

Article

# Ocean Literacy Beyond Knowledge: Investigation of Ocean Connections Among a Sample of Italian School Students

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## Abstract

Ocean Literacy (OL), introduced in the early 2000s, refers to the essential knowledge individuals should acquire about the ocean by the end of formal education. Over time, the concept has expanded beyond cognitive understanding to include affective and behavioral dimensions that support attitudes and actions. Among these, emotional connections emerged as a significant driver of environmentally friendly behavior and represent a potential lever for educational practices. In this context, we conducted an informal survey involving 313 students (aged 8–12 and 14–15) living in a coastal area of northeastern Italy by means of a single open-ended question: “What is the sea to you?” Responses were analyzed through qualitative content analysis. Emotion-related expressions were the most frequent category (60.1%), followed by descriptive comments (42.8%), references to uses of the marine environment (35.8%), and statements identifying the ocean as a source of life (21.1%). Mentions of personal memories and references to the need for ocean conservation were less frequent. These findings suggest that, in our sample, frequent exposure to coastal environments may have fostered emotional connections with the ocean. Use of alternative teaching approaches (including technology-mediated ones) and further investigations into youths’ ocean connections could enhance the diffusion of OL in education settings.

**Keywords:** Ocean Literacy; sustainability education; ocean connections; *emoceans*; school students; content analysis

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## 1. Introduction

### 1.1. From Sustainability Education to Ocean Literacy

Environmental education initiatives that emerged in the 1970s constituted the epistemic foundation of what later developed into sustainability education. The field gained momentum following the so-called Brundtland Report, which defined sustainable development as “meeting present needs without compromising those of future generations”, thereby institutionalizing an intergenerational normative framework [1].

Education was formally positioned as a strategic lever for sustainable development in Chapter 36 of Agenda 21 at the 1992 United Nations Conference on Environment and Development. This recognition led UNESCO to articulate the first conceptual framework for Education for Sustainable Development (ESD) [2]. The launch of the Millennium

Development Goals and the United Nations Decade of ESD (2005–2014) accelerated the global mainstreaming of ESD through policy guidance and implementation frameworks across formal education systems [3].

The adoption of the 2030 Agenda for Sustainable Development further structured the sustainability paradigm through the 17 Sustainable Development Goals (SDGs), reinforcing the strategic role of education in transformative change [4]. The publication of “Education for Sustainable Development Goals Learning Objectives” provided guidance on implementing ESD within this framework [5]. Concurrently, sustainability theory expanded beyond intergenerational equity to emphasize societal capacity, conceptualized as “the collective ability to maintain viability, vitality, and integrity over time while enabling equivalent conditions for other societies” [6]. Agenda 2030 also marked a pedagogical reorientation from content transmission toward competency development.

Within the SDG framework, SDG 14 (“Life Below Water”) foregrounds the conservation and sustainable use of marine resources and highlights the systemic interconnections between oceanic processes, climate regulation (SDG 13), and terrestrial ecosystems (SDG 15). These linkages align with the Earth Systems science paradigm, which conceptualizes the planet as an integrated system of interacting spheres—lithosphere, atmosphere, hydrosphere, cryosphere, and biosphere—connected through feedback mechanisms and biogeochemical cycles [7]. This systems-based approach expanded the scope of sustainability education, embedding complexity, interdependence, and a holistic view within its epistemological framework. The ocean, situated at the intersection of terrestrial systems, is fundamental to sustaining life and heavily affected by anthropogenic pressures; thus, it constitutes the perfect scenario for developing sustainability competencies, as further elaborated in the educational framework of Ocean Literacy (OL).

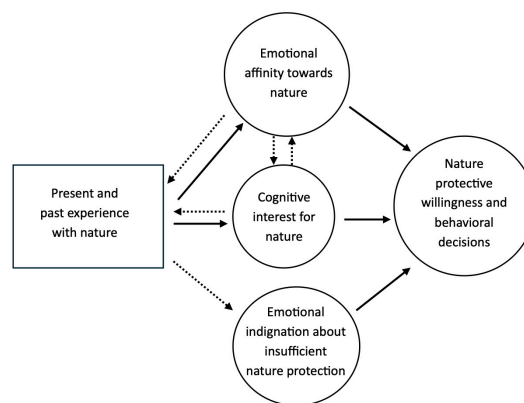
The Ocean Literacy movement emerged in the early 2000s in the United States as a response to widespread public misunderstanding of marine issues and the limited presence of ocean-related topics in national school curricula. In 2005, an extensive OL working group published *Ocean Literacy: The Essential Principles and Fundamental Concepts*, a document outlining what individuals should know about the importance of the ocean by the end of formal education [8].

Since then, the OL movement has gained momentum and expanded internationally [9]. Ocean Literacy has been defined as “an understanding of the ocean’s influence on you, and your influence on the ocean”. An ocean-literate individual is described as someone who understands the essential principles and fundamental concepts of ocean science, can communicate about the ocean in meaningful ways, and is able to make informed and responsible decisions regarding the ocean and its resources [8]. This definition primarily emphasizes the dimension of knowledge, followed by communication and decision-making. However, research has shown that knowledge alone is an insufficient driver of pro-environmental behaviors [10,11], which represent a central objective of Ocean Literacy and sustainability education more broadly. For instance, in an extensive literature review addressing ocean-related behavior in the period 2000–2019, Stoll-Kleemann evidenced “no evidence that more knowledge, education, and public awareness of the oceans directly leads to sustainable behavior” [10], confirming previous findings by Kollmuss and Agyeman from the analysis of the most commonly used analytical frameworks developed by environmental psychology [11].

### *1.2. The Research on Ocean Literacy*

In recent years, growing recognition of the complexity of human–ocean relationships has stimulated academic research on the multidimensional nature of Ocean Literacy. This body of work highlights the importance of incorporating additional dimensions such as awareness, attitudes, behaviors, communication, and activism [12], as well as emotional

connections, access and experience, adaptive capacity, and trust and transparency [13]. These expanded frameworks aim to ensure that Ocean Literacy encompasses diverse forms of knowledge, values, and lived experiences. Furthermore, the OL movement has increasingly acknowledged the need to integrate principles from environmental psychology and social sciences—particularly the Theory of Change—into its efforts to “restore society’s relationship with the ocean”, as articulated in Challenge #10 of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) [14]. According to the Theory of Change, pro-environmental behaviors are shaped by a range of internal and external factors. Among the internal factors, emotional connections—defined as “affective relationships with the natural world”—appear to play a particularly important role in influencing human behavior [11,15–17]. In particular, Kals et al. [15] emphasize the interplay among cognitive interest, lived experiences with nature, and positive and negative emotions in affecting attitudes and behaviors toward nature protection (Figure 1).



