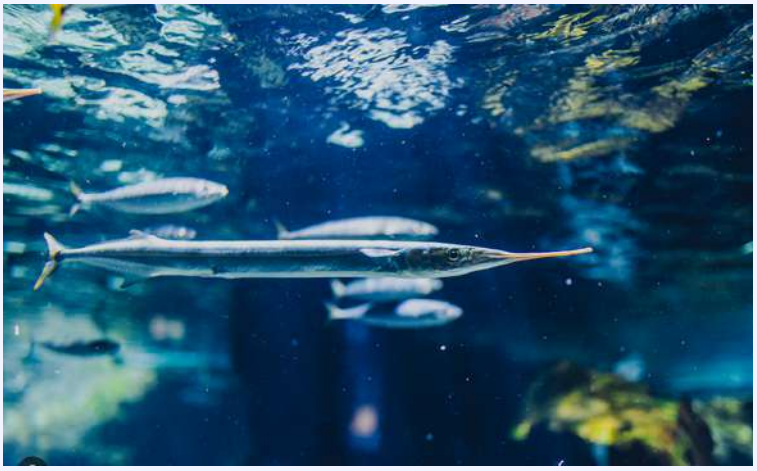
The event "**Kashubia on the Wave of 2024**" is intended for preschool children and students in grades 1–3. The classes enrich the Kashubian language curriculum by **introducing vocabulary related to natural sciences**, particularly the **fauna and flora of the Baltic Sea** —an environment that has significantly shaped Kashubian culture. Participants and teachers emphasize the uniqueness of these **interdisciplinary lessons**, which combine learning the regional language, exploring Baltic nature, and strengthening cultural identity.

The event "**Meeting with the Baltic Sea for Gdynia 2024**" is designed for preschool children and second-grade students and encourages interest in ecology and marine environment protection among Gdynia's youngest residents. It offers an opportunity to gain practical knowledge in marine biology, regional culture, and the biodiversity of the Baltic Sea.

The **Baltic context is explored through three exhibition rooms** at the Gdynia Aquarium: **Zostera Marina**, which introduces the ecosystem of the Inner Puck Bay—an area with the highest biodiversity along the Polish coast; **the Baltic Room**, which presents the unique features and environmental characteristics of the world's youngest and least saline sea; and **Cold Seas**, an educational path showing the connection between the Baltic Sea and the World Ocean.

Zoostera Marina - Source: Gdynia Aquarium

The Baltic room - Source: Gdynia Aquarium



Cold Seas - Source: Gdynia Aquarium

The event "**Meeting with Seabirds in Gdynia 2023**" is intended for preschool children and students in grades 1–3. As part of the "Gdynia Bird City" campaign, the activity begins at the Gdynia Aquarium and takes the form of an **educational walk**. Participants are introduced to the **avifauna of the Polish Baltic coast,** learning about bird characteristics, species diversity, and various methods of identifying species associated with the marine environment. The walk also covers information about the diets of gulls, ducks, and swans, along with guidelines for responsible feeding of waterfowl. Using binoculars, **children observe seabirds in their natural surroundings** and put their newly gained knowledge into practice. Together, the group explores the port area and the beach, discovering the seabirds that shape the everyday landscape of Gdynia.

The event "**Kashubia on the Wave 2023**" is designed for preschool children and students in grades 1–3 and offers a unique blend of nature and language education. During classes conducted in the regional Kashubian language, participants l**earn about the beauty of Baltic nature and the close relationship between the Kashubian community and its environment**. Lakes, forests, and especially the sea have strongly shaped Kashubian mentality, with fishing — alongside agriculture — serving as one of the community's traditional occupations.

The project aims to educate younger generations about this **cultural heritage while raising awareness of the threats that human activity poses to Baltic fauna and flora**.

The event "**From the Baltic to the Atlantic – Biodiversity, Climate, and the Impact of Human Activity**" is intended for preschool children and students in grades 2–3. It expands participants' knowledge of the **marine environment** through activities that go beyond the standard school curriculum. The classes help children understand the c**onnections between the ocean, climate, biodiversity, and human life**, emphasizing the importance of building environmental awareness from an early age.

The event "**Young Sea Explorers Club**" is designed for preschool children and students in grades 1–3. Membership in the club brings together young **enthusiasts fascinated by the underwater world** and offers them the opportunity to gain knowledge and hands-on experience. Participants take part in **dedicated educational games** and activities, and they also have a unique chance to learn more about the work of an aquarist, deepening their understanding of marine life and aquarium care.

As part of the activities related to OML, a series of educational activities focusing on marine and ocean literacy are carried out at **Wrocław Zoo**. The programme offered diverse forms of learning tailored to different age groups – from preschool children to primary school pupils – **and aimed to introduce participants to the richness of aquatic ecosystems, the importance of ocean biodiversity and the role humans play in protecting marine environments.** All activities combined i**nteractive workshops, observation, storytelling and the use of educational materials**, providing an engaging learning experience supported by the unique setting of the Afrykarium.

The activity **"Journey Through Africa"**, designed for **preschool children**, introduced the youngest participants to the natural diversity of the African continent, including its **coastal and marine habitats**. During the workshop, children took part in a **symbolic trip across Africa**, exploring the life of giraffes on the savannah, discovering how camels survive in the Sahara, and finally cooling off on the ocean shore, where they could listen to the characteristic calls of penguins. The session helped to develop curiosity, ecological awareness and a basic understanding of how ocean environments influence life on the African continent.

