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Contribution to the Special Issue: "Ocean Literacy across the Mediterranean Sea region"

Implementation of a new research tool for evaluating Mediterranean Sea Literacy (MSL) of high school students: A pilot study

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Abstract

The Mediterranean Sea is recognized as a key component in the development, economy, and culture of European, North African, and Middle East countries. With respect to heterogeneity across the region in different sectors, Ocean Literacy, though still in its infancy, is nevertheless a requisite for a better understanding of the two-way interaction between the Sea and its people. In the present study, marine issues in relation to the content knowledge of 154 high school students from the Mediterranean region were investigated by using a structured questionnaire based on the recently published Mediterranean Sea Literacy guide. Data analysis involved descriptive statistics to portray frequencies and knowledge scores of the participants, and inferential statistics to assess the effects of grade level on students' knowledge. The study which focused for the first time on the unique features of the Mediterranean marine ecosystems, found the level of content knowledge of the participants to be low to moderate. It is therefore of the utmost importance for the organizations and networks working on marine issues in the Mediterranean Sea to develop synergies and coordinate research programmes to broaden engagement with human societies in the region.

Keywords: Ocean Literacy; Mediterranean Sea Literacy; content knowledge; high school students; environmental education; Mediterranean region.

Introduction

The global framework of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) has been launched recently to offer support for ocean science issues and societal challenges, underpinning at the same time the global Agenda 2030 (Ryabinin *et al*., 2019). In this context, the Mediterranean Sea is recognized as a key component in the development, economy, and culture of European, North African, and Middle East countries as well as an agent for the "transformative change" needed to achieve a sustainable future in this region (Cappelletto *et al*., 2021).

Ocean Literacy (OL), defined as the understanding of the ocean's influence on human beings and their influence on the ocean (Cava *et al*., 2005), is essential not only for bringing knowledge of marine science to society but also for inspiring marine scientists to provide acceptable and workable solutions for sustainable development and bridging the gaps among the relevant stakeholders, users and actors in different economic and cultural sectors (Cappelletto *et al*., 2021; Kelly *et al*., 2021). With respect to the heterogeneity among European, Asian and African countries all over the Mediterranean Sea region in different sectors (e.g., state of development, accessibility to education), research on OL is still in its infancy, existing

mostly as a part of environmental education (Ben-zvi-Assaraf & Orion, 2005; Erdoğan *et al*., 2009; Yavetz *et al*., 2009; Boubonari *et al*., 2013; Mogias *et al*., 2015; Squarcina & Pecorelli, 2017; Realdon *et al*., 2019a, b; Mokos *et al*., 2020a). In parallel, though there is a relatively high number of sea-related educational projects along the Mediterranean coasts, there have been few international projects which involved non-EU Mediterranean countries (MIO-ECSDE, 2003; 2004; Mokos *et at*., 2021).

Currently, OL is a key asset of several initiatives, networks, educational programmes, and capacity building in the Mediterranean Sea region (Mokos *et al*., 2020b; 2021; Cappelletto *et al*., 2021; Eparkhina *et al*., 2021). The first Mediterranean Blue Schools – included in the European Blue Schools network launched by EU4Ocean Coalition (made up of three components: a platform for organisations and individuals engaged in OL initiatives, a European Youth Forum for the Ocean, and a Network of European Blue Schools) in 2020 in order to commit them to make the ocean a relevant part of their curriculum – began their OL projects during the school year 2020-2021 (Copejans *et al*., 2020); more joined in the following school year, which increased the number of teachers and students actively engaged in ocean education and citizenship.

In 2015, as part of the European Marine Science Educators Association (EMSEA) annual conference held in Crete (Greece), EMSEA Working Groups were formed with a common purpose, to disseminate OL principles and concepts in Europe's various sea basins. One such regional group, the EMSEA Mediterranean Working Group, was launched specifically for the Mediterranean Sea region (Previati *et al*., 2018; Realdon *et al*., 2018). Since then, this group has not only translated the OL principles and concepts into several Mediterranean languages (see https://www.marine-ed.org/ocean-literacy/translations) but has organized research, events and educational activities at various local and international levels to promote OL (Cheimonopoulou *et al*., 2019a, b; Realdon *et al*. 2019b; Koulouri *et al*., 2021a, b, c). In parallel, its members created the regionally-specific Mediterranean Sea Literacy (MSL) guide, which comprises seven essential principles and 43 fundamental concepts. The MSL guide was developed based on the Ocean Literacy Framework, documents of which were adapted by the group to the specificities of the Mediterranean Sea (Mokos *et al*., 2020b; 2021). A brochure of the MSL guide, translated into Italian, Croatian, and Greek was also published (see https://www.emsea.eu/ocean-literacy/publications). Translation into other Mediterranean languages is now being undertaken to promote the MSL issues to stakeholders, end-users, policymakers, actors, and in general the societies of the Mediterranean countries. During the same period, the group prepared an educational research programme investigating ocean-related knowledge, attitudes, and behaviour among primary and secondary school students, as well as university students of several Mediterranean countries (Mogias *et al*., 2015; 2019; Cheimonopoulou *et al*., 2019a, b; Realdon *et al*., 2019a, b; Mokos *et al*., 2020a; Koulouri *et al*., 2021d; 2022).