**Figure 1.** Emotional factors affecting environmental behavior. Redrawn from [15].

Moreover, McKinley and colleagues, in a report for the European Commission’s Mission Board for Healthy Oceans, Seas, Coastal and Inland Waters, call for these connections to be further studied and accounted for when planning Ocean Literacy initiatives, with a view toward bringing about effective behavioral change [16].

After several decades of OL research primarily focused on knowledge and, to a lesser extent, on attitudes, more recent studies have begun to examine personal connections between individuals and the ocean. These studies address perceptions, relationships, and, to a lesser extent, emotional connections—referred to as “*emoceans*” and included for the first time among the OL dimensions by McKinley et al. in 2023 [13]. For example, Kim et al. investigated the perceptions and relationships with marine organisms among urban Korean sixth-grade students through the lens of a socio-cultural approach using a questionnaire based on images of marine organisms and open questions on personal experiences and connections with these organisms [18]. In Italy, Squarcina and Pecorelli explored ocean perceptions through the drawings produced by primary school pupils (aged 9–10 years) of an inland region, who were asked to “represent their sea” [19]. Alves et al. [20] studied Brazilian middle school students living inland, addressing, among other variables, perceptions of and connections with the marine environment by means of open-ended questions asking for “the first words that came to their mind when thinking about the ocean” and for “the connections between their daily life and the ocean”. Similarly, Rocha and Bermudez dos Reis Lauria [21] piloted a questionnaire that included perceptual dimensions, asking Brazilian primary school pupils, “What do you think of when someone says the word ocean?”

Research on ocean perceptions has also been conducted among adult populations. A literature review was carried out in 2021 by Jefferson et al. [22], who examined the geographic distribution of ocean perceptions research, the topics of research focus, and the methods used. The review found that, since 2007, there has been a growing rate of these studies, mainly performed in a few regions (USA, Australia and Europe) and focused on limited topics (e.g., charismatic species and habitats). Moreover, the study revealed that among 349 peer-reviewed articles, most of them focused on knowledge, followed by concern about specific marine issues, while emotions and positive connections were rarely addressed. More recently, O'Halloran investigated ocean connectedness, environmental identity, emotions, ocean experiences and pro-environmental behaviors in a large sample of US adults using specific assessment tools. Ocean connectedness was measured using a composite score adapted from the Inclusion of Nature in Self (INS) scale. He found that these factors, especially ocean connectedness, were significantly associated with pro-environmental behaviors [23].

Research examining emotional connections and relationships with the ocean remains in a nascent stage. This may be attributed to the relatively recent emergence of the topic, alongside the limited development and application of specialized research instruments. Existing tools—either adapted from environmental psychology or newly developed, such as the Ocean & Society Survey [24]—are still in the early phases of use with adult populations and are not well suited for studying younger cohorts [17]. As a result, empirical evidence addressing these dimensions remains limited [16,25].

### 1.3. Purpose of This Study

To address this gap, the present study aims to provide further insight into dimensions of Ocean Literacy—specifically ocean connections and perceptions—that are considered crucial for educating future citizens about the ocean and its sustainable management [11,16,17,22]. Drawing on opportunities to interact with student groups by running Ocean Literacy-related workshops, we investigated the existence and nature of personal connections with the ocean among a sample of school students of different ages participating in various educational activities. We supposed that, given the geographic setting of the sample, students could have developed some kinds of connections due to personal experiences of the coastal environment through family activities (visits to local beaches during the summer), school teaching, aquatic sports (a sailing course) and a summer camp in a Marine Protected Area. This investigation employed an open-ended instrument (a single question) designed to allow students complete freedom in expressing their thoughts and perceptions on this topic.

Accordingly, the study was guided by the following research questions:

- (1) Do students at different school levels exhibit personal connections with the ocean?
- (2) If so, what is the nature of these connections?
- (3) Are there any differences associated with the different backgrounds of the groups in the study sample?

## 2. Materials and Methods

### 2.1. Materials

Our investigation was performed on a convenience sample: two groups of students of different ages attending a workshop on Ocean Literacy, run by one of the authors (Realdon) in northeastern Italy. The teaching activity, performed after the survey, consisted of a workshop on Ocean Literacy principles lasting between 60 and 90 min, with varying depth of the topic according to the students' ages.

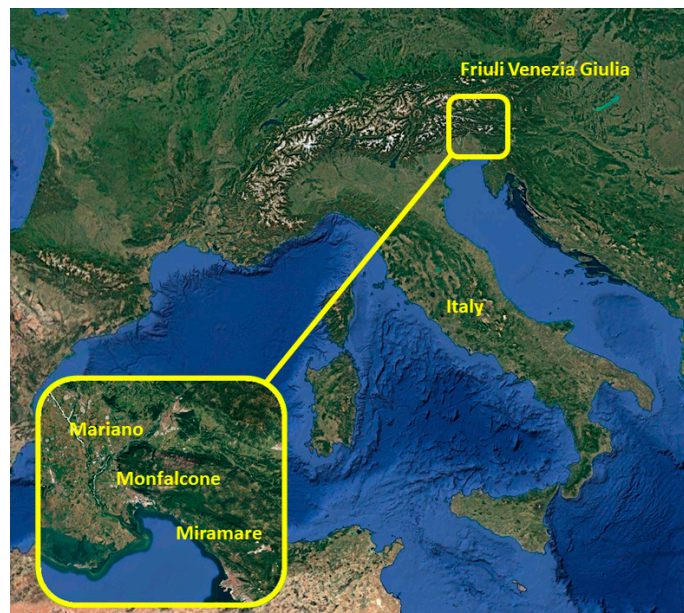
The two groups differed by age range and are referred to as “younger students” (aged 8–12 years) and “older students” (aged 14–15 years).

- The younger students’ group (N = 148) was composed of three different subgroups enrolled in one of the following activities:
  - A summer course at a sailing school for kids in Monfalcone (SVOC subgroup, N = 39);
  - A summer camp in the Marine Protected Area of Miramare–Trieste (Miramare subgroup, N = 49);
  - A curricular Sustainability Week in the middle school of Mariano del Friuli (Mariano subgroup, N = 60).
- The older students’ group (Buonarroti group, N = 165) was a more homogeneous sample that included 9th-grade students, all attending Liceo Buonarroti high school of Monfalcone and participating in a project aimed at becoming a European Blue School.

All groups participated in their respective activities in coastal locations of the Friuli Venezia Giulia Region (NE Italy) except for the middle school group, located about 20 km from the coast (Figure 2). At the time of data collection, students in the SVOC and Miramare subgroups maintained daily contact with the marine environment, as they were enrolled full-time in educational programs focused on water sports or marine science. In contrast, participants from the other sample groups (Mariano and Buonarroti) were surveyed during the academic year and therefore did not experience regular interaction with the sea during the study period. Nevertheless, these students demonstrated a degree of familiarity with coastal settings, likely attributable to the common practice among families in this area of visiting local beaches during summer weekends.