For pupils in grades 1–3, the workshop **"Sharks – the Terror of Seas and Oceans?"** focused on **debunking myths surrounding sharks** and presenting them as essential predators within marine ecosystems. Through a combination of **multimedia presentations, an engaging puppet theatre, educational props, worksheets, magnifying tools and shark models**, students learned how these fascinating fish live, what adaptations they possess and why their protection is crucial. An important part of the session is a guided visit to the **Mozambican Channel exhibition**, where pupils could directly observe marine species and better understand the functioning of ocean habitats.

The activity **"Journey Through Poland",** for pupils in grades 2–3, encouraged participants to explore the **natural beauty of Poland with particular attention to the Baltic Sea and its marine life.** During the workshop, students solved **maritime riddles and discovered which species inhabit the depths of Polish waters**. By opening specially prepared "mystery boxes," they uncovered various facts about native marine organisms. The workshop is supported by educational props, animal figurines and soft toys, as well as a multimedia presentation, ensuring a dynamic and engaging learning environment.

The workshop **"Do Pink Dolphins Really Exist?"**, prepared for pupils in grades 1–3, introduced participants to the fascinating world of whales and dolphins. During the session, conducted in the **educational room and dry walarium**, children explored the existence of pink dolphins, learned about anatomical and behavioural similarities between humans and cetaceans, and listened to **examples of underwater vocalisations that can be heard in the depths of the oceans**. The workshop also addressed the important question of why live cetaceans are not kept at Wrocław Zoo. The session incorporated **multimedia presentations, an audio listening experience, educational props and life-sized 1:1 models of whales**, offering a highly engaging and scientifically grounded learning environment.

Another key component of the programme was the **Polar Regions Conservation Campaign 2013–2015**, which targeted both preschool children and pupils in grades 1–3. The campaign, conducted from 1 October 2013 to 30 September 2015, focused on the **environmental challenges facing polar ecosystems**. It addressed issues related to climate change, the exploitation of polar areas and the protection of vulnerable species inhabiting the Arctic and Antarctic. The campaign highlighted several flagship species representing both poles: the polar bear, Arctic wolf, narwhal, reindeer and snowy owl for the Arctic, as well as krill, the crabeater seal, emperor penguin, leopard seal and sooty albatross for the Antarctic.

Through these examples, participants learned about the fragility of polar environments and the global importance of their conservation.

In addition to structured workshops, children from preschool groups and pupils from grades 1–3 took part in **demonstration feedings** organised during spring and summer 2024. These sessions allowed participants to observe the **feeding behaviours of various aquatic and semi-aquatic species, including harbour seals, African fur seals, the West Indian manatee, African penguins, piranhas and sharks.** The demonstrations provided an opportunity to **better understand the dietary needs, natural behaviours and ecological roles of these animals**, while giving children a dynamic and memorable experience connected directly with marine and aquatic life.

Source: https://zoo.wroclaw.pl/pawilony/afrykarium/

"**The Prince, the Dragon and the Golden Fish – Do Fairy-Tale Characters Really Exist**?"

This educational activity at the **Poznań Zoo** introduces **children to the world of fish, amphibians, and reptiles** by comparing the way these animals are **portrayed in fairy tales** with how they actually live in nature. During the lesson, participants explore familiar stories featuring princes, dragons, and magical fish, and then discover which elements of these tales are based on real animal traits and which belong to pure fantasy. The activity concludes with a **guided visit to the Cold-Blooded Animals Pavilion,** where children have the opportunity to observe living species up close, learn about their behaviour and adaptations, and better understand the difference between myth and reality. The programme is designed for preschool groups and students from Grades 1–3.

At the **Łódź Zoo**, a variety of educational activities invite children to explore the natural world in engaging and imaginative ways. "**Journey into the Ocean Depths**" takes participants on an underwater adventure into the **realm of coral reefs, highlighting their remarkable biodiversity.** During this activity, children **learn about corals, shrimp, sea urchins, and many extraordinary fish species, including venomous lionfish, mysterious moray eels, and spectacular sharks.** They discover the vibrant colours of the underwater world and find out why coral reef ecosystems—familiar from the stories of Dory and Nemo—require protection and care.

Another offering, "**Orientarium Up Close**," is a guided tour that introduces young visitors to the residents and remarkable stories of the Orientarium. Children learn who belongs to the team surrounding Alex the elephant, hear the dramatic tale of the crocodiles Kraken and Penelope, and discover why the sharks living in the exhibit do not attack other fish. The tour provides engaging **insights and brings participants closer to the daily lives of these fascinating animals**.

For older groups, the programme **"A Behind-the-Scenes Look at the Orientarium"** allows day-camp participants to experience the facility from the perspective of animal keepers. Children take part in selected **feeding demonstrations, visit backstage husbandry areas for species such as elephants and sharks, and join educational workshops.** The activity also includes a tour of the underground section of the Orientarium, an innovative pathway that shows how oceans are created and maintained. These programmes are designed for **preschool groups and students in Grades 1–3**, offering a rich blend of discovery, learning, and first-hand experience with the natural world.

At the **Warsaw Zoo**, children can take part in a range of educational activities designed to deepen their understanding of animals and their natural environments. During the "**Underwater Adventure**" programme, participants watch a **short multimedia presentation and explore hands-on educational materials such as shells, crustacean carapaces, and fish models**.

The activity continues with a **visit to the aquarium section,** where children **observe various species of fish and invertebrates and learn how these animals have adapted to life underwater.** This activity is suitable for preschool groups and students in Grades 1–3.

