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SEAQUEST

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1. Executive Summary

The SEAQUEST initiative— Seagrass Education for children towards Awareness Quotient for Environmental Sustainability — promotes ocean literacy at the primary education level through the tangible, place-based prism of seagrass habitats. This State-of-the-Art Report (WP2) synthesizes both European policy and literary review and new cross-nation field research to provide a solid foundation for seagrass literacy in schools and to guide the development of the SEAQUEST teaching resources and advocacy of policy. It extends over Greece, Cyprus, Belgium, Denmark, and Portugal, tracing seagrass science, seagrass education, and seagrass policy to where it has gone and where it has yet to go.

Seagrass meadows—vitally essential for biodiversity, coast protection, freshwater quality, and blue-carbon sequestration—are hardly referred to in primary programs or coursebooks. Educators tend to be environmentally qualified and experienced but do not receive specialized training in marine and even less in seagrass ecosystems. This structural incompatibility—high ecological value but low course coverage—results in an overarching capacity shortfall at the classroom scale. The fieldwork carried out in SEAQUEST complements this scene with analogous survey and focus-group evidence in four partner nations.

In Greece, most primary teachers taught environmental education, but 70% report not knowing seagrasses, 77.5% rate knowledge of ecosystem services as none or little, and 85% have never taught the subject. Little previous use of seagrass learning materials for training is reported by teacher educators, although they positively prefer experiential, field-based, and online methods and exhibit high willingness to upskill. Researchers name core ecosystem services and advantages of digital resources, but highlight curricular gap, limited school–university cooperation, and scarce resources. Cyprus presents positive dispositions and a sound core of knowledge from researchers, with teacher educators reporting at least elementary seagrass familiarity.

Practice in the classrooms is uneven: primary teachers often do not teach seagrass at all, and inclusion is poor. Interviewees agree on what most desire: pre-planned lesson plans, professional training geared to their needs, exposure to marine professionals and NGOs, and financing for school field trips and in-field research. Learning style is remarkably homogeneous—fieldwork, inquiry learning, games, and video training—whereas technology acts merely as a supporting pace setter rather than an experienced replacement. Belgium presents an entirely different type of difficulty: institutional lethargy and questionnaire fatigue took major tolls on sample sizes for stakeholder groups.

The single teacher and principal survey shows administrative pressure, congestion of the curriculum, and low perceived relevance all function as gatekeepers which hold back new subject take-up. As there are no longer any natural seagrass beds within Belgian waters today, the most sensible entry point is

to encompass seagrass as a background with which children can be taught habitats, human impacts, and coastal management within the context of typical outdoor "sea classes" and coastal education centers and draw in with strand material washed up and with local North Sea restoration stories rather than following with a stand-alone seagrass strand throughout the curriculum. Portugal enjoys highly experienced teachers with much stronger environmental engagement but weak marine specialism.

Very large proportions of teachers highly value marine/seagrass literacy but do not teach it to over half. Classroom activity is dominated by videos and hands-on materials and teachers require partnership with scientists, PD, and field-trip facilitation. Teacher educators indicate fairly higher awareness of seagrass and support practical workshops and study tours; researchers agree seagrass features too little in primary curricula though there is extensive research experience at the scholar level. Individually, and collectively in aggregate across the 12 interview groups and the 12 foci, the findings imply increased national capacity building readiness if appropriate resources and frameworks exist. Focus-group interview with 10–12-year-olds in each of the four nations indicates strong interest, strong sensory involvement with the sea, and ready identification of seagrass as shelter and nursery with widespread misconceptions (above all confusion with the less complex related species seaweed) and incomplete systems knowledge.

Children always prefer experiential learning—field trips, at places where it makes sense, scientist-guided experiences—and to some degree, highly immersive digital media such as VR. The results recommend dual-track pedagogy blending place-based, inquiry-experiential with inclusive digital experiences and robust conceptual scaffolding. Together, the results imply AIDA : SEAQUEST's achievable agenda.

First, create curriculum-matched plug-and-play classroom materials that directly redress widespread misconceptions and give seagrass ecological services center billing. Second, invest in teacher capacity with modular PD blending core marine science, age-grade pedagogy, and assessment-ready activities. Third, create school-expert partnerships that grant access to the field, citizen-science involvement, and possibilities for co-teaching, and provide substitutes where fieldwork is ruled out. Fourth, enrich the role of experiential learning with digital augmentation—games, simulation, and VR—to round out access and sustain interest. Finally, take action at the policy levels to move ocean content into adaptive curricular architectures such that seagrass becomes an in-context living laboratory for science, geography, citizenship, and sustainability. This report thus places seagrass literacy on the agenda as an opportune time-sensitive, high-leverage entryway for the construction of Europe's blue curriculum. By putting strong marine science in the hands of the classroom teacher through training teachers and seizing policy windows opened by the Ocean Decade, SEAQUEST can stimulate coherent, scalable take-up across many systems. Outputs go directly to the project's Educational Toolkit and interactive

education materials and provide the unambiguous basis for national and regional recommendations embracing the scientific knowledge, the schooling reality, and European children's everyday living near the coast.

2. Introduction

The SEAQUEST project (Seagrass Education for children towards Awareness Quotient for Environmental Sustainability) aims to bridge an important knowledge gap in European environmental education—the absence of seagrass literacy in the primary curriculum. Seagrasses are large marine flowering plants that create extensive underwater meadows and hold pivotal importance in providing for biodiversity, shore stability, filtration of waters, and sequestration of carbon. With their ecological importance and tangible relevance to climate resilience and sustainable development, such ecosystems remain invisible in the conventional education space. Children across Europe learn about forests and rainforests much earlier than seagrass meadows—if at all. SEAQUEST aims at reversing the picture by incorporating seagrass as the gateway to the development of ocean literacy, environmental empathy, and pro-sustainability orientations at an early age.

The State of the Art Report has been produced by Work Package 2 (WP2) with lead organization STANDO LTD and provides the project's pedagogic tool kit and teachers' guidance material foundations in the science, the pedagogy, and the policy. It integrates two parallel lines of work:

1. Desk research, tracing the presence of seagrass and marine literacy concerns in the European and member states' schooling systems, tracing appropriate frameworks, policies, and pedagogies;
2. Field research, empirical data collection among educators in schools/VET schools in Greece, Cyprus, Belgium, and Portugal in order to question prevailing knowledge, perceptions, and approaches to education regarding seagrass and sea ecosystems.

The field work used a standardized mixed-methods design adopted by all the consortium partners. Quantitative data collected involved the use of three online questionnaires among (a) primary teachers, (b) teacher/VET trainers, and (c) researchers/larger-education lecturers. Partners tried to register at least 30 teachers, 10 VET teachers, and 10 researchers. The qualitative data were then produced through the use of focus groups with 6–10 children aged 10–12 years old selected from primary schools in the following manner: semi-structured settings and visual prompts used to capture the awareness, attitude, and imagination of children regarding seagrass ecosystems. This format made it possible to compare across the countries while permitting contextual detail in interpretation.

General objectives of this report are to:

- Clarify the status today of seagrass literacy in primary schooling in European countries;
- To identify knowledge lacunas, misconceptions, and the needs of teachers' professional
- Learn children's knowledge and emotional bonding with the sea environment;
- Identify national deterrents and avenues for curriculum infusion; and
- Form evidence-informed recommendations in terms of education resources, teacher training, and policy coordination.

Findings report the similar picture throughout all Europe: teachers report strong motivation and awareness concerning the environment but no formal training in pedagogic support and institutional equipment for incorporating marine or seagrass themes in their own teaching. Relevance in curricula is weak with seagrass not featured at all in national curricula for schools. Teacher educators call for experiences and interdisciplinary approaches but mention the necessity of balanced modules, cooperation among specialists, and easily accessed materials. Researchers refer to disconnects in systems between science knowledge and classroom practices. Meanwhile, students report strong enthusiasm, creativity, and emotional concern with marine animals but misconstrued in their knowledge regarding seagrass with them commonly picturing it as seaweed and having no idea at all about the functions of seagrass in ecosystems.

Through documenting such trends, the SEAQUEST State of the Art Report provides an agenda for action. It uncovers leverage points for embedding marine and seagrass literacy in all school curricula and teacher education programs and non-formal learning pathways. It makes the seagrass finally an effective learning resource for the acquisition of ecological empathy, systems thinking, and sustainable habit among Europe's youngest citizens—an uncommon contribution to the UN Decade of Ocean Science for Sustainable Development (2021–2030) and the agenda for education in the EU Green Deal.

3. Methodology

The SEAQUEST State of the Art Report methodological design was developed to provide a coherent, evidence-based conceptualization of seagrass literacy within European primary education. It combined desk research with field research across all the partner nations—Greece, Cyprus, Belgium, Denmark and Portugal—to provide both a conceptual and empirical foundation for the educational outputs of the project going forward. The research adopted a comparative mixed-methods design, which enabled cross-national consistency but also allowed each partner to place findings within their own local educational, environmental, and cultural contexts.

3.1. Research Design

Two fundamental phases were used in the approach:

1. Desk Research – Plotting national education systems, policy documents, and curricula to identify the inclusion—or absence—of marine and seagrass topics in primary education. Analysis reviewed academic literature, environmental education guidelines, teacher education programs, and national or regional agendas for ocean literacy and sustainability.
2. Field Research – The collection of primary data from selected stakeholder groups (educators, trainers, researchers, and children) through facilitated focus groups and surveys. The purpose of this phase is to establish current knowledge levels, teaching practices, attitudes, and perceived barriers to the integration of seagrass and marine ecosystems into education.

The fieldwork was directed by a shared protocol elaborated collectively by all partners under STANDO LTD's coordination. This assured methodological coherence, comparability across countries, and the integration of diverse educational expertise.

3.2. Data Collection Tools

3.2.1. Surveys

Three structured online surveys were implemented in every country via Google Forms, targeting the subsequent stakeholder groups:

- Primary School Teachers: to examine their awareness, knowledge, and practices regarding marine and seagrass literacy.
- Teacher Educators and VET Trainers: in order to ascertain how environmental and marine education is addressed in teacher education courses and to identify professional development needs.
- Researchers and University Lecturers: to understand the academic perspective of seagrass ecosystems, any existing outreach programs, and the extent of liaison between research institutions and schools.

Each questionnaire included a combination of closed-ended and open-ended questions addressing knowledge levels, teaching frequency, pedagogical resources, resource needs, and perceived challenges. Quantitative data were analyzed with descriptive statistics, and qualitative responses were coded thematically to uncover repeating patterns and insights.

3.2.2. Focus Groups

A single focus group in each partner country was conducted with 6–10 children within the 10–12 year

age bracket. Sessions were semi-structured and used storytelling, images, and guided discussion to elicit children's conceptual understanding of marine ecosystems, their affective connection with the sea, and their identification of human impacts. Activities were designed to promote imagination, empathy, and open expression while eliciting qualitative data on attitudes and conceptual awareness in students.

Parental consent and school authorization were obtained for all focus groups. The sessions were held in child-friendly, comfortable settings, e.g., school libraries or classrooms, and lasted approximately 45–60 minutes.

3.3. Sampling and Participation

A minimum of 30 primary school teachers, 10 VET teachers, and 10 researchers per country were aimed for, achieving a representative spread across sectors. Children were enlisted from partner schools and participated voluntarily.

- Greece: Questionnaires were completed by 40 primary teachers, 11 VET teachers, and 17 researchers. Two focus groups comprised 31 students.
- Cyprus: 32 teachers, 11 VET teachers, and 10 researchers participated, along with one focus group of 20 students.
- Belgium: Despite extensive distribution to over 800 schools and 30 institutions, there was minimal response due to systemic barriers; however, qualitative returns from the small number of respondents and focus group discussions provided insight rich context on institutional participation barriers.
- Portugal: Questionnaires engaged 39 teachers, 10 VET teachers, and 17 researchers, while two focus groups engaged 29 children.

This extensive and diverse involvement ensured a multi-perspective, multi-level data set balancing classroom realities, teacher training experiences, academic insights, and student views.

3.4. Data Analysis

We employed a mixed-method analytical strategy:

- Quantitative data were subjected to descriptive analysis to summarize frequency distributions, mean responses, and percentages of key indicators such as knowledge levels, materials use, and barriers.
- Qualitative data from open-ended survey questions and focus group transcripts were thematically analyzed, yielding recurring categories such as motivation, misconceptions, preferred pedagogical methods, and structural obstacles.

Cross-national comparison became possible by an integrative synthesis of country reports, highlighting convergences and divergences between education systems. Triangulation by such multiple methods increased the stability of findings and provided a consistent image of Europe-wide trends in seagrass literacy education.

3.5. Ethical Considerations

All procedures in the study were in compliance with the EU General Data Protection Regulation (GDPR) and with the national research ethics standards for research with human beings. All adult respondents provided their informed consent; parental consent was provided in the case of children. Data anonymization and confidentiality were guaranteed in the strongest form possible; participation remained entirely voluntary. The field study emphasized respect, inclusiveness, and responsiveness at the center of the school environment such that the research process itself embodied the values of sustainability and moral education advocated by SEAQUEST.

3.6. Limitations

The study also had some constraints like the response rate in Belgium and the availability of curricular details in all the participating countries. Institutional workload, limited knowledge of seagrass themes, and bureaucracy made it difficult for schools and teacher education institutions to participate. Nevertheless, the wealth and variety of the data obtained among upwards of 200 adults and 100 children provide the solid groundwork for informing the European seagrass literacy landscape.

4. Results

4.1. Part 1: Literature Review

The first component of the SEAQUEST State-of-the-Art Report is an extensive review of the current level of ocean and seagrass knowledge among European primary schoolchildren. It collates the outcomes from scientific studies, national school programmes, policy reports, and institutional research to make an educated estimate of the coverage by formal school structures of marine and seagrass concepts. The research is carried out for the five partner countries—Greece, Cyprus, Belgium, Denmark, and Portugal—and sets out national patterns as well as trans-country seagrass education trends.

The current section provides an intelligence baseline on what is currently covered by education materials on how seagrass habitats, important sites for biodiversity, carbon sequestration, and

coastlines, are treated. It integrates evidence from scientific research, curriculum reviews, and government reports to identify substantial mismatches between their eco-importance and their coverage by education. Although ocean literacy is gaining inclusion in European school agendas, seagrass is hardly considered, highlighting the lack for an integratively holistic approach to education. By systematically mapping current studies, this review provides the conceptual foundation for the learning outcomes from the SEAQUEST project. The review provides preliminary information to feed the design of learning material development, teacher professional growth, and policy recommendations in the subsequent work packages. The outcome reveals the urgent need to integrate seagrass literacy with broad-based sustainability education frameworks to develop ocean-literate and environmentally aware future generations.

4.1.1. Ocean and Seagrass Literacy in European Education

An overview of academic articles focused on Ocean Literacy in Greece was conducted. The study was conducted during January 2025 through a bibliographic survey using the Scopus and Google Scholar multidisciplinary databases. Publications were searched from the databases' custom data using "ocean", "literacy" and "greece" or "greek" as search criteria. The documents where the afore-mentioned search criteria appeared in the title, keywords, and/or abstract were included in the study. Records belonging to the article category were selected for further analysis.Articles were included if they focused on Greece and/or the location of the first author was Greece.

The search resulted in 11 articles, all written in English.

The presence of ocean science topics in Greek primary school textbooks and secondary school textbooks has been analyzed, revealing limited and fragmented information (see Mogias et al., 2021 for primary school and Mogias et al., 2022 for secondary school). The material analyzed in the study of Mogias et al. (2021) consisted of the textbooks developed for teaching natural sciences in the Greek primary education. More specifically, three series of textbooks comprised the corpus under study: (a) Study of the Environment (grades 1–4), (b) Physica (grades 5–6), and (c) Geography (grades 5–6). Each of the three series 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.

According to Mogias et al. (2021), textual material related to ocean sciences issues was included in 112 out of 1,077 pages (10.4%) of the examined reading books (Study of the Environment, Physica, and Geography), and 33 out of 654 pages (5.0%) of the corresponding workbooks. Regarding pictorial material, 217 out of 3,762 illustrations (5.8%) included in the examined reading books and 93 out of

1,733 (5.4%) in the corresponding workbooks, were related to the ocean sciences issues. Textbook analysis of both textual and pictorial material revealed that although all OLPs are presented in the textbooks under study, most of their supporting fundamental concepts are absent for most of the principles (Mogias et al., 2021). Specifically, Study of the Environment (grades 1–4), covers most of the concepts of OLPs 6 and 1, while it deals much less with OLPs 2 and 3, and not at all with OLPs 4and 7 (Mogias et al., 2021).

The aim of a study (Markos et al., 2017) was to respond the increasing demand for comprehensive tools for the measurement of ocean literacy, by investigating the psychometric characteristics of a Greek version of the Survey of Ocean Literacy and Experience (SOLE), an instrument that assesses conceptual understanding of general ocean sciences content, focusing on the knowledge component. Four hundred twenty- one pre-service primary school teachers participated in a cross-sectional study. The dichotomous Rasch model was used to examine the measurement properties of the SOLE, namely, person-item targeting and separation, reliability, dimensionality and differential item functioning (DIF). Steps were taken to improve the instrument, where any of these attributes were outside acceptable ranges. Results suggested that a modified SOLE showed an adequate fit to the Rasch model, is unidimensional, free of DIF, and is particularly well-suited to the population under study. This study findings suggest that the SOLE constitutes a valuable tool which can be applied to a different cultural context and population. The proposed use of the instrument could contribute to the assessment of the quality of marine education in school-based and non-formal education contexts and to the cross-cultural comparison of ocean literacy, which are prerequisites for the improvement of ocean literacy.

A number of articles has focused on assessing the level of Ocean Literacy among primary school students (ages 8-12 years) (Mogias et al., 2019), secondary school students (Cheimonopoulou et al., 2022; Koulouri et al., 2022) and pre-service primary school teachers (Boubonari et al., 2013; Mogias et al., 2015), indicating, generally, a low to moderate knowledge of ocean science issues and positive attitudes towards ocean stewardship. In particular, Mogias et al. (2019) found that elementary school students (grades 3–6) of three Mediterranean countries, i.e., Italy, Croatia, and Greece possess rather moderate knowledge of ocean sciences issues, holding also some misconceptions. The majority of the participants was located in coastal areas and drew on their ocean content knowledge mainly from school environmental activities and TV documentaries. More specifically, the Italian students turned up to have a relatively higher ocean-related knowledge level than the rest of their counterparts, but with a slightly decreasing trend in higher grades. This was not the case for the Greek students who although appeared less knowledgeable among the three countries, their ocean- related knowledge increased progressively with higher grades; Croatian students followed a rather similar to the Greek's

pattern. In the study of Boubonari et al. (2013), a structured questionnaire was administered to assess Greek pre-service primary teachers' knowledge, attitudes, and self-reported behavior toward marine pollution issues. Exploratory factor analysis revealed several factors, all demonstrating adequate internal consistency, and showed that pre-service teachers demonstrated a moderate level of knowledge about marine pollution issues, although they also held misconceptions. They scored high or relatively high on all attitude factors, and scored moderately high on individual action and low on collective action. Moreover, Mogias et al. (2015), found that Greek pre-service primary school teachers possessed a moderate knowledge of ocean sciences issues and positive attitudes toward ocean stewardship; they obtained most information on ocean content from the Internet and mass media and less from formal education, nongovernmental organizations, books, and out-of-school settings. Students who mostly preferred the Internet and mass media scored significantly higher on the knowledge questionnaire.

In addition, a didactic intervention focused on digital storytelling and experiential hands-on activities covering concepts of marine pollution confirmed the importance of digital storytelling for high school students' ocean literacy enhancement (Andriopoulou et al., 2022). The impact of a teaching intervention on primary school students' understanding of ocean acidification has been also investigated (student ages 11-12 years) (Boubonari et al., 2023). In particular, eighty-five 11 to 12-year-old students from five different classes of two public primary schools in Greece participated in the 8-h intervention. The intervention included inquiry-based and knowledge-integration activities, and students worked in groups during all activities. Rich pictures, made by the groups at the beginning and the end of the intervention, were used to evaluate their progress in their knowledge concerning the carbon cycle, as well as in their systems thinking. The findings showed that the intervention contributed to primary students' conceptual knowledge of the carbon cycle and the inclusion of ocean acidification in the carbon cycle. It also helped them improve their systems thinking, indicating that students' systems thinking at this age could be developed through formal instruction with interventions which emphasize content knowledge and use an earth systems approach.

Moreover, study's findings indicate that the systems thinking perspective can serve as an effective approach to help children better understand and critically engage with complex environmental issues, such as ocean acidification. Moreover, the impact of an integrated educational program on primary and secondary school students' knowledge about coastal lagoons and attitudes towards marine environment conservation was investigated (student ages 11-13 years) (Kevrekidis et al., 2024). In particular, an educational resource titled "Exploring the Coastal Lagoons" was developed to facilitate the non-formal educational intervention. The program involved classroom, fieldwork/outdoor and laboratory activities, focusing on enhancing understanding of coastal lagoons' abiotic and biotic

characteristics and human interconnection. Results showed improved knowledge and slightly more positive attitudes after the didactic intervention. The study underlines the effectiveness of targeted educational interventions in marine sciences, suggesting that non-formal educational settings influence student outcomes more than family or informal sources. Younger students appeared more adaptable and responsive to educational stimuli. The study advocates for refined educational strategies integrating cognitive and emotional elements, emphasizing real nature experience.

An overview of scientific documents focused on Seagrass Literacy in Greece was conducted. The study was conducted during January 2025 through a bibliographic survey using the Scopus and Google Scholar multidisciplinary databases. Publications were searched from the database's custom data using the following sets as search criteria: seagrass (or marine AND angiosperm) AND literacy, seagrass (or marine AND angiosperm) AND education, seagrass (or marine AND angiosperm) AND education AND school, seagrass (or marine AND angiosperm) AND education AND student, seagrass (or marine AND angiosperm) AND education AND child, seagrass (or marine AND angiosperm) AND education AND teaching, and seagrass (or marine AND angiosperm) AND education AND learning.

The documents where the afore-mentioned search criteria appeared in the title, keywords, and/or abstract were considered. Screening was conducted at the title, abstract and full text level. Articles were included if they focused on Greece and/or the location of the first author was Greece. The search resulted in two documents, an article written in English and published in a scientific journal (Apostoloumi et al. 2021, Marine Pollution Bulletin), and a PhD Thesis written in Greek (Apostoloumi 2022).

The article of Apostoloumi et al. (2021) conceptualize and define Seagrass Literacy. This aimed to contribute to the creation of a seagrass-literate society, by defining key principles and concepts in relation to seagrasses that a seagrass-literate person should know. Six principles about seagrasses were defined. Each one is underpinned by a set of concepts. These principles and concepts concern key issues of seagrass biology (Principles 1-4), value (Principles 3-5), loss and protection (Principle 5), and research (Principle 6). The Seagrass Principles are as follows:

1. Seagrasses are unique plants.
2. Seagrasses form extensive underwater meadows.
3. Seagrasses support a great diversity of life.
4. Seagrasses stabilize the seabed, improve water quality and store carbon.
5. Seagrasses and humans are inextricably interconnected.
6. Seagrasses are largely unexplored.

The Seagrass Principles and Concepts essentially constitute a thematic adaptation of the Essential Principles and Fundamental Concepts of the Ocean Literacy (NOAA, 2013). The development of the

Seagrass Principles and Concepts reflects the need for more recognition of the value of seagrass habitats on a global scale that has been repeatedly mentioned in the seagrass literature.

The seagrass Principles and Concepts can be used as a tool to inform scientists, policy- and decision-makers, non-governmental organizations, stakeholders, and the Blue Economy sector about what seagrasses are, their importance to the environment and to people, and the consequences of their loss, in order to make responsible decisions on seagrass sustainability. These principles and concepts can also be used to improve public outreach and can be applied to social media campaigns. They can also be incorporated into educational textbooks, curricula and practice, in combination with the Essential Principles and Fundamental Concepts about the Ocean.

The study of Apostoloumi (2022) aimed to contribute to the promotion of Ocean Literacy. The study was driven is driven by four core purposes: (a) defining and conceptualizing Seagrass Literacy, (b) evaluating Ocean Literacy level, (c) developing scale to determine Seagrass Literacy level, and (d) evaluating Seagrass Literacy level. To accomplish this purpose, Seagrass Principles and Concepts were identified. Additionally, a typology of future Greek pre-service teachers was developed in terms of their knowledge of seagrasses, as well as general Marine Sciences issues. For this purpose, the SOLE-30 and SeAS questionnaires were administered to a sample of 250 undergraduate students of a Primary Education Department in Greece. The Seagrass Awareness Scale (SeAS) developed to determine Seagrass Literacy level. This questionnaire contains 25 multiple-choice questions aimed at assessing fundamental knowledge on critical issues related to important topics of seagrasses, including their characteristics, origin, evolution, taxonomy, biogeography, ecology, ecosystem function, value to the environment and humans, threats, loss, conservation and scientific research.

The pre-service teachers average score rate in the SOLE-30 questions demonstrated a low to moderate level of knowledge on general Marine Science issues, while the corresponding average score rate in the SeAS questions evidenced a low level of knowledge of seagrasses. The application of appropriate data analysis methods showed three distinct groups of prospective teachers in terms of their level of knowledge. In terms of knowledge of general Marine Science issues, the groups differ in the educational level of their parents, but also in the use of the Internet as a means of information on issues related to the marine environment. In terms of particular knowledge of seagrasses, the groups differ in the level of knowledge on general issues of Marine Sciences, the most important source of information on issues related to these sciences, but also in terms of the use of the Internet as a means of information. The above findings could be utilized for the design of customized educational strategies and interventions in the curricula of the Departments of Primary Education, in order to strengthen the knowledge of prospective teachers on significant issues of Marine Sciences.

Seagrass ecosystems are recognized for their ecological and environmental importance, providing

critical services such as carbon sequestration, biodiversity support, and coastal protection (Duarte et al., 2013). In the Mediterranean region, Posidonia oceanica is particularly significant, yet it faces increasing threats due to human activity and climate change (Marbà & Duarte, 2010). Despite its ecological importance, marine literacy and seagrass-specific education remain underdeveloped in Cyprus' primary education curriculum.

The integration of seagrass ecosystems into primary school education in Cyprus remains an underexplored area, despite its ecological significance. This section explores seagrass ecosystems, marine literacy, and their relevance to primary education.