The investigation with the younger students was carried out in 2023, and that with the older students in 2024.

Since the study was conducted in a Mediterranean country, the term currently used to refer to the marine environment is “sea” rather than “ocean”; the two terms will be used interchangeably in this article.



**Figure 2.** Location of the Italian Region Friuli Venezia Giulia and of the study area (modified from Google Earth).

## 2.2. Methods

### 2.2.1. Survey Tool Administration

The survey tool was administered to the different student groups prior to the commencement of the teaching activity in order to avoid influencing participants' responses or expectations. Students in both groups were provided with a Post-it® note and asked to respond in writing to a single open-ended question, "What is the sea to you?", without receiving any additional instructions or prompts.

After 10 min, the Post-it® notes were collected, and the responses were analyzed using a conventional inductive content analysis approach [26].

The survey was authorized by the teachers or instructors responsible for the participating groups and was conducted under conditions of complete anonymity. Consequently, no demographic data were collected. The students were informed of the purpose of our study, the voluntary nature of their participation, and the assurance that their responses would remain completely anonymous. The Post-it® notes containing their responses (whether written on or left blank) were collected in a box to ensure that their participation in the survey remained confidential. Very few students exploited the opt-out possibility and did not provide an answer (marked as "N/A" in the figures in Section 3.). This procedure ensured compliance with the European Union General Data Protection Regulation (GDPR), as no sensitive personal data were obtained and no additional ethical approvals were required.

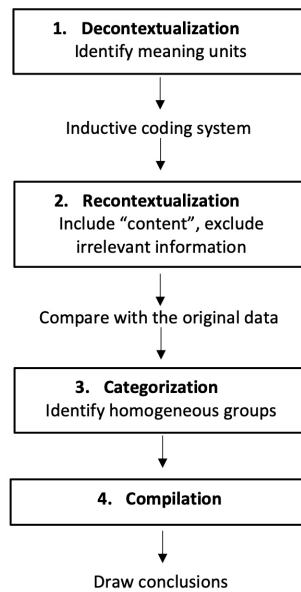
### 2.2.2. Content Analysis

Content analysis enables "an interpretation of the content of textual data through a systematic process of coding and the identification of themes or patterns" [27].

The analysis was conducted by adapting the qualitative methodology proposed by Stemler [28] and performed without the use of computer programs, which were deemed less suitable for analyzing the natural language of young students. The unit of analysis was defined as a meaning unit, namely a word or group of words conveying a shared central meaning [29]. In our case, as a given answer could include one or more different concepts, any distinct concept within an answer was considered a meaning unit.

In the present study, we applied a conventional inductive analysis. This analysis is defined as conventional because it aims to describe the phenomenon under investigation, and inductive because it does not rely on predefined categories, allowing analytical categories to emerge directly from the data [27,28]. The phases of the analytical process are summarized in the flowchart presented in Figure 3.

In the initial phase, two coders—both natural sciences teachers and researchers in science education—independently and iteratively reviewed the students' responses to develop a preliminary category checklist. The meaning units extracted from the students' responses were grouped according to similar meaning and classified under overarching themes known as categories (points 1–3 in Figure 3). Coding categories had to be homogeneous, non-overlapping, and mutually exclusive. The coders subsequently compared their respective category lists, discussed discrepancies, and reached an agreement on a consensus category codebook to be employed in the coding process (point 4 in Figure 3). The consensus category codebook can be found in Section 3).



**Figure 3.** Phases of the content analysis.

For the survey administered to the younger student group, the coding was carried out independently by the two primary researchers together with a third coder, an experienced natural sciences teacher, using the agreed-upon codebook. For the survey involving the older students' group, the analysis was conducted by the two primary researchers, who first examined the responses of this group to identify any additional coding categories that might emerge beyond those previously established. As no new categories were identified in this sample, the same codebook was applied to independently code the responses.

Following the independent coding phase for each group of students, the coders met to review instances of disagreement and resolved them through discussion to reach a final consensus. The outcomes of this final coding phase are presented in Section 3. An example illustrating the progression of the analytical process from raw data to categorized results is provided in Table 1.

**Table 1.** Examples of the coding process.

Meaning Unit	Condensed Meaning Unit	Code	Category
For me, the sea is a vast expanse of water teeming with marine life.	Large expanse of water with underwater life	Description of marine environment and life	Descriptive comment
It gives me a feeling of happiness, something beautiful and relaxing.	Happiness, beauty, relaxation	Positive feelings	Emotional comment
Holidays all year round and wonderful memories.	Beautiful holiday memories	Leisure memories	Memory comment
The sea is a place of release for me, where anxiety, anger and nervousness disappear.	The sea as a place that soothes negative feelings	The sea as a source of emotional relief	Emotional comment
Life for all marine and terrestrial living beings.	The sea is life for every living being	The sea as the source of life	Awareness comment

### 2.2.3. Statistical Data Treatment

Given the categorical nature of the data, statistical treatment was limited to descriptive and inferential analyses appropriate for nominal variables. These analyses were performed with the use of Social Science Statistics (for chi-square, Fisher's exact test, and Cohen's Kappa) and of Randolph's Online Kappa Calculator (for Fleiss' Kappa, <http://justusrandolph.net/kappa/> (accessed on 22 January 2026)). Specifically, inter-coder agreement and inter-rater reliability were calculated separately for the younger and older students' groups.

For the younger students' group, the percentage of agreement among coders was 87%, exceeding the commonly accepted threshold of 70% for qualitative analyses [30]. Inter-rater reliability was assessed using Free-Marginal Fleiss' Kappa (required when there are more than two raters), yielding a value of 0.83.

For the older students' group, the agreement between the two raters was 91.5%, and inter-rater reliability was calculated using Cohen's Kappa (suitable when there are two raters), which also resulted in a value of 0.83. As both Fleiss' and Cohen's Kappa are higher than 0.81, the agreement between raters is considered "almost perfect" for the responses of both groups.

Following the identification of coding categories and the calculation of their relative frequencies, differences in the proportions of categories across student groups and subgroups were tested for statistical significance using the chi-square ( $\chi^2$ ) test and Fisher's exact test, due to the small N-values in the subgroups. The level of statistical significance was set at  $\alpha = 0.05$ .

## 3. Results

We collected 148 answers from the first sample (students aged 8–12 years from SVOC sailing school, Miramare Marine Protected Area, and Mariano middle school) and 165 from the second sample (students aged 14–15 years from Liceo Buonarroti high school).