The zoo also offers thematic field games, such as "**Explorer Trails at the Warsaw Zoo,"** organised during special educational weeks like Biodiversity Days or Water Animals Week. Children follow **a route through the zoo using a worksheet that guides them to specific locations and challenges them with questions related to the theme**. The worksheet can be downloaded from the zoo's website or collected on-site, and participants who complete the route receive a small educational reward. This programme is designed for primary school children in Grades 1–3.

Another field game, **"Protecting Endangered Species,"** focuses on animals that require special conservation efforts. As they move through the zoo, participants **learn about species supported by conservation programmes, such as the lynx, the European pond turtle, and various birds of prey**. By solving tasks and answering questions on their worksheet, children discover how modern zoos contribute to the protection of threatened species. This activity is offered for preschool groups as well as students in Grades 1–3.

At the **Chorzów Zoo**, children can take part in a variety of educational programmes designed to expand their understanding of nature and the challenges facing today's environment. The activity **"Coral Reefs and Aquatic Ecosystems"** introduces participants to the fascinating world of aquatic organisms. During the session, children **learn about different types of water environments**—saltwater, freshwater, and brackish ecosystems—and the species that inhabit them. Particular attention is given to the **biodiversity of coral reefs and the complex relationships that connect their inhabitants.** This activity is available for preschool groups and students in Grades 1–3.

Another programme, "**From Pole to Pole,"** is inspired by an EAZA educational campaign focusing on **polar species and the threats they face due to climate change**. Through **multimedia materials, discussions, and observations,** children learn about iconic animals of the Arctic and Antarctic, including polar bears, walruses, reindeer, arctic foxes, penguins, seals, and various seabird species. The programme **highlights the impact of global warming on polar ecosystems and encourages young learners to reflect on how everyday actions influence the planet.** This activity is offered for preschool groups and for students in Grades 1–3.

The zoo also presents the activity **“Which Fish – What Kind of Fish?”,** based on another EAZA campaign aimed at raising awareness about **marine species and the importance of sustainable fishing practices**. Participants discover that many commonly consumed fish and seafood species are threatened by overfishing, habitat destruction, or unsustainable harvesting. The lesson explains **how consumer choices affect the future of marine life and introduces children to responsible seafood labels, conservation projects, and ways to protect ocean biodiversity**. This programme is intended for preschool children as well as students in Grades 1–3.

At the **Płock Zoo**, children can take part in the educational activity **“Underwater World,”** which introduces them to the **fascinating lives of fish from different parts of the globe.** During this session, participants discover the secrets of species such as **clownfish, piranhas, sharks, rays, and seahorses**. They learn about the unique adaptations, behaviours, and environments of these animals, gaining a deeper understanding of the diversity of aquatic life. The activity is designed for preschool groups as well as students in Grades 1–3.

At the **Kraków Zoo**, students can take part in educational programmes designed to enrich school learning and deepen their understanding of the animal world.

The activity **“Animals Connected to Aquatic Environments”** introduces participants to **species that live in or near water, including fish, frogs, caimans, waterbirds, otters, tapirs, and pygmy hippos**. Conducted on the zoo grounds in the **form of a lecture and discussion**, the programme expands students’ knowledge of diverse aquatic and semi-aquatic animals and their unique adaptations. It is intended for children in Grades 1–3.
Another programme, **“Residents of the Eozootarium – Fish, Amphibians, Reptiles,”** also takes the form of an **on-site lecture and guided discussion**. During the session, students l**earn about the biology, behaviour, and ecological roles of the species inhabiting the zoo’s Eozootarium,** including a variety of fish, amphibians, and reptiles. The aim of the activity is to **complement school lessons and provide students with a deeper understanding of cold-blooded animals**. This programme is likewise designed for students in Grades 1–3.

At the **Zamość Zoo**, children could participate in the Provincial Art Competition **“In the World of Seas and Oceans,”** organised on **8 June 2024 as part of the celebration of World Oceans Day**. During the competition, participants presented their **artistic interpretations of the mysteries of seas and oceans and the extraordinary creatures that inhabit them.** This activity was intended for preschool children as well as students in Grades 1–3.

7. BARRIERS AND CHALLENGES IN IMPLEMENTING MARINE AND OCEAN LITERACY

Implementing marine and ocean literacy in preschool education can face several barriers and challenges due to factors related to early childhood education or the broader educational system.

Marine and Ocean Literacy has been a concept introduced in the early 2000s and there has been increasing recognition of a range of additional dimensions which contribute to this concept (McKinley, et al, 2023) . These dimensions include **knowledge, communication, behaviour, awareness, attitudes, activism, emotional connection, access and experience, adaptive capacity and trust and transparency**. Considering these multi-dimensional concepts of ocean literacy, **educators challenge to find a way of including them to the educational curriculum** so that they could cover through all.

Recent studies conducted by Eidietis and Jewkes (2011), Boubonari, et al. (2013), McHugh et al. (2018). have **revealed several barriers lacking Marine and Ocean Literacy from the educational system**. The most commonly noted obstacle named by marine educators is the **overcrowded curriculum** (O'Brien, et al. 2023). Teachers are struggled to include new topics such as the ocean literacy by sacrificing other content.