Key Findings on Seagrass Ecology, Its Importance, and Its Role in Marine Ecosystems

Seagrass ecosystems play a vital role in marine biodiversity, serving as critical habitats for various marine species, stabilizing sediments, and acting as carbon sinks. This highlights the global importance of seagrass in carbon sequestration, emphasizing that Posidonia oceanica meadows in the Mediterranean, including Cyprus, hold significant carbon storage potential. Duarte et al. (2013) reinforce this by explaining how seagrass contributes to mitigating climate change and maintaining coastal health. Marbà & Duarte (2010) provide evidence that seagrass meadows are increasingly threatened by human activities, such as pollution, coastal development, and climate change. This makes their conservation through education essential.

Marine Literacy Concepts and Their Application in Primary Education

Marine literacy refers to understanding the ocean's influence on humans and vice versa (Cava et al.,

2005). Studies suggest that integrating marine literacy into early education fosters long-term environmental stewardship. Children who engage in marine-based environmental education programs exhibit stronger conservation- oriented behaviours in adulthood.

Despite the importance of marine literacy, structured marine education programs remain underdeveloped in Cyprus, with few school initiatives explicitly addressing marine ecosystems.

Despite the ecological significance of Posidonia oceanica, marine biodiversity education in Cyprus remains limited. The Ministry of Education, Cyprus (2022) mandates sustainability education while European Commission (2022) reports that compared to other EU Mediterranean countries, Cyprus lags in integrating marine ecosystems into the curriculum (European Commission. Directorate General for Education, Youth, Sport and Culture., 2022).

How These Findings Relate to Primary Education in Cyprus Curriculum

Integration

Current curricula lack a structured marine literacy component, limiting exposure to seagrass ecology (*Cyprus Ministry of Education, Sport and Youth*, 2021). Countries such as Spain and Italy have successfully embedded marine studies into their education systems, providing a model for Cyprus to follow (*Ocean Literacy - European Commission*, 2022).

Teacher Training

Many teachers lack training in marine science, making it difficult to incorporate seagrass literacy into lesson plans. Digital tools and professional development programs can be solutions to this gap.

Student Engagement

Studies advocate for experiential learning approaches, such as virtual reality (VR) tools and field trips, to engage students in marine education.

Research Gaps and Opportunities

Despite existing research advocating for marine education, Cyprus has no national program dedicated to seagrass literacy. This presents an opportunity to integrate structured marine literacy programs within primary education.

Key Recommendations:

-Developing marine-focused curricula with specific reference to Posidonia oceanica.

-Implementing teacher training in marine science education.

-Strengthening collaboration between schools and NGOs to introduce seagrass awareness programs.

-Enhancing experiential learning opportunities through VR, field trips, and digital resources.

Belgium is located along the North Sea. The primary Belgian marine habitat consists of marine sandbanks that are shallow (up to 45 meters deep) but always remain submerged beneath the sea surface. The surface sediments include fine sand, coarse sand, and shell fragments. The sandbank surfaces may be flat or feature large or small sand ripples. Silt is present only in small amounts on the tops and flanks of the sandbanks.

In the past, some of these sandbanks supported seagrass vegetation, providing habitat for species such as *Zostera noltii* and *Zostera marina*. Today, however, only unvegetated sandbanks remain. Source

Zostera noltii and *Zostera marina* thrive in shallow, nutrient-rich environments such as the Belgian

part of the North Sea but are vulnerable to anthropogenic pressures, including pollution, habitat destruction, and climate change.

In the broader North Sea region, the Wadden Sea offers a telling example of seagrass decline. According to the Wadden Sea Quality Status Report, both *Zostera marina* (eelgrass) and *Zostera noltii* (dwarf eelgrass) experienced significant losses over the past century. The main causes include the outbreak of the “wasting disease” in the 1930s, combined with increasing eutrophication, physical disturbances from human activities, and changing hydrodynamic conditions. While some natural recovery has occurred in the northern parts of the Wadden Sea, the central and southern regions continue to show limited regrowth, underscoring the complexity of successful restoration efforts in dynamic coastal systems. Source

Conservation efforts in the North Sea, led by marine research institutions and environmental organizations in countries such as the Netherlands, the United Kingdom, and northern France, where seagrass is more abundant, aim to protect and restore these valuable ecosystems. Several research programs to restore seagrass habitats have been initiated in recent years.

In Belgium, the research project "PLANT a Million Seagrasses," initiated in 2020, involves collaboration between Ghent University, the Belgian dredging companies DEME and Jan De Nul, and Portuguese research institute CCMAR. This project explored the role of seagrass beds in coastal protection and climate change mitigation, focusing on the North Sea region.

In the Netherlands, areas such as the Waddensea, the Oosterschelde and Grevelingenmeer still host small patches of dwarf eelgrass (*Zostera noltii*) and larger areas of eelgrass (*Zostera marina*).

Figure 1: Field of dwarf eelgrass (Zostera noltii) at the base of a dike in the Oosterschelde. Source: Delta Expertise

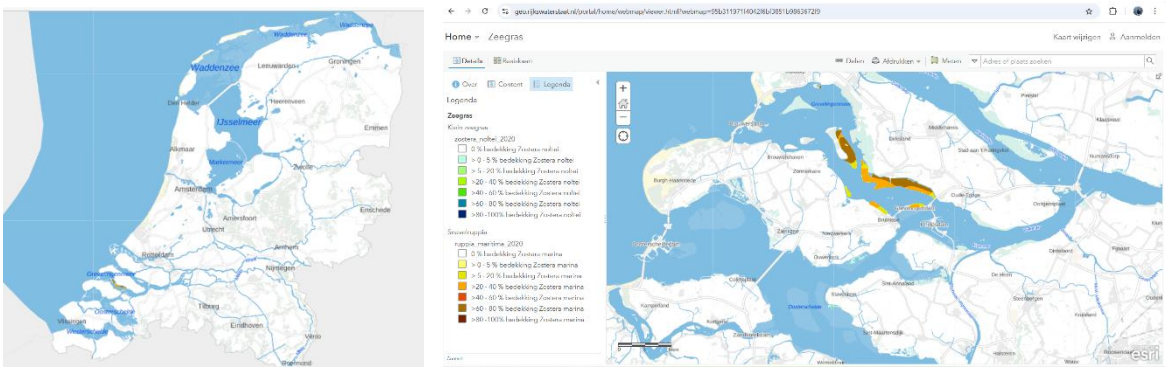

Figure 2 Map Distribution of seagrass in the Netherlands (left) and southern part of the Netherlands (Oosterschelde and Grevelingenmeer). *Geoportal Rijkswaterstaat. Data from 2020, last update 13 February 2024. Source: Rijkswaterstaat Geoportal*

Additional insights and updates on seagrass restoration in the Netherlands can be found at zeegrasherstel.nl.

In northern France, restoration projects are active particularly in the Arcachon Bay area. The Arcachon Basin Marine Nature Park has engaged in restoration efforts targeting *Zostera noltii* using both seed-based and transplant-based methods. Moreover, the European Seagrass Restoration Alliance (ESRA https://esra-europe.eu/) held its second European Seagrass Restoration Workshop in Arcachon in April 2025, emphasizing cross-border collaboration and knowledge exchange among researchers and conservationists.

In the United Kingdom, the LIFE Recreation ReMEDIES project (Reducing and Mitigating Erosion and Disturbance Impacts affecting the Seabed) recently concluded. Led by Natural England, this initiative focused on restoring seagrass meadows in five Special Areas of Conservation (SACs) in southern England. The project combined habitat restoration through planting seagrass and implementing measures to reduce seabed disturbance caused by recreational activities, such as installing eco-moorings.

A relevant publication on seagrass ecosystems in the broader North-East Atlantic region, which includes Belgian coastal waters was published by the OSPAR Commission in 2009: "Background Document for Zostera Beds, Seagrass Beds,". This document offers comprehensive information on the distribution, status, and threats to seagrass beds, with a focus on *Zostera* species. It also outlines conservation measures applicable to the OSPAR maritime area, which encompasses Belgium. Source

Interestingly, seagrass from other regions in the North Sea washes ashore on Belgian beaches and can be found along the tidal lines. This is documented in the largest Belgian biodiversity database,

Waarnemingen.be. This offers a valuable opportunity to raise awareness among children who visit the beach with school and the general public (tourists and coastal inhabitants).about the importance of this marine habitat.

Conclusion:

No seagrass habitats currently exist in Belgium—they are considered extinct.

Several restoration projects are active in the Netherlands, France and the UK where there are still some areas with seagrass.

Since seagrass occasionally washes ashore in Belgium from other North Sea countries (e.g., the UK and France), it presents a unique opportunity to educate children.

Seagrass, particularly eelgrass (Zostera marina), is a vital component of Denmark's coastal ecosystems, offering benefits such as habitat provision, carbon sequestration, and shoreline stabilization. These seagrass meadows have experienced significant declines, primarily due to eutrophication, which leads to reduced water clarity and light availability essential for seagrass growth. Despite efforts to reduce nutrient inputs and improve water quality, the anticipated recovery of eelgrass has been limited, suggesting that factors beyond water clarity, such as sediment quality and physical disturbances, may impede restoration efforts (Danmarks Miljøtilstand., 2025). There are initiatives regarding transplanting eelgrass in Danish oceans as described in a study by Syddansk Universitet (Lange et al., 2020).

An overview of academic articles focused on Portugal-wide marine education was conducted. The study was conducted during January 2025 through a bibliographic survey using the Scopus multidisciplinary database. Publications were searched from the database's custom data using "ocean", "literacy" and "school" and "Portugal" as search criteria. The documents where the afore-mentioned search criteria appeared in the title, keywords, and/or abstract were included in the study. Screening was conducted at the title, abstract and full text level. Articles were included if they focused on Ocean Literacy issues in Primary Education in Portugal.

In total, 9 references published before January 23, 2025 were imported. A complete list of these 10 publications is given in the Appendix A. Eight articles published in journals, one as review and one in book chapters, made up the literature base.

To support this analysis, a similar research study was conducted using the following search criteria: seagrass (or marine AND angiosperm) AND literacy, seagrass (or marine AND angiosperm) AND education, seagrass (or marine AND angiosperm) AND education AND school, seagrass (or marine AND angiosperm) AND education AND student, seagrass (or marine AND angiosperm) AND education AND child, seagrass (or marine AND angiosperm) AND education AND teaching, and seagrass (or marine AND angiosperm) AND education AND learning. However, only two studies were identified: Barracosa

et al. (2019) and Rangel et al. (2015), both focusing on seagrass education in the southern region of Portugal. This limited number of studies highlights the scarcity of research on seagrass literacy in the national educational context and underscores the need for further investigation and integration of this topic into primary education curricula.

Costa et al (2025)

The Blue School Program is an educational initiative aimed at promoting ocean literacy, combining scientific, cultural, and ethical approaches to increase awareness of the ocean's importance. The article analyzes its implementation in Portugal, highlighting its impact on different educational fields.

- Target Group: Students, teachers, and local communities.
- Methods Used: Document review and program implementation analysis, including case studies of participating schools.
- Outcomes: The program significantly increased school and community engagement in ocean literacy. Additionally, it established strong public-private partnerships, which contributed to its sustainability. However, challenges such as lack of resources and geographical disparities hinder uniform implementation. The article suggests that collaborative networks could help strengthen ocean education in different contexts.

Torres et al, (2024) This study examines the importance of Local Ecological Knowledge (LEK) and Traditional Ecological Knowledge (TEK) in ocean literacy education within fishing communities. The research was conducted in the Caparica School Group, where many students come from fishing families. The article discusses how social and economic factors affect students' engagement with the ocean.

- Target Group: Students from a fishing community in Costa de Caparica.
- Methods Used: Mixed methodology based on Critical Ethnography and Design- Based Research. The study included observations of socio-ecological practices, interviews, and the co-creation of a virtual museum.
- Outcomes: A Virtual Museum was created, allowing students to document and preserve traditional knowledge about fishing and sustainability. A local curriculum was also developed, incorporating ancestral and identity-based knowledge into formal education. The study highlights the potential of digital tools to connect technology, culture, and sustainability, promoting digital inclusion and student employability.

Costa et al (2024). This study investigates Azorean teachers' perceptions of ocean literacy and how ocean-related themes are incorporated into school activities.

- Target Group: Teachers from public schools in the Azores archipelago.
- Methods Used: Online questionnaire sent to all public schools in the archipelago, with 426

valid responses (from a total population of 5502 teachers).

- Outcomes: Despite a high level of awareness about ocean importance, 58% of teachers do not integrate ocean-related themes into their lessons. Moreover, most schools do not participate in ocean literacy projects. The study suggests that including ocean themes in official curricula and developing accessible educational materials could strengthen environmental education and ensure ocean sustainability.

Silva et al (2024). The study evaluates how environmental education can influence sustainable fish consumption habits among 4th-grade children.

- Target Group: 4th-grade elementary school students.
- Methods Used: Pre-test and post-test assessments combined with focus group interviews. During the study, students participated in three educational modules on fish consumption sustainability.
- Outcomes: Before the activities, students had little knowledge about sustainable fish consumption practices. After the activities, there was a significant increase in understanding endangered species, minimum catch sizes, and closed seasons. The study also demonstrated that both in-person and online education were effective in building knowledge.

Leitão et al (2022) The article investigates how gamification can be used to enhance students' understanding of the impacts of climate change on the ocean.

- Target Group: Secondary school students (ages 11 to 14) in Portugal and the United Kingdom.
- Methods Used: Use of a gamified mobile application, which incorporated game elements such as points, badges, and leaderboards. A systematic assessment of the effects of these elements on students' learning was conducted.
- Outcomes: The results showed that gamification increased students' motivation and engagement. Moreover, certain game elements were more effective than others in promoting learning. The study suggests that incorporating gamification into formal education can make ocean literacy more accessible and appealing to students.

Aurelio et al (2021). The study investigates the use of a children's book as an educational tool to enhance environmental awareness, with a strong focus on Ocean Literacy (OL).

- Target Audience: Elementary school students (ages 8–10) from public and private schools.
- Methods Used: Book reading sessions combined with a sequential explanatory mixed-methods approach, including pretest-posttest assessments and focus group interviews.
- Outcomes: The study demonstrated an increase in students' knowledge about river basin biodiversity and environmental threats, reinforcing the connection between local freshwater ecosystems and the ocean. Students from private schools and urban areas performed better

in posttests, suggesting that socioeconomic factors influence environmental knowledge acquisition. The findings highlight that using a children's book is an effective and engaging way to promote Ocean Literacy by illustrating how local environmental actions impact marine ecosystems.

Carvalho, 2021. The study evaluates how environmental education interventions can enhance the appreciation of migratory species in an estuary in northern Portugal.

- Target Group: Basic school students and the scientific community.
- Methods Used: Pretest-posttest on ocean literacy and analysis of communication through social media.
- Outcomes: There was a significant increase in students' knowledge about the biology of migratory fish. Additionally, social media proved to be an effective tool for disseminating scientific information to the general public.

Barracosa et al (2019) The study highlights the importance of education on ecosystem services for Ocean Literacy (OL) in Portugal, being the only article found that focuses on the role of seagrass meadows in carbon sequestration.

- Target Group: Teachers, students form all levels, and general public.
- Methods Used: Establishment of the Environmental Education Network for Ecosystem Services (REASE), including citizen science initiatives and a children's book illustrated by students.
- Outcomes: The program led to a greater understanding of ecosystem services, particularly those provided by coastal vegetation in carbon storage, and increased community engagement in marine conservation.

Rangel et al (2015) This study highlights the importance of self-guided underwater routes at Marinha Beach (Portugal).

Target Group:

The study focused on snorkelers visiting Marinha Beach (Algarve, Portugal) who participated in self-guided underwater routes designed for environmental education and biodiversity awareness.

Methods Used:

- Three self-guided underwater routes were designed based on scientific data, with in situ interpretation and guidance to educate snorkelers.
- The routes were implemented during two consecutive summer seasons.
- Visual census techniques were used to assess flora composition and cover area (seaweeds and seagrasses) before and after each season, to evaluate human impact.
- Questionnaires were administered to snorkelers after their activity to assess their opinions

and perceptions regarding the routes' role in raising environmental awareness.

Outcomes:

- An inter-annual difference in flora assemblages was observed, likely due to natural variability rather than snorkelers' impact.
- The study indicated that in situ education and interpretation effectively raised environmental awareness.
- Properly structured educational underwater routes can engage snorkelers in marine conservation, enhancing their appreciation for biodiversity and helping to prevent negative ecological impacts.

Conclusion

The bibliographic analysis reveals a deficit of structured educational programs that explicitly address seagrass meadow ecosystems. Despite their critical role in carbon sequestration, biodiversity conservation, and coastal protection, these ecosystems are often overlooked in formal education and Ocean Literacy (OL) initiatives.

This gap underscores the need for targeted educational strategies that integrate scientific knowledge, hands-on learning experiences, and community engagement to enhance awareness and appreciation of seagrass meadows. By incorporating these ecosystems into school curricula, citizen science projects, and outreach programs, it is possible to foster a deeper understanding of their ecological importance and promote more effective conservation efforts.

Furthermore, global initiatives under the framework of the UN Decade of Ocean Science for Sustainable Development present a valuable opportunity to address this gap. Leveraging these efforts can help promote seagrass-focused education, support interdisciplinary collaborations, and drive innovative approaches to integrating these vital ecosystems into ocean literacy programs.

Strengthening educational frameworks focused on seagrass meadows is essential to ensuring that future generations recognize their value and take an active role in protecting these vital marine habitats.

4.1.1.1. Conclusion

The review of scientific literature and research publications on ocean and seagrass literacy in Greece, Cyprus, Belgium, Portugal, and Denmark reveals progress but also persistent inadequacies in the integration of marine education into formal educational systems. In Greece, research has shown sparse and scattered presentation of concepts of ocean science in school textbooks, while examination of knowledge levels among students and pre-service teachers generally report modest awareness and various misconceptions. Yet, educational interventions, such as digital storytelling and inquiry-based learning, were found to work effectively towards enhancement of ocean literacy and

systems thinking.

Cyprus also shows a substantial seagrass-specific educational deficit, despite the ecological importance of Posidonia oceanica in the nation. Although education for sustainability is mentioned in policy documents, additional structured marine literacy initiatives and teacher training are not present. Belgium is a unique case because seagrass ecosystems no longer exist in its coastal waters. However, regional efforts within the neighboring North Sea countries and the washing up of seagrass on Belgian beaches provide hopeful entry points for awareness and place-based learning.

Portugal presents a more vibrant research landscape with various innovative projects promoting ocean literacy using digital media, gamification, and local ecological knowledge. While these exist, seagrass education remains peripheral to the official curricula, and few studies address it explicitly. Denmark, with its history of seagrass loss and partial recovery, highlights the importance of restoration efforts and consideration of a variety of environmental problems in educational content.

Across the countries, there is a particular need for targeted strategies to promote seagrass literacy through curricula development, teacher professional development, and experiential learning. The programmatic and research gaps highlighted here represent great opportunities to expand marine education and promote ocean stewardship. By leveraging interdisciplinary frameworks and international efforts, such as the UN Decade of Ocean Science, these countries can build more integrated and effective marine literacy systems.

4.1.2. Seagrass Literacy in National Education Policies

Official Reports or Educational Circulars on issues related to environmental Literacy that the Greek Ministry of Education, Religion and Sports has issued during the school years 2022-2023, 2023-2024 and 2024-2025 were searched. This search revealed that the Ministry of Education, Religion and Sports normally issues two circulars annually that addressed to School Units of Primary Education and concern environmental literacy issues. The first circular concerns educational visits and training activities at the Environmental and Sustainability Education Centers (K.E.PE.A.) (e.g. Circulars Φ11/944/Δ7/ 04.01.2023, Φ11/11511/Δ7/ 02.02.2024 and Φ11/10114/Δ7/ 29 - 1 - 2025, http://www.minedu.gov.gr/ypapegan/ypour-apof) . The second circular concerns the World Environment Day Celebration (e.g. Circular Φ11/66547/Δ7/ 01.06.2022 and Circular 60277/Δ7/ 03.06.2024) . It is entitled "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, and its main thematic axis is the "Environment and Climate Change".

The above findings reveal that no official reports or educational circulars regarding Seagrass Literacy

have been issued by the Greek Ministry of Education, Religion and Sports during the school years 2022-2023, 2023-2024 and 2024-2025.

While Cyprus has established various policies and frameworks for environmental education, seagrass ecosystems remain underrepresented in formal primary school curricula. This section provides directives, policies, or programs related to marine education in Cyprus and their effectiveness in promoting seagrass literacy through key official reports.

a. National Education Strategy for Sustainability (Ministry of Education, Cyprus, 2022)

The National Education Strategy for Sustainability outlines a structured approach to integrating sustainability concepts into the education system. While the framework emphasizes climate change, biodiversity, and conservation, it does not explicitly include seagrass ecosystems.

Key Directives:

- Mandates sustainability education in all primary schools.
- Encourages active learning methods, including outdoor environmental activities.
- Lacks specific mention of marine literacy or Posidonia oceanica.

Effectiveness:

- Provides a broad foundation for environmental education.
- Requires further integration of marine-specific topics, particularly seagrass ecosystems.

b. EU Marine Strategy Framework Directive (European Commission, 2008/56/EC)

As an EU member, Cyprus adheres to the Marine Strategy Framework Directive (MSFD), which aims to achieve Good Environmental Status (GES) of marine waters(Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive) (Text with EEA Relevance), 2008).

Key Directives:

- Promotes marine conservation through national strategies.
- Encourages member states to incorporate marine biodiversity into education.
- Recognizes Posidonia oceanica as an essential marine habitat.

Effectiveness:

- While the directive influences national policies, its direct impact on primary education is minimal.

- Provides an opportunity for curriculum alignment with marine conservation goals.

c. Environmental Education Reports (Ministry of Education, Cyprus, 2021)

The Environmental Education Reports review progress in sustainability education in Cyprus (Cyprus Ministry of Education, Sport and Youth, 2021).

Key Directives:

- Assesses environmental education implementation across schools.
- Highlights gaps in marine and seagrass education.
- Recommends curriculum updates to include marine conservation topics.

Effectiveness:

- Identifies weaknesses in the current environmental education system.
- Acknowledges the need for marine-focused education but lacks clear implementation strategies.

Conclusion and Recommendations

While Cyprus follows several environmental policies and educational strategies, formal primary education does not sufficiently address seagrass ecosystems. The reviewed reports provide a strong policy foundation but lack direct implementation in primary school curricula.

Key Recommendations:

1. Integrate seagrass literacy into national curricula through sustainability education reforms.
2. Develop teacher training programs to enhance marine science education.
3. Establish partnerships between schools and conservation organizations to incorporate hands-on marine conservation programs.
4. Align national education policies with the EU Marine Strategy Framework Directive to ensure compliance with marine conservation goals.
5. Encourage experiential learning through field trips, digital tools, and interactive classroom activities focused on seagrass ecosystems.

By addressing these gaps, Cyprus can enhance marine literacy and promote seagrass conservation through education.

In Belgium, education is managed by three linguistic regions: Flemish, French, and German-speaking. Each region has full autonomy over its educational content, resulting in distinct curricula across the country. Within each region, various school networks—such as Catholic, public, and independent

schools—develop their own curricula based on the overarching guidelines set by their respective regional authorities, leading to a large variation in curricula across the country. As the coastal region of Belgium is located in Flanders, for the purpose of this study, only the Flemish curricula set out by the Flemish region will be discussed.

Primary education is targeted at children from 6 to 12 years old and comprises six school years. At the primary level, the curriculum focuses on foundational subjects such as mathematics, reading, writing, basic sciences, history, geography, and arts.

An analysis of the curricula, conducted by European Schoolnet in 2020 (*European Schoolnet, 2020. Ocean Literacy for All: A toolkit* Source), covered Belgium (Flanders), Croatia, Finland, France, Germany, Greece, Portugal, Romania, and the United Kingdom (England). It provided the following insights: the common core curriculum for primary education in these countries typically consists of areas of learning and cross-curricular themes. Environmental education is often integrated into these subjects, emphasizing general science and ecological concepts across Europe.

> Pocze, B.; Tasiopoulou, E.; Copejans, E. (2020). Ocean literacy for all: curriculum analysis. European Schoolnet (EUN): Brussels. 55 pp.,

In Flanders, the ocean literacy subject of interest is called "**World Orientation**,". This course covers nature, technique, humankind, society, time and space and the use of resources. Overall, the study highlighted several topics as potential entry points for integrating ocean-related themes into the classroom: oceans and seas, floating and sinking, habitats and organisms (with examples from the local environment), the marine food web, human impacts on Earth, weather, and adaptations to climate.

Although the topic of seagrass ecosystems is not addressed specifically in the Flemish primary school curricula, the broader topic of habitats and impact of humans presents a useful entry point for introducing students to seagrass and its ecological importance.

To teach about seagrass, the following two curricula objectives are relevant:

> Subtopic *Living Nature*:
>
> > “Students know two different habitats and can recognize and name the most common species of these habitats”
>
> Subtopic *Environment*:
>
> > “Students can illustrate with examples from their environment how people interact with nature in both positive and negative ways.”

Source: https://onderwijsdoelen.be/

The database of scientific publications mentions several papers on ocean literacy in Flanders. Two theses on integrating the ocean in the secondary school curricula from Eggermont and Copejans:

Eggermont, M. (2007). Upgrading basic knowledge of oceans and seas through secondary education. MSc Thesis. Universiteit Gent; MARELAC: Gent. 103 + 1 cd-rom pp.,

Copejans, E.; De Doncker, K. (2007). Mare incognitum. *De Aardrijkskunde 31(1)*: 21-32 ISSN 1784-2387,

And Copejans wrote an article in the Geography Teacher magazine on what every student should know about the ocean, hereby translating the ocean literacy principles in Flemish.

Copejans, E. (2014). Wat iedere leerling over de oceaan zou moeten weten, Ocean literacy. *Jaarb. aardrijkskd (Gent) 2014*: 63-70,

No further studies exist on ocean literacy in Flanders and in particular seagrass literacy in primary school education in Flanders.

UNESCO published in 2025 **Promoting Ocean Literacy – An Education Policy Brief**, calling on European and national policymakers to support a better integration of ocean-related content into national curricula. In this policy brief we read about how ocean topics were incorporated in the Flemish schools

PROMOTING OCEAN LITERACY - AN EDUCATION POLICY BRIEF

BELGIUM (FLANDERS)

Contributor: *Evy Copejans, Network of European Blue Schools*

Collaboration of research institutes

Context

Flanders has been at the forefront of Blue Education for nearly two decades, starting with a mandate from the Flemish Government that designated the Flanders Marine Institute[11] (VLIZ) as a central hub for ocean education. Early research highlighted the absence of ocean topics in the Biology and Geography curricula, prompting VLIZ to collaborate with educational stakeholders to raise awareness and advocate for Ocean Literacy. This culminated in a series of national and international conferences and projects, positioning Ocean Literacy as a strategic goal for educational reform.