Given the available writing space (a Post-it® note), students' answers ranged from a few words to whole sentences, particularly among older students. One student of the younger group even wrote a short poem about the sea. Older students often provided articulated considerations on their psychological relationship with the marine environment.

In accordance with the inductive content analysis methodology (Figure 3), the answers were grouped in categories, as detailed in the following codebook (Table 2).

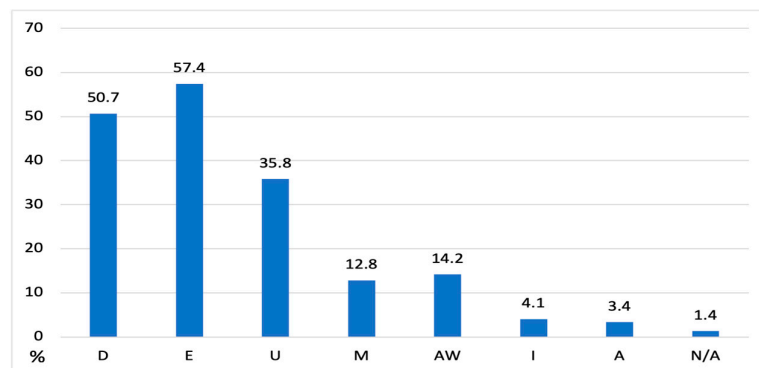
**Table 2.** The codebook used for the content analysis.

Category Code	Description	Examples
Descriptive (D)	Comments that focused on the physical and biological characteristics of marine environment, including images, colors, sounds.	To me, the sea is a vast expanse of water. The sea is home to millions of creatures beneath the waves. For me, the sea is: the sound of fish, the gentle breeze, the shades of blue and azure.
Emotional (E)	Mentions of feelings and emotional states, like beauty, wonder, joy, peace, relaxation, fear, etc.	To me, the sea is wonderful. Happiness and joy. For me the sea is a place where I feel safe, I've been always felt connected to the sea.
Utilitarian (U)	Considerations of the uses and goods provided by the sea, as holidays, leisure, sports, food.	For me, the sea is a place where we can have fun and do lots of activities such as fishing, sailing and snorkeling.

		You can play sports there and go on holiday there.
Memories (M)	Mentions of experiences lived in the marine and coastal environment, such as specific places, events with family and friends.	It reminds me of the beach and when I went fishing with some friends. It recalls the joy of playing in the water with my friends, but also the feeling of taking a dip after a hot day.
Awareness (AW)	Statement on the importance of the sea for the planet, e.g., as a source of life.	For me, the sea is the source of life for all living things. The sea is important for animals and humans. We can't live without it.
Impacts (I)	Comments on anthropogenic pressures and threats, as marine litter and pollution.	It's a shame that some people litter it, and I don't like that. All the plastic and rubbish.
Agency (A)	Comments stressing the need to act, e.g., collect waste and preserve the sea.	I find loads of rubbish and pick it up. A world to be carefully preserved, so that future generations can explore it too.

### 3.1. Data from the Younger Students' Group

This section describes the results of the younger group of students, first viewed as a whole (Figure 4) and then analyzed by subgroups (SVOC, Miramare, Mariano).



**Figure 4.** Percentages of the coding categories (see above) in the answers of younger students' group (SVOC + Miramare + Mariano). For category details, see Table 2.

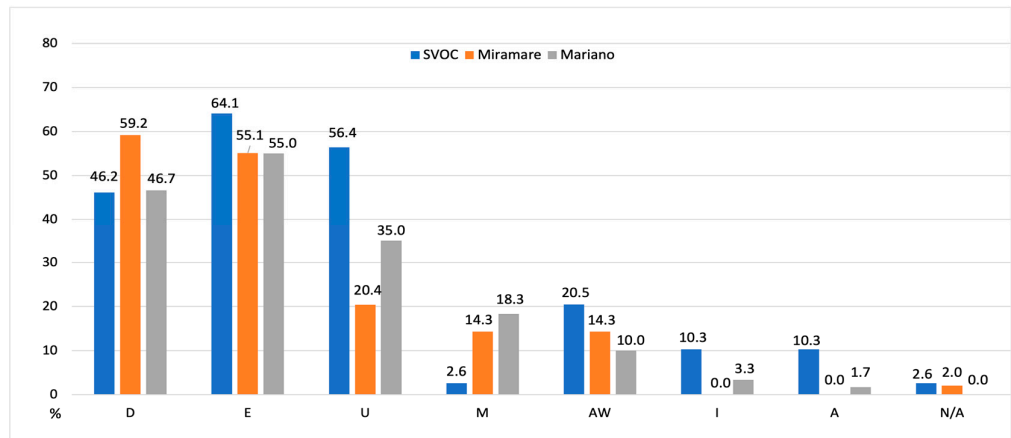
In this group, considered globally, the most frequent answers regarded emotions (E, 50.7% of the students' responses), e.g., *"The sea is a wonderful thing"* and *"It's another world full of peace"*, and descriptions (D, 50.7% of responses), resulting both from direct experience as, for instance, *"Sea animals, the sun, the sounds of the sea"*, and from school learning, as *"It is a large expanse of salt water"*.

Mentions of the uses of the sea (U, like *"The sea is useful for many things, such as food, animals, etc."*, *"Summer holidays"*) ranked third (35.8% of responses).

Statements evidencing students' awareness (AW) of the importance of the ocean, e.g., *"Source of life"*, were also present at lower percentages in all three groups, as were memories (M) of summer holidays on the coast, e.g., *"The days spent with my grandparents at the beach"*. Comments included in the categories Impacts (I) and Agency (A) ranked even lower in frequency. N/A refers to missing answers.

The percentages of the different categories, relative to the total number of the expressed concepts, seemed to evidence some differences between the three subgroups of younger students, which had been exposed to different experiences prior to this survey:

- The SVOC subgroup was being trained in an aquatic sport (sailing).
- The Miramare subgroup was involved in marine environmental education activities.
- The Mariano subgroup was participating in curricular school activities on sustainability (Figure 5).



**Figure 5.** Percentages of the coding categories in the answers of the three subgroups of younger students (SVOC, Miramare, Mariano).

We tested the apparent differences among these subgroups for their statistical significance by means of chi-square and Fisher's exact test, comparing the three subgroups in pairs. The results are detailed in Tables 3–5.

The SVOC subgroup and the Miramare subgroup showed significant differences in the Utilitarian, Impacts and Agency categories (Table 3, shaded in gray).