Many educators reported discomfort in teaching specialized content due to insufficient background knowledge, making them hesitant to approach these subjects in depth. In addition, the **lack of familiarity or expertise in marine science topics** among teachers is also discussed in many studies (Freitas et al., 2022) as well as the difficulties **due to time limitations and the aging teaching workforce** in adopting new curricula. Many teachers expressed a **lack of time to develop new lessons** or undertake additional training to become more comfortable with marine topics. A practical challenge educators mentioned is that some schools **located further from coastal areas face difficulties in accessing marine environments for experiential learning**. This situation is becoming worse when one considers the **financial limitations that hinder field trips and the acquisition of resources**, essential for effective marine education.

Another barrier to integrating Marine and Ocean Literacy into teachers' professional development noted by Linsky (2012) was the **lack of funding**. This limited the number of teachers who could participate and led to program gaps in certain geographical regions.

Such **gaps in ocean-focused pedagogical training raise concerns**, as what students learn in the classroom, depends heavily on the alignment of the planned curriculum with the teacher's subject knowledge and experience (Gillan, 2011) However, this funding obstacle has eased somewhat with recent initiatives, such as **ProBleu**, **Blue Lights**, **SHORE**, and **Erasmus+ projects** which **encourage educational institutions to incorporate ocean literacy into activities** aligned with the EU Mission for Ocean and Waters.

Finally, **National and local educational standards in some countries often place limited emphasis on Marine and Ocean Literacy,** especially in early childhood curricula. This gap results in young children having **minimal exposure to foundational concepts of ocean ecology, conservation, and sustainability.** Consequently, the lack of structured support and prioritization for these topics means that **children miss early opportunities to develop an appreciation and understanding of marine ecosystems and their global importance** (Mogias et al., 2021). The challenge to implement Marine and Ocean Literacy in **formal or informal education settings** requires a step further, and this is the behaviour step: to change humanity's relationship with the ocean (O'Halloran et al., 2023).

Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean.

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8. FUTURE DIRECTIONS IN MARINE AND OCEAN LITERACY EDUCATION

Future directions in marine and ocean literacy education emphasize **integrating climate resilience, emotional well-being, and standardized metrics within educational frameworks**. Dewi et al. (2024) identify emerging topics such as **citizen science and sustainable development** as pivotal to advancing research and practice in ocean literacy. Their bibliometric analysis demonstrates a **growing emphasis on ocean literacy's role in environmental sustainability.** Similarly, Husna et al. (2024) highlight the **importance of linking ocean literacy with public health and climate adaptation strategies**, suggesting participatory approaches to engage communities effectively. Murray et al. (2023) emphasize **emotional resilience among young learners, proposing interactive coastal experiences to balance distress from ecological degradation with solution-oriented learning**. This dual approach supports mental well-being and fosters actionable optimism. Meanwhile, Ezgeta-Balić and Balić (2024) **advocate for revising national curricula to address gaps in ocean literacy principles, promoting interdisci-plinary and age-appropriate education.**

Freitas et al. (2022) emphasize **teacher professional development** as a cornerstone for embedding ocean literacy into primary education. They propose a **strategic focus on creating accessible educational resources and enhancing teachers' marine science knowledge.**

8.1. Integrating Ocean Literacy into School Curricula

To effectively integrate ocean literacy into school curricula, **schools can adopt interdisciplinary approaches, experiential learning models, and innovative teaching tools**. Dewi et al. (2024) emphasize incorporating emerging topics like sustainable development and citizen science into **science education to enhance students' understanding of ocean-related issues. Curricular frameworks should embed Ocean Literacy Principles** (OLPs) across multiple subjects, as Ezgeta-Balić and Balić (2024) highlight **gaps in textbook content** that can be addressed through collaboration between educators, scientists, and policymakers. **Interactive and experiential learning methods**, such as coastal field trips and digital simulations, are crucial for fostering engagement and emotional connection to marine environments.

Murray et al. (2023) show that **hands-on activities** can enhance students' emotional well-being and inspire solution-oriented thinking about marine conservation. Freitas et al. (2022) advocate for professional **development programs to equip teachers with the knowledge and resources needed to teach marine science effectively.** Additionally, **technology**-driven educational tools, such as **e-books and virtual reality** experiences, can make learning more interactive and appealing, particularly for digitally native students (McCauley et al., 2021). Aligning curriculum content with the United Nations Sustainable Development Goals (SDGs) can further promote awareness of global ocean challenges while encouraging local action. **These combined strategies ensure students develop a comprehensive understanding of the ocean's critical role in ecological and human systems.**

8.2. Teachers' Role in Promoting Ocean Literacy

Teachers play a pivotal role in advancing ocean literacy by integrating marine science into classroom curricula, fostering experiential learning opportunities, and modeling sustainable practices. They act as **knowledge brokers who translate complex ocean-related topics into accessible, age-appropriate content for students.**

Freitas et al. (2022) emphasize that **teachers are the arbiters** of whether marine science topics are included in lessons, making their training and access to resources critical for promoting ocean education. Professional development programs, such as **Project ISLE** highlighted by Linsky (2012), empower teachers with both scientific knowledge and pedagogical strategies, enabling them to present interdisciplinary content that connects ocean science with real-world issues like climate change and conservation. Teachers also **facilitate hands-on, immersive learning experiences, such as field trips and citizen science projects**, which Murray et al. (2023) show are vital for **fostering emotional connections to marine environments and promoting actionable optimism in students.** Additionally, teachers play a crucial role in **addressing students' emotional responses to marine issues**, such as anxiety about environmental degradation, by framing challenges in a solution-oriented manner. This approach helps students feel empowered rather than overwhelmed. Dewi et al. (2024) suggest that **teachers can also drive awareness of global ocean sustainability challenges** by aligning lessons with frameworks like the UN Sustainable Development Goals