Actions and Rationale

The curriculum modernization process began in 2021, focusing first on secondary education. A significant innovation was the integration of systems thinking in geography, enabling the inclusion of essential ocean-related topics, such as ecosystem services and climate-ocean interactions. The decision to make some ocean-related topics optional stemmed from an overloaded teaching schedule, allowing motivated teachers to incorporate these themes into their lessons. Professional development sessions and supportive textbooks were implemented to provide educators with the necessary tools to teach multidisciplinary ocean concepts effectively. Notably, pioneering schools like Sint Lodewijks College and Sint Paulus School have taken proactive steps to introduce ocean science courses, demonstrating the potential for interdisciplinary learning.

Promising aspects

The experience in Flanders underscores the vital role played by a research institute such as VLIZ as a collaborative hub among education stakeholders in advancing Ocean Literacy. It has revealed the need for tailored didactic frameworks to help teachers navigate complex, multidisciplinary topics. Furthermore, the initiative highlights the significance of continuous investment in ocean education. With a sustained focus on Ocean Literacy, there is significant potential to equip the next generation to contribute effectively to sustainable marine resource management and stewardship.

Figure 3 Case study Belgium from the UNESCO publication Promoting Ocean Literacy – An Education Policy Brief

Although ocean literacy is not considered a priority in primary school education, according to the study of Pocze, et al (2020), one long-standing initiative in Belgium is worth highlighting: **sea classes**. Sea classes are a form of outdoor education that became rooted in Belgian schools in the 1970s. As a result of educational reforms introduced after May 1968 -including the introduction of project weeks— schools began organizing outdoor programs for the last year of primary school.

Each year, around 30,000 children travel to the Flemish coast for a week to learn about the sea. During

these excursions, they explore the nature, culture, history, and various other aspects of the Belgian coastline. Sea classes offer one of the most significant opportunities for ocean literacy in Flemish primary education. The topic of seagrass could easily be introduced during these outdoor learning experiences.

Figure 4 Sea classes at the Belgian coast @Spermaliehoeve

Coastal education organizations like Horizon Educatief vzw, the Marine Ecological Center and the visitor center The Duinpanne have developed over the years a wide range of workshops on sea-related topics for schools. Such initiatives complement formal education by providing hands-on experiences related to marine environments, potentially including seagrass ecosystems.

While it is not recommended to aim for the explicit inclusion of seagrass ecosystems as a standalone topic in the official curriculum, since this habitat no longer exists in the Belgian waters, seagrass can serve as a powerful learning context. It can be used in textbooks, teacher guides, and educational resources to illustrate broader ecological themes such as marine biodiversity, habitats, and human impacts on coastal environments. This approach supports flexible integration and contextual learning without requiring formal curriculum reform.

Conclusion:

While not explicitly covered in the Flemish curriculum, seagrass can be introduced through topics related to habitats and environmental impacts.

Sea classes and coastal education centers provide a key opportunity to integrate seagrass education into experiential, place-based learning at the coast.

Aiming to explicitly integrate the topic of seagrass in the curricula is not recommended. However, it

can be used as a learning context in school handbooks and educational resources on marine habitats.

Governmental and Institutional Guidelines

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 (PACF), 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 OECD (Organization for Economic Co-operation and Development) 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."

Although seagrass literacy is not explicitly mentioned in official educational documents, several policies support ocean literacy in general:

- "Environmental Education Framework for Sustainability" (DGE, 2018): Highlights the need for education on marine ecosystems but does not provide specific guidelines for seagrass meadows.
- Portugal's "Biodiversity 2030" Agenda: Recognizes the importance of protecting coastal and marine habitats, including seagrass meadows, as part of broader conservation efforts.

Challenges and Educational Gaps

Despite these policies, seagrass literacy remains largely overlooked in the national curriculum. Many educators lack access to resources and specialized training on this topic, making it difficult to integrate it into classroom activities.

Seagrass Training Initiatives in Portugal

However, in recent years, several training initiatives focused on seagrass ecosystems have been conducted in Portugal, led by CCMAR (ALGAE Group) and the non- governmental organization OCEAN ALIVE. These initiatives have been primarily aimed at teachers and educators as part of continuing professional development programs and have included specific actions tailored for educators at all levels of education across the country.

The training sessions have been concentrated in the southern and central regions of Portugal, covering key protected areas such as Sapal de Castro Marim, Ria Formosa, and the Sado Estuary. These areas serve as important case studies for hands-on learning, allowing educators to better understand the ecological significance of seagrass meadows, their role in marine biodiversity, and their contribution to climate change mitigation through carbon sequestration.

These training initiatives have been developed within the framework of the REASE, SeagHorse, and Blue Forests Education projects, which are referenced later in this document.By equipping teachers with scientific knowledge and practical resources, these initiatives aim to bridge the gap in seagrass literacy and foster greater integration of seagrass-related topics into school curricula. Expanding such training programs across a wider geographical area and ensuring long-term institutional support will be essential in strengthening ocean literacy and marine conservation education in Portugal. As part of these projects, educational materials have also been developed to support seagrass literacy and marine conservation education. These resources can be accessed through the respective project websites.

Expanding Seagrass Education Initiatives

Despite these efforts, the absence of structured teaching materials and specific learning objectives related to seagrass ecosystems still limits students' exposure to their ecological importance. Addressing these gaps requires targeted educational strategies, including teacher training programs, curriculum development, and the creation of interactive learning tools that emphasize the role of

seagrass meadows in marine conservation and climate regulation.

To effectively bridge this educational gap, these types of initiatives must be expanded and multiplied across different regions and educational levels. Strengthening institutional support for seagrass-focused ocean literacy is essential to ensuring that students and future generations recognize the value of these ecosystems and actively contribute to their protection.

4.1.2.1. Conclusion

Examination of official documents and education policies in Greece, Cyprus, Belgium, and Portugal reveals that while environmental education is increasingly supported at policy levels, seagrass literacy is either absent or only indirectly referred to in formal primary school education in all four nations.

In Greece, the Ministry of Education takes up general environmental matters through annual circulars but does not have any explicit focus on sea or seagrass-related subjects. Cyprus possesses a strong policy framework towards education for sustainability and compliance with EU directives but not extension of marine-specific material, particularly seagrass, into primary-level curricula. Belgium, especially the Flemish community, has loose entry points for integrating ocean content through environmental subject matter and experiential experiences like sea classes. But rather than an explicit mention, the inclusion of seagrass is not advisable because of its local extinction, although still worth being used as a contextual teaching tool.

Portugal leads in legislative support for curriculum adaptability and ocean literacy in national policies such as PACF, but systematic incorporation of seagrass ecosystems remains rare. NGO efforts and teacher training have moved forward in closing the gap, but large-scale curriculum integration and long-term institutional support are needed.

More generally, there remains a disconnect between macro-environmental policies and direct incorporation of seagrass systems into national curriculum for basic schooling. For every country, education towards seagrass literacy would be ensured by targeted modifications of the curriculum, improved educator training, and wider implementation of experience- and e-learning paradigms for enhanced awareness and ownership among young students.

4.1.3. General European Situation

Ocean Literacy is considered to be of high importance for raising awareness of the people concerning conservation, restoration and sustainable use of the ocean and its resources. Among the highlighted concepts of ocean literacy are the seagrass ecosystems. By enhancing seagrass literacy, Europe can mobilize collective action to promote the health and resilience of these vital ecosystems, ensuring they continue to provide essential services to marine life and human communities alike. In this section, we provide an overview of the marine and seagrass literacy at the European level by examining official

reports from EU bodies or international organizations, introducing key initiatives, frameworks, and policies that apply to multiple countries, as well as an overview of academic articles focused on Europe-wide seagrass or marine education.

In 2015, IOC-UNESCO embraced the concept of Ocean Literacy and began working to boost the global reach of the movement. In 2017, the United Nations General Assembly declared the Decade of Ocean Science for Sustainable Development (2021-2030), the Ocean Decade. As a result, 193 countries recognized the key role of ocean science in finding innovative ocean-based solutions for the major global challenges of our time. Structured around ten Ocean Decade Challenges, which represent the most immediate and pressing needs for ocean knowledge, the Ocean Decade aims to transform the way that ocean science and knowledge is generated and used, and thus precipitate a shift from the ocean we have to the ocean we want by 2030. The commitment 'Ocean Literacy for All', launched at the first UN Ocean Conference in 2017 marked the start of a series of activities to promote Ocean Literacy worldwide. This work included the launch of the "Ocean Literacy For All Toolkit" (Santoro et al., 2017) and the creation of the Ocean Literacy Portal, acting as a one-stop-shop for Ocean Literacy practitioners around the world. These initiatives have inspired the birth of a multicultural community of Ocean Literacy practitioners who are constantly promoting the concept at an international level. Specifically, the IOC-UNESCO "Ocean Literacy for All -A toolkit" (Santoro et al., 2017) is the result of a joint work and it provides to educators and learners worldwide the innovative tools, methods, and resources to understand the complex ocean processes and functions and, as well, to alert them on the most urgent ocean issues. It also presents the essential scientific principles and information needed to understand the cause-effect relationship between individual and collective behavior and the impacts that threaten the ocean health. The resources are designed to be relevant for all learners of all ages worldwide and to find their application in many learning settings, while in their concrete implementation they will, naturally, have to be adapted to the national or local context. In the same context, the IOC-UNESCO released the "Ocean Literacy and the IOC" (2017) providing examples of the IOC collaboration with other sectors in order to enhance activities for ocean literacy. Also, in 2017, the UN General Assembly declared the United Nations Decade of Ocean Science for Sustainable Development (2021–2030), the 'Ocean Decade', where 193 countries recognized the key role of ocean science in finding innovative ocean-based solutions for the major global challenges in our rapidly changing world. This initiative underlines that the support of new educational approaches is crucial to the success of the Ocean Decade.

In 2019, the release of the "Ocean Literacy for All Initiative - Summary of Achievements (2017-2018)" brochure aimed at presenting the activities that were undertaken by the IOC-UNESCO Project Office at the UNESCO Regional Bureau for Science and Culture in Europe throughout 2017 and 2018. Three

main activities were implemented in 2017:

1. Development of a highly visible online platform – www.oceanliteracy.unesco.org – to share resources, projects and knowledge on ocean literacy and sustainable development.
2. Organization of the First International Conference on Ocean Literacy, aiming to bring together the most prominent personalities from the scientific and academic world, public and private sector, art foundations, NGOs, to develop innovative methods and resources to communicate ocean literacy.
3. Production and dissemination of a multilingual publication of education material in the form of a toolkit, available in English, French and Spanish (Santoro et al., 2017).

The following activities were implemented in 2018:

1. Creation and development of an international module of Ocean School, a ground-breaking ocean science educational programme, to promulgate ocean literacy with high technological immersive methodologies. Specifically, the Ocean School comprised of engaging audio-visual materials such as video, virtual reality, augmented reality, educational games, and other interactive digital content to create an emotional and lasting connection with the environment, boosting motivation and leading students to address critical challenges by taking action. Placing local issues at the forefront of student projects allows for the development of transferable skills later in life.
2. Organization of the first training workshop on the Ocean School programme to test its use in different cultures and levels of expertise. The Ocean School Teacher Training Workshop in San José, Costa Rica (2-4 December 2018) was the first step to test the possibility of adapting the Ocean School programme and technology to different educational systems and geographical & cultural contexts. The 2.5 day training workshop, introduced the participants to the interactive tools and active learning materials provided through the platform. The sessions encompassed capacity building, planning and collaboration lectures to prepare teachers to implement Ocean School in their classrooms, giving them a concrete base of knowledge and plans for implementation of the tools and the approaches to use in their countries. The training also allowed to foster new collaborations among the teachers creating a regional community of educators interested in promoting ocean literacy locally and nationally.
3. Organization of the first meeting of experts to support decision making processes related to ocean management through ocean literacy. The aim of the workshop was to discover the most effective ways to communicate ocean knowledge to different audiences, and to share best practices and innovative views on the challenges of transforming knowledge into action, using creative and interactive Ocean Literacy tools.

The publication “Ocean Literacy within the United Nations Ocean Decade of Ocean Science for Sustainable Development-Framework for Action” released in 2021 describes an implementation plan in four specific priority areas in order to enhance ocean literacy and protect and conserve the ocean environment. Two of the priority areas concern formal education:

1. Mainstreaming Ocean Literacy in Education Policy Formulation: Policies govern and help shape the operation of formal and non-formal education systems globally. While the adoption of overall policies regarding environmental education and education for sustainable development is increasing worldwide, in many cases there remains a critical need to further strengthen specific ocean issues within these agendas, by considering the importance to inform policy-makers and develop further policies to advance Ocean Literacy. Systemic change in terms of Ocean Literacy will require relevant, context-specific and coherent policies designed by ministries and local governments, supported by cross-sectoral and multi-stakeholder engagement. The potential actions for this area are:
    - Establish a National Ocean Literacy Strategy and Ocean Literacy coordination mechanism, and designate a National Focal Point for Ocean Literacy.
    - Include Ocean Literacy in National Curriculum Standards in order to embed ocean education in primary and secondary schools.
    - Offer/Organize training programmes for government officials on ocean sustainability and/or Blue Economy opportunities.
    - Boost investments in Ocean Literacy schools and/or Ocean Literacy programmes.
2. Enhancing Formal Education of Ocean Literacy: Formal education institutions at every level from primary to secondary are key to help shape knowledge, attitudes, behaviours and actions towards ocean sustainability. Too often the ideas and knowledge of society around the ocean and sustainability issues in general are conceived in silos. Ocean Literacy, applied through a multi-disciplinary and cross-cutting approach, can be incorporated into most classroom courses and subjects, thus supporting ocean stewardship and regular subject delivery. Additionally, by fostering context-specific and hands-on learning and inquiry-based learning, Ocean Literacy can provide opportunities to enhance critical thinking, problem-solving and leadership skills, among other significant educational outcomes. The potential actions for this area are:
    - Training programmes for pre-service educators and active educators from multiple disciplines, including Ocean Literacy workshops, courses and field trips, in person and online.
    - Knowledge exchanges between formal educators and experts.

- Development of curriculum materials for primary and secondary schools, including digital resources and tools.
- Nature-based opportunities and educational actions for students (e.g. field trips, interactive workshops).

The IOC-UNESCO “A new blue curriculum” toolkit for policy-makers released in 2022 aims to achieve the targets proposed by the strategic vision of “Ocean Literacy within the United Nations Ocean Decade of Ocean Science for Sustainable Development-Framework for Action” which establishes “mainstreaming ocean literacy in education policy formation” and “enhancing ocean literacy in formal education” as a priority for the ocean decade. This publication invites education authorities and Ministries to engage with emerging trends in school curricula, and aims to support policy-makers and curriculum developers in implementing Ocean Literacy into their national curriculum framework. To advance behavioural change through the uptake of Ocean Literacy in school curricula, the toolkit highlights the Theory of Change offering the following four-part matrix for designing a curriculum rich in ocean content: knowledge and awareness, nature connectedness, values and attitudes and competences. According to the toolkit the following emerging trends in educational approaches and methods can shape a progressive blue curriculum:

- Embracing Ocean Literacy through a whole-school approach promotes a holistic understanding of the ocean’s importance, encouraging student agency to act, interact and participate as active citizens.
- Flexible and hybrid teaching and learning methods facilitate inclusive ocean education through the use o innovative tools like virtual reality, diverse materials and attention to individual student needs.
- Providing teachers with training and ready-to-use materials on Ocean Literacy builds networks of confident, connected educators.
- Extracurricular activities and field trips enhance student well-being and provide opportunities for cooperation with NGOs, academic institutions and local communities on initiatives to raise awareness and protect the marine environment.
- Understanding and valuing local, traditional and Indigenous knowledge about the ocean contributes to a multi-perspective approach to ocean content.
- Including blue case studies and examples helps to overcome terrestrial bias and misconception about the ocean, and foster Ocean Literacy in regions far from the coast.
- A blue curriculum considers the ocean across multiple disciplines, connecting knowledge between the sciences and humanities; and spans local and global scales, educating as students forward looking global citizens.

- Raising awareness of Ocean Literacy elevates its inclusion in policy frameworks, highlighting its connections with national priorities and attracting funding for initiatives.

To support blue curriculum development and implementation, the second part of this Manual provides a Toolbox to guide policy-makers through the process of:

- Considering approaches for developing a blue curriculum
- Implementing the Theory of Change
- Understanding the elements of a blue curriculum
- Revising the current curriculum structure
- Mapping national priorities, policies and Ocean Literacy

According to the "State-of-the-Art of Ocean Literacy" report (2022), the focus of the global community of Ocean Literacy researchers and practitioners is shifting – from making space for the ocean in formal education, towards developing critically informed, context-specific initiatives for ocean-literate societies. This report reviews methods and approaches in the current Ocean Literacy landscape, as well as research priorities. A set of successful case studies is presented in section, which inspires an aspirational checklist for Ocean Literacy initiatives. Five proposals or critical Ocean Literacy are offered, to envision a way forward for researchers, practitioners and stakeholders involved in the common goal to advance Ocean Literacy across the globe.

The "Best Practice Manual for National Decade Committees" (2023) manual includes eight National Decade Committee Case Studies, following their formation and activities. They provide some national background context for ocean science, considerations for creating a National Decade Committee, as well as examples of successful strategies and actions. The Manual also contains 21 vignettes highlighting how National Decade Committees are tackling specific priorities and challenges. National Decade Committees are also targeting schools for Ocean Literacy programming. In particular, through activities or the development of ocean-focused curricula.

The report "Collaborating with the ocean - A new model for ocean-literate corporate action" (2023) develops supportive tools to establish and advance programs with a positive impact on the marine and coastal environment, local communities, and society. The report analyses best-practice cases of private sector involvement in advancing ocean literacy programs, ocean research, and marine conservation and regeneration projects around the world. The goal of the report is to offer guidance to private company executives and managers, researchers, institutions and nonprofits on facilitating collaboration across sectors to further advance ocean conservation. The case studies described in the report are the following:

- Accenture - ReefCloud
- AXA - Ocean Education Encounter Edu

- Bioderma (NAOS) - Gorgònia Barcelona
- Biotherm (L'Oreal Groupe) - Water Lovers
- Bloomberg Philanthropies - Ocean Initiative
- Deloitte - The Ocean Cleanup partnership
- Deutsche Bank - Ocean Resilience Philanthropy Fund
- E.ON Italia - Save the Wave
- Google - Ocean Education
- ISDIN - Posidonia regeneration programme
- Panerai - Ocean Initiative
- Prada Group - SEA BEYOND
- Red Eléctrica de España - Marine Forest
- Rolex - Mission Blue Perpetual Planet
- Taylors Wines – SeaBnB

In July 2023, there was a call, IOC Circular Letter No 2951, to Official National Coordinating Bodies for liaison with the IOC to include Ocean Literacy in school curricula by 2025 as a part of the Education for Sustainable Development. According to the call, the IOC would offer support to member states in:

1. Advocating for the promotion of a Blue Curriculum within Educational Ministries, National Specialized Agencies, and Secretaries by 2035;
2. Encouraging all regions to embed Ocean Literacy in national educational frameworks including syllabuses, textbooks, and lesson plans;
3. Ensuring that Ocean Literacy is adapted to local realities allowing conscious decision-making regarding the ocean;
4. Organizing locally tailored Blue Curriculum training in the local national language, which can encourage efforts at the national level and help with coordinated action around the world; and
5. Holding training workshops and develop resource materials in different languages

The report "Ambition, Action, Impact: The Ocean Decade Pathway to 2030. Consolidated Outcomes of the Vision 2030 Process" (2024) summarizes the results and priority recommendations of the Vision 2030 process that was undertaken to refine the future direction of the Ocean Decade and further strengthen engagement and impact to 2030 and beyond. The vision 2030 process was the framework that was used to foster discussion during the 2024 Ocean Decade Conference that was held in Barcelona in April 2024.

The report "Ocean Literacy and the Atlantic Region – A Toolkit for Educators" (2024) seeks to contribute to the advancement of Ocean Literacy (OL) and the Sustainable Development Goals in the

Atlantic Region, by providing teachers adequate Ocean Literacy tools and supporting the inclusion of Ocean Literacy in the school curriculum, contributing to a literature review and examples of the diverse aspects of the Atlantic and examples of successful initiatives in the Atlantic Region. This publication aims to showcase and bring examples of how teachers and educators can use examples and adapt Ocean Literacy concepts to the classroom, making the ocean accessible to a large number of students. Specifically, one of the sections of this toolkit provides an interactive material for teachers with lesson plans to be developed with students and explore in particular the novel concepts of the AtlantECO project.

The “Venice Declaration for Ocean Literacy in action” (2024) finalized and signed during the first World Ocean Literacy Conference in Venice in June 2024, is a statement of intent for the Ocean Literacy community as it seeks to shape the agenda at the United Nations Ocean Conference (UNOC) to be held in Nice, France, in June 2025, and more generally to engage society to regenerate the most valuable ecosystem on our Planet. One of the proposed actions concerns the development of a solid and adaptable Ocean Literacy framework for formal and non-formal educational systems for all stakeholders, from students to educators, and policy makers.

In the same context and in response to the environmental challenges and human activities affecting European seas, the EU has established an extensive policy framework to manage and address these issues. Specifically, the European Commission recognizes the urgent need to enhance the ocean literacy of European Citizens as a crucial element of the implementation of sustainable management of the ocean.

The European Ocean Coalition (EU4Ocean) brings together diverse organisations, projects, and individuals dedicated to promoting ocean literacy and sustainable ocean management. The Network of European Blue Schools is one of the three pillars of the Coalition, established as a hub for all schools and teachers that strive to engage students with oceanic topics and educate a new generation of ocean literate young citizens. This initiative aims to integrate marine and maritime topics into classrooms, creating awareness and responsibility for our oceans among students. Schools can join the network by taking up the Find the Blue Challenge and identifying an ocean-based topic relevant to students, collaborating with pupils to create a school project and making the ocean a part of the school curriculum through project-based learning.

The European Atlas of the Seas is a publicly accessible web-based tool, providing interactive and diversified information in a comprehensive way to a broad public covering topics such as environment, tourism, security, energy, transport, litter, sea bottom, fishing activity, aquaculture. It is composed of a collection of maps with reliable data on natural and socio-economic features in the coastal regions of Europe. The Atlas Teachers' Corner aims to provide a platform where teachers can find exercises by

age group on a wide range of marine topics. The Atlas can be used in the classroom to expand knowledge of ocean science, geography, earth science, ecology, conservation, climate change, economics, and sustainable development and help students develop a multitude of competencies. It can also support cross curricular activities and school projects.

The “Out of the blue: The value of seagrasses to the environment and to people” was the first global report to be launched in 2020 by the United Nations on the importance of seagrass ecosystems to the environment and to people; it was hoped that this report will help raise awareness of the importance, but also the vulnerability, of this critical but often undervalued marine ecosystem. This global synthesis report builds on the foundation laid by countless individuals around the world who put their time, energy, and resources into understanding these amazing habitats. The World Seagrass Association was established in 2000 by a group of 11 such individuals from 7 different countries to raise awareness of the importance of seagrasses, facilitate training and information exchange, collect and make management information readily available for the conservation of seagrass habitats, and to provide political support for the sustainability, biodiversity, and resilience of the marine environment. Since then the WSA has grown to include members from more than 20 countries, facilitated scientific exchange via the International Seagrass Biology Workshop series, contributed to the development of the first Global Atlas of Seagrass, and most recently, spearheaded an effort to develop an informal ‘World Seagrass Day’, in order to heighten global awareness on these important ecosystems. It is the hope of the World Seagrass Association that this report will further raise the profile off these underappreciated resources and provide a path forward for their conservation and science-based management.

The document “Protecting Seagrass Through Payments for Ecosystem Services: A Community Guide” released in 2020 explores the ways in which community groups could use Payments for Ecosystems Services to run a seagrass conservation project. It outlines the requirements of running a project and includes best practice guidance on governing and operating a community-based conservation project. According to the guide, among the benefits of conservation could be opportunities for recreation, education and research. Among the best practices mentioned in the report “Collaborating with the ocean - A new model for ocean-literate corporate action” (2023), the following programs concern education on seagrasses.

Save the Wave is a IOC/UNESCO project that E.ON and its customers support and which is part of the broader Ocean Decade initiative created by the United Nations and the UNESCO Intergovernmental Oceanographic Commission (IOC/UNESCO). The project has a focus on Posidonia oceanica meadows. The program involved educational programs and training activities which aimed at young people, students, fishermen and entrepreneurs in the coastal tourism sector and beyond, and especially many

primary and secondary students.

ISDIN is heading up the Posidonia Recovery Programme off the island of Formentera in the Balearic Islands, and has stepped into the front line to actively support this green seabed and to safeguard the sea and its creatures, with the aim of repopulating the fields of Posidonia, as well as launching a campaign to raise awareness about the key role this plant plays. Among others, the project offers an educational programme called Dive Camp, in which young people and children (8 17 years old) get involved in planting Posidonia oceanica, as well as a volunteer programme in which tourists and divers can assist with planting Posidonia.

Red Eléctrica's Marine Forest is a pioneering global project, initiated in 2012 in partnership with the Spanish National Research Council (CSIC), to restore Posidonia oceanica beds around Mallorca. The project has also extended into the field of environmental education with the "La Posidònia a l'Aula" (Posidonia in the Classroom) programme, developed by IMEDEA for Mallorca's primary and secondary schools.

In May 2022, the General Assembly proclaimed 1 March as World Seagrass Day. The resolution highlights the urgent need to raise awareness at all levels and to promote and facilitate actions for the conservation of seagrasses in order to contribute to their health and development, bearing in mind that enhancing ecosystem services and functions is important for the achievement of the Sustainable Development Goals.

An overview of academic articles focused on Europe-wide marine education was conducted. The study was conducted during January 2025 through a bibliographic survey using the Scopus multidisciplinary database. Publications were searched from the database's custom data using "ocean", "literacy" and "school" as search criteria. The documents where the afore-mentioned search criteria appeared in the title, keywords, and/or abstract were included in the study. Screening was conducted at the title, abstract and full text level. Articles were included if they focused on Ocean Literacy issues in Primary Education in Europe.