**Table 3.** Comparison between SVOC and Miramare subgroups.

Category	SVOC N = 38	Miramare N = 48	Chi-Square Test		Fisher's Exact Test	
			$\chi^2$	<i>p</i>	OR *	<i>p</i>
Descriptive	18	29	1.46	0.227	0.60	0.278
Emotional	25	27	0.81	0.369	1.48	0.386
Utilitarian	22	10	12.47	<0.001	0.39	<0.001
Memories	1	7	3.59	0.058	0.22	0.072
Awareness	8	7	0.62	0.432	1.542	0.569
Impacts	4	0	4.90	0.021	0.035	0.035
Agency	4	0	5.30	0.021	0.035	0.035

\* OR = Odds Ratio.

These findings indicate that SVOC students were more prone to appreciate the practical uses of the marine environment, possibly due to their sporting activity. For the same reason, they may have had more opportunities to see anthropogenic impacts (e.g., marine litter in the water) and take a stance against them by means of comments in the Impact and Agency categories.

While the frequency of descriptive comments from both subgroups was comparable, the Miramare students, exposed to immersive naturalistic experiences in a Marine Protected Area, provided more detailed descriptions of fish and other marine organisms (mollusks, jellyfish, etc.) in comparison to the SVOC group. Both subgroups expressed a

similar range of sea-related emotions, mostly positive ones (joy, peace, relaxation, beauty, etc.).

The SVOC and Mariano subgroups also exhibited statistically significant differences in the Utilitarian and Memories categories (Table 4, shaded in gray).

**Table 4.** Comparison between SVOC and Mariano subgroups.

Category	SVOC	Mariano	Chi-Square Test		Fisher's Exact Test	
	N = 38	N = 60	$\chi^2$	<i>p</i>	OR *	<i>p</i>
Descriptive	18	28	0.00	0.946	1.03	1.000
Emotional	25	33	1.12	0.290	1.55	0.399
Utilitarian	22	21	4.95	0.026	2.50	0.036
Memories	1	11	5.34	0.021	0.17	0.026
Awareness	8	6	2.32	0.128	0.15	0.148
Impacts	4	2	2.09	0.148	3.05	0.203
Agency	4	1	3.77	0.052	5.17	0.073

\* OR = Odds Ratio.

In this context, participation in sporting activities may have afforded to SVOC students greater opportunities to engage with and appreciate the utilitarian dimensions of the marine environment. Conversely, students in the Mariano subgroup made significantly more references to personal memories, particularly summer holidays at the beach.

This pattern may be partially explained by differences in temporal context: SVOC students were in daily contact with the sea at the time of the survey and were therefore more likely to emphasize immediate, lived experiences. In contrast, the survey administered in Mariano took place at the beginning of the academic year, when recollections of recent holidays were still salient and readily accessible for students.

Although the overall frequency of descriptive comments was comparable between the two subgroups, the content of these descriptions differed substantially. On average, SVOC students' responses reflected personal and experiential engagement with the marine environment, whereas Mariano students more frequently provided impersonal, physical descriptions, such as characterizing the sea as "*a wide expanse of saltwater*".

Despite the involvement of Miramare students in intensive naturalistic activities, the distribution of their comments did not reveal statistically significant differences when compared with those of Mariano students, who participated in curricular school activities focused on sustainability (Table 5).

**Table 5.** Comparison between Miramare and Mariano subgroups.

Category	Miramare	Mariano	Chi-Square Test		Fisher's Exact Test	
	N = 48	N = 60	$\chi^2$	<i>p</i>	OR *	<i>p</i>
Descriptive	29	28	2.02	0.155	1.73	0.178
Emotional	27	33	0.02	0.897	1.96	0.139
Utilitarian	10	21	2.62	0.106	0.68	0.504
Memories	7	11	0.27	0.603	1.028	1.000
Awareness	7	6	0.53	0.467	1.20	0.241
Impacts	0	2	1.63	0.202	0.30	0.520
Agency	0	1	0.81	0.087	0.52	1.000

\* OR = Odds Ratio.

Emotional comments were similar in range and frequency across both groups, as were utilitarian comments (e.g., references to the sea as a site for leisure activities or summer holidays).

As observed in the earlier comparison between the SVOC and Mariano subgroups, the frequency of descriptive comments was comparable; however, the content differed significantly. Miramare students more frequently provided numerous and detailed references to marine organisms, whereas Mariano students tended to produce more abstract, physical descriptions, often reflecting formal school-based knowledge. This difference was statistically significant (Fisher's exact test: OR = 6.59,  $p = 0.003$ ).

Given that the Mariano middle school subgroup—unlike the other two—was located approximately 20 km from the nearest coastline, a further analysis was conducted to examine potential differences between coastal and inland students' groups. The results of this comparison are presented in Table 6.

**Table 6.** Comparison between the coastal (SVOC + Miramare) and inland (Mariano) subgroups.

Category	Coastal Group	Inland Group	Chi-Square Test		Fisher's Exact Test	
	N = 86	N = 60	$\chi^2$	$p$	OR *	$p$
Descriptive	47	28	0.90	0.342	1.37	0.515
Emotional	52	33	0.43	0.510	1.25	0.609
Utilitarian	32	21	0.07	0.775	1.10	0.862
Memories	8	11	2.55	0.111	0.47	0.136
Awareness	15	6	1.59	0.207	1.82	0.239
Impacts	4	2	0.16	0.693	1.28	1.000
Agency	4	1	0.95	0.081	2.168	0.649

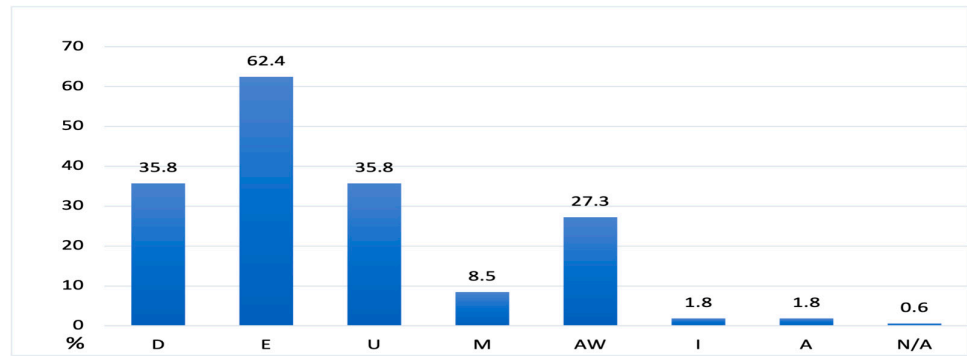
\* OR = Odds Ratio.

No statistically significant differences emerged between the coastal (SVOC + Miramare) and inland (Mariano) groups in their overall responses. This suggests that, within the present sample, students with or without direct and continuous exposure to coastal environments—whether through sporting or nature-based activities—were nonetheless able to produce comments on the sea with a comparable frequency and range. In other words, both groups demonstrated a similar pattern of associations across all categories identified in the survey.