Ultimately, **teachers are not only educators but also mentors** who inspire students to value and protect marine ecosystems through informed decision-making and stewardship. **Teachers can design interdisciplinary lessons about ocean literacy** by integrating content from science, geography, mathematics, language arts, and social studies, making connections between marine science and broader environmental, cultural, and economic contexts. For example, Freitas et al. (2022) highlight the importance of **linking ocean literacy principles** (OLPs) to various subjects in the curriculum, such as using **marine biology to teach ecological systems in science or exploring ocean-related issues like climate change in geography**. Project-based learning (PBL) can be a powerful tool for integrating multiple disciplines. Murray et al. (2023) **recommend incorporating real-world issues into lessons**, such as designing projects where students analyze the impact of plastic pollution on marine ecosystems. This approach can include mathematical data analysis, persuasive writing assignments, and even art projects focused on raising awareness. Linsky (2012) emphasizes that **teachers should use local and cultural contexts** to create meaningful, relatable content. For instance, incorporating indigenous knowledge about marine ecosystems or regional conservation efforts into lessons fosters both cultural relevance and interdisciplinary learning.

Additionally, Dewi et al. (2024) suggest using technological tools like virtual reality to simulate underwater exploration, integrating science and technology, while encouraging collaboration with other educators to co-develop interdisciplinary units (Dewi et al., 2024). Such collaborative efforts can enrich lessons, ensure curriculum alignment, and make ocean literacy a more dynamic, cross-curricular experience.

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9. CONCLUSIONS AND RECOMMENDATIONS (GAPS AND CHALLENGES)

Despite the progress in promoting ocean literacy, significant challenges remain. **One primary obstacle is the lack of specialized training for educators**, compounded by a high percentage of aging teachers in Portugal, which limits the adoption of new educational practices. Additionally, the **integration of marine topics into curricula is often hindered by a lack of interdisciplinary collaboration, time constraints, and limited resources** (Barracosa et al, 2019; Correia, 2020; Caldas, 2021). Those autors emphasize the importance of **continued professional development and partnerships with research institutions** to bridge these gaps and facilitate the effective teaching of ocean literacy. Several challenges in integrating Ocean Literacy into education have been highlighted by various authors:

- the **lack of a clear connection with school curricula** (Fauville, 2018)
- overly **fragmented curricular programs** spread across multiple subjects;
- **limited time in the standard curriculum**, which discourages extracurricular activities (Barracosa et al, 2019)
- the **absence of a national strategic education plan specifically for OL**, as identified by Portuguese teachers (Fauville, 2018);
- a **weak tradition of interdisciplinary projects** and limited opportunities for collaborative work among educators (Barracosa et al, 2019).

Additionally, **teachers' insecurities due to a lack of awareness and knowledge about ocean topics** have been noted as obstacles to implementing OL in classrooms across various countries (Fauville, 2018; Castle, 2010). There is a recognized **need for scientific support for teachers and schools to better understand ocean issues** and effectively incorporate OL, which could help them teach more efficiently. The main obstacles to the inclusion of OL in the Portuguese school is the **overly fragmented curricular program by many disciplines**, the length of the ordinary curricular program that does not encourage extra-curricular activities, the weak tradition of interdisciplinary project development as well as the lack of conditions for collaborative work among teachers (OECD, 2018a).

This is particularly relevant because **ocean problems are complex and require transdisciplinary approaches**.

In addition, the Portuguese educational system based on national exams to access higher education at universities exerts a pressure on teachers, students and families, for whom the main objective is to prepare the students for the exams, **promoting a general standardization of school education**. However, important reforms have been recently introduced, which may provide an opportunity for the inclusion of OL in the standard curriculum.

Specifically for early childhood education UNESCO (2022) refers:

- **Lack of Specialized Training for Educators**: one of the major gaps is the **limited training available for educators in ocean literacy**. Many teachers lack specific knowledge of marine topics, which can lead to low confidence in delivering content effectively.
- **Insufficient Resources and Materials:** early childhood education often **lacks age-appropriate, hands-on materials that introduce young children to ocean concepts** in an engaging way. Resources are crucial for sensory-based and interactive learning methods suited to young learners.
- **Regional Disparities in Implementation:** access to ocean literacy programs can **vary significantly by region.** Coastal areas may have more opportunities and resources than inland regions, leading to disparities in children's exposure to marine topics.
- **Curricular Limitations:** ocean literacy topics a**re not always integrated into the national curriculum**, making it challenging to include these themes consistently across different schools and early education settings.

OPPORTUNITIES

• **Expanding Programs like Escola Azul and REASE:** the Escola Azul and REASE **initiative offers a strong model for integrating marine literacy** and could be scaled further to include more early childhood centers, not just primary and secondary schools.

- **Community Involvement and Partnerships:** collaborations with **marine research centres, aquariums, and local environmental organizations** can provide valuable resources and learning experiences for children, such as field trips and interactive workshops.
- **Development of Teacher Training Programs:** s**pecialized training in ocean literacy for early childhood educators** would empower them with the skills and confidence needed to teach marine topics effectively.
- **Integration of Ocean Literacy in Early Education Policies: embedding Ocean literacy into national educational standards** and early childhood policies would ensure more uniform access to marine education across regions and age groups.

These gaps and opportunities **underscore the importance of targeted investment in resources, training, and policy to build a robust foundation for ocean literacy** in early childhood education in Portugal.