In total, 135 references published before January 20, 2025 were imported. Screening at the title and abstract level, and, at a second stage, at full-text level excluded 101 references and left 34 references, which met all search criteria. A complete list of these 34 publications is given in the Appendix A. Twenty-nine articles published in journals (n=29, 85.3% of all articles), four book chapters (n=4, 11.8%) and one article published in conference proceedings (n = 1; 2.9%) made up the literature base.

The earliest article on Ocean Literacy, dealing with the content knowledge of ocean sciences issues of Greek primary school pre-service teachers and their attitudes toward ocean stewardship, was published in 2015 (Mogias et al. 2015). The number of articles increased from 2018 onwards, peaking in 2024 (n=8).

Ocean Literacy studies have been most frequently conducted in Portugal (n=7), followed by Greece (n=4), Croatia (n=3), Ireland (n=2), Italy (n=2), Poland (n=2), Spain (n=2) and UK (n=1), while ten (n=10) studies had multiple study locations.

The Ocean Literacy (OL) articles are placed in several categories according to their content. Each publication could belong to more than one category. In particular, these articles can be distinguished, among others, in articles defining and conceptualizing OL (Mokos et al. 2020a), articles that include studies analyzing and reviewing OL studies (e.g. Ahmad-Kamil et al. 2022), articles containing the use and evaluation of books in terms of OL (e.g. Aurélio et al. 2021, Mogias et al. 2021, Ezgeto-Balic and Balic, 2024), articles including scale development studies to determine students' OL levels (e.g. Markos et al. 2017), articles measuring and evaluating students and teachers' OL levels (e.g. Mogias et al. 2015, 2019, Ashley et al. 2019, Realdon et al. 2019, Costa et al. 2024), articles containing studies on the development of students' and/or techers' OL levels (e.g. Ashley et al. 2019, Mokos et al. 2020b, Boaventura et al. 2021, Baldrighi et al. 2022, Kevrekidis et al. 2024, Silva et al. 2024),articles for organizing and improving teaching environments for OL (e.g. Zielińsky et al. 2021, Miovi, 2022, Chappell and Hetherington 2023, Schio and Reis 2024), articles on the use of digital technologies for OL teaching (Leitão et al. 2022a, b, Chappell and Hetherington 2024), articles exploring the use of games for teaching OL (Leitao et al. 2022a, b), articles on educational programs designed for teaching OL (e.g. Baldrighi et al. 2022, Kevrekidis et al. 2024), articles where sustainability is associated with OL (e.g. Ashley et al. 2019, Mokos et al. 2020b), and articles containing the Citizen Science approach (e.g. Ceccaroni et al. 2023).

To more thoroughly capture the research on Ocean Literacy in Primary Education that has been developed in Europe, a brief description of some representative articles, based on article's abstract, is presented below.

Mogias et al. (2015): Greek pre-service teachers' level of ocean literacy was assessed using a revised questionnaire concerning ocean content knowledge and an instrument about ocean stewardship. Rasch analyses showed that the items of both measures were well targeted to the sample. Pre-service teachers possessed a moderate knowledge of ocean sciences issues and positive attitudes toward ocean stewardship; they obtained most information on ocean content from the Internet and mass media and less from formal education, nongovernmental organizations, books, and out-of-school settings. Students who mostly preferred the Internet and mass media scored significantly higher on the knowledge questionnaire. The results could contribute to the enhancement of teacher's ocean literacy.

Mogias et al. (2019): In this study, the content knowledge of elementary school students (grades 3-6) in regards to ocean sciences issues were examined. A structured questionnaire was administered to

1004 students participating in a cross cultural study from three Mediterranean countries (Italy, Croatia, and Greece). The results of the study indicated a rather moderate level of knowledge in the total sample, while slight differences were recorded among the three countries revealing common knowledge gains and misconceptions. Rasch analysis was applied to further evaluate the validity of the results, while the influence of certain demographics on students' knowledge level was also investigated. This study concluded with a discussion of the implications on national curriculum development in elementary education level, in order to promote ocean literacy and to ensure protection and conservation of the Mediterranean Sea.

Mokos et al. (2020a): Based on the Ocean Literacy framework, marine scientists and educators developed the "Mediterranean Sea Literacy" (MSL) guide adapted to the specificities of the Mediterranean region, presented in this article. The MSL principles (7) and concepts (43), serving as guidance for research, education, informed decision-making, and improved citizens' lifestyles, aim to contribute to environmental protection, conservation, and restoration of the Mediterranean Sea as well as to help to achieve a blue innovative and sustainable economy.

Mokos et al. (2020b): This study presented the level of marine knowledge in a sample of primary school students before and after different themed non-formal educational interventions and the effect of non-formal educational activities on students' knowledge. These activities led to significant increase in the knowledge level three weeks after they were performed, indicating the retention of gained information. Performed educational activities and knowledge transfer from graduate level to primary school level significantly increased the level of students' knowledge, and consequently ocean literacy, and revealed some of the learning misconceptions. Results of this study showed that there is a need for an integrated approach to the teaching of Ocean Literacy starting from the early grades by combining teacher's professional development, strengthening ocean-related topics in school curricula, and promoting non-formal educational activities.

Costa et al. (2021): The aim of this work was to present the Portuguese Blue School programme, an initiative born in response to the above need, to prepare ocean-literate citizens and support the development of the blue economy. The Blue School PT programme promotes an integrated political strategy for marine education capable of engaging all sea sectors, with the goal of improving the level of ocean literacy in the short and long term. Headed by the Ministry of Sea, the Blue School is supported by universities, governmental and non-governmental organizations, municipalities, industries and companies. Over the different sections the authors presented an overview of the ocean literacy context underlying the creation of the Blue School, the Blue School concept and functioning and the results of its first years of implementation. This programme, fitting the objectives of the United Nations (UN) Sustainable Development Goals (SDG) 4, 14 and 17, accounted for the national strategies

for sea and education and the evolving view of ocean literacy, addressing identified barriers to its implementation in schools.

Miovi (2022): The “Percorsi nel Blu” project is a revolutionary “Blue School” model of well-integrated ocean literacy (OL) and marine citizen science (MCS), promoted by a science teacher and independent researcher of the ISA2 secondary school institute of La Spezia, Italy. Since 2011, the project has been setting up a network among schools, institutions and citizens, as well as a partnership with research centres for data collection activities within coastal sites located in the “Pelagos” Mammals’ Sanctuary in the Ligurian and Tyrrhenian seas. The project focuses on the key points of OL and MCS, promoting a gradual implementation of scientific literacy in marine biology and coastal monitoring techniques in school curricula during a period of vertical and incremental long-lasting training, from kindergarten to university. “Percorsi nel Blu” harmonises the existing educational plans with the last recommendations of the United Nations Sustainable Development Goals (UN SDGs) of the 2030 Agenda in order to improve the teaching of science, technology, engineering and mathematics (STEM disciplines). The OL process follows the complete educational path, actively involving students in the recognition of marine flora and fauna during research activities on the beach and scuba surveys in research campaigns. The great impact on the community, the remarkable number of participants and the relevant scientific results of the first records of alien and native species increase students’ interest in STEM disciplines and marine sciences and encourage them to disseminate their experiences, thus creating the awareness of global citizenship, which includes the whole community, both inside and outside school.

Ceccaroni et al. (2023): The Network of European Blue Schools established under the EU4Ocean Coalition for Ocean Literacy has improved ocean and water literacy; however, this Network needs to grow and be supported. This study presented ProBleu, a recently funded EU project that will expand and support the Network, partly through the use of citizen science. The core of the proposed methodology is facilitating school activities related to ocean and water literacy through funding calls to sustain and enrich current school activities, and kick-start and support new activities. The outcomes of the project are anticipated to have widespread and long term impacts across society, and oceanic, coastal and inland water environments.

Ezgeta-Balic and Balic (2024): This study analyzed the integration of ocean literacy principles (OLP) and concepts in Croatian elementary education. The content of textbooks for grades 1–8 across subjects like Nature, Biology, Geography, Chemistry, and Physics was examined. In total, 7,520 pages across 55 textbooks were analyzed. The results revealed that, although all seven OLPs were present, numerous concepts were absent or only partially addressed. Discrepancies with the recommended Ocean Literacy Scope and Sequence were identified, particularly in lower grades. The findings highlight gaps

in incorporating ocean sciences topics into formal education. Enhanced inclusion of OL principles and concepts across subjects and grades would provide students with comprehensive knowledge about the ocean, empowering future generations to make informed decisions and take responsible actions regarding ocean sustainability and conservation. The findings highlight the necessity for collaboration among ocean scientists, educational specialists, and policymakers to incorporate OL into curricula and textbooks, thereby enhancing students' understanding of ocean sciences.

Schio and Reis (2024): Following a design-based research methodology, this investigation developed a pedagogical model to foster ocean citizenship through the application of a design cycle consisting of four phases: (1) preliminary research, (2) planning, (3) action and (4) evaluation. This article presents the results of phases 1 and 2, which define the conceptual foundation of the pedagogical model, and the planning of actions for its implementation in the school environment. The conceptual foundation was established by drawing upon the theoretical principles of a systemic/complex approach to education, along with theoretical methodological elements compiled from literature in the field of ocean literacy and ocean citizenship. During the planning phase, six educational activities were defined, to be conducted as part of a citizen science project to monitor the coastal zone. This model was developed with the objective of going beyond theoretical concepts, to offer schools a practical and objective guide for fostering ocean citizenship in basic education.

Costa et al. (2024): This study explored the perception of Azorean school teachers on ocean literacy. This study aimed to evaluate how ocean-related themes are incorporated into regular teaching activities and how Azorean schools are educating students to become environmentally responsive regarding ocean sustainability. Targeting SDG 14, an online questionnaire was sent to all public schools in the archipelago and distributed to teachers during the 2021/22 school year. A total of 426 answers from a potential target population of 5502 teachers were accepted as valid. The authors found that the teaching community has a generalized awareness of ocean literacy, which is not reflected in the pedagogical practice, as 58% of the respondents do not integrate ocean-related themes into their activities. Moreover, most schools in the archipelago are not integrated into ocean literacy projects. The results highlight the need to incorporate ocean themes in official curricula and manuals and develop easy-to-access ocean-related learning materials to ensure the ocean's environmental sustainability.

Kevrekidis et al (2024): The primary objective of this study was to contribute to the conservation and sustainable use of seas by promoting Ocean Literacy. It investigated the impact of an educational program on Greek primary and secondary public school students' knowledge about coastal lagoons and attitudes towards marine environment conservation. An educational resource titled "Exploring the Coastal Lagoons" was developed to facilitate the non-formal educational intervention. The

program involved classroom, fieldwork/outdoor and laboratory activities, focusing on enhancing understanding of coastal lagoons' abiotic and biotic characteristics and human interconnection. Results showed improved knowledge and slightly more positive attitudes after the didactic intervention. The study underlines the effectiveness of targeted educational interventions in marine sciences, suggesting that non-formal educational settings influence student outcomes more than family or informal sources. Younger students appeared more adaptable and responsive to educational stimuli. The study advocates for refined educational strategies integrating cognitive and emotional elements, emphasizing real nature experience.

An overview of academic articles focused on Europe-wide seagrass education was conducted. The study was conducted during January 2025 through a bibliographic survey using the Scopus multidisciplinary database. Publications were searched from the database's custom data using the following sets as search criteria: seagrass (or marine AND angiosperm) AND literacy, seagrass (or marine AND angiosperm) AND education, seagrass (or marine AND angiosperm) AND education AND school, seagrass (or marine AND angiosperm) AND education AND student, seagrass (or marine AND angiosperm) AND education AND child, seagrass (or marine AND angiosperm) AND education AND teaching, and seagrass (or marine AND angiosperm) AND education AND learning.

The documents where the afore-mentioned search criteria appeared in the title, keywords, and/or abstract were considered. Screening was conducted at the title, abstract and full text level. Articles were included if they focused on a European country and/or the location of the first author was a European country.

In total, 89 references published before January 21, 2025 were imported. Screening at the level of the combination of the location of the study with the first author location, excluded 65 articles and left 24 articles. Namely, the location of the study and/or of the first author was at a European country in 24 articles. Screening, at a second stage, at the title, abstract and full-text level excluded 13 references and left 11 references, which met all search criteria and made up the literature base.

All eleven articles were published in journals. The earliest articles on seagrass literacy related issues were published in 2002 (Duarte 2002, Milazzo et al. 2002). From 2014 onwards, the number of articles varied between 0 and 1 per year. Combining the location of the study with the first author location, it was found that studies on seagrass literacy related issues have been most frequently conducted in Italy (n=4) and Spain (n=3), followed by Portugal (n=2),

and Greece (n=1) and UK (n=1).

According to their content, the articles were divided into six categories. The first category includes articles related to the global status and prospects of seagrass ecosystems (Duarte, 2002, 2008a, 2008b). Duarte (2002) noted that three key actions are needed to ensure the effective conservation of seagrass ecosystems: (1) the development of a coherent worldwide monitoring network, (2) the development of quantitative models predicting the responses of seagrasses to disturbance, and (3) the education of the public on the functions of seagrass meadows and the impacts of human activity. Duarte (2008a) reported that more effective communication of scientific knowledge about these ecologically important coastal habitats is required; effective use of formal (e.g., school curricula, media) and informal (e.g., web) education avenues and an effective partnership between scientists and media communicators are essential to raise public awareness of issues, concerns, and solutions within coastal ecosystems.Similarly, Duarte (2008b) noted that seagrass ecosystems are in need of active management to ensure their persistence and long-term survival, requiring education, increased awareness, management and conservation on a global scale.

The second category includes one article defining and conceptualizing seagrass literacy (Apostoloumi et al., 2021). The study of Apostoloumi et al. (2021) aimed to contribute to the creation of a seagrass-literate society, by defining key principles and concepts in relation to seagrasses that a seagrass-literate person should know. Six principles about seagrasses were defined. Each one is underpinned by a set of concepts. These principles and concepts concern key issues of seagrass biology (Principles 1-4), value (Principles 3-5), loss and protection (Principle 5), and research (Principle 6). Seagrass principles and concepts can be primarily used for educational purposes and as a practical resource to policy- and decision-makers. This attempt could stimulate a collaborative effort of scientists and educators, aiming to improve the recommended principles and concepts, and to contribute to seagrass conservation.

The Seagrass Principles are as follows:

1. Seagrasses are unique plants.
2. Seagrasses form extensive underwater meadows.
3. Seagrasses support a great diversity of life.
4. Seagrasses stabilize the seabed, improve water quality and store carbon

5. Seagrasses and humans are inextricably interconnected.
6. Seagrasses are largely unexplored

The third category includes articles on environmental protection projects, implementing communication and environmental education actions (Cunha et al. 2014; Acunto et al. 2017). The study of Cunha et al. (2014) deals with the LIFE BIOMARES project. This project aimed at the restoration and management of the biodiversity of the marine park Prof. Luiz Saldanha, in the coast of Arrábida, through several actions. The restoration of the seagrass prairies that were completely destroyed by fishing activities and recreational boating, was one of the most challenging. It included the transplanting of seagrasses from donor populations and the germination of seagrass seeds for posterior plantation to maintain genetic diversity in the transplanted area. One of the most popular actions was the implementation of environmental friendly moorings to integrate recreational use of the area with environmental protection. Several dissemination and environmental education actions concerning the marine park and the project took place and contributed to the public increase of the park acceptance. The study of Acunto et al. (2017) regards RES MARIS, an environmental protection project, which was co-financed by the European Union through the LIFE + Nature and Biodiversity Programme. The project aimed at the conservation and recovery of marine and terrestrial ecosystems, included in the marine Site of Community Interest "Isola dei Cavoli, Serpentara, Punta Molentis e Campulongu". Among the habitats selected for the implementation of the project were Posidonia beds. Sea-land integrated actions were needed to achieve the project objectives. Communication actions used various conventional and multimedia tools including brochures, panels, a role-playing game, and an application/game for mobile phones. Environmental education and awareness-raising activities were addressed to schools and local stakeholders; a good practices manual on the integrated management of the coastal zone was devoted to key territorial players.

The fourth category has articles on sustainable managements of beach-cast seagrass in Mediterranean coastal areas (Rotini et al. 2020, Manfra et al. 2024). Rotini et al. (2020) proposed an integrated management model for Posidonia oceanica deposits and suggested that several activities including educational programs must be implemented to successfully spread the model. Manfra et al. (2024) reported that the analysis of twenty research projects related to the topic revealed a limited effort towards communication and education activities.

The fifth category has articles related to the impact of human recreational activities on marine

habitats, including seagrass meadows (Milazzo et al. 2002, Parry-Wilson et al. 2019). Milazzo et al. (2002), who reviewed the relevant literature, suggested that management strategies should be implemented through education, training and changes in legislation and policy. The study of Parry-Wilson et al. (2019) focused on a bespoke eco-mooring design deployed in 2017 to protect seagrass (Zostera marina) beds within a popular anchorage in Southwest England. The authors assessed the behavioural and social responses of recreational boaters to the trial eco-mooring through 1) mapping of boating activity pre- and post deployment and 2) structured questionnaires both on-site and online to local and national audiences respectively.

Finally, the sixth category includes one article dealing with the tourism dimension of seagrass meadows (Rangel et al. 2015). In the study of Rangel et al. (2015), three underwater self-guided, eco-touristic snorkeling routes were designed at Marinha Beach (Algarve, Portugal), based on scientific information, in terms of location, presence of charismatic species and protected species (e.g. seagrasses), with in situ interpretation and guidance, as a way to enhance biodiversity awareness. The routes were implemented in two consecutive summer seasons. Snorkelers' opinions and perceptions about several issues related to the routes' environmental education role (e.g. role in enhancing biodiversity awareness) were investigated by questionnaire after the snorkelling activity. Results indicated that, in fact, in situ education and interpretation can raise environmental awareness if properly addressed, resulting in a satisfactory way of engaging snorkelers in the protection and in the conservation of the visited environments.

4.1.3.1. Conclusions and Recommendations

The overall above literature review reveals that to date, a significant number of Ocean Literacy initiatives have been developed and implemented at the European level. They range from educational programmes focusing on ocean issues, to Ocean Literacy centres promoting hands-on activities and company-funded education programmes for students, as well as public-awareness campaigns and immersive learning programmes at aquariums. Accordingly, a noteworthy number of academic articles have been published concerning ocean literacy in formal education. However, the reports and articles concerning seagrass literacy in general and specifically for primary education are extremely limited. This disparity offers educators, decision-makers, and environmental groups a critical chance to create organized programs that improve seagrass literacy. In this context, it is of fundamental importance the fact that the key principles and concepts about seagrasses that a seagrass-literate person should know have been defined (Apostoloumi et al., 2021).

The attempt to develop the Principles and Concepts about Seagrasses could stimulate a collaborative effort of scientists and education professionals, aiming to improve these principles and concepts, to include key issues associated with important seagrass-related topics into educational curricula and

practice, and, ultimately, to promote public awareness of seagrasses. The Marine Science Educators' Association (EMSEA) that has been developed in the context of the Ocean Literacy movement in Europe could lead this effort, in close collaboration with the research team that developed the Seagrass Principles and Concepts and the World Seagrass Association, which "supports training and information exchange and raises global awareness of seagrass science and environmental management issues" (https://wsa.seagrassonline.org/).

4.2. Part 2: Best Practices and Case Studies

The second section of the SEAQUEST State-of-the-Art Report looks at best practice in the form of case studies of marine and seagrass literacy education throughout Europe. Following the theoretical and policy recommendations of the Literature Review, this section looks at practice on the ground—how schools, NGOs, research centres, and communities are already building marine awareness and responsibilities among young people.

Based on both non-formal as well as formal educational environments, this section presents effective examples of experiential learning, citizen science, gamified online platforms, as well as cross-curriculum learning. The section includes projects such as Blue Schools, environmental education networks, local marine literacy projects, with projects examining educators' professional learning that demonstrate hands-on, locally focused learning can make the ocean and seagrass issues tangible to students.

The study highlights the translatability of such practices across different contexts, pinpointing the success factors of institutional support, educator involvement, curriculum adaptability, as well as cooperation with marine scientists and NGOs. The study also discusses the difficulties of scale-up such activities and incorporating them systematically into national educational frameworks.

In the end, this section provides a bank of inspiration to educators and policymakers to adopt and extrapolate effective models of marine education. The results from these lessons here actually guide the future stages of the SEAQUEST project—namely the creation of the Educational Toolkit and Interactive Game—by showing.

4.2.1. Best Practices in Seagrass and Marine Literacy

The program "Cyclades Posidonia Alert" developed by the "Cyclades preservation Fund" (https://cycladespreservationfund.org/el/programs/cyclades-posidonia-alert/) adapting the training material of the "LIFE SEPOSSO" programme, aims to educate primary and secondary students and raise their awareness of the importance and responsibility of conserving Posidonia oceanica meadows in Cyclades and marine protected areas in the Natura 2000 network. The kit is organized into sections

and the teacher can choose the section according to students' needs and difficulty level.

The educational material "Searching for the natural treasures in the Special Protection Area of Andros" aims to introduce primary and secondary students to the special features of area of Andros, using experiential activities accompanied by lesson plans ready to be used by the teacher. The material includes activities about seagrasses, aiming to raise students' awareness about the species of angiosperms and their contribution to marine life (Αντύπας & Λαντζούδη, 2014).

The purpose of the educational material "Exploring the coastal lagoons» is to raise primary and secondary students' knowledge of the lagoon ecosystem and its sustainable management by conducting field research in an estuarine environment. Collecting seagrasses and studying them in the lab are among the activities of the educational guide (Κεβρεκίδης, et al., 2023).

The Action "Exploring the Posidonia meadows", using educational audiovisual material, presented to students the marine angiosperms, emphasizing on the meadows of Posidonia. During the presentation, students were informed about their ecological importance and value for humans, the threats they receive from human activities as well as the ways in which all can contribute to their protection (Hellenic Foundation for Research and Innovation, H.F.R.I., https://www.elidek.gr/2024/11/13/14758/).

The Vodafone Foundation, through a nationwide information campaign, starring children and their contact with Posidonia meadows, invites everyone to discover this precious lung of the Mediterranean and actively participate in the protection of a unique underwater treasure, the Posidonia meadows. It created the platform "Citizen Science" posidonia.vodafone.gr, an information and awareness platform for Posidonia, which enables all members of the public to become citizen-scientists and contribute in simple ways, both to the enrichment of scientific knowledge and to protection actions.

The Hellenic Phycological Society has developed the educational material "Getting to know algae" with activities to be used in class. The material also includes information and activities concerning seagrasses to help children understand the differences between the two plant categories (https://phycology.gr/index.php/en/).

To effectively integrate seagrass literacy into primary education, various best practices have been implemented across different regions, including Cyprus and the broader Mediterranean. This section examines five successful educational programs that serve as models for enhancing marine literacy in primary schools.

a. Mediterranean Seagrass Awareness Program (WWF Mediterranean, 2023)

This awareness campaign, led by WWF Mediterranean, aims to educate children about Posidonia oceanica and its role in marine ecosystems (The Mediterranean, 2023). Target Group: Primary school students in Cyprus and other Mediterranean countries.

Methods Used:

- Interactive classroom lessonsfocusing on seagrass biodiversity and conservation.
- Field trips to seagrass meadows to observe marine life and ecosystem interactions.
- Hands-on activities such as seagrass restoration and cleanup events.

Outcomes:

- Increased student awareness of marine conservation.
- Improved understanding of human impacts on marine habitats.
- Engagement in conservation activities, fostering environmental responsibility.

b. EU Ocean Literacy Toolkit (European Commission, 2021)

This initiative, supported by the European Commission, provides a comprehensive digital and print toolkit to help teachers incorporate marine literacy into classrooms (Purpose of This Toolkit - European Commission, 2021.).

Target Group: Teachers and primary school students across Europe, including Cyprus.

Methods Used:

- Lesson plans focused on marine biodiversity and seagrass ecology.
- Educational games and virtual reality experiences exploring underwater habitats.
- Training sessions for teachers on how to integrate ocean literacy into existing curricula.

Outcomes:

- Teachers gained confidence and resources to teach marine science.
- Students developed higher engagement through interactive digital learning.
- Increased integration of seagrass topics in classroom discussions.

c. Seagrass Field Studies (Local Universities, 2023)

In collaboration with marine research institutions, this program provides students with first-hand exposure to seagrass meadows and their ecological importance (McKenzie et.al, 2023).

Target Group: Primary school students in Cyprus.

Methods Used:

- Guided field studies where students collect data on seagrass ecosystems.
- Workshops with marine biologists, offering insights into seagrass conservation.

- Classroom follow-ups using student-led research projects.

Outcomes:

- Enhanced scientific inquiry skills among students.
- Increased environmental stewardship and community involvement.
- Strengthened connections between schools and marine research organizations.

d. Virtual Learning on Marine Ecosystems (Cyprus Environmental Education Centers, 2022)

This initiative utilizes virtual reality (VR) technology to immerse students in marine environments, including seagrass ecosystems (Cesc – Terra Cypria, 2022.).

Target Group: Primary school students, particularly in urban areas with limited access to marine habitats.

Methods Used:

- VR simulations that allow students to “dive” into seagrass meadows.
- Interactive online modules on marine biodiversity and conservation.
- Integration of multimedia content, including videos and quizzes.

Outcomes:

- Broadened access to marine education, especially for inland schools.
- Higher engagement and retention of information compared to traditional learning.
- Encouragement of digital learning tools in environmental education.

e. Citizen Science in Marine Conservation (WWF Mediterranean, 2023)

A community-based initiative that involves students in real-world environmental research on seagrass ecosystems (WWF, In Challenges Time, We Are Working for People and Nature, 2023.).

Target Group: Upper primary school students, teachers, and local communities.

Methods Used:

- Citizen science projects where students collect and analyze data on seagrass health.
- Collaboration with marine researchers to monitor local ecosystems.
- Public outreach campaigns where students present findings to their communities.

Outcomes:

- Encouraged active participation in environmental conservation.

- Increased student engagement through real-world applications of science.
- Fostered stronger community involvement in marine protection.

Conclusion and Recommendations

These best practices highlight effective approaches for integrating seagrass literacy into primary education.

Key Recommendations:

1. Expand teacher training programs using resources from the EU Ocean Literacy Toolkit.
2. Encourage experiential learning through field studies and citizen science projects.
3. Integrate digital tools such as VR into marine education.
4. Strengthen partnerships between schools and conservation organizations.
5. Develop national policies incorporating marine literacy into sustainability education.

By adopting these successful strategies, Cyprus can enhance marine literacy, leading to greater student engagement and environmental stewardship.