An exception was observed in the nature of the descriptive comments. Consistent with previous findings, Mariano students' responses were more frequently formulated as impersonal, school-derived descriptions, whereas those of the coastal group were more often grounded in personal, experiential knowledge. This difference was statistically significant (Fisher's exact test: OR = 3.53,  $p = 0.018$ ).

### 3.2. Data from the Older Students' Group

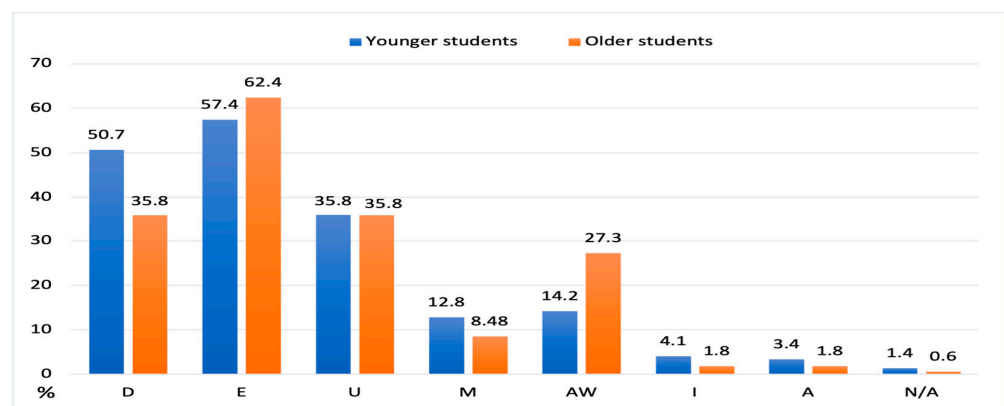
Among older students (Figure 6), similarly to the younger group, the answers pertaining to the Emotional (E) category were also the most numerous (62.4%).



**Figure 6.** Percentage of different coding categories in the answers of the older students' group (Liceo Buonarroti high school).

In this group, expressions of emotions and feelings were more nuanced and often characterized by introspective remarks as, for example, *“The sea is a place where I feel safe, I’ve always felt connected to the sea”*; *“When I go to the sea my brain frees itself”*. Similarly, the range of the feelings was wider: students cited not only peace, beauty, freedom, happiness, relaxation, but also a sense of mystery, immensity beyond knowledge, danger, spiritual connection, and relief from rage and anxiety. The answers focused on the uses of the marine environment (U) ranked second and equal in number to those of a descriptive (D) nature (35.8%). In the Descriptive category, the concepts covered a wide range of aspects, from personal experiences (e.g., mention of colors, sounds, underwater faunal encounters) to scientific knowledge (e.g., ocean extension, salinity, etc.) and to ecosystem services provided by the sea (e.g., oxygen production, food provision). The awareness category (AW) was also frequently addressed (27.3%), evidencing the understanding of the vital role the ocean plays for the planet and humans, not only from the ecological perspective but also from the marine economy perspective (fisheries, tourism).

The percentages of the coding categories addressed in the answers provided by the high school students evidenced some differences compared with the answers of the younger students' group (Figure 7).



**Figure 7.** Percentages of the coding categories in the answers of the younger and older students' groups.

To test this hypothesis, we performed a chi-square and Fisher's exact test to assess if the observed differences were statistically significant. The results are detailed in Table 7.

**Table 7.** Comparison between the younger and the older students' groups.

Category	Younger Students	Older Students	Chi-Square Test		Fisher's Exact Test	
	N =148	N = 165	$\chi^2$	<i>p</i>	OR *	<i>p</i>
Descriptive	75	59	7.09	0.008	1.84	0.009
Emotional	85	103	0.81	0.368	0.81	0.419
Utilitarian	53	59	0.00	0.992	1.00	1.000
Memories	19	14	1.57	0.211	1.57	0.269
Awareness	21	45	8.03	0.005	0.45	0.006
Impacts	6	3	1.40	0.067	2.12	0.317
Agency	5	3	0.76	0.383	1.78	0.484

\* OR = Odds Ratio.

Statistically significant differences between the younger and older student groups emerged in the Descriptive and Awareness categories (shaded in gray in Table 7). These findings indicate that, within the present sample, older students—despite possessing greater knowledge—were less focused on describing the physical characteristics of the marine environment when reflecting on their connection with the ocean. In contrast, such features (e.g., saltwater, fish and other marine organisms, waves, and colors) appeared more salient and more readily recalled by younger students.

Conversely, older students demonstrated a higher level of awareness regarding the importance and role of the ocean. This outcome is consistent with expectations, given their longer exposure to formal education, including natural sciences and environmental education across all school grades.

Although the proportion of emotional comments was comparable between the two groups, notable differences were observed in their linguistic expression. Older students tended to articulate their emotional responses in a more complex and nuanced manner, often reflecting deeper psychological resonance or even philosophical considerations (e.g., *“To me, the sea is like life: it doesn't care if you can't swim. The sea gives life, but it also takes it away.”*). By contrast, younger students generally conveyed similar concepts using a more concise and simpler lexicon, typically through shorter and less elaborated statements. This pattern may be associated with developmental processes characteristic of adolescence (for participants aged 14–15 years), which are often linked to increased introspection and emotional awareness.

A selection of representative emotional comments addressing similar themes is presented in Table 8.

**Table 8.** Examples of younger and older students' answers addressing similar emotional concepts.

Examples of Younger Students' Answers	Examples of Older Students' Answers
<ul style="list-style-type: none"> <li>• For me, the sea is peace.</li> <li>• Freedom, tranquility.</li> <li>• For me, the sea is like a friend who helps and protects me.</li> <li>• The sea is a source of inspiration</li> <li>• For me, the sea is an outlet for my anger when I swim</li> </ul>	<ul style="list-style-type: none"> <li>• For me, the sea is a peaceful place; you dive in and you can live in your own world. It's a peaceful place, where I think only of myself.</li> <li>• For me, the ocean is a place full of inspiration and tranquility for everyone.</li> <li>• For me, the sea is a place where I feel safe; I've always felt connected to the sea, probably because I grew up by the sea.</li> </ul>

- 
- For me, the ocean is a place full of inspiration and tranquility for everyone.
  - A sense of freedom, a place where you can feel free and let yourself go, freeing yourself from stress and worries.
- 

#### 4. Discussion

This study was initiated within the context of a relatively recent and still limited body of literature on human–ocean connections [10,17,23,31–34]. At the outset, it was unclear whether students in the study area exhibited such connections, or what forms they might take; therefore, we started our investigation with a basic open-ended question, allowing maximum freedom of response. It is worth noting that other studies investigating ocean connections among school students used similarly open-ended research tools, including drawings [19–21].