Such OL dimensions have been shown to improve environmental literacy of citizens (e.g., Hynes *et al.*, 2014; Hartley *et al.*, 2015). In addition, knowledge seems to be affected by misconceptions as a result of poor use of relevant concepts in both formal and non-formal educational settings (Boubonari *et al.*, 2013; Mogias *et al.*, 2019). Moreover, ocean/sea sciences constitute only a minor part of national curricula in the Mediterranean Sea region (Pocze *et al.*, 2020; Mokos *et al.*, 2021; Mogias *et al*., 2022). The present pilot study is the first attempt aiming to investigate (a) the content knowledge of high school students from the Mediterranean region on Mediterranean Sea-related issues, and (b) potential common misunderstandings and/or misconceptions. The findings of this pilot study are expected to function as a baseline for further research on the content knowledge level of students of many different Mediterranean countries in relation to marine issues of this region.

Methodology

This pilot research study employed a convenience sampling method to a group of 154 high school students (grades 11-12, 16-17 years-old) mostly from coastal areas of two Mediterranean countries (Italy and Greece). A structured questionnaire (Supplementary material S1) investigating knowledge related to Mediterranean Sea issues was first developed in English (the common language among the researchers) and then the national versions were written in the respective languages using translation and back translation (Brislin, 1970). The new questionnaire designed and implemented for evaluating content knowledge in relation to Mediterranean marine issues was developed based on the recently published principles and concepts of the MSL guide (Mokos *et al*., 2020b) and on validated OL surveys (e.g., Greely, 2008; Markos *et al*., 2017). The questionnaire contained only the grade level and age of students (therefore supporting the anonymity of the participants) and 30 multiple choice questions making the instrument easy to use, code, and score for statistical analyses. Each correct response received a numeric value of 1, and incorrect responses were coded 0. Scores could therefore vary between 0 and 30, with lower-scale scores indicating lower student knowledge and higher-scale scores indicating a higher level of knowledge, respectively. All items contained five well distinct distractors, including an "I don't know" option in an effort to limit guessing. Moreover, the questionnaire was examined by a panel of marine scientists and marine educators, for content validity in terms of content clarity, language, and difficulty, and also the extent to which the items truly represented basic concepts of the MSL principles (Table 1), while the reliability of the instrument was also measured with the Cronbach α index, revealing high internal consistency (α=0.825). In addition, normality tests using the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) criteria were also carried out to determine whether the sample data were drawn from a normally

Table 1. Alignment of the survey questions with the 7 essential principles of the Mediterranean Sea Literacy guide.

	Mediterranean Sea Literacy principles	Questions
1	The Mediterranean Sea, semi-enclosed by land of three continents, is part of one big ocean and has many unique features	1, 2, 3, 4, 5
2	The Mediterranean Sea and its living organisms shape the features of the Mediterranean region and its adjacent landmasses	6, 7, 8, 9, 10
3	The Mediterranean Sea has a major influence on the climate and weather of the Mediterranean region	11, 12, 13
4	The Mediterranean Sea made the Mediterranean region habitable through its richness of life thus becoming the cradle of western civilization	14, 15, 16
5	The Mediterranean Sea is a marine biodiversity hotspot, with a high level of endemism	17, 18, 19, 20, 21, 22
6	The culture, history, economy, lifestyle, health, and well-being of the peoples of the Mediterranean region are inextricably inter-connected	23, 24, 25, 26, 27, 28
7	Although the Mediterranean Sea has been explored for centuries, it remains largely unknown	29, 30

distributed population, revealing normal distribution of the sample [K-S(154)=0.071, p>0.05 and W(154)=0.984, p>0.05] (Fig. 1).

Participants were informed about the purpose of the study and the voluntary basis of participation by their classroom teachers, and the pilot survey was administered to them in September-October 2021. In addition, participants were asked to make comments on the terms used in the questionnaire which were difficult to understand. Completion time ranged between 20 and 25 min. Data analysis involved descriptive statistics to portray frequencies and knowledge scores of the participants, and inferential statistics to assess the effects of grade level on students' knowledge. Statistical analyses were performed with the use of the Statistical Package for Social Sciences (SPSS v. 27), while the significance level was predetermined at a probability value of 0.05 or less.