Although seagrass-focused education in Belgium remains limited, several related initiatives demonstrate a growing momentum to bring marine topics—including seagrass, algae, and biodiversity—into primary school classrooms. These initiatives serve as inspiring examples of how ocean literacy can be strengthened through creative and engaging programming.

- **Horizon Educatief – Expedition Coastline**: Horizon Educatief, a coastal education center based in Ostend, has launched the concept of 'marine educational areas' to promote place-based learning and establish EU Blue Schools in Belgium. This pilot initiative, *Expeditie Kustlijn* (Expedition Coastline), invites students to explore and investigate various aspects of the Belgian coast, fostering a sense of connection and curiosity about local marine environments. Link

- **VLIZ – Wild van Water**: The Flanders Marine Institute (VLIZ) has developed a spectacular science show and accompanying experiment book titled *Wild van Water* (Crazy About Water), designed specifically for children from primary schools. This resource introduces pupils to oceanography, marine life, and environmental stewardship in an exciting and accessible way. Link

- **VLEET**: The Belgian marine education encyclopedia VLEET for school pupils (all ages) mentions seagrass, linking it to beachcombing activities. Link

- **De Wilde Noordzee (The Wild North Sea)**: This stunning new wildlife documentary features rich footage of marine biodiversity across the North Sea, including seagrass meadows found in neighboring regions. The film is currently being shown in schools across Belgium, offering a rare opportunity for children to encounter these habitats visually and emotionally.
- **Best Practice on Seaweed Education**: A pioneering Flemish primary school has piloted an innovative classroom module on seaweed, showcasing how marine plant life can be introduced into everyday learning. The project includes taste tests, biology lessons, and sustainability discussions, helping students connect with the sea in multiple ways. Link
- **Educational Videos on Algae**: A series of engaging Dutch-language videos introduces students to the world of algae. These clips cover their biology, ecological functions, and their use in food and industry, and can serve as supplementary resources in lessons on marine plants:
    - Wat zijn algen?
    - Algen in de zee
    - Eetbare algen
- **Provincie West-Vlaanderen – Sea Class Educational Materials**: The Province of West Flanders provides tailored educational materials for sea classes. These resources support outdoor experiential learning by connecting classroom topics with real-world coastal observations and interactive fieldwork.

Together, these Belgian initiatives illustrate that even without native seagrass habitats, there are ample opportunities to integrate marine themes—including underwater plants—into education. They demonstrate the power of storytelling, place-based exploration, and sensory learning in fostering a deeper understanding of marine ecosystems.

There exist no curricula specifically mentioning seagrass in Denmark. The curriculum for the science courses in Danish primary school consists of the following topics: humans,

organisms, and water, air and weather. It is up to the teacher to decide what teaching material to use within these topics (Danish Ministry of Children and Education., 2019).

Ocean literacy is not evaluated in the Danish school system. At primary levels there are no national or official tests or exams evaluating either ocean literacy or the students' skills in the subject (Andersen, P. U., Brandt, H., & Lund Nielsen, B., 2019).

Seagrass meadows play a crucial role in Portugal's coastal ecosystems by providing essential services such as carbon sequestration, habitat provision, and shoreline stabilization. Several leading research

institutions and organizations are actively engaged in studying, conserving, and restoring these valuable marine habitats, while also promoting environmental education through university extension programs.

Several universities in Portugal have developed extension programs that integrate research and community engagement, focusing on environmental education and ocean literacy:

University of Algarve (CCMAR) - Environmental Education Programs

CCMAR runs initiatives aimed at educating school students, teachers, and the general public about seagrass conservation. Their outreach activities include guided field trips, workshops, and citizen science programs, where participants contribute to monitoring seagrass meadows.CCMAR. "Seagrass Education and Citizen Science Programs." Available at: [https://ccmar.ualg.pt]

University of Aveiro - Marine Education for Schools

The University of Aveiro collaborates with schools to provide educational programs on marine biodiversity, including seagrass meadows. The institution develops teaching materials and organizes field visits, allowing students to gain hands-on experience with coastal ecosystems.University of Aveiro. "Bringing Marine Science to Schools." Available at: [https://www.ua.pt]

CIIMAR - Blue School Program

CIIMAR promotes marine literacy through its Blue School Program, which integrates seagrass ecology into primary and secondary school curriculums. They conduct hands- on learning experiences, helping students understand the importance of marine conservation.CIIMAR. "Blue School Program: Fostering Marine Literacy." Available at: [https://www.ciimar.up.pt]

Several programs in Portugal have successfully promoted Ocean Literacy, some of which can serve as models for integrating seagrass meadow literacy into education:

Ocean Alive – Community-Based Conservation

Ocean Alive is a cooperative dedicated to the protection of seagrass meadows in the Sado Estuary. Their work involves engaging local fishing communities, particularly women, in conservation efforts. Through their "Guardians of the Sea" program, they raise awareness about the importance of seagrass habitats and promote sustainable fishing practices. Ocean Alive. "Guardians of the Sea: Engaging the Community in Seagrass Conservation." Available at: [https://www.ocean-alive.org]

Blue school program

Promoting ocean literacy has been a priority in Portugal, as reflected in various official documents and government initiatives. The Directorate-General for Maritime Policy (DGPM) plays a central role in this effort by developing training programs and providing educational resources aligned with school curricula. These initiatives also include projects tailored for different educational levels, ensuring a comprehensive approach to marine awareness. One of the flagship initiatives is the "Escola Azul" (Blue

School) program, coordinated by DGPM. This initiative distinguishes and supports schools that incorporate marine-related topics into their curricula, fostering an educational community committed to ocean sustainability. While primarily focused on general ocean literacy, these programs provide a foundational structure that could be expanded to include specific education on seagrass meadows and their ecological significance. Directorate-General for Maritime Policy (DGPM). Available at: [https://www.dgpm.mm.gov.pt]

These projects and programs reflect Portugal's commitment to integrating ocean literacy into education policies and society, aiming for greater environmental awareness and responsibility. By leveraging these established frameworks, future initiatives could extend their reach to include specialized education on seagrass meadows, ensuring that their conservation becomes a core part of marine sustainability efforts.

4.2.1.1. Conclusion

The overview of Greek, Cypriot, Belgian, Danish, and Portuguese ocean and seagrass best practices offers a broad range of activities that can serve as models for the integration of marine education into primary school systems. In Greece, several programmes—"Cyclades Posidonia Alert" and "Exploring the Posidonia Meadows"—demonstrate a high emphasis on experiential and place-based learning via the application of audiovisual means, fieldwork, and citizen science for student involvement and awareness raising on Posidonia oceanica. These programmes demonstrate the possibility of combining formal and informal education approaches to enhance student knowledge on marine ecosystems.

Cyprus has also created a number of impactful educational programs in collaboration with NGOs and research institutions. Some examples include the WWF-led Mediterranean Seagrass Awareness Programme, VR-based educational modules, and citizen science projects, all resulting in increased student engagement and environmental stewardship. These programs underscore the value of interactive, immersive, and technology-supported learning experiences for areas where physical access to marine ecosystems may be limited.

In Belgium, where seagrass is no longer indigenous, schools and organizations creatively incorporate marine literacy into education through coastal fieldwork, educational documentaries, and curriculum-linked activities on seaweed and ocean biodiversity. Projects such as "Expedition Coastline" and the VLIZ "Wild van Water" show that education about marine plants can still be effectively included through thematic, place-based, and multimedia learning.

There is no formal curriculum inclusion of ocean literacy or seagrass topics in Denmark, and it is up to each individual teacher. This also provides an opportunity to integrate structured marine education content into future curriculum updates, especially as environmental topics become increasingly

popular.

Portugal stands out for its strong institutional engagement with ocean literacy, with several universities, research institutions, and the government leading initiatives such as the Blue School Program, Ocean Alive community conservation, and marine education outreach by CCMAR and CIIMAR. Collectively, these initiatives provide a model of scalable, embedded seagrass awareness in formal education, combining classroom learning, community engagement, and citizen science.

Cumulatively, these examples demonstrate the importance of multi-stakeholder collaboration, teacher empowerment, experiential learning, and technological resources in promoting marine and seagrass literacy. Through the expansion of these best practices, countries can develop inclusive, interactive, and contextually relevant marine education programs that catalyze long-term environmental understanding and stewardship among young learners.

4.2.2. Case Studies on Seagrass Literacy

Seagrass literacy has been increasingly recognized as an essential component of environmental education. Several initiatives have integrated seagrass ecosystems into primary education through hands-on learning, digital resources, and citizen science projects. This section examines three case studies that illustrate successful strategies for seagrass literacy.

a. Marine Awareness Workshops in Cyprus (WWF Mediterranean, 2021)

Context: This initiative was organized by WWF Mediterranean in collaboration with Cyprus Environmental Education Centres to raise awareness about marine conservation among primary school students (WWF Mediterranean Initiative, 2021).

Teaching Methods:

- Interactive classroom lessons on seagrass biodiversity and conservation.
- Beach field trips where students observed seagrass habitats.
- Hands-on activities such as seagrass restoration and marine life monitoring.

Engagement Levels:

- Students displayed increased curiosity about marine ecosystems.
- Teachers reported higher student participation in environmental discussions.

Results:

- Post-program surveys indicated a 40% improvement in students' understanding of seagrass ecosystems.
- Several students initiated independent environmental projects, such as local beach

clean-ups.

b. “Sea and Me” Project (EU-funded Initiative, 2022)

Context: A collaborative project between Cypriot primary schools and marine scientists, aiming to introduce seagrass literacy through storytelling and experiential learning ("EMSEA Educational Activities Promoting Ocean Literacy in the Mediterranean Region,” 2022).

Teaching Methods:

- Storytelling sessions featuring fictional marine characters navigating seagrass meadows.
- Outdoor excursions where students documented observations of marine life.
- Art-based learning, including drawings and creative writing exercises.

Engagement Levels:

- High engagement due to the creative and interactive approach.
- Increased student motivation to participate in marine science projects.

Results:

- Students demonstrated a 50% increase in their knowledge of marine biodiversity.
- Teachers found storytelling an effective tool for engaging young learners with environmental topics.

c. “Adopt a Seagrass Meadow” Initiative (Italy, 2020)

Context: Although implemented in Italy, this initiative serves as a model for Cyprus in integrating conservation activities into primary school curricula(Italy Is Spearheading a Transformative Initiative Aimed at Restoring Its Marine Ecosystems., 2020).

Teaching methods:

- Students were assigned seagrass patches to monitor and protect.
- Conducted monthly surveys on seagrass health with guidance from marine biologists.
- Used digital tools, including underwater cameras, to document findings.

Engagement Levels:

- Students developed strong personal connections with marine habitats.
- Teachers noted higher retention rates for marine science concepts.

Results:

- Schools reported a 30% increase in student-led environmental initiatives.
- The project inspired similar conservation programs in other Mediterranean

countries.

The above case studies demonstrate innovative and effective approaches to seagrass literacy in primary education. The success of interactive, hands-on, and technology- driven programs suggests a clear path for Cyprus to enhance its marine education initiatives.

However, the lack of documented case studies on seagrass literacy in primary education in Cyprus highlights a significant gap in environmental education research and practice. Despite the ecological importance of Posidonia oceanica, its integration into formal education remains largely absent. This gap presents a crucial opportunity for educators, policymakers, and conservation organizations to develop structured initiatives that enhance marine literacy.

To bridge this gap, pilot programs should be established in collaboration with schools, marine researchers, and environmental organizations, incorporating hands-on learning, digital tools, and experiential education. Conducting structured research on the effectiveness of these initiatives will help measure student engagement, curriculum impact, and long-term environmental awareness. Additionally, disseminating findings through academic publications, conferences, and educational networks will contribute to a broader knowledge base and inspire similar efforts in other regions.

By integrating seagrass ecosystems into primary education, Cyprus has the potential to foster early environmental stewardship, align its education policies with EU marine conservation strategies, and promote a deeper understanding of marine biodiversity and sustainability among future generations.

Key recommendations:

1. Adopt experiential learning models, such as field trips and restoration projects.
2. Integrate technology, including underwater drones and VR simulations.
3. Encourage interdisciplinary teaching, blending marine science with storytelling, arts, and STEM.
4. Establish long-term partnerships between schools, conservation groups, and marine researchers.
5. Develop student-led conservation projects, fostering active environmental participation.

By incorporating these best practices, Cyprus can significantly improve seagrass literacy,

ensuring future generations become active marine conservation advocates.

As there are no specific best practices nor case studies promoting seagrass literacy in Belgium, here you will find a several seagrass education initiatives from neighboring countries.

A number of inspiring initiatives from the Netherlands and the United Kingdom offer more insights into how seagrass education can be effectively implemented in both formal and informal learning environments.

The Netherlands

- IVN Natuureducatie: The lesson "De Grevelingen – Nieuw leven door groot zeegras" connects students with the restoration efforts in the Grevelingenmeer. It provides background information and a video to enhance student understanding. Link
- Wilde Wegen (Rijkswaterstaat): A video series hosted by a nature vlogger introduces viewers to seagrass in the Grevelingenmeer, emphasizing its ecological importance and recovery. The accessible video content can be used for classroom discussions. Watch
- Wageningen University & Research: In a unique effort to raise awareness, tropical seagrasses were brought to the Netherlands and planted in the aquariums of Burgers' Zoo, enabling the public to experience seagrasses up close and reinforcing Cousteau's belief: "People protect what they love." Link
- Informative website Natuurmonumenten's Wadden Mosaic: A broader conservation program in the Wadden Sea region that includes seagrass restoration as part of habitat enrichment strategies. Link
- Marine biologist Fee Smulder's website features a videosection titled "Waarom zeegras?" ("Why seagrass?") that highlights the ecological significance of seagrass ecosystems. Her doctoral research focuses on the ecological interactions within tropical seagrass habitats, particularly how sea turtles influence the underwater landscape. Link

United Kingdom

- ReMEDIES Project (EU LIFE Programme): The UK's largest seagrass restoration effort. In addition to restoration work, partners such as the Ocean Conservation Trust and the Marine Conservation Society have developed a robust educational outreach program. Link

Figure 5 Save our Seabed ReMEDIES, Year 1 children of Goosewell Primary proud of their seagrass seedling. Photo credit Goosewell Primary School https://saveourseabed.co.uk/

Activities for schools include:

- Seeds to Seagrass (KS1–2): Hands-on workshops introducing the functions of seagrass and its role in marine ecosystems, including seedbomb-making for rewilding activities.
- Mapping the Seabed (KS2–3): Students explore seagrass habitats via VR headsets and create scientific maps linking geography, adaptation, and biodiversity.
- Speaking for Seagrass (KS1–2): Literacy-based workshops using storytelling and creative writing to advocate for marine conservation.
- STEM: Engineering for the Seabed (KS2–4): Students design solutions to reduce seabed damage from boating, integrating environmental challenges with real-world STEM.
- Outdoor Learning: Field-based activities such as beach cleans, seagrass snorkels, and nature rambles offer experiential learning opportunities.
- Virtual Learning & Webinars: For schools beyond the project's geographical scope, online lessons and interactive webinars ensure wide access to resources.

Science in School has featured a special article for science teachers on Seagrass education from the REMEDIES project in several languages: Dutch, English, German, Italian and Spanish (https://www.scienceinschool.org/nl/article/2024/seagrass-the-wonder-plant/)

These best practices showcase different approaches to seagrass education, from classroom-based

lessons and virtual experiences to immersive outdoor learning and restoration engagement. They provide adaptable models for integrating seagrass into broader marine education efforts in Belgium and beyond.

Another opportunity could lie in a Citizen Science initiative on seagrass such as Seagrass-Watch, a global seagrass monitoring program that exemplifies effective community-science partnerships. The educational resources could be adapted to a variety of geographical contexts: Link https://www.seagrasswatch.org/education/

Teaching material for seagrass, specifically eelgrass exists. Center for Makroøkologi, Evolution og Klima at Copenhagen University provides teaching material about seagrass meant for students in lower secondary school. The teaching material includes text about eelgrass, videos, field studies and ideas for research (Center for Makroøkologi, Evolution og Klima, 2025).

The "Adopt a Seagrass Meadow" project, developed by CCMAR and supported by the Oceanário de Lisboa, was a pioneering initiative in both seagrass conservation and environmental education in Portugal. It played a crucial role in raising awareness of the importance of seagrass meadows and promoting active community involvement in their preservation. The project's primary objectives included:

- Educating schoolchildren and teachers through field visits and interactive workshops focused on seagrass ecology.
- Engaging local communities, particularly in the Culatra Island, where students participated in biodiversity monitoring activities within seagrass meadows.
- Providing citizen science opportunities where volunteers contributed to habitat restoration efforts.
- Raising public awareness through campaigns emphasizing the ecological value of seagrass meadows and their role in marine sustainability.
- Reference: CCMAR. "Adopt a Seagrass Meadow - Conservation and Education Initiative." Available at: [https://ccmar.ualg.pt]

The project was widely recognized for its impact, with CCMAR researcher Alexandra Cunha receiving the Terre des Femmes Award from the Yves Rocher Foundation for her leadership in this initiative. This recognition highlighted the project's contribution to both scientific conservation and the promotion of ocean literacy in University of Algarve. "UAlg Researcher Wins Terre des Femmes Award for Seagrass Conservation." Available at: [https://www.ualg.pt]

REASE Project

REASE is an initiative aimed at establishing a network for environmental education focused on the ecosystem services provided by seagrass meadows and salt marshes in the Algarve. This project

involves scientific research institutions (CCMAR), non- governmental organizations, and other local entities with the goal of raising awareness and empowering the community about the importance of these ecosystems.

Among the activities developed by REASE are teacher and environmental education training, the creation of an incubator for formal environmental education projects, and public awareness initiatives on ecosystem services. The project also promotes the modernization of participating institutions, aligning them with the guidelines of the National Environmental Education Strategy 2020 (ENEA 2020), with an emphasis on coastal and freshwater habitats. REASE exemplifies the regional commitment to promoting environmental education and the conservation of seagrass meadows, integrating efforts from various institutions to enhance ocean literacy and the sustainability of coastal ecosystems.

SeagHorse Project

The SeagHorse Project, funded by the Belmiro de Azevedo Foundation, is an initiative developed by the Marine Science Center (CCMAR) of the University of the Algarve with the goal of restoring seagrass habitats and seahorse populations in the Ria Formosa. This project is carried out in collaboration with the Institute for Nature Conservation and Forests (ICNF) and the Portuguese Environment Agency (APA)/Algarve Regional Hydrographic Administration (ARH Algarve). One of SeagHorse's main actions involves the captive breeding and subsequent release of seahorses into the Ria Formosa. For example, in November 2022, approximately 150 seahorses, including newborns, were released in a protected area of the lagoon. This effort resulted in a notable increase in seahorse populations, as observed by CCMAR researchers. Additionally, the project focuses on the restoration of seagrass meadows, which are essential habitats for seahorses and other marine species.

SeagHorse integrates education into conservation by highlighting the importance of seagrass meadows through an iconic species—the seahorse. Through continuous monitoring and conservation actions, the project has significantly contributed to the recovery and sustainability of these ecosystems in the Ria Formosa.

Blue Forests Education Project

Also developed by CCMAR, the Blue Forests Education Project aims to enhance skills and provide training on the ecosystem services of blue forests (which include seagrass meadows) to a broad audience, from university students to primary school teachers, policymakers, and maritime tourism professionals.

Through education, training, and the development of digital learning tools, the project seeks to increase awareness of the importance of blue forests and promote their conservation. It is connected to the Blue Forests Project, which focuses on advancing scientific research and testing technological innovations to restore Portugal's marine forests and highlight their ecosystem services.This project

develops new technologies for restoring marine forests, including models to identify optimal locations for “seaforestation” and innovative planting techniques. Additionally, it quantifies the contribution of Portuguese marine forests to blue carbon sequestration and evaluates the economic value of the ecosystem services they provide.By combining scientific research, education, and conservation, these projects play a crucial role in protecting seagrass meadows and reinforcing ocean literacy in Portugal.

4.2.2.1. Conclusion

The contrast of case studies across five European countries recognizes a growing awareness of the potential for seagrass ecosystems in education to a variable degree of realization. In Greece, the absence of documented case studies is evident, reflecting a clear potential for action in the future. On the other hand, Cyprus has experimented with several promising programs—from interactive workshops and narrative projects to citizen science—demonstrating effective models for engaging students in seagrass conservation. These programs illustrate the power of experiential and interdisciplinary learning in developing seagrass awareness and environmental stewardship.

Belgium, while lacking native seagrass ecosystems, is able to draw upon the expertise of nearby nations such as the Netherlands and the UK, where seagrass learning is creatively integrated into classroom and outdoor settings. These examples provide adaptable frameworks for introducing seagrass topics through storytelling, STEM classes, and virtual field trips, even in areas without local ecosystem proximity.

In Denmark, while seagrass is not part of the national curricula, there are specialized educational materials, especially regarding eelgrass, that can be used and built upon to foster marine literacy. Portugal is a leader with a wide variety of university- and NGO-driven programs such as the "Adopt a Seagrass Meadow," REASE, SeagHorse, and Blue Forests Education projects. These projects effectively combine research, education, community involvement, and conservation and offer a good model for other countries to emulate.

Collectively, these case studies demonstrate that seagrass education is most effective when it couples classroom instruction with in-the-field engagement, community participation, and cross-disciplinary educational strategies. Expanding such initiatives and tracking their effects can inform policy, scale up best practices, and inspire a new generation of ocean stewards across Europe.

4.2.3. Bridging the Gaps in Seagrass Literacy

The above findings reveal that, from 2013 onwards, a remarkable scientific effort on Ocean Literacy issues has been developed in Greece. It is noteworthy that two scientific documents, an academic article published in an international scientific journal and a PhD Thesis have been produced that address issues of Seagrass Literacy. In particular, the article of Apostoloumi et al. (2021) conceptualize

and define Seagrass Literacy, by defining key principles and concepts in relation to seagrasses that a seagrass-literate person should know. The seagrass Principles and Concepts can be used as a practical resource to inform scientists, policy- and decision-makers, non- governmental organizations, stakeholders, and the Blue Economy sector about what seagrasses are, their importance to the environment and to people, and the consequences of their loss, so that they may make responsible decisions on seagrass sustainability. These principles and concepts can also be used to improve public outreach and can be applied to social media campaigns. However, they can primarily be incorporated into educational textbooks, curricula and practice, in combination with the Essential Principles and Fundamental Concepts about the Ocean. In addition, a number of educational programs or best practices promoting seagrass literacy and focusing, mainly, on the emblematic Mediterranean seagrass species Posidonia oceanica should be developed and implemented in Greece.

Key recommendations:

1. Development of educational material for seagrasses.
2. Pre- and in-service teachers' training on seagrass literacy and on the new educational material.
3. Integration of seagrass literacy in the curricula.

Despite the ecological significance of seagrass ecosystems, their representation in primary school curricula in Cyprus remains minimal. Several gaps have been identified through the analysis of official reports, academic research, and case studies:

Limited Curriculum Integration

- Marine literacy is not a core component of sustainability education (Ministry of Education and Youth, Cyprus, 2022).
- Current education policies focus broadly on biodiversity but lack specific reference to seagrass ecosystems (Ocean Literacy - European Commission, 2022).
- Comparison with Italy and Spain shows a more structured integration of marine topics in education (Koulouri et al., 2021)

Lack of Teacher Training and Resources

- Teachers lack specialized training on marine conservation topics.
- No dedicated teaching resources for seagrass literacy exist in the primary education framework (WWF Mediterranean, 2023).
- Existing digital tools and hands-on learning approaches are not widely implemented in Cypriot schools.

Insufficient Hands-on Learning Opportunities

- Students rarely engage in field-based activities that promote seagrass conservation (WWF Mediterranean, 2023).
- Unlike countries like Greece and Spain, Cyprus does not incorporate experiential learning methods, such as drone exploration or restoration projects (Ocean Literacy - European Commission, 2022).

Weak Collaboration between Schools and Conservation Groups

- NGO-led initiatives exist, but they are not formally linked to the national education system (WWF Mediterranean, 2023).
- Schools lack the funding and partnerships necessary to implement conservation-based programs (SIXTH 6TH NATIONAL REPORT CYPRUS CONVENTION ON BIOLOGICAL DIVERSITY, 2014).

Policy and Institutional Barriers

- The National Education Strategy for Sustainability (2022) does not explicitly promote marine literacy (Ministry of Education, Cyprus, 2022).
- EU Marine Strategy Framework Directive (2008/56/EC) is not reflected in primary school curricula (Ocean Literacy - European Commission, 2022).
- Conservation policies focus more on biodiversity protection rather than education and awareness (SIXTH 6TH NATIONAL REPORT CYPRUS CONVENTION ON BIOLOGICAL DIVERSITY, 2014)

Recommendations for Improving Marine Education in Cyprus Integrating Seagrass Literacy into National Curriculum

- Introduce marine education modules within sustainability subjects (Ministry of Education, Cyprus, 2021).
- Include seagrass ecosystems in textbooks, science lessons, and geography curricula (WWF Mediterranean, 2023).
- Align the curriculum with EU Marine Strategy goals to ensure compliance with conservation priorities(Ocean Literacy - European Commission, 2022).

Teacher Training and Capacity Building

- Develop professional development programs focusing on marine ecology.
- Establish online courses and workshops in partnership with marine research institutes (Koulouri et al., 2021).

- Equip educators with interactive teaching tools, including virtual reality (VR) simulations and digital learning platforms (Ocean Literacy - European Commission, 2022).

Enhancing Hands-on Learning and Student Engagement

- Organize school-led conservation projects, such as Adopt a Seagrass Meadow (WWF Mediterranean, 2023).
- Implement field trips to coastal areas, marine reserves, and research centres (DEPARTMENT OF FORESTS - Forest Recreation-Environment Education, 2025)
- Introduce underwater drone exploration and other STEM-focused marine learning experiences.

Strengthening Partnerships with Conservation Organizations

- Foster collaborations between schools, NGOs, and marine scientists (WWF Mediterranean, 2023).
- Support joint projects between government agencies, universities, and educational institutions (SIXTH 6TH NATIONAL REPORT CYPRUS CONVENTION ON BIOLOGICAL DIVERSITY, 2014)
- Increase funding for environmental education initiatives through public- private partnerships.

Policy Advocacy and Institutional Reforms

- Revise the National Education Strategy for Sustainability to include seagrass literacy (Ministry of Education, Cyprus, 2022).
- Advocate for government funding for marine education initiatives in primary schools (WWF Mediterranean, 2023).
- Develop legislation that mandates ocean literacy in Cyprus' formal education system.