Given the coastal location of our sample, it was reasonable to assume that many students had at least some personal experience with the marine environment, primarily through tourism and seasonal visits to nearby beaches.

On this basis, we explored students' connections with the sea across groups of different ages, ranging from the final years of primary school to the first year of high school, in a limited geographic area. The sample included students with heterogeneous backgrounds: some had direct experience with marine environments through a sailing course or environmental education activities in a Marine Protected Area, others had followed standard school curricula comprising environmental education, and others had participated in ocean-related educational projects.

Despite this diversity of ages, educational pathways, and experiential backgrounds, the responses to the open-ended question showed a high degree of consistency across groups. Rather than the expected variability, students' written responses converged on a limited number of thematic categories ( $N = 7$ ). This consistency suggests the presence of shared representations and meanings associated with the sea, independent of age or prior experience. These representations appear in other studies carried out among students of similar ages. In the sample of Brazilian students investigated by Rocha and Bermudez dos Reis Lauria [21], the word-clouds made from students' answers evidence many expressions also used by our students, for example, emotional comments like "*I love the ocean, beautiful, important, mysterious, place of peace, infinite, fear*", or descriptive comments as "*fish, many species, marine life, unknown animals, whale shark*". In another sample of Brazilian students located in an inland area, Alves et al., with a prompt asking for "the first six words that come to your mind", when thinking about the ocean, received mostly descriptive comments addressing biotic (*fish, sharks, etc.*) and abiotic elements (*water, beach, boat, etc.*), but only a minority of remarks addressing feelings, memories, and the beauty of the ocean [20]. In Italy, Squarcina e Pecorelli, exploiting graphical representations for assessing primary school students' connections with the sea, found that most of their drawings represented the coastal environment as a recreational space, namely a beach on summer holidays. The second most represented theme in this sample was underwater life with colored fish and fantastic elements like mermaids or hidden treasures [19]. In this case, the tool used (drawing) influenced the students' responses, prompting them to provide visual representations of real or virtual experiences (e.g., documentaries, movies, cartoons) whilst avoiding abstract concepts—such as feelings and emotions—which were difficult for them to depict through drawings.

In our sample, among the identified categories, emotional responses were the most prevalent across all age groups and were nearly constantly associated with positive

affective states, occasionally accompanied by feelings of awe or fear linked to the perceived vastness of the ocean. We can deduce that for our students, the ocean was a source of joy, beauty, wonder, awe, and sometimes mystery. Only one comment from a younger student reflected ambivalence, describing the sea as “*A place that evokes both good and bad emotions*”, and two responses from older students conveyed explicitly negative perceptions: “*For me, the sea is like life; it doesn't care if you can't swim. The sea gives life but also takes it away*” and “*The sea for me is a dangerous place and I hate it*”. These latter comments suggest negative experiences, perhaps associated with tragic events reported in the media or involving people they knew. Overall, it can be said that, in our students' perception, the positive aspects of the sea far outweigh the fear of the dangers that may arise from an environment unaccustomed to human life.

These results underscore the strong psychological resonance elicited by reflections on the marine environment, which may represent an important prerequisite for the development of pro-environmental attitudes and behaviors. According to Le Busque, in fact, “*Emotions shape how people relate to the ocean, how they interpret information, and whether they choose to act*” [17]. In a recent investigation on a sample of US adults, O'Halloran found a strong positive association between the emotions the participants experienced toward the ocean and their pro-ocean behaviors. Despite the difference in the age of the studied subjects, we can suppose that similar mechanisms could also be active among young people [23]. Unfortunately, we could not find published research on the influence of emotions on the behavior of young people toward the marine environment.

The second most frequently occurring category comprised Descriptive responses, particularly numerous among younger students. Within this segment of the sample, in the non-coastal group, many of these responses reflected knowledge acquired through formal education and were expressed in impersonal terms, whereas in the coastal group, descriptions appeared to be grounded in direct personal experiences, likely facilitated by greater access to the coastal environment. This finding is similar to those described by Squarcina e Pecorelli among primary school students [19] and partially overlaps with those reported by Alves' and Rocha's groups among Brazilian students [20,21]. It is worth noting that the first two studies were carried out in inland regions. Access and experience, a recognized dimension of OL, may be particularly relevant in fostering place attachment, also evidenced, among adults, as an important factor associated with pro-environmental behaviors [31,32].

The Utilitarian category is also well represented in both age groups of our sample with references to the coast as a setting for recreational and sporting activities, often associated with school holidays, relaxation, and enjoyment, frequently addressed also in the Memories category. Similarly, the utilitarian perspective was also found by Kim et al. [18] among Korean sixth graders surveyed about their connectedness with marine organisms: it is possible that this point of view may be linked with the young age of the respondents. Notably, in our sample, the responses of the Utilitarian category were particularly numerous among the sailing school (SVOC) subgroup, evidencing a specific perspective of these students on the sea, possibly linked with their sporting activity. Water sports, e.g., surf practice, have been found to be associated with pro-ocean behaviors among adults [32], so the utilitarian perspective in our sample could eventually evolve into a more conscious connection with the marine environment.

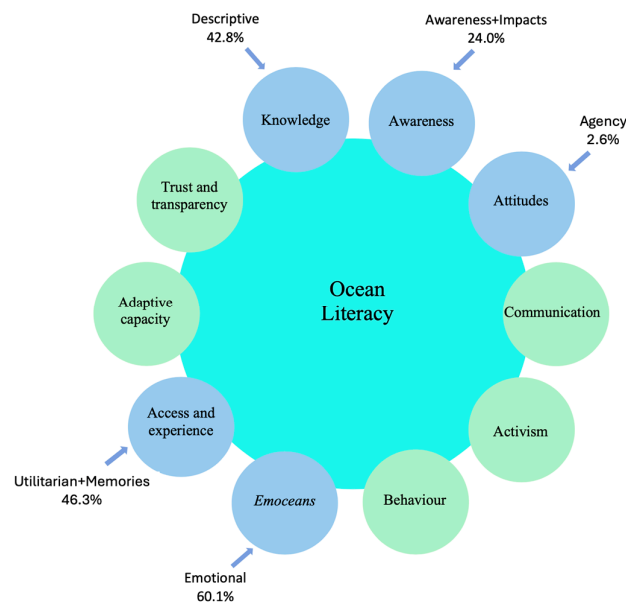
Responses classified under the Awareness category were more common among older students, though they were also evident among younger participants, indicating a broad recognition of the ocean's significance for both humanity and planetary systems. The presence of such awareness even among the youngest respondents was unexpected. Together with the less frequent references to visible anthropogenic pressures on marine environments (Impacts, e.g., marine litter and pollution) and condemnation of these impacts

(Agency), this pattern of responses points to the emergence of an environmental identity. This kind of ocean connectedness has been found to be associated with pro-environment and pro-ocean behaviors among adults [23,33], so it possibly represents an important prerequisite toward these behaviors also for our students.