Provide **insights and recommendations for improving curriculum development, teacher training, and educational practices** related to Marine and Ocean Literacy in early childhood education.

1. INSIGHT: **NEED FOR SPECIALIZED TRAINING FOR EDUCATORS**
Recommendation: Develop and implement s**pecialized training programs for early childhood educators focused on ocean literacy**. These programs should cover **essential marine science topics, pedagogical strategies for young learners, and confidence-building techniques** for teaching complex environmental themes. Providing teachers with **targeted training and professional development opportunities** will enhance their ability to deliver ocean literacy content effectively, creating a knowledgeable and motivated teaching workforce.

2. INSIGHT: **INSUFFICIENT RESOURCES AND MATERIALS FOR ENGAGING YOUNG LEARNERS**
Recommendation: Invest in the development and distribution of age-appropriate, hands-on educational materials that bring ocean concepts to life for young children.

These **resources should support sensory-based and interactive learning,** making abstract ocean concepts tangible and engaging. Creating a **national repository of resources**, accessible to all early childhood centers, can ensure that teachers have the tools needed to foster curiosity and understanding about the ocean from an early age.

3. INSIGHT: **REGIONAL DISPARITIES IN ACCESS TO OCEAN LITERACY PROGRAMS**
Recommendation: Establish **initiatives to promote equitable access to ocean literacy programs** across all regions, including in land areas. This could involve **partnerships with local organizations, mobile educational units, or virtual learning platforms** to bridge the gap for schools located far from coastal resources. Ensuring that **all children, regardless of location, have access to high-quality marine education** can help cultivate a widespread culture of ocean stewardship.

4. INSIGHT: **INCONSISTENT INTEGRATION OF OCEAN LITERACY IN THE NATIONAL CURRICULUM**
Recommendation: Advocate for the **formal integration of ocean literacy into Portugal's national curriculum for early childhood education**. This integration would standardize ocean literacy content across schools, ensuring consistent exposure to marine topics and fostering early environmental awareness.

By embedding ocean literacy within national educational standards, **schools can align their efforts to build a foundation of ocean knowledge** that progresses through all levels of education.

5. INSIGHT: **OPPORTUNITIES FOR EXPANDING SUCCESSFUL PROGRAMS LIKE ESCOLA AZUL OR REASE**

Recommendation: Scale up the Escola Azul (national level) or REASE (regional level, coastal zones) program to reach more early childhood centers, expanding beyond primary and secondary schools. **By adapting the program's framework for younger age groups**, those kinds of initiatives could help to introduce ocean literacy at earlier stages of education, laying the groundwork for continuous learning. This expansion could **include tailored activities, resources, and teacher support** specifically designed for early childhood education.

6. INSIGHT: **POTENTIAL OF COMMUNITY INVOLVEMENT AND PARTNERSHIPS FOR ENRICHING LEARNING EXPERIENCES**

Recommendation: Strengthen partnerships with marine research centers, aquariums, and environmental organizations to provide interactive and experiential learning opportunities for young children. Such collaborations could **facilitate field trips, workshops, and guest speakers, making ocean concepts more relatable and vivid.** These community connections can also help instill a sense of responsibility and connection to local marine environments.

7. Insight: **Importance of Integrating Ocean Literacy in Early Childhood Education Policies**

Recommendation: Encourage policymakers to formally include ocean literacy in early childhood education policies. This policy-level support would ensure uniform access to ocean literacy across regions, **guiding schools to include marine topics in their curricula.** Policy backing can also open doors to d**edicated funding and resources, supporting the long-term sustainability** of ocean literacy initiatives.

By addressing these insights and implementing the recommendations, Portugal can create a **robust framework for ocean literacy in early childhood education,** fostering a generation that values and protects marine ecosystems.

Several challenges remain in consistently integrating MOL into early childhood curricula **in Cyprus**. **Urbanization and limited access to coastal areas restrict opportunities for children to directly interact with the ocean**. Furthermore, there is a need for more comprehensive educational resources and teacher training programs focused on marine science (UNESCO, 2020).

Efforts to address these challenges include **developing educational materials tailored to young learners, providing professional development for educators, and fostering collaborations between schools and marine organizations.** These measures are essential for creating a more ocean-literate society that understands the critical role of marine environments in sustaining life on Earth (Ryan, 2021).

GAPS

The integration of Marine and Ocean Literacy into the curriculum in Cyprus is inconsistent, and there is a **lack of age-appropriate educational materials tailored to Cyprus's marine ecosystems.** Additionally, many educators lack training in marine science, hindering effective teaching (UNESCO, 2020; Ryan, 2021; Reid & Strathairn, 2024).

CHALLENGES

Urbanization limits children's direct access to marine environments, reducing experiential learning opportunities. Limited funding for MOL initiatives hampers the development of educational programs and resources. Furthermore, **there is a need for greater public awareness and community support for marine conservation** (Friedlander, 2018; UNESCO, 2020; Ryan, 2021).

OPPORTUNITIES

Developing comprehensive, context-**specific educational resources and enhancing teacher training** can significantly improve MOL education. Strengthening **collaborations between schools, marine organizations, and the community** can provide valuable experiential learning opportunities. **Advocacy for stronger policy support can ensure MOL is prioritized in educational frameworks** (Springer, 2021; Reid & Strathairn, 2024; UNESCO, 2020).