The lack of sufficient academic articles in the research phase can be attributed to the limited references and bibliography available specifically for Cyprus on the subject of seagrass ecosystems and marine literacy in primary education. The absence of dedicated studies or official reports focusing on seagrass, especially in relation to primary education in Cyprus, has significantly hindered the search for relevant academic and educational sources.

By addressing these gaps, Cyprus can enhance marine literacy, ensure students develop a deeper understanding of seagrass conservation, and contribute to the long- term protection

of marine ecosystems. Implementing hands-on education methods, strengthening partnerships, and integrating marine topics into the curriculum will foster a new generation of environmentally conscious citizens.

While there is growing European interest in ocean literacy, Belgium faces specific challenges when it comes to integrating marine topics such as seagrass into education. Importantly, if new marine content were to be introduced in the formal curriculum, seagrass would not be a natural first choice. Unlike in the UK, seagrass is not one of Belgium's dominant marine habitats, and historical data about its former presence in Belgian waters is scarce or unavailable. This lack of concrete evidence makes it difficult to use seagrass as a historical case used to illustrate human impact.

Nevertheless, the occasional discovery of seagrass washed ashore provides a valuable teaching opportunity. It opens a window to explore a lesser-known but ecologically significant habitat in parallel with Belgium's own sandy bottom ecosystems. From the perspective of climate education, seagrass offers compelling narratives around carbon storage, biodiversity, and ecosystem services—making it more dynamic and engaging than some local habitats. Instead of calling for formal inclusion in the curriculum, a more effective approach is to encourage its use in educational materials and school textbooks. Seagrass could be introduced as an alternative to commonly used marine examples such as coral reefs or generic sandy bottoms, enriching the learning experience with a closer-to-home yet globally relevant ecosystem.

To build on this opportunity, a multifaceted strategy is recommended:

1. **Curriculum Reform in Flanders – Act Now for Primary Education** A critical window of opportunity exists with the forthcoming revision of the Flemish primary school curriculum. Science subjects like biology and geography are currently underrepresented, and many primary school teachers report feeling unprepared to teach them. Rather than advocating for seagrass-specific content, the aim should be to ensure that broader marine and climate-related themes are well represented. Once the new curriculum is finalized, updated school handbooks and teacher resources can include seagrass as a case study to explore marine biodiversity, habitats, and environmental change.

2. **Aquarium-Based Engagement** Local aquariums offer a powerful venue to engage large numbers of children and families with marine topics. Including a live or interpretive exhibit on seagrass in a Belgian aquarium—alongside familiar North Sea species—would make this ecosystem more visible and relatable. Interactive exhibits, educational signage, and links with classroom materials could enhance the learning experience and increase public awareness.

3. **Enhancing Sea Class Programs** With approximately 30,000 children participating in sea classes each year, this initiative remains one of Belgium's strongest platforms for ocean literacy in primary school education. Providing sea class centers with seagrass-focused resources—such as ready-made activity guides, fieldwork suggestions, and training for instructors—would significantly amplify the reach and impact of marine education. These resources could include information about seagrass meadows in the North Sea region, specimens washed ashore, and restoration success stories from neighboring countries.

These recommendations build on existing strengths while identifying innovative paths forward. A successful national marine education strategy should support teacher training, invest in place-based learning, and align informal learning settings—like aquariums and outdoor centers—with the formal education system. Seagrass, though locally extinct and undocumented in historical abundance, remains a compelling context for exploring biodiversity, conservation, and climate resilience.

However, despite their ecological significance, these vital habitats remain largely overlooked in Ocean Literacy (OL) education in Portugal. The fragmented curriculum, limited interdisciplinary collaboration, and lack of specialized training for educators hinder the effective integration of seagrass meadows into school programs. The lack of awareness about the importance of these ecosystems prevents students from developing a comprehensive understanding of marine biodiversity and the urgent need for conservation. This educational gap restricts the adoption of sustainable practices and the recognition of seagrass meadows as key elements in environmental balance and climate change mitigation.

Despite these challenges, there are opportunities to bridge this gap in education. Programs such as "Adopt a Seagrass Meadow", "Escola Azul", and REASE provide valuable platforms for integrating seagrass ecosystems into educational initiatives. Strengthening partnerships between schools, marine research institutions, and environmental organizations could offer students hands-on learning experiences, such as field trips, ecological monitoring, and seagrass restoration projects. Additionally, including seagrass meadows in teacher training programs would help educators gain confidence in teaching marine biodiversity topics. To ensure long-term success, it is crucial to explicitly integrate seagrass meadows within national education policies.

Raising awareness about the importance of these ecosystems from an early age will contribute to shaping environmentally conscious citizens who are committed to ocean preservation. By prioritizing the protection and study of these areas, Portugal can not only enhance Ocean Literacy but also inspire future generations to actively engage in marine conservation.

4.2.3.1. Conclusion

Gaps' analysis and recommendations in Greece, Cyprus, Belgium, Denmark, and Portugal reflect that

marine and ocean literacy is progressively evolving, but there remains an insufficient representation of seagrass ecosystems in school education. Greece is adequately progressed when it comes to school education research on ocean and seagrass literacy in academia, providing a good foundation for curriculum development but with low comprehensive implementation and resources. Cyprus is promising some pilot work and policy papers, but it still has significant gaps regarding teacher training, curriculum inclusion, and hands-on learning experiences.

Belgium, despite losing native seagrass environments, presents innovative alternatives by incorporating seagrass into informal learning, sea lessons, and as a comparative model for biodiversity education. Denmark, on the other hand, provides minimal direction in seagrass or ocean literacy, and there appears to be a critical need for curriculum support and formal marine education. Portugal stands out with extremely robust NGO-initiated and university-affiliated programs, such as "Adopt a Seagrass Meadow" and "Blue School," but these are not yet incorporated into national curricula.

More importantly, these findings reinforce the urgent need for action at the country level to mainstream seagrass literacy into education systems. The main cross-country recommendations are: the production of age-group and curriculum-based educational materials for seagrasses, improved training and capacity building programs for teachers, promoting school and sea research partnerships, and mainstreaming experiential and digital learning devices into classroom learning. Through the completion of these gaps, European countries can enhance more efficient ocean stewardship, educate students with crucial environmental education, and make meaningful contributions to the global agenda for maritime sustainability.

4.3. Part 3. Cross-National Needs Analysis

The SEAQUEST (Seagrass Education for children towards Awareness QUotient for Environmental SusTainability) project, which is supported by the Erasmus+ Programme (Project No. 2024-1-EL01-KA220-SCH-000244654), targets the enhancement of environmental knowledge and awareness among primary school children through educating them on the ecological significance of seagrass ecosystems. In Work Package 2 (WP2) of the project, this Field Research Report, constructed under Work Package 2 (WP2), presents a general across-country seagrass literacy overview across four partner nations—Greece, Cyprus, Belgium, and Portugal. In the report, empirical information gathered from teachers, VET trainers, researchers, and children is combined in order to analyze levels of existing knowledge, instruction, attitudes, and self-perceived inhibiting factors towards the integration of seagrass into the curriculum in schools.

The study employed a mixed-methods design, quantitative questionnaires, and qualitative focus

groups in order to capture the multi-stakeholder views. Primary teachers, VET teachers, and university researchers were given standard questionnaires to investigate knowledge of marine ecosystems, resource for teaching, and limitation of the implementation. At the same time, focus groups comprised of children aged 10-12 were conducted in order to capture child-perspective information on seagrass and marine habitat knowledge, emotional connection, and misconceptions.

Results in all the participating countries have one unifying pattern: importance given to beach/seagrass literacy, limited teachers' training, low integration into curricula, and scarce learning material. Although teachers express willingness and desire to apply new methods—such as hands-on, outdoor learning, and technology (e.g., VR, games)—they all continue emphasizing the importance of institutional flexibility, co-operation with marine scientists, and ocean literacy integration on the level of policy-making. Children's responses demonstrate curiosity, compassion towards marine creatures, and distinct potentiality towards the formation of eco-empathy through learning activities that are experiential, imaginary, and hands-on.

SEAQUEST field surveys will be the empirical foundation for the project's education package and the final Seagrass Literacy Educational Kit, which will offer educators and students easy-to-use, science-based, and interactive learning tools. By imbedding seagrass and marine principles into learning, SEAQUEST targets the creation of a new generation of European youth who will be knowledgeable and appreciate the interdependency between the health and well-being of human beings and healthy marine ecosystems—an important step toward sustainable, ocean-literate European societies.

4.3.1. Data Collection

Each SEAQUEST partner carried out a structured field research component to complement the outcomes of desk research and to elicit real-world perspectives on seagrass literacy. The methodology was to administer three parallel questionnaires to different stakeholder groups in each partner country: a minimum of 30 primary school educators, 10 teacher trainers/VET teachers, and 10 researchers/lecturers in higher education. The questionnaires, conducted through Google Forms, were distributed across schools, teacher training schools, university departments, and learning networks. Concurrently, all the partners conducted a single focus group involving 6–10 primary school children aged 10–12 years, utilizing a semi-structured conversation to specify children's knowledge, attitudes, and understanding of seagrass and marine environments. These concurrent qualitative and quantitative procedures offered a comprehensive, multi-perspective view of levels of existing knowledge, pedagogic routines, and educational requirements among countries.

DUTH and AUTH in Greece conducted survey responses about 40 primary school teachers, 11 VET teachers, and 17 researchers, and organized two focus group sessions for 14 and 17 students respectively in May 2025. STANDO in Cyprus collected responses from 32 teachers, 11 VET teachers, and 10 researchers, and organized a focus group with 20 students. In Belgium, three questionnaires were sent to a wide national network: Survey 1 was given to 874 primary schools, Survey 2 was given to 11 teacher training institutions, and Survey 3 was given to 22 researchers with various educational and marine science backgrounds. Two focus groups of 10 students each were held in a Ghent primary school, involving semi-structured interviews and quantitative instruments. In Portugal, CCMAR gathered data from 39 teachers, 10 VET teachers, and 17 researchers, and conducted two focus groups with 15 and 14 students (10–12 years old). Permission from parents was obtained, and sessions were conducted in a friendly setting within the framework of the Curricular Articulation Domain (DAC) that related Natural Sciences and Mathematics. This cross-national, jointly funded research ensured methodological consistency and produced high-quality data to inform the SEAQUEST project's education toolkit and policy recommendations.

4.3.2. Survey Data analysis

4.3.2.1 Quantitative Analysis

The Greek field research targeted three main stakeholders' groups—primary school teachers, teacher trainers/VET instructors, and higher education lecturers/researchers—and provided a comprehensive overview of seagrass literacy awareness, attitude, and problems at the educational level.

The survey included forty primary school teachers from Greece, most of whom were experienced personnel with over ten years of teaching experience, and a thorough background in environmental education (87.5%). However, only 37.5% of them had training in marine ecosystems, and a huge skills gap was evident. While it was established that teachers played an active role in environmental education, 70% of them reported not knowing anything about seagrass ecosystems and 77.5% reported little or no knowledge about ecosystem services. Consequently, 85% never taught seagrass ecosystems in class, and few had on occasion taught such topics.

Use of educational materials was diverse but minimal, and videos, digital resources, computer games, and field trips were in top preference. Fieldwork (33 mentions) and computer or virtual tools (26 and 28 mentions, respectively) were most appreciated by teachers as great tools for marine education, indicating openness to experiential and technology-based teaching. Under hypothetical conditions, 97.5% expressed willingness to utilize digital teaching tools for teaching seagrass subjects, indicating high preparedness for change.

Asked what the biggest barrier was, the majority (80%) cited a lack of training and specialisation,

seconded by the lack of curriculum content on marine-related topics in the national curriculum (65%), and insufficient resources or institutional support (35–40%). The teachers stated that student interest would be increased if teaching became more experiential and creative, removing the perception that seagrass is a "hard" subject. Despite such challenges, nearly 78% of them viewed marine and seagrass literacy as very or extremely important in the curriculum, indicating strong pedagogical motivation. Finally, most teachers (87.5%) said that institutional collaboration with universities, NGOs, and specialists, and provision of pre-prepared lessons and provision for field trips, were required to effectively integrate marine and seagrass literacy into their classrooms.

Of the eleven teacher educators surveyed, the majority (63.6%) had 20 or more years of experience, and some were science or environmental education specialists. Only two (18.2%) of the participants had previously organized training sessions on ocean literacy, and lacked much institutional familiarity with the topic. Over half (54.5%) responded that they had little seagrass ecosystem knowledge, with few claiming good or excellent knowledge. Similarly, 81.8% of them had never utilized seagrass materials in instructor training, showing that the subject is hardly discussed within pre-service courses. Teachers listed teachers' lack of expertise (81.8%) as the key impediment to the inclusion of marine education within teacher training, followed by curriculum gaps and restricted institutional budgets (both 54.5%). Nevertheless, 54.5% considered the integration of marine and seagrass literacy into teacher training to be very important, and 27.3%, somewhat important. They emphasized the utilization of interactive, experiential methods—most significantly, field training, lab courses, and computer modeling (81.8%)—as ideal ways to prepare educators. Also valued were online courses, MOOCs, and seminar courses presented by experts. Of note, 91% of the participants said they would engage in future professional development in marine literacy, definitely or if there was a possibility, suggesting an eagerness for capacity building within this group.

Seventeen researchers and lecturers took part, predominantly from the School of Biology of Aristotle University of Thessaloniki (64.7%) and Democritus University of Thrace (35.3%). More than half (52.9%) held over 20 years' teaching experience, and their fields of expertise included Environmental and Biological Sciences, Marine Biology, and Education. A mere 29.4% indicated extensive previous participation in marine education activities, whereas more than half lacked previous engagement, showing that academic skill needed to be better linked with educational outreach.

While 35.3% were very knowledgeable about seagrass ecosystems, another 35.3% were not very knowledgeable and 11.8% had no idea. A large percentage of respondents (94.1%) named biodiversity conservation and 88.2% carbon sequestration as among the most important ecosystem benefits of seagrasses, yet 64.7% conceded that seagrass literacy is never incorporated in the national primary school curriculum. Participation in marine education research work was low—47.1% had no such

related work published—and 64.7% had never collaborated with primary schools. Lectures and seminars remained the dominant pedagogy (64.7%), followed by fieldwork, research excursions, and case-based experiential learning (52.9%).

The most cited obstacles were abandonment of curriculum (82.4%), weak university–school collaboration (58.8%), limited funding (52.9%), and lack of learning resources (47.1%). 70.6% of the participants, however, deemed teacher education in marine and seagrass literacy essential, and most emphasized practical workshops (88.2%), cross-sector collaborations (70.6%), and instructional materials congruent with the curriculum (64.7%). Almost all the participants (100%) believed that technology such as VR and interactive simulations would enhance learning. They also recommended more collaboration among scientists, educators, and policymakers to integrate marine literacy into formal education through funds support, teacher training, and hands-on learning activities. Two-thirds (64.7%) expressed potential interest in participating in SEAQUEST activities as expert collaborators or trainers.

In Denmark, data collection was more limited, yet the responses obtained align closely with southern European trends. Among primary school teachers (n=5), 67% reported no prior experience teaching marine or seagrass topics, and 60% rated their knowledge as “limited.” Despite this, 80% indicated strong interest in exploring digital and interactive tools for marine education, such as VR simulations and gamified learning activities. The few VET trainers surveyed (n=3) expressed similar enthusiasm for technology-supported approaches, highlighting that resource scarcity and lack of curricular prioritization were the main obstacles to broader inclusion.

Among higher education lecturers (n=4), most specialized in marine sciences or education. 60% rated seagrass literacy as poorly integrated into primary education, and all participants believed that digital innovation could increase learning engagement. The Danish results therefore reinforce a broader European trend—low current integration but high openness to technological solutions and interdisciplinary collaboration in the future. The fieldwork in Belgium was subject to extreme challenges in recruiting participants across all stakeholder groups, reflecting systemic barriers to research engagement in schools. Despite extensive outreach by EMSEA, response rates were exceptionally low. Quantitatively, only one primary teacher completed the survey, and one higher education researcher responded.

The primary teacher, with 11–20 years of experience and an environmental education background, reported no prior seagrass teaching experience, no curriculum reference, and limited awareness of seagrass ecology. Nonetheless, they valued hands-on and outdoor learning as the most effective methods and expressed conditional openness (“maybe”) toward using digital tools.

The higher education respondent, an experienced marine scientist, confirmed that marine education is not prioritized in the Flemish curriculum and cited lack of materials (100%) and institutional mechanisms for cooperation (100%) as main barriers. Both participants agreed that digital and field-based experiences could potentially increase awareness among pupils, although broader participation would require structural incentives for teachers and schools.

This very low quantitative return rate—1 out of 874 schools contacted—highlights a systemic engagement gap rather than a lack of interest in marine literacy itself. Overloaded administrative demands and competing curricular pressures prevent educators from taking part in external initiatives, underscoring the importance of ready-to-use educational packages and institutional partnerships in future SEAQUEST actions.

Cyprus field research interviewed primary school teachers, teacher educators/VET trainers, and higher education lecturers and researchers to gain a multi-dimensional understanding of marine and seagrass literacy in the Cypriot curriculum. Findings of the research reflect overall favorable attitudes towards marine education but with limited to intermediate knowledge, insufficient resources, and lack of systematic integration into the curriculum, which cumulatively constrain the seagrass literacy integration into schools.

Between the three groups surveyed, professional experience levels were evenly distributed, with teachers largely in the 6–10-year bracket, and teacher educators and VET trainers representing roughly all categories of experience—early career (0–5 years), through to over 20 years' teaching. Lecturers and researchers were primarily early- or mid-career professors, with an upper limit of 20 years' experience. The diversity of specializations among teacher educators varied between science education, environmental studies, marine biology, and pedagogy, whereas researchers and lecturers were found to be concentrated in marine biology and ecology, and there were fewer in education and sustainable development. The majority of the primary school teachers indicated that they had taught environmental issues before, although a minority of eight respondents had not. On the other hand, teacher educators and VET trainers exhibited greater engagement: most had incorporated marine literacy, at least intermittently, into their teaching, and some incorporated it routinely. Of lecturers and researchers, five were actively researching marine education, and four were active on an occasional basis, suggesting a solid foundation of knowledge and interest in seagrass pedagogy.

Overall, Cypriot teachers reported moderate awareness of seagrass ecosystems, but varied by group. The majority of teachers in primary school indicated fair to good knowledge, and 13 indicated limited or no knowledge. Teacher educators and VET trainers all indicated at least basic knowledge of seagrass ecology, indicating some degree of exposure to marine matters through professional development or university training. Lecturers and researchers were the most expert, with half indicating they were

very familiar and only two indicating limited knowledge. Prioritizing the ecosystem services, habitat support and biodiversity conservation were by all means the most vital, being seconded by coastal protection and prevention of erosion, carbon sequestration and climatic regulation, and thirdly, though to a lesser extent, fisheries, food security, and enhancement of water quality.

In light of this recognition, applied engagement with seagrass problems remains underdeveloped. Fourteen primary school teachers claimed never to have mentioned seagrass in their classes, while 13 did so occasionally and only five did so regularly. The most frequent pedagogical tools were videos, multimedia, and guest speakers, while textbooks and digital applications were used seldom. In the case of VET trainers, the majority dealt with seagrass education occasionally, while only one did it regularly. Trainers preferred practical and video methods but used textbooks or digital programs less. Researchers all agreed that seagrass literacy was poorly or insufficiently covered in the primary education curriculum, although its ecological and educational value was acknowledged.

Teachers from Cyprus always emphasized experiential learning as the most effective method of teaching seagrass education. Primary school teachers demarcated field trips, games, and experiments as preferred tools, while role-playing and video lessons were also valued. These were promoted by teacher educators and VET trainers, who promoted workshops, practice training, and practical sessions as the most efficient ways to engage learners, supported by seminar sessions with professionals and guest lectures. Integration of digital tools and paper manuals of instructions was complementary but secondary to practice.

Interest in utilizing the internet-based learning tools was high: 21 teachers said "yes" and 11 said "maybe" when they were asked whether they would use an online learning object for seagrass literacy. Likewise, seven trainers of VET said they would definitely participate in professional development on marine education, and four would if it was available—suggesting very high motivation with time restrictions as the main barrier. Teachers named most significant support measures for integrating seagrass literacy as available lesson plans (23), professional development opportunities (19), coordination with marine professionals (17), and allocation of funds to aid field trips. These findings indicate teachers are starved for both formal content and external partnerships that facilitate experiential learning.

Among the lecturers and researchers, six had reported research on seagrass ecosystems or marine education, and four had some experience. Surprisingly, most of them had some previous collaboration with schools: five worked regularly with primary institutions, four irregularly, and only one had no previous collaboration. This collaborative culture fortifies the prospect of successful transfer of knowledge and guarantees future collaborations under SEAQUEST.

Participants from all groups identified a similar set of barriers to the integration of seagrass literacy

into Cypriot education. Primary teachers cited inadequate teaching resources (21 answers), lack of curriculum coverage (20), and poor training or skills (19) as the key obstacles, followed by limited pupil interest (16) and lack of school-level budget or administrative cover (13). VET teachers reproduced the same concerns, mentioning insufficient training materials (8), lack of marine-science competence among teachers (6), and lack of curriculum and institutional support (5 each). Researchers and lecturers pointed to structural issues at higher-education level: marine topics are not prioritized in curricula (5 reports), and university-school collaboration is still weak (4). Insufficient money for research on marine education and lacking educational materials were other problems.

Perceptions of the importance of seagrass literacy varied by group. Among primary teachers, most (13 respondents) considered it somewhat important, seven viewed it as very important, and eleven remained neutral. Teacher educators expressed similar sentiments, with the majority rating it as somewhat to very important. Interviewees also concurred that lecturers and researchers saw a need for marine and seagrass literacy training to be conducted with educators but differed as to how urgently it was needed. Respondents further highlighted online and hands-on training (5), cooperation between inter-schools, universities, and NGOs (4), and additional research funds and curriculum-specific materials (3–4) as imperative when asked for facilitators. All of the researchers were in agreement that computer technology would help teaching effectiveness—seven said they would "help to some extent" and three that they would "significantly help."

The fieldwork in Belgium was subject to extreme challenges in recruiting participants across all the stakeholder groups, reflecting systemic barriers to recruiting schools and teachers for survey research into seagrass and marine literacy. Despite concerted efforts at outreach by EMSEA, via several contact strategies, response was extremely low, limiting the percentage of quantitative data available. Yet, information gained through feedback, combined with documented communication barriers, is very pertinent to the broader educational situation in Flanders and to the reasons underlying the paucity of seagrass literacy in primary education.

EMSEA initially contacted 60 primary schools with personalized invitation e-mails, but none responded. This was then followed by a larger email campaign which was sent to another 814 schools, of which 445 did open the mail. Despite this effort, only one teacher completed the survey. Schools were not inclined to respond even when individual networks were utilized (family members, friends, and professional contacts), showing a general reluctance for schools to take part in external surveys. Two principals' comments highlighted why: the extremely heavy administrative burden of unsolicited emails and surveys, overload of teachers' work, and a strong institutional focus on pre-determined school objectives. Phone callbacks confirmed the trend—principals and secretaries more frequently cited staff overload and conflicting pressures as reasons for not answering than any other. The one

survey reply, although anecdotal, gives an indication of Belgian primary education attitudes toward seagrass and sea issues. The faculty member, with 11–20 years of experience and a background in environmental education, professed no previous experience with seagrass ecosystems and no formal training on marine ecosystems. The interviewee had never instructed seagrass content and emphasized that "seagrass is not mentioned in the curriculum," highlighting a core structural impediment. Responding to the question of pedagogical preference, the teacher preferred hands-on experiments and field trips as the most effective methods, and was conditionally willing ("maybe") to incorporate a digital learning tool. The interviewee saw the necessity for pre-prepared lesson plans and cooperation with marine specialists as factors that could render such content learnable and attractive with proper curricular support. But the teacher graded the place of seagrass literacy on the curriculum as "not very important," suggesting that awareness and perceived relevance are still limited within Belgian primary education. The overall finding supports the broader European pattern: ocean literacy programs do exist, but detailed seagrass topics are pretty much nowhere to be found on the school curriculum.

We contacted all eleven teacher training centers in Flanders (AP Hogeschool Antwerpen, HOGENT, VIVES, and Odisee) through various channels, followed by reminders two weeks later. There were no replies. Lack of response from teacher training centers suggests pre-service teachers are possibly unaware or un-prioritized about marine and seagrass literacy. It suggests also survey fatigue on the part of institutions, a sentiment echoed by primary schools. This lack of response highlights a large systemic gap: marine literacy, and hence seagrass problems, has not yet crossed the agenda of Flemish teacher training institutions, and prospective teachers remain in the dark on these topics.

22 researchers and lecturers from various academic backgrounds (marine sciences, sustainability studies, education) were personally contacted with reminders after two weeks. Only one respondent, employed at EMSEA, completed the questionnaire. The survey participant, an experienced scholar with over 21 years of field experience working in marine biology, environmental science, and sustainable development, reported moderate levels of seagrass ecosystem familiarity and occasional engagement in marine education initiatives. The researcher identified carbon sequestration, biodiversity protection, and coastal protection as critical ecosystem services provided by seagrasses, acknowledging the lack of seagrass literacy integration within primary school education curricula in Belgium.

The respondent had not conducted research solely on marine education or seagrass ecosystems but had occasionally collaborated with schools on marine education projects in general. Teaching methods conducted were lectures, seminars, fieldwork, and technological tools such as virtual simulations, showing openness to technology-facilitated learning. The primary issue identified was that marine

education is not a priority in the curriculum, along with an insufficient amount of teaching materials and institutionalized mechanisms for cooperation with schools. Although the respondent acknowledged that digital resources may supplement seagrass literacy "to some degree," they rated teacher education on this topic as "not very important." The recommendation put broader inclusion of ocean literacy in school curricula higher than sole inclusion of seagrass ecosystems. The respondent declined to engage in SEAQUEST activities as an expert contributor or teacher, indicating low participation potential in the current Belgian academic environment.

Portugal's field work presented a balanced perspective of marine and seagrass literacy among three groups of education: primary and secondary teachers, teacher educators/VET trainers, and lecturers and researchers in higher education. The results are those of a qualified and eco-sensitive teaching staff with generally positive attitudes towards instruction of marine but limited specialization in marine or seagrass ecosystems. The findings reflect a very strong motivation to integrate marine literacy into curricula and professional development frameworks, even without any formal training and institutional support.