Notably, many of the identified categories align closely with the dimensions of Ocean Literacy proposed by McKinley et al. [13] (Figure 8).

Specifically, these include:

- Knowledge, reflected in the D category, encompassing descriptive observations of biological and physical marine features, personal knowledge, and school-based learning;
- *Emoceans*, represented by the E category, including emotional responses such as joy, peace, freedom, and perceptions of beauty;
- Access and Experience, captured in the U and M categories, referring to leisure activities at sea and personal memories of the coastal environment;
- Awareness, addressed in the category AW, including perceptions of the ocean as a source of life and provider of ecosystem services and in category I, highlighting anthropogenic impacts, e.g., marine litter;
- Attitudes, represented by the A category, particularly referencing the need to act against the mentioned impacts and to protect the marine environment.



**Figure 8.** Percentages and categories of our sample’s responses addressing the Ocean Literacy dimensions (blue circles) vs. the 10 dimensions described by McKinley et al. The OL dimensions in the green circles were absent from our sample. Figure modified from [13].

Other OL dimensions did not emerge from the students’ answers, and this can be due to different factors. Communication about the ocean, as well as behavior toward the marine environment, was not elicited with the prompt “what is the sea to you?”, even if some students’ remarks in the categories Impacts and Agency may be interpreted as a predisposition toward communicating pro-ocean behavior. Activism also was not addressed by the prompt, nor was it expected, particularly among younger students. The same considerations apply to the remaining dimensions—trust and transparency and adaptive capacity—which were also not addressed in the survey question and, where possible, can be expected only of older subjects.

## 5. Conclusions

The findings derived from this sample are encouraging, as they indicate that most of our students across different age groups exhibit positive and multifaceted connections with the marine environment. These connections encompass approximately half of the Ocean Literacy (OL) dimensions identified to date and may represent a foundational condition for the development of pro-environmental attitudes and behaviors. In this sense, fostering students' emotional and experiential engagement with the ocean appears to be a promising pathway toward sustainability-oriented action.

These results have relevant implications for educational practice and school policy, particularly within the framework of the United Nations Decade of Ocean Science for Sustainable Development, during which OL has gained increasing visibility in public discourse and policy agendas. Educational systems may capitalize on students' existing connections with the ocean to strengthen sustainability education and integrate OL more systematically into curricula. However, to make the most of young people's connections with the ocean, more in-depth research is needed into these connections and behavior toward the marine environment. The research tools currently available are primarily drawn from environmental sociology and must be adapted to the specific study of ocean connections and made suitable for research among children and youth in order to implement educational approaches leveraging these connections.

At the same time, several limitations must be acknowledged. The sample is taken from a limited geographic area characterized by relative cultural homogeneity and a tradition of environmental education in school teaching, so it may represent a relatively privileged segment of the young population. In addition, the study was conducted in a developed Western country where frequent and easy access to coastal environments—facilitated in part by a Mediterranean climate—may enhance opportunities for direct interaction with coastal marine ecosystems. The contextual specificity, as in other similar studies (refs. [19–21]), limits the generalizability of the findings. For this reason, it would be necessary to conduct studies on representative samples of larger populations to confirm or adjust our conclusions. Future research should therefore extend the investigation to inland regions, particularly those located far from the coast, as well as to countries characterized by different geographic, cultural, and socio-economic conditions. Such comparative studies would enable a more robust examination of the role of contextual variables in shaping Ocean Literacy and its behavioral correlates.

In addition, as noted by McKinley et al. [16], further research within environmental psychology is needed to refine the conceptualization and measurement of the dimensions of OL that have emerged from recent literature, as done, for example, in the development of the framework of the Ocean & Society Survey, aimed at adults and still in the initial phase of application [24]. The development of validated instruments capable of assessing the relationships between OL dimensions and sustainability-oriented behaviors, specific to young people, is essential for strengthening the empirical basis of OL and enhancing its application in educational settings [17].

Despite these limitations, expanding opportunities for direct engagement with marine environments remains a key priority. Here are some suggestions for achieving this goal:

1. Schools located in coastal or near-coastal regions could implement structured, curriculum-integrated coastal educational activities. Such initiatives should be feasible in many countries, given that approximately 29% of the global population resides within 50 km of the coastline [34].
2. Existing programs, such as the Blue Schools Network, provide operational models for integrating OL into formal education, particularly with the use of methodologies

based on active learning, interdisciplinary approaches comprising arts and humanities, and practical activities that promote students' engagement through personal experiences accessible with limited equipment and low costs [35].

3. Moreover, especially for older students, OL-oriented projects can make an important contribution to the development of sustainability competencies aligned with the objectives of Agenda 2030. For example, systems-thinking competency can be strengthened through the study of ocean–climate interactions in the context of global warming, while anticipatory competency can be fostered by engaging students with future environmental scenarios and related adaptation and resilience strategies, as addressed in the dimension of “adaptive capacity” within Ocean Literacy.
4. In the framework of the UN Decade of Ocean Science for Sustainable Development, access to comparable educational opportunities should be promoted across a wider range of countries, particularly in the Global South. This effort should involve local coastal communities and ensure the recognition and safeguarding of Indigenous and traditional knowledge related to marine environments and resources by integrating local culture in school curricula and teaching practice.
5. For inland regions distant from the coast, alternative strategies are required. In addition to classroom hands-on activities based on models and simulation of ocean-related phenomena, media-based resources (e.g., documentaries and educational videos) and emerging technologies such as virtual reality and augmented virtual reality may partially compensate for the absence of direct experience of the ocean. Although these approaches cannot fully replace in situ engagement, they hold significant potential to foster Ocean Literacy and encourage pro-environmental attitudes and behaviors across diverse geographical contexts [36–38].

Humans have an inherent affinity with the natural world that needs to be fostered and strengthened by building on students' existing emotional and experiential connections with the ocean, with the aim to “Restore society's relationship with the ocean”, as highlighted in the Ocean Decade Challenge #10, which constitutes the very heart of the Ocean Literacy endeavor. Such transformation is essential for a transition from “The ocean we have” to “The ocean we want”, so as to achieve a more equitable and sustainable future [14].

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## Abbreviations

The following abbreviations are used in this manuscript:

UNESCO	United Nations Educational, Scientific and Cultural Organization
ESD	Education for Sustainable Development
SDG	Sustainable Development Goal
OL	Ocean Literacy
EU	European Union
GDPR	General Data Protection Regulation
UN	United Nations

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