Results

This pilot study revealed the existence of certain specific terms difficult for the high school students to understand, such as "precipitation", "submarine canyons", "lacustrine formation", "abiotic variables", "endemism", "phanerogams", "gastropods", "gorgonians", "benthic beds", "mangrove swamps", "intertidal and sublittoral reefs", "calcareous algae", "rhodoliths", "non-indigenous species", "nursery areas", "citizen science". Underpinning these specific terminological difficulties, their answers to the questions showed that they possessed a low level of content knowledge in terms of the Mediterranean Sea issues, with a mean value of correct answers being 40.1% (Table 2).

Leaving out those terms which had proved to be difficult for the participants to understand, both the easiest and the hard-to-answer questions were detected. The easiest questions for the total sample were found to be:

- Q.23 (with 70.8% correct responses), referring to the influence of the Mediterranean Sea and its climate on the history, culture, health, and well-being of its inhabitants;
- Q.30 (66.9%) concerning the access of tourists to Marine-Protected Areas (MPAs) and whether this activity protects Mediterranean resources;

Q.7 (59.7%) about the formation of the Mediterranean Sea which came about as a result of the African and Eurasian lithospheric plate movement;

Q.10 and Q.25 (57.8%) related to glacial valleys which cannot be found at the bottom of the Mediterranean Sea, and major human impacts on the Mediterranean Sea

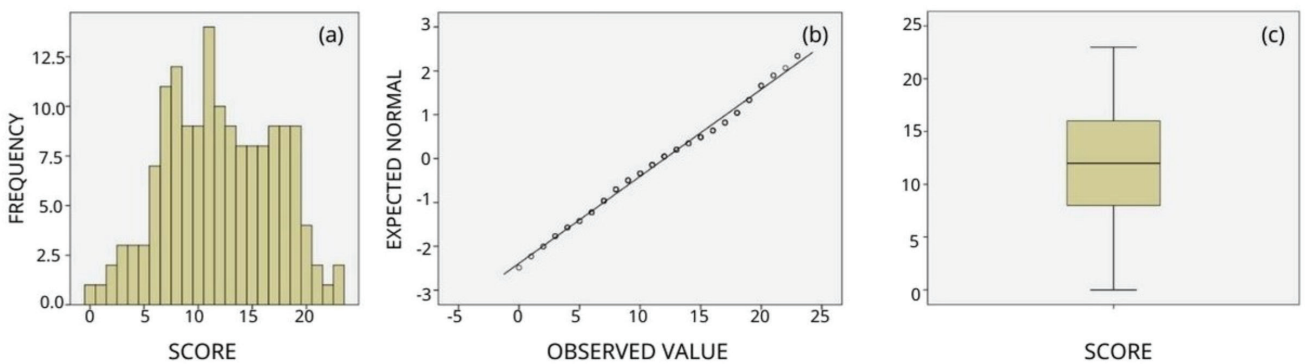

Fig. 1: Normality graphs of the data presented with (a) a histogram, (b) a normal Q-Q plot, and (c) a boxplot.

Table 2. Relative mean frequencies of correct answers per question.

	Questions – Statements	Mean frequency
1	The Aegean Sea is connected **to all parts of the ocean**	35.7
2	The Mediterranean Sea **is the largest and deepest semi-enclosed Sea on Earth**	28.6
3	Water circulation in the Mediterranean Sea is powered by **water exchange through the Gibraltar Straits, freshwater supply from rivers, and heat input**	35.7
4	In the Mediterranean Sea **evaporation greatly exceeds precipitation and river run-off**	9.1
5	Resources in the Mediterranean Sea **are limited and its management should be realized sustainably**	37.0
6	Typical Mediterranean cultivations, such as vineyards, flourish in soils that originate from limestone rocks mainly of **marine formation**	25.3
7	The formation of the Mediterranean Sea is the result of **the African and Eurasian lithospheric plate movement**	59.7
8	**Wave motion (action)** contributes most to the shaping of the Mediterranean Sea coasts	29.9
9	Mediterranean seagrass meadows play a significant role in the greenhouse effect **as they can store carbon through photosynthesis**	26.0
10	**Glacial valley**s cannot be found at the bottom of the Mediterranean Sea	57.8
11	**Hot and dry summers, mild and wet winters** are the typical features of the Mediterranean climate	53.9
12	**Monsoon** is a NON-typical wind of the Mediterranean region	29.2
13	The Mediterranean Sea **is warming more than the rest of the ocean**	