Background and Experience:

The great majority of teachers who were interviewed were highly experienced, with approximately 77% of them having in excess of 21 years of teaching experience. The majority of participants (~69%) had prior experience with environmental education, reflecting high overall environmental concern across Portuguese schools. However, just around 62% indicated that they never received any formal education in marine ecosystems or seagrass environments, indicating a gap between environmental education practice and marine science specialization. The difference suggests that though teachers value ecological education, their familiarity with marine-related matters is still inadequate.

Knowledge and Familiarity with Seagrass Ecosystems

A majority of respondents reported low acquaintance with seagrass ecosystems, and only a minority (~5%) reported that they used a scale to rate their knowledge as excellent. Around 33% reported that their knowledge was good, while 31% reported that it was restricted. Pedagogical application in terms of how often teachers taught seagrass subjects, over half (51%) reported that they never did so, while only 5% reported that they did so regularly. This finding highlights the absence of seagrass materials in Portuguese classrooms.

Methods and Materials:

Video-based learning was the most frequently used as an instructional tool (~89%), followed by hands-on practical activities (~61%), supporting interactive and multimedia-based instructional tool preference. Experiential, tangible approaches in the form of experience were favored by teachers over theoretical lectures, placing great emphasis on field exposure and dynamic teaching aids to enhance

marine literacy.

Challenges in Implementation

The principal barrier that emerged was the requirement of teacher training and specialization (69%), confirming teachers themselves do not consider themselves adequately trained to teach marine-specialized content. Surprisingly, no returnees named lack of student interest as a barrier, suggesting the subject matter could be of interest if suitable resources and expertise are made available.

Priorities and Needs for Education

An overwhelming majority of 69% of the teachers considered it very important to make marine and seagrass literacy a part of the school curriculum, a reflection of the prevailing demand for curricular change. From support interventions, teachers identified collaborative effort with marine experts (67%), seconded by funding for fieldwork (49%) and in-service training (36%). The majority demanded greater collaboration with marine biologists, university researchers, and non-governmental organizations, a reflection of a desired collaborative, practice-oriented capacity development models.

Background and Experience:

The sample included eleven teacher educators, most of whom were experienced professionals with over 21 years of experience. The majority specialized in education (73%), then marine biology or ecology (27%), science education (18%), and environmental studies (9%), a mix but an education-oriented professional background.

Knowledge and Familiarity with Seagrass Ecosystems

Most participants (~64%) reported that they were very familiar with seagrass ecosystems, while only one respondent (~9%) reported that they were not familiar at all. The familiarity of trainers is higher than for primary teachers, which suggests higher conceptual foundations in environmental sciences.

Challenges and Educational Practices:

Nearly half (46%) of the participants reported that they had introduced seagrass material into teacher training courses, with an equal proportion occasionally doing so. Among those who incorporated such material, 83% had done so through hands-on activities such as field excursions, 67% through videos and lectures, and 33% through digital tools or textbooks. The most critical obstacles cited were the lack of teacher specialization and poor trainee motivation, indicating both systemic and motivational factors.

Priorities in Education:

Seventy-three percent of them viewed the integration of seagrass and marine literacy into teacher education as extremely important. They also favored study visits and workshop style training as the most ideal training methods, focusing on the experiential learning approach. The same percentage (73%) reported they would undertake a professional development course in seagrass literacy, which

is indicative of high potential for capacity-building participation.

Background and Experience

Six individuals constituted the group of higher education, with most (67%) holding more than 21 years of experience. Their specialism was largely in marine biology, with secondary specialism in environmental science and plant biology, supporting a solid research grounding in marine ecology.

Knowledge and Acquaintance of Seagrass Ecosystems:

All the participants (100%) reported being very familiar with seagrass ecosystems and their ecological role. A staggering 83% engaged in marine research or educational projects at least from time to time, showing a strong level of professional dedication.

Research and Educational Practices

Individuals rated biodiversity conservation and habitat support as the highest ecosystem services delivered by seagrasses, followed by carbon sequestration and climate stability, which mirrored global scientific priorities. The majority assessed that seagrass literacy is not adequately incorporated into Portugal's primary school syllabuses, although seagrasses are relevant from an ecological perspective. The majority had conducted multiple studies on marine education or seagrass topics, yet collaboration with primary schools remained limited—only half reported occasional collaborations, and one-third had never worked with primary schools.

Challenges and Opportunities in Higher Education:

The most frequent challenge mentioned was the low priority given to marine education in national curricula (83.3%), as well as institutional gaps between schools and universities. Nevertheless, most respondents believed that basic training on marine conservation and seagrass literacy for educators is required. The cluster emphasized the need for unified interaction among educational levels, bridging research specialization with classroom application through collective programs, workshops, and curriculum integration.

Cross-National Comparison

Across the four SEAQUEST partner countries—Belgium, Greece, Cyprus, and Portugal—the field research provides a common story of dedicated teachers struggling against structural and systemic impediments in adopting seagrass literacy across primary and teacher education. Teachers across all contexts exhibit high environmental awareness and favorable attitude towards marine education but are lacking in definite training, equipment, and curriculum frames to manage seagrass ecosystems positively. In Greece and Portugal, the majority of educators are experienced professionals with more than a decade of service and some background in teaching environmental topics but none of whom have ever received overt training in marine environments and rate their understanding of seagrass as poor. Educators in Cyprus, albeit slightly more knowledgeable, describe analogous requirements for

hands-on materials, on-the-ground education, and collaboration with specialists. In Belgium, outreach efforts encountered widespread institutional exhaustion, with schools and training institutions resistant or unable to participate due to administrative congestion—an enlightening finding that exposes a systemic barrier to educational innovation. Overall, the evidence suggests that environmental education exists in many forms but that seagrass literacy is almost non-existent at national curriculum and teacher training levels.

Despite these limitations, there is striking similarity across countries in the value accorded to the pedagogic value of experiential and digital methods. Teachers and trainers across all the countries stressed the importance of hands-on experience, observation in the field, and interactive learning aids such as virtual simulations and videos. They identified these as powerful and captivating tools for generating interest among students towards marine conservation. The main barriers quoted—poor training, inadequate integration into curricula, low resource availability, and poor institutional support—were uniformly echoed between stakeholder groups, ranging from primary teachers to university lecturers. Across all nations, researchers and staff at higher education institutions concurred that marine and seagrass literacy are weakly integrated into national curricula, although all of them unequivocally recognized the ecological and educational significance of the subject. Others demonstrated willingness to cooperate by conducting workshops, seminars, and joint research, supporting the potential of the project to promote cross-sectoral cooperation.

Cross-nationally, several trends emerge. Greece and Cyprus exhibit strong teacher motivation and desire to adopt new methods, as well as a clear need for curriculum-aligned materials and organized professional development. Portugal has a highly experienced teacher population and a strong sense of curricular appropriateness of marine literacy but specialist restriction. The Belgian model, however, illustrates the challenge of institutional engagement and the need for top-down, centralized solutions to ignite awareness. Across the four environments, teachers in all asked for collaboration with universities, NGOs, and ocean specialists, as well as access to pre-prepared lesson plans and field trip grants. These outcomes prove a shared need for systemic support, online materials, and experiential tools that can make marine science classroom-worthy learning.

Lastly, the SEAQUEST fieldwork demonstrates that seagrass literacy education in Europe is in its infancy but holds great promise. Teachers are green and enthusiastic but need the tools, training, and curriculum support to integrate seagrass education meaningfully into their practice. The consistent emphasis on experiential education, digital enrichment, and partnerships provides SEAQUEST with an apparent action agenda: produce effective, adaptable pedagogical assets; facilitate school and marine specialist collaboration; and advocate policy uptake of school integration of marine and seagrass literacy. By fulfilling these cross-country conditions, the project will be able to best close the gap

between scientific know-how and school teaching so that future generations possess a higher level of understanding and appreciation of marine ecosystems.

4.3.2.2. Qualitative Analysis

The qualitative content analysis of the Greek questionnaires gives detailed insights into teachers' attitudes, incentives, and challenges towards seagrass and marine literacy in education.

Among primary school teachers, free-response answers indicate a clear appreciation of experiential and emotionally engaging pedagogies. Teachers emphasized that student engagement increases significantly through collaborative and immersive practices such as field trips, underwater viewing, and narrative learning. They find emotional connection and sensory engagement as essential to fostering concern for the marine environment among students. Teachers simultaneously expressed a keen preference for systemic reform—most significantly, incorporating marine and seagrass literacy into the national curriculum, having available pre-prepared digital and print materials, and forging partnerships with marine experts, NGOs, and research institutions. Misconceptions that were prevalent among them were the confusion of seagrass with algae or horticultural crops and underestimation of children's capacity to grasp ecological interdependence. Affective disposition had teachers referring to seagrass as a "gateway" for instilling environmental stewardship as well as concern for the marine ecosystem. The responses as a whole suggest that teachers are committed and willing to undergo change but require structured training and the accompaniment of their institution. There is a clear call for curriculum reform, professional training geared to particular skills, and increased access to computer-based learning resources in order to bring marine education nearer and ready to incorporate into the classroom.

Teacher educators and VET trainers provided an alternative but more system-oriented perspective. They responded in terms of the need for systematic integration of marine literacy into formal teacher education and lifelong learning systems. They recommended weaving ocean and seagrass concerns into interdisciplinary subjects—geography, biology, physics, and chemistry—and creating national-level partnerships between teacher training schools, research centers, marine parks, and NGOs. They also recommended creating educational toolkits and peer-reviewed teaching manuals that reconcile scientific accuracy with pedagogical value. They recommended a double focus in training models: pedagogical expertise of the marine ecosystems and pedagogical ability to guide that expertise into effective classroom practice. The preferred styles of instruction were mostly experiential and collaborative, such as coastal fieldwork, workshop exercises, storytelling, role-playing, and arts-based instruction.

Where institutional and policy support is concerned, respondents painted with broad brushstrokes particular expectations. They urged the education institutions to introduce marine literacy courses at

undergraduate and postgraduate levels, organize training seminars, and sponsor research projects and field internships. At the parliamentary level, they asked for official recognition of marine literacy as a national educational priority, introduction into all levels of schools, and the appropriation of funds for environmental programs. From the environmental groups and NGOs, they demanded co-organized field activities partnerships, joint awareness programmes, and access to international marine education networks. Collectively, these responses convey a clear and coherent vision: seagrass and marine literacy need not be an esoteric topic but rather an institutionalized component of teacher training, developed through intersectoral partnerships, committed resources, and sustained policy engagement.

Briefly, the Greek qualitative data describe an ecosystem of dynamic educators operating within systemic constraints. Both trainers and educators alike have an interest in marine education as a way to build environmental consciousness, but they lack the curriculum format, professional training, and coordination to enable it. Their replies confirm SEAQUEST's top-down top priorities of capacity development via experiential and online training, cross-sector coordination, and curriculum integration to move marine literacy from an isolated initiative to an organized educational practice.

The qualitative content analysis of the Cypriot surveys indicates a clear pedagogical emphasis on interactive, experiential, and affective learning as the basis for inculcating students' curiosity and concern for marine ecosystems. Teachers in primary schools across the board indicated that children learn more about seagrass if the lesson is experiential, outdoor-based, and applied to their daily lives. Coastal excursions, seagrass meadow viewing, and outdoor classes were considered the strongest ways of eliciting real involvement. Virtual reality simulation and virtual touring of aquatic environments were also called powerful ways of modeling real experiences within the classroom environment. Teachers continually stressed the need for integrating classroom learning with real-world ecological and societal contexts—such as the role that seagrass plays in augmenting marine biodiversity, mitigating climate change, and maintaining ecosystem integrity—in order to provide learners with an appreciation for the real-world relevance of marine literacy. They recommended a variety of creative and interdisciplinary pedagogies including role-playing, story-telling, model construction, art and craft projects, and collaborative experiments. Collectively, these practices were seen as essential to making marine education a relevant, enjoyable, and enduring learning experience.

In their suggestions, Cypriot teachers asked for systemic and structural support in order to facilitate marine and seagrass literacy in schools. They suggested integrating marine education into the national curriculum, designing pre-packaged lesson plans, and conducting teacher training workshops to further enhance teachers' confidence and competency. Teachers requested schools to collaborate with local marine institutions, aquariums, and experts, to allow students to engage with marine

ecosystems directly. They emphasized that experiential, collaborative, and inquiry-based pedagogies not only boost motivation but also deepen students' sense of responsibility and ownership toward protecting the environment.

VET teacher educators and trainers also testified, emphasizing that effective practical and well-supported models are needed in order to be able to successfully integrate marine education into teachers' training programs. They recommended integrating experiential learning modules, outdoor education camps, and hands-on workshops to create educators' hands-on self-esteem. Off-the-shelf teaching materials, electronic resources, case studies, and real-life scenarios were recommended as necessary tools to facilitate straightforward classroom transfer of knowledge. Trainers also stressed the need for aligning marine education with national schemes of overall sustainability and environmental literacy so that it is in sync with national education policy. Support from institutions—via policy support, grants, and collaborative partnerships—was considered necessary for long-term sustainability of marine education and training. They advocated for regular professional development sessions, open-source learning material, and cooperation with NGOs and marine professionals for ensuring the competitiveness and quality of training schemes.

Scholars and educators at the tertiary level seconded these priorities, that is, the demands of experiential and inquiry pedagogies that make marine science both relevant and transformative. They advocated fieldwork, local place-based study of the immediate surrounding marine habitats, as well as active interaction with digital media to facilitate conceptual understanding. Respondents underscored that teachers must be empowered through constant training, provision of pre-prepared classroom materials, and collaboration with external supporters such as sea experts, NGOs, and aquaria. Besides, they underscored cross-curricular and interdisciplinary coherence, linking oceanic challenges to science, geography, and art, and allowing students to translate ecological issues to their own local environments. Finally, qualitative results from Cyprus affirm a shared vision across school levels: cultivating curiosity, empathy, and stewardship through experiential learning and collaborative institutionalization. By integrating marine literacy into pedagogy and policy frameworks, educators envision Cyprus as the location to educate a generation of nature-aware learners known to and concerned with the marine world.

Qualitative Portuguese survey analysis suggests that trainers, teachers, and researchers are deeply committed to increased marine and seagrass literacy through experiential, interdisciplinary, and community-based education. The open-endedness of primary school teachers' answers suggests there is a strong pedagogical belief that direct experience of nature is the best way to inspire students. Educators across the board referred to field trips, outdoor inquiry activities, hands-on games, and experiments as the most effective means of encouraging students' curiosity and making them feel

associated with ocean worlds. They also emphasized the need to have direct exposure to the expertise—i.e., field demonstrations and lectures by marine scientists—and virtual fieldtrips as a way of bringing underwater worlds to the classroom. These strategies, they stated, ground learning in reality and are motivating and allow students to understand how human activities impact the marine environment.

Educators proposed several hands-on steps to make marine literacy a mainstream offering in schools. Key recommendations were to conduct more fieldtrips, provide more specialized instruction for teachers to teach marine and coastal ecosystems, and facilitate collaboration with researchers, universities, and local environmental organizations. The participants also called for activities at schools and communities, such as coastal events and awareness drives, to take learning beyond the classroom. Some teachers requested integrating marine literacy into current courses like Environmental Studies and Portuguese to encourage interdisciplinarity and curriculum reform. The need for logistical and institutional support—such as fare-free transportation for trips, online resources, and accessible learning materials—was highlighted as crucial to make it happen. They also proposed inter-class and cross-subject assignments to instill a culture of environmental responsibility at the school level. Generally, teachers expressed strong motivation to teach marine literacy but emphasized the imperative need for training, resource, and system support to make such teaching possible and sustainable.

Teacher educators and VET trainers repeated all these priorities but took them further to structural and policy-level change in teacher education. They called for the inclusion of certain subjects or modules within teacher education programs based on sustainability, ocean ecosystems, and the oceans' contribution to the achievement of the Sustainable Development Goals (SDGs). Trainers proposed the establishment of problem-solving workshops with field applications by marine specialists and the inclusion of citizen-based courses linking environmental education with social responsibility. They also emphasized the importance of experiential learning, encouraging experiments such as tracking alien species or field investigation to develop teachers' practical ecological skills. In addition, they expressed that the education of teachers should be pluralized in order to accommodate different professional settings and local needs, leaving teachers all over Portugal with the potential for marine-specific schooling.

When asked about the character of policy and institutional support needed, trainers emphasized that investment in resources and multi-level cooperation is critical. Trainers called on policymakers and educational authorities to increase knowledge dissemination about the significance of marine literacy towards achieving the SDGs as well as programs that bring teachers directly to engage with marine scientists and local universities. Respondents also laid great stress on the continued collaboration

among research institutions, NGOs, and schools in order to ensure scientific integrity, pedagogical creativity, and durability in the long run. Financial and logistical assistance for school excursions, the development of tailored educational materials, and mechanisms for long-term funding were among the priorities listed. Trainers also emphasized the need for verifying schools' marine education efforts through professional involvement, which would raise credibility and impact.

In brief, Portuguese qualitative data provide a description of an education society that is visionary and motivated but constrained by structural limitations. Both educators and teachers recognize that marine literacy must go beyond theoretical knowledge to experiential, emotional, and socially meaningful interactions. Their responses all demand institutional backing, inter-sectorial partnerships, and curriculum changes that incorporate marine and seagrass literacy into formal education and teacher training. All parties agree that Portugal has the intellectual and human assets necessary to propel marine education—if, that is, teachers are provided with the resources, the conditions for cooperation, and structural reinforcement necessary to translate enthusiasm into sustainable teaching practice.

4.3.3. Focus Group Data Analysis

4.3.3.1. Quantitative Analysis

The quantitative analysis of the Greek focus group reveals encouragingly high levels of awareness and interest in primary school children, along with notable conceptual gaps in their understanding of marine ecosystems. In Part A, there was high exposure to coastal habitats: all children had visited a beach and were acquainted with seagrass meadows, either through direct experience or exposure to media, such as advertisements for the conservation of seagrass. When asked to name ocean creatures, fish and crabs were named across the board, indicating these as the most recognized species. But the range of responses—such as jellyfish (21 responses), squid (18), octopus (13), and fewer noting shrimp, sea urchins, and "sea bugs"—indicates partial but growing biodiversity understanding. The reference to familiar and unknown species indicates that while children possess a concrete knowledge of sea creatures, it is largely limited to visible or much-discussed animals.

In Part B, while imagining life under the sea, students revealed a rich anthropomorphic perspective of sea life. Students viewed fishes as communicative animals that converse, play, and socialize in complex habitats. A majority of associated fish with seaweed or seagrass (16 statements), and some also noted interactions with corals (3) or people (9). This shows an early, if significant, recognition of ecosystem interrelatedness. When asked to imagine themselves being a fish in a storm, the majority of students intuitively understood seagrass meadows as sheltering refuges (25 statements), showing an intrinsic valuing of their protective ecological function. Some reported that they hid in caves (4), remained

close to other fish (6), or stayed away from strong waves (12), reflecting an intuitive but conceptually sound grasp of animal survival behavior.

Children's responses in Part C revealed a growing awareness of the ecological role of seagrasses. All associated them with oxygen production—a fundamental ecological benefit—while 13 linked seagrass with fish protection, 8 with water purification, and 4 with food sources. These findings show that children can identify major ecosystem services, though in simplistic terms. When describing human impacts, respondents showed explicit environmental awareness by citing pollution by plastics (21 times), cigarettes (11), and food waste (16), and oil spills (5). They also recognized damaging human activities such as illegal fishing (12 times), anchoring (3 times), and seagrass pulling for beach grooming (22), which they correctly perceived as inimical not just to seagrasses, but to marine life as a whole. This indicates great moral and ecological awareness of human-induced environmental damage.

Finally, in Part D, the students expressed strong interest in active, experiential learning about seagrass ecosystems. All participants stated that they would like to go on field trips to observe seagrass meadows firsthand, and many were excited to learn through video games and stories. These interests highlight the importance of supplementing outdoor education with interactive digital media in order to sustain engagement and deepen understanding.

Overall, the Greek focus group results show that while children possess a foundation of knowledge about marine ecosystems and the environment, their knowledge of seagrasses is contextual and superficial. Their willingness, empathy, and desire to learn via experiential and creative approaches, however, provide good foundations for seagrass literacy education. Integrating field-based and digital pedagogies that connect emotional engagement with scientific information could therefore foster deep and long-lasting learning outcomes.

The quantitative analysis of the Cypriot focus group reveals that the children present had a very high degree of familiarity and comfort with marine environments, due in large part to their direct contact with coastal areas. Nearly all the children reported frequent visits to beaches or seaside areas—some citing specific places such as Thasos and Paphos—implying that direct exposure to the marine environment is both common and prominent in their lives. This experiential connection provides a sound foundation for environmental and marine education because an understanding of natural spaces is regularly coupled with more general environmental awareness. When questioned about plants in water, many children referred to "seaweed," "sea grass," or "grass in the sea," and used these terms interchangeably. Though this reveals a lack of terminological precision, this still shows children's recognition of the existence of underwater plants, though they are not yet capable of accurately distinguishing seagrass from other underwater plants.

With regard to biodiversity and animals, children showed the beginnings of ecological consciousness

by mentioning sea anemones and fish, with a child recalling that "little fish came out of it" upon touching the seagrass-like plants. This remark implies an unconscious understanding of seagrass beds as refuges and habitats for marine organisms. Their imaginative stories also reaffirmed this observation—some children envisioned fish taking cover within the vegetation, seagrass guarding sea anemones, discovering underwater caves, and even behavioral adaptations like "playing dead." These responses bear witness to creativity and an emerging comprehension of ecological relations, especially the protective role of seagrass for marine organisms.

However, as the questions progressed to environmental processes and ecosystem function, student responses became more limited and descriptive and focused largely on observable behavior rather than underlying ecological process. None of the students discussed photosynthesis, oxygen production, nutrient cycling, or seagrasses' contribution to seafloor stabilization—illustrating that while their observational knowledge exists, their conceptual knowledge of ecosystem services is novice. Likewise, no references to human impacts such as pollution, litter, or habitat destruction were made, suggesting that the idea of anthropogenic impact on marine ecosystems has yet to be introduced or internalized at this age group.

In general, the quantitative findings from Cyprus reveal that children have a vivid sensory and emotional connection with the sea that can be utilized as an effective starting point for environmental education. Their accounts show interest, sympathy for marine animals, and an ability to recognize uncomplicated ecological relationships, although they lack the scientific vocabulary and conceptual framework to describe them accurately. These findings suggest that experiential and narrative models of teaching—i.e., underwater exploration, role-play, or guided discovery—would be highly effective in helping Cypriot children shift from concrete observation to a more deeply appreciative understanding of marine ecology and the role of seagrass ecosystems.

The qualitative responses from Denmark show that teachers are generally positive but cautious about marine and seagrass literacy. Primary school teachers showed a real interest in marine-related topics, especially when they were linked to real-life experiences and the Nordic context of living on the coast and on islands. They stressed that kids learn best when they are outside, doing things that are concrete and sensory-based, like going for walks along the coast, looking at local ecosystems, and doing small experiments with sand and sea plants. But they also said that a lack of local teaching materials and not enough time in the curriculum are still problems. Teachers said that subjects like seagrass or marine ecosystems are often seen as "extra" material and don't get much attention in class unless they are connected to bigger environmental education topics like climate change or biodiversity.

VET trainers and teacher educators said that marine and environmental education are there in theory but not in practice, and that it often depends on what each teacher wants to do. They asked for clear learning frameworks, lessons that crossed disciplines, and interactive modules that could be easily added to Danish education in science, geography, and sustainability. Respondents said that hands-on activities, fieldwork on the coast, and working with museums, local nature centres, and NGOs were all motivating and useful.

University professors and researchers in Denmark talked about how strong the research base is in marine sciences, but they also said that it isn't very easy to get this knowledge into schools. They suggested making connections between research projects and schools, such as workshops, easier ways for research projects and schools to share data, and getting students involved in citizen science activities. Across all groups, the qualitative evidence indicates a collective motivation to enhance marine literacy, alongside a demand for practical, curriculum-aligned resources, digital supplements, and institutional collaboration that would enable educators to translate Denmark's marine identity into significant classroom experiences.

The quantitative analysis of the Belgian focus group highlights that the children participating showed high exposure to marine environments, though mostly through recreational or mediated experiences rather than organized learning. Twenty students, nineteen having already visited the beach, in Belgium or abroad—mentioning countries such as Spain, France, Italy, Norway, Turkey, Croatia, and Morocco. This shows that almost all the kids had observational or first-hand exposure to coastal environments. When shown images of seagrass meadows, nine students believed they had seen them before, either on Mediterranean holidays or through online mediums like YouTube and nature documentaries. Though none could correctly identify the plant as "seagrass," confusing it with "seaweed," many were surprised when some inquired whether the photos were real or fabricated, showing not only interest but also some degree of digital media literacy.

In describing marine biodiversity, students possessed a moderate range of knowledge, listing eleven various animals or groups of species, both typical and ecologically mismatched. They included small and medium-sized fish, jellyfish, octopus, squid, lobsters, shrimp, crabs, sardines, small sharks, swordfish, and piranhas—demonstrating both knowledge about marine animals and misconceptions about the distribution of species in seagrass meadows.

In the story and imagination task, children actively interacted with behavioral and ecological concepts. They described marine animals "looking for food," "playing hide and seek," "having babies," and even "sleeping" or "pooing," indicating that they could recognize biological and ecological processes, though in simple, everyday terms. Five processes were identified in their stories: feeding, protection, reproduction, defecation, and rest, indicating an emergent conception of marine life cycles. When

asked to explain how seagrass would help protect fish during storms, the children attributed passive and active protection roles to it—stating that fish would either "hide in the grass" to be protected or "hold onto the grass" so they would not be swept away. One student compared seagrass to "breakwaters," demonstrating early analogical ecological reasoning, and another compared it to "rays hiding in the sand." Together, these answers demonstrate intuitive comprehension of seagrass's protective ecological functions against predators and wave action.

In exploring ecosystem benefits and human impacts, students enumerated seven benefits of seagrass—five ecological and two anthropogenic. They defined its role as a habitat, nursery, fish food source, and indicator of overall marine ecosystem health, connecting it also to human benefits of food provision and water filtration. At the same time, they defined six major human impacts, which included pollution (especially plastic waste), climate change, habitat degradation from boats and recreation, seagrass direct removal, and invasive species. The mention of human-induced pressures shows an increasing awareness of environmental hazards and the connection between human and marine systems.

In terms of learning modality, most of the children preferred interactive and experiential learning. Eight students, predominantly boys, mentioned Virtual Reality (VR), while seven students, predominantly girls, enjoyed field trips, snorkeling, boat rides, and visiting the beach. This gendered distinction shows that immersive digital technologies and exploration of the real world have varying appeals among learner groups, which aligns with the offering of multi-modal learning pathways in marine education.