By addressing these gaps and challenges, **Cyprus can enhance Marine and Ocean Literacy education, fostering a generation of ocean-literate individuals who value** and protect marine environments. Provide insights and recommendations for improving curriculum development, teacher training, and educational practices related to Marine and Ocean Literacy in early childhood education.

CURRICULUM DEVELOPMENT

Integrate marine science into various subjects like science and geography to provide a holistic understanding of the ocean's importance (UNESCO, 2020). Develop engaging, **age-appropriate materials**, such as picture books and **interactive digital content,** tailored to Cyprus's local context (Springer, 2021; Ryan, 2021).

TEACHER TRAINING

Implement comprehensive **training programs focusing on marine science and effective teaching strategies.** Provide ongoing support through access to updated resources and professional learning communities (Reid & Strathairn, 2024; UNESCO, 2020).

EDUCATIONAL PRACTICES

Promote **hands-on activities such as beach clean-ups and aquarium visits** to connect theoretical knowledge with real-world experiences (Friedlander, 2018). Strengthen collaborations between schools, marine organizations, and the community to enhance educational impact and promote environmental stewardship (Ryan, 2021).

Marine and Ocean Literacy is increasingly recognized as an **essential component of early childhood education** in Cyprus. Integrating MOL into the curriculum helps **young learners develop a foundational understanding of the ocean's significance, its biodiversity, and the impact of human activities on marine environments**. Despite the progress made, there are still gaps and challenges, such as inconsistent curriculum integration, limited educational resources, and insufficient teacher training.

Effective pedagogical strategies, including inquiry-based learning, experiential activities, and the use of multimedia resources, have shown promise in engaging young children and fostering a deeper connection to marine science. Initiatives at national, state, and local levels, such as the inclusion of marine topics in the national curriculum and collaborations with local marine organizations, have played a significant role in advancing MOL education. **Addressing the identified gaps and challenges requires a concerted effort to develop comprehensive educational materials, enhance teacher training, and secure policy support and funding.** Strengthening community and stakeholder engagement can also provide valuable experiential learning opportunities and foster a culture of environmental stewardship. By leveraging these opportunities and implementing the recommended strategies, **Cyprus can significantly enhance Marine and Ocean Literacy education, cultivating a generation of ocean-literate individuals committed to the conservation and protection of marine environments.**

In Poland, however, OML **remains insufficiently integrated into education** — particularly at the preschool and early primary levels — despite growing global emphasis on ocean literacy promoted by UNESCO (Santoro et al., 2017) and the EU4Ocean initiative (Zieliński, Kotyńska-Zielińska & Garcia-Soto, 2022). **Countries with long-standing maritime cultures, such as Cyprus, Greece, and Portugal, offer valuable models and practices that can help Poland accelerate progress in this field.**

Poland's challenges begin with limited public awareness of marine ecosystems, especially the Baltic Sea, which is one of the world's most vulnerable semi-enclosed seas (HELCOM, 2021). Studies show that **Polish society lacks understanding of marine biodiversity, ocean processes, and human impacts on the marine environment** (Węsławski et al., 2018). **This lack of awareness is reflected in early education, where ocean-related content is almost absent from the national curriculum**. While preschool and early primary education introduce basic environmental concepts, **these focus predominantly on forests, meadows, and terrestrial animals, with very few references to marine ecosystems** (Sobczyk, 2017). Consequently, **children grow up with minimal exposure to the Baltic Sea's ecological role and the ways oceans influence climate, weather, biodiversity, and human society** (McKinley & Fletcher, 2020).

Teacher **preparedness is another barrier.** Many educators **do not feel confident teaching ocean-related topics due to limited training, insufficient resources, and lack of age-appropriate materials**. This challenge is well documented in early childhood environmental education research, showing that teachers require specific pedagogical tools to translate scientific concepts into developmentally appropriate learning (Wilson, 1994; Harlen & Qualter, 2014). Without such support, **ocean-related themes are often introduced through purely imaginary or decorative narratives, disconnected from ecology or climate science.**

Geographical distance also plays a role. Most Polish children live far from the coast and **have limited opportunities to engage directly with marine environments**. Yet environmental psychology and early childhood studies emphasise that direct or sensory engagement with nature is essential for building ecological empathy (Pramling Samuelsson & Asplund Carlsson, 2008; DeBoer, 2019). The lack of experiential opportunities in Poland further widens the gap between children and marine ecosystems.

Despite these limitations, **Poland has substantial opportunities to strengthen OML from early childhood onward**. Young children learn best through sensory exploration, hands-on experiments, and guided play—methods that align naturally with marine themes (Wilson, 1994; Harlen & Qualter, 2014).

Activities such as experimenting with saltwater, exploring buoyancy, observing shells, or identifying Baltic species can foster curiosity and foundational understanding. Digital tools — including virtual underwater tours, animated stories, and interactive games—can overcome geographical barriers, making marine learning accessible nationwide (Fauville et al., 2021).

Drawing from Greece, Portugal or Cyprus, **Poland could adopt a multi-layered approach that incorporates curriculum integration, teacher training, outdoor learning, digital resources, and cultural storytelling**. Partnerships among preschools, primary schools, scientific institutions, NGOs, and local governments — already common in Portugal and Greece — could significantly expand OML's reach and impact.