Overall, the Belgian quantitative findings demonstrate that children possess a sound imaginative potential, interest, and a starting conceptual awareness of marine ecology, particularly protection, habitat, and biodiversity. Confusion over terms and the absence of comprehension of ecological processes, however, signify the need for systematic, conceptually oriented environmental education. Practical experiences such as field trips, combined with interactive digital technologies such as VR, can bridge the gap between children's tacit ecological knowledge and scientific literacy, as needed for the SEAQUEST goal of establishing higher seagrass literacy and ocean stewardship.

The quantitative analysis of the Portuguese focus group indicates that children who participated had high exposure to marine ecosystems and moderate to high factual knowledge of seagrass ecosystems. All of the participants had, at some point, visited a marine environment, which pointed to high experiential familiarity with underwater or coastal ecosystems. Twenty students identified seagrass beds, with the majority attributing their knowledge to mediated or indirect sources like films, books, online images, or school excursions. There were few who had come into direct contact with seagrass, testifying that while media and informal learning comprise an important component of marine

awareness, first-hand experience remains scarce.

When asked about marine animals, students provided a wide variety of species, encompassing knowledge and fantasy. Fish (22 responses) were the most common response, followed by seahorses (11), crabs (6), starfish (4), turtles (2), shrimp, sea urchins, seaweed, and sea snakes. A few students also mentioned sea animals such as octopuses, jellyfish, cockles, clams, and whales, suggesting broad ecological interest. Citations such as "Nemo" from a Disney film and "fishing bait" are also interesting, showing how popular culture and daily life shape children's mental imagery of sea animals. Only three students showed doubt or ignorance, which meant that overall knowledge of marine biodiversity was both diverse and rich, though sometimes symbolically or culturally mediated rather than scientifically correct.

In Part B (Imagine and Explore), children's imaginative stories conveyed strong anthropomorphic and empathic thinking. Most described fish daily life in humanized conditions, giving them names and attributing social behavior similar to humans' lives. This fish-people analogy, characteristic at this level of development, illustrates a narrative way of knowing ecology, where fantasy and empathy precede fact. Pollution was an issue for a vast majority of the group, with trash and plastics being volunteered as major threats to sea life. When asked to imagine themselves as fish during a storm, most depicted a tangible intuitive awareness of the seagrass's sheltering role, describing fish "hiding under seaweed" or "holding on to it" for cover. Some even stated that "the seagrass saves the fish," demonstrating a distinct intuitive awareness of ecosystem services such as protection and habitat stability. Some talked of being amazed by seagrass after a storm, indicating emotional appreciation and wonder at its resilience.

In Part C (What Do You Think?), all of the respondents were capable of associating seagrass with significant ecological functions, indicating emerging systems thinking. They identified seagrass as a source of oxygen, a food source for sea creatures, a provider of shelter, a habitat for biodiversity, a nursery for young sea creatures, and a cleaner of the sea by "absorbing bacteria." All of these responses reflect that the children could identify a number of ecosystem benefits, integrating biological, ecological, and environmental thinking. They also showed a recognition of human impact, with trampling, plastic, and boat damage being frequent references to harmful actions by humans that can affect seagrass meadows. Four students, however, were unsure of how humans are impacting the sea, which suggests that causal environmental thinking is still developing for some learners.

In Part D (What Would You Like?), the most popular learning preference was field trips—named by twenty-two students—confirming strong interest in experiential learning and direct exposure to nature. Smaller groups were interested in video games (2), expert lectures (2), Lego-based construction (2), and videos (1). The other interests were participating in beach clean-ups (1) and

storytelling sessions (1). These responses show that children enjoy interactive, exploratory, and hands-on learning experiences more than passive methods of teaching.

Overall, the Portuguese children showed high enthusiasm, ecological interest, and affective engagement with marine environments. Their understandings were diverse and often inflected by emotion, imagination, and symbolic connection but with clear signs of environmental literacy emerging—particularly in their understanding of how seagrass helps protect marine animals and increase biodiversity. Their identification of human impact and interest in real-world exploration herald great promise for environmental education that is transformative, especially for a blending of field-based education with new digital capacity and storytelling to extend scientific knowledge and emotional connection.

4.3.3.2. Qualitative analysis

The Greek focus group qualitative findings give intensive data on children's cognitive, symbolic, and emotional construction of seagrass ecosystems, as well as data on their growing ecological consciousness. Part A of the children's initial response was indicative of a strong emotional identification with the sea that they associated with freedom, happiness, and leisure—swimming, fishing, and sandcastle construction were among the activities that they mentioned. But their first reaction to seagrass was universally negative: they found it upsetting and even sickening to have to tread over seagrass washed up on the beach, describing it as "weird" or "slippery." This emotional revulsion means that, while the sea is a good, known environment, parts of it—such as seagrass—are still thought of as unpleasant or unwanted, a normal aesthetic preference for "clean" beaches. When sea creatures were named, children used common and familiar species, including fish, crabs, jellyfish, and octopuses, and some used introduced less familiar animals like "sea bugs" (here interpreted as invertebrates), indicating interest and developing ecological awareness.

Part B was where the process of narrative transfer was key to attitude shift. Through imaging the life of the marine animals, students gained an appreciation of the ecological significance of seagrass meadows as productive habitats and sanctuaries. The reference to Finding Nemo exemplified how popular culture maintains children's understanding of sea creatures, interpolating fiction and environmental education. The identification by students of seagrass as a refuge for fish during threats demonstrated that, in the absence of infrequent scientific vocabulary, they naturally grasp ecological interconnectedness and the sheltering function of these ocean grasslands.

Part C's discussion of the importance of seagrass ecosystems saw rising conceptual complexity and environmental awareness. They noted that the fact that seagrass is found along the beach is a sign of a healthy ocean, relating it to oxygen generation ("They photosynthesize") and food chain balance ("If they no longer exist, some fish won't have anything to eat, and they will die, affecting the food chain").

They demonstrated comprehension of human actions harming ocean ecosystems—in citing pollution, oil spills, plastic trash, and anchor damage—and recognized that destruction of seagrass to create neater tourist shores devastates the very important ocean habitats. Such results suggest that children can understand advanced cause-and-effect relationships between human activity and environmental consequence, particularly when in concrete, tangible terms.

Part D saw students' excitement with experiential and interactive learning. They all favored the prospect of field trips to see seagrass meadows in person, with a few even proposing swimming in the ocean to investigate them in close-up. Mention of virtual reality as an attractive learning device indicates their willingness to marry technology with discovery—a future direction that holds great potential for educational programs.

The discussion also revealed popular misconceptions it was important for teachers to clarify. The most common was that seagrass is the same as seaweed; all participants initially answered that seagrass is "seaweed." After visual aids and a brief commercial on seagrass conservation, students were able to quickly dispel this misconception to learn that seagrasses are flowering marine plants, not algae. Other students overgeneralized the function of seagrass to "food for all sea animals," but most came to understand that its functions include oxygenation, creating habitat, and protecting coastlines.

Finally, the affective and symbolic content of the sessions indicates children's capacity for empathizing and reflecting morally. They showed concern for pollution and responsibility for one's own behavior—in claiming, for example, that "we must throw away our trash when we leave the beach." Once brought to appreciate the environmental contribution of seagrass, their distaste turned to admiration, and they claimed protective feelings, saying that "we should not pull them out because they clean the sea." The story method was particularly effective in producing emotional investment and fanciful thinking, allowing children to take on the role of sea creatures and to proclaim a sense of stewardship over the sea.

Overall, Greek qualitative findings confirm that kids possess a deep emotional affinity for the marine environment, an ecological awareness, and a learning willingness through imaginative, experience-based, and technological media. Misconceptions and aesthetic prejudices, however—such as viewing seagrass as "dirty" or "unpleasant"—highlight the need for extensive education and positive portrayal of marine ecosystems in the classroom. Storytelling, experiential learning, and interactive learning media become particularly potent methods of translating emotional relationship into environmental awareness and concern.

The qualitative content analysis of the Cypriot focus group portrays an intimate, expressive, and experiential relationship between children and the world of the sea. The session was recounted in sensory and expressive language, reflecting children's bodily engagement with the sea as a site of play,

adventure, and exploration. They represented the world at sea in terms of tangible objects such as "rocks," "sand," "pebbles," and "waves," indicating that they consider the sea a close and familiar place rather than an abstract thing. They were excited as evidenced by vivid narratives like "We went down deep in the sea to see and we saw a cave," which convey interest and wonder. Such familiiarity with sea spaces, more often linked to family vacations and leisure pursuits, serves as the ground for strong affective attachment, which in turn sustains other environmental learning.

While discussing seagrass, the children used strongly imaginative and empathetic metaphors-describing it as a "fish house," "cover-up blanket," and "shelter." Such terminology suggests that they intuitively understood seagrass as protective and secure shelter. Phrases like "they hide so bigger fish won't eat them" and "they cover the sea anemones so other sea creatures won't eat them" indicate that children had assigned seagrass protective and caring functions in the sea environment. One child even stated, "I would pretend to be dead on top of these plants," using imaginative play to indicate identification and empathy towards sea creatures. This symbolic interpretation of seagrass as a place of safety and comfort is proof of a nascent eco-empathy—a moral and emotional connection to non-human life before scientific understanding.

Intellectually, a lot of participants began to display early signs of ecological thinking. Some recognized predator–prey relationships and functional roles of habitats, and a child correctly observed that seagrass "grows in the light zone, very deep down," and thus demonstrated some knowledge of the ecological role of sunlight. However, even with these hopeful results, their conceptualization remained bound to material experience. The discussion was not yet transferable to abstract ecological phenomena such as cycling of nutrients, oxygen generation, or human–environment relationship. This means that their ecological knowledge is in its baby stage and must be guided into changing from observational knowledge into systemic thinking.

Several misconceptions were consistently encountered. The most common was the interchangeable use of "seaweed" and "seagrass," with an indication of a conceptual mix-up among different species of marine flora. Some kids also confused seagrass with "sea flowers" or "corals" and were not able to differentiate between plants and other sea flora and fauna. Some students did correct themselves spontaneously in peer discourse, shifting from "seaweed" to "sea grass" and demonstrating that collaborative talk and visual cues have the potential to enhance vocabulary. Interestingly, all of the children accepted that plants grow in water, showing that they did not share the common false assumption that plants grow only on the ground.

Emotionally, their responses were filled with amazement, concern, and empathy. They demonstrated affection for sea animals, imagining fish as fragile and requiring care. Humor and fantasy in the guise of mocking remarks such as "playing dead" or "hiding behind them" demonstrated application of

embodied imagination, where they put themselves in the place of sea creatures. Imaginative empathy demonstrates the development of early environmental sensitivity based on feeling more than on rational thinking.

The implication of this information is that kids in Cyprus possess a moderate but affectively rich conception of seagrass ecosystems. They recognize the seagrass as a living space but have not yet equated it to greater ecological processes or human-driven environmental issues. They are well-situated through their creative activity and interest, however, for more sophisticated learning. The high-energy engagement tone, with frequent personal references to family outings and normal living experience, ensures that experiential and narrative methods are extremely effective for this group.

Finally, the Cypriot focus group confirms that 10–12-year-old children interact with the world under the sea in terms of sensory experience, creativity, and compassion and build the emotional basis upon which environmental stewardship can be founded. Myths regarding classification continue but can be resolved through deliberate, experiential clarification activities. Teaching approaches based on this sound emotional foundation should proceed along symbolic and narrative learning, helping children to convey their creative interest in scientific information. Activities such as comparing seagrass to seaweed, investigating photosynthesis through experiments, and demonstrating the impacts of human effects upon sea habitats can convert their empathetic intuition into orderly ecological literacy. By combining scientific accuracy and creative passion, SEAQUEST teachers are well equipped to foster both the minds and hearts of next-generation ocean guardians.

The qualitative findings from Denmark indicate that children have a profound emotional and cultural affinity for the sea, influenced by Denmark's coastal geography and their daily exposure to marine environments. Students talked about the sea as a place where they could be free, spend time with family, and relax. They thought of swimming, fishing, and walking on the beach. Some people said the ocean was "alive" or "mysterious," which showed both love and respect. Many kids knew that seagrass meadows were "sea plants" when they saw pictures of them, but they couldn't name them specifically. This shows that they didn't know much about the concept even though they could see it. People were often confused about the difference between seagrass and seaweed, just like in other countries.

When students learnt that seagrass provides shelter and food for marine animals, they were curious and caring about it. Their comments showed that they understood that the seagrass meadow serves as a natural habitat for fish, just like "forests for fish." Teachers who led the discussions said that these metaphors came up on their own, which showed that the kids were ready to turn abstract ecological concepts into more concrete examples.

Danish students liked to learn best through outdoor exploration and creative experimentation. They

were excited about going to the beach, watching videos or using goggles to see things underwater, and "diving" virtually through digital simulations. The students' creative answers, like wanting to "build a home for fish in the seagrass" or "make a story about life under the waves," show that they are both curious and morally aware. The Danish focus group shows that people have a strong emotional connection to marine life, a basic understanding of science, and a clear preference for learning through experiences, stories, and technology. This is very similar to the SEAQUEST teaching framework.

The qualitative data from the Belgian focus group provide an in-depth perspective of children's cognitive, emotional, and sensory association with seas and seagrass ecosystems. The results reflect a strong imaginative and sensory significance to the sea but poor conceptual knowledge, wherein emotional reactions and situational family were strong determinants of their environmental knowledge and learning style.

In Part A (Q1–3), children asserted their allegiance to the sea in rich sensory accounts of Mediterranean and northern sea waters as "clear" and identifying the marine world with play and comfort. When shown photographs of seagrass meadows, the interviewees did not know the term "seagrass," though some said that it "felt like grass to play soccer on" or "soft to lie down on." Seaweed was familiar only as a food item, which was "tasty," and there was a disconnected but tangible acknowledgment of sea vegetation. Reactions to seagrass photographs were very emotional—half of them responded with surprise or wonder, exclaiming "waaaaaw! " while viewing the pictures, and some showed fear for certain sea creatures such as sharks or seahorses.

Some of the participants acknowledged alienation from the marine world, terming it as being less familiar than on land, while others showed indifference, revealing variable amounts of affective investment in the group. In Part B (Q4–5), the children demonstrated high levels of imagination and anthropomorphism.". They envisioned seagrass grasslands as underwater community, likening them to "villages" with "streets and houses" where fish take care of "school," "shops," or "local celebrations." Others envisioned fish "playing soccer" or "lolling on the seagrass bed." Such readings illustrate how kids bestow human social structures and emotions upon marine ecosystems—a very early stage of symbolic eco-imagination where fantasy and empathy precede scientific knowledge.

These anthropomorphic remarks show that children conceptualize the sea as a living, human world, where emotional bonds would be built in the future, forming the basis of environmental learning. Cognitive limitations were present in Part C (Q6–7). It was challenging for most students to explain cause-and-effect relationships between human action and the environment. Plastic pollution was volunteered but deeper ecological thought had to be cued. But with prompting, some children came up with quite advanced thoughts—such as the one that proposed human beings might "introduce new

fish species that consume seagrass more quickly than the native ones"—which showed emerging systems thinking.

These examples suggest that intuitive knowledge is still limited, but with facilitation, the children can demonstrate wise connections to ecological interdependence and human disturbance. More preferred learning styles in Part D (Q8) suggested curiosity and creativity. The most frequent ideas were experiential and participatory encounters: beach shelling, boat tour with a scientist, snorkeling, diving, and drawing. While virtual reality (VR) was also mentioned, the students struggled to explain what kind of VR experience they envisioned, indicating that direct contact with nature is still more resonant for most.

But this varied depending on prior exposure to nature—children from more ecologically engaged families preferred real-world experiences, while others preferred digital means like VR. A number of misconceptions were discovered. Many children thought seagrass was seaweed, coral, or flowers and were amazed at encountering underwater snails or seahorses, indicating the absence of knowledge on biological classification. They did not know that plants could bloom underwater and were amazed at this phenomenon. More far-reaching misconceptions existed within general marine awareness—such as believing the North Sea is "dirty" because it's brown (not appreciating sediment suspension) or that the Mediterranean is "clean" because it's blue.

Others thought that sharks in general are dangerous and plankton are animals, exemplifying a need for differentiation between marine plants and animals.

The emotional and symbolic content of the discussions was profound. Children showed empathy toward marine life, describing marine animals as “odd,” “fragile,” and deserving of protection. One student’s statement—“I would cry because I’d be scared during a storm at sea”—exemplifies eco-empathy, where emotional identification with non-human life drives moral awareness of nature. Humor and imagination were also used to express these emotions, reinforcing that emotional engagement can serve as a bridge to deeper cognitive understanding. A revealing sociocultural insight was derived from cross-comparison of the two focus groups. Although the two groups were in the same age group and school, their knowledge level as well as attitudes differed. The first group was keen, questioning, and knowledgeable—some even reciting facts concerning ocean depth, water pressure, and marine life—while the second group did not appear interested and less knowledgeable. These differences were strongly related to family background measures, including parents' concern for biodiversity, exposure to documentaries, nature walks, and travel experiences. This suggests that family influence is more significant in achieving marine awareness and attitude than education.

Likewise, kids who came from environmentally engaged families favored real-world learning activities like trips, while those with minimal exposure favored virtual ones. In conclusion, qualitative analysis

shows that Belgian youngsters possess dynamic sensory imagination and affective affinity with the seagrass world but not strictly organized scientific knowledge. Their misunderstandings, anthropomorphisms, and irregular knowledge distribution confirm the need for experiential and narrative pedagogy in seagrass literacy. Pedagogic interventions need to harmonize haptic discovery (e.g., snorkeling, excursions) with led contemplation and visual contrast (e.g., learning to distinguish seagrass from seaweed). Including VR technology might be appealing to those with limited access to nature, whereas experiential learning through hands-on activities can further reinforce learners' knowledge.

By combining imaginative narrative with scientific facts, teachers can leverage kids' sense of curiosity, empathy, and sensory engagement to build a long-term and inclusive sense of ocean responsibility.

4.3.4. Cross-National Needs and Barriers

From Portugal, Belgium, Greece, and Cyprus, SEAQUEST field research testifies to keen goodwill on the part of educators and student interest in the marine environment as well as to systemic lacunae that dissuade the uptake of seagrass literacy in everyday school life. The common point of departure is clear: environmental education is present across all four contexts, yet seagrass literacy is not often named in curricula, rarely appears in teacher education, and is only sporadically enacted in classrooms. Where teachers have taught related content, they have typically done so without official training in marine ecosystems and have relied on general environmental materials rather than seagrass-specific resources. This structural deficit creates low teacher confidence, infrequent classroom use, and an overall impression that seagrass is "specialized" or "difficult," despite strong agreement that it must be taught in the curriculum.

The needs teachers articulate are remarkably consistent. First, there is a widely articulated need for curriculum-aligned, ready-to-teach lesson packages with explicit mapping back to national goals and minimum learning outcomes. Second, teachers ask for hands-on, credit-bearing professional development that models experiential pedagogy—fieldwork, labs, and inquiry—supported by digital enhancements such as simulations and VR. Third, they ask for long-term collaboration with universities, marine institutes, NGOs, aquaria, and local conservation stakeholders to provide scientific credibility, guest expertise, and possibilities for authentic learning beyond the school gate. These needs are endorsed by higher education respondents, who sanction practice-led workshops, cross-sector collaboration, and openly licensed teaching materials as the most rapid way of closing gaps of care in the classroom.

Constraints of resources and capacity cut across all partner countries. The most frequent constraints are lack of teacher specialization in marine topics, limited access to seagrass-specific resources, school budget limitations for field trips and transport, and weak institutional mechanisms connecting schools

with marine experts. Curricular silence is particularly limiting: when seagrass is not explicitly named, instructors have no time or inclination to insert novel content. In Belgium, institutional bandwidth is an additional barrier—severe survey fatigue and administrative burden suppressed participation across school and teacher-training domains, suggesting even well-designed interventions need top-down contextualization, simplified requests for engagement, and obvious curricular leverage points to gain traction.

The student data add another complementary facet to these findings. Throughout all countries, children show strong affective attachment to the sea and high interest in interactive learning; they readily identify protection, shelter, and habitat functions of vegetated coastal ecosystems when prompted by story or photographs. They have, nonetheless, rudimentary ecosystem-process knowledge (photosynthesis, carbon sequestration, nutrient cycling, shoreline protection) and terminology is often incorrect, with common confusion between "seagrass" and "seaweed." Such misconceptions are not deep-seated: brief, well-resourced activities—visual comparisons, simple experiments, and guided narration—alter understanding quickly. Students all appreciate experiential experiences (shoreline surveys, boat trips, snorkeling, field trips) and also respond well to digital immersion, albeit varied by prior exposure, with VR emerging as a successful bridge for lower nature-access students.

Matters of equity emerge in two important ways. First, home background appears to mediate both marine knowledge and learning style: students whose homes include nature activities, documentary watching, or seaside visits have higher initial knowledge and a preference for real-world field trips; others like virtual ones. Second, access of schools to transportation, seaside sites, and expert partners is heterogeneous, so logistics and small-scale financing are determinative of implementation. These inequalities need to be met by mixed-modality pathways—blending fieldwork where feasible with high-quality virtual alternatives—and small grants or partnerships that remove cost and access obstacles.

Teacher education systems represent a parallel requirement set. Pre-service and in-service programs rarely include seagrass or ocean literacy as explored, and credit-bearing components in contexts are assessed. Teacher educators facilitate the integration of ocean literacy into interdisciplinary approach courses (science, geography, maths, language) and promote modular toolkits that are both scientifically rigorous and pedagogically prepared. Assessment and recognition—micro-credentials, CPD certificates, and portfolio artefacts—are also emphasized for normalizing and rewarding marine literacy in teacher professionalism.

Policy and institutional alignment are the enabling conditions that bind these strands together. Without explicit curricular reference to seagrass literacy, school leaders face rival priorities and

teachers have no justification for time and resources. Partners therefore identify three levers of systemic change: short policy briefs aligning seagrass literacy with national outcomes and SDGs; brokerage mechanisms connecting schools with local sites and expertise; and recurrent resourcing for transport, field equipment, and teacher release time. In environments like Belgium where institutional capacity is under pressure, streamlined, curriculum-connected offers—compact, plug-and-teach units with clear value to core subjects—are required to overcome engagement friction.

Overall, the cross-country picture is one of high enthusiasm constrained by low specialization, thin resources, and absent curricular anchors. The solution space is likewise consistent: classroom-ready, curriculum-aligned materials; practice-first professional learning with field and virtual components; structured partnerships delivering expertise and access; and light-touch policy levers legitimating time and funding. Responding to these needs—while being mindful of equity by multimodal pathways and small-scale logistic facilitation—will turn enthusiasm into long-term practice, increase teacher confidence, and move seagrass literacy from fringe interest to mainstream environmental education across Europe.

5. Overall conclusion

The SEAQUEST State of the Art Report shows that Greece, Cyprus, Denmark, Belgium, and Portugal all have the same clear and consistent picture. Awareness and interest in marine and environmental education are steadily increasing in many areas, but seagrass literacy is still almost nonexistent at the primary school level in Europe. Teachers, educators, researchers, and students all want to learn about seagrass ecosystems, but the lack of formal training, recognition in the curriculum, and support from institutions makes it hard to include them in teaching practice in a systematic way. Seagrass is important for protecting biodiversity, regulating carbon, and protecting the coast, but it is almost never taught in schools or in teacher training programs.

Teachers of young children in all countries are very positive about marine and environmental learning, but they don't feel very confident about teaching about seagrass. Most of them have never talked about seagrass in class because they haven't had enough training, there aren't enough materials, and there aren't any curriculum references. Even with these problems, there is a lot of interest in digital and experiential teaching tools and a strong willingness to take part in capacity-building activities. This shows that teachers are open to new ideas and are motivated to learn. Teachers in both southern and northern Europe agree that marine literacy is important for helping students care about the environment. However, they need structured, ready-to-use materials and support from their schools to make this happen.

Teacher educators and VET trainers backed up these findings by calling for hands-on, cross-disciplinary methods that connect science, education, and sustainability. They stressed the importance of working with marine research centres, NGOs, and museums, and they asked for professional development modules that included both field-based and digital training. Participants from all countries, particularly Denmark and Portugal, emphasised the significance of digital tools and interactive media as effective and scalable methods for integrating seagrass literacy into educational settings. They also stressed that continued funding and commitment to policy are necessary for marine education programs to last.

Researchers and higher education personnel exhibited substantial knowledge of seagrass ecology and ocean sustainability; however, they observed a continual disjunction between academic research and its application at the school level. They all wanted to talk about ways to share knowledge, work on projects together, and work together on curriculum that could turn scientific knowledge into lessons that are appropriate for their age group. Researchers from Denmark and Greece, in particular, pointed to the possibilities of digital communication, virtual reality, and citizen science as useful links between schools and universities.

Focus groups of children in all partner countries showed very similar patterns: they were very emotionally involved, curious, had vivid sensory imaginations, and felt a strong sense of empathy for marine life. Students from Greece, Cyprus, and Denmark thought of seagrass as a "home" or "forest" for fish, which shows that they understood how important it is for the environment. People still thought that seagrass was seaweed in all situations, which shows that they needed to see and learn about it in person. However, when given explanations or pictures, kids quickly learnt the right way, showing that they were very open to learning through stories and hands-on activities. Students all over Europe were excited about field trips, storytelling, art projects, and digital simulations. These activities turn hard-to-understand ecological ideas into real, emotional experiences.

In short, the cross-country synthesis shows that there is a lot of coherence even though there are some differences between countries. Some of the main problems are that there is no integration of the curriculum, there is not enough specialised training, there are not enough resources, and there is not enough collaboration between schools and research. The best chances for success are in making digital and experiential learning materials, cross-disciplinary teaching models, and networks of schools, marine research institutions, NGOs, and policymakers that work together. Denmark's contribution strengthens this message: even in countries with strong environmental traditions, seagrass literacy is still a "missing link" that can be fixed with modular, digitally supported, and hands-teaching.

In the end, SEAQUEST shows that the groundwork for improving seagrass literacy in Europe is already in place: teachers are willing, students are interested, and researchers are ready to get involved. The next step is to turn this group of people into organised educational practice through structured training, aligning the curriculum, and ongoing policy action. SEAQUEST sets the stage for a generation of ocean-literate, environmentally conscious citizens who understand how important seagrass meadows are for life on Earth and in the ocean by giving teachers the tools they need, motivating students, and connecting schools.

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