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10. SUMMARY

Generalizing all the aspects related to maritime awareness indicated in the report, based on the identified educational gaps and looking at the educational challenges, it should be stated in summary that to increase marine and ocean literacy and foster greater awareness of the importance of oceans, a comprehensive approach is required across multiple levels of society. **Education plays a pivotal role in this process**. **It is essential to integrate marine topics into school curricula by embedding them in subjects such as biology, geography, and environmental studies.** Interdisciplinary projects should be encouraged to connect different fields of knowledge, and specialized training should be offered to teachers to enhance their ability to deliver ocean-related content effectively. Additionally, **developing age-appropriate and engaging educational materials, such as books, films, apps, and experimental kits, can make learning about the ocean more appealing and accessible to students**. Non-formal education and public awareness campaigns are equally important. Organizing practical workshops, such as beach clean-ups, aquarium visits, or hands-on activities focused on marine conservation, can provide engaging learning opportunities.

Public campaigns, both in traditional media and on social platforms, can raise awareness about marine issues. **Hosting thematic events**, like "Ocean Day," can further **involve local communities in activities that promote ocean literacy**. **Collaboration with local communities and organizations is another key strategy**. Partnerships with research institutions, aquariums, national parks, and NGOs can help create impactful educational programs. Engaging local stakeholders, including fishermen and businesses related to the sea, ensures that diverse perspectives contribute to awareness-raising efforts. Promoting sustainable practices, such as responsible fishing and biodiversity protection, can also reinforce the importance of marine conservation. **Government policies and support are critical to sustaining MOL initiatives.** National strategies should prioritize marine and ocean literacy, incorporating it into educational policies and curricula. Governments can provide funding and grants to support programs, research, and activities that enhance public understanding of marine environments. Collaboration with international organizations like UNESCO can also help align national efforts with global ocean literacy goals.

Technology and media play a significant role in reaching wider audiences. Interactive digital tools, such as apps and virtual reality experiences, can provide **innovative ways to explore marine ecosystems**. Producing educational videos and documentaries can highlight the beauty and challenges of marine environments, while social media campaigns can effectively engage younger audiences with concise and visually appealing content. **Experiential learning is particularly impactful in promoting MOL**. Field trips to coastal areas, ports, islands, or marine reserves provide direct interaction with marine ecosystems, fostering a deeper connection to the ocean. Citizen science projects, such as monitoring water quality or identifying marine species, empower individuals to actively contribute to conservation efforts. **Promoting sustainable practices** and encouraging informed daily choices are also essential. Educating people about the environmental impact of their actions, such as reducing plastic use or choosing sustainable seafood, can have a significant effect on marine conservation. Local initiatives aimed at protecting nearby ecosystems can further connect communities with the ocean and its importance.

NETX STEP FOR THE TEACHBLUE PROJECT

To support teachers educating young children in preschools and early primary schools (grades 1–3), it is **essential to provide educational materials that are engaging, age-appropriate, and aligned with their cognitive abilities.** These resources should include **practical guides, interactive tools, and creative activities.**

Teacher guides are a crucial resource, offering **lesson plans on marine topics** such as “Life in the Ocean,” “Why Water is Important,” and “How to Protect Oceans.” These guides should also include suggestions for **playful and physical activities,** like mimicking the movements of sea creatures or creating “wave dances,” as well as discussion prompts and visual aids that help explain ocean concepts. Worksheets and coloring pages are excellent tools for young learners, featuring creative tasks such as drawing marine creatures, coloring coral reefs, solving simple puzzles, and completing mazes with ocean themes. These activities can foster observational skills and creativity while reinforcing the subject matter. **Educational posters and charts can visually introduce marine ecosystems, biodiversity, and the water cycle.** Posters showcasing ocean animals, coral reefs, or deep-sea habitats can serve as both teaching aids and classroom decorations, creating a stimulating learning environment.

Storybooks and **thematic tales** are engaging ways to teach about oceans. Stories featuring relatable marine characters, such as a curious crab or a lost jellyfish, can convey lessons about marine life and environmental protection. Illustrated books can bring these tales to life, captivating young learners. **Experimental kits and sensory activities** allow children to explore concepts hands-on. Simple experiments, such as understanding buoyancy or the salinity of seawater, can be paired with sensory materials like shells, sand, or small marine models to spark curiosity and tactile learning. **Interactive multimedia tools, including short educational videos**, songs, and rhymes about the ocean, can capture children's attention while teaching key concepts. Digital games and applications on tablets or interactive boards can offer activities such as identifying marine animals or learning about ocean habitats in a playful, engaging way. **Group games and play-based learning activities are also effective.** Teachers can organize games like "Marine Memory," where children match pictures of ocean animals, or role-playing exercises where they pretend to be different sea creatures.
Movement-based activities, such as "Escape the Wave," can incorporate physical activity while teaching about marine environments.

Teachers also need informative resources to build their own understanding of marine topics. Simplified explanations of scientific concepts like ocean currents, ecosystems, or marine biodiversity, as well as interesting facts about oceans, can equip educators with the knowledge they need to answer questions and inspire curiosity. Support for class projects is another valuable resource. Teachers can guide children in creating projects such as "My Dream Ocean" or celebrating an "Ocean Protection Day." Materials like templates for posters, charts for group discussions, or instructions for art projects can simplify project implementation. Additional resources include visual aids, such as marine animal models, ocean photographs, or tactile props, as well as art supplies, like paints and paper, for creative activities. **Educational puzzles and games with marine themes can further enhance learning in a fun and interactive way**. These materials should be designed to inspire children through play, creativity, and hands-on exploration, making the learning process enjoyable and effective. **By incorporating these tools into their teaching, educators can foster an early appreciation for the ocean and its importance, creating a strong foundation for environmental awareness.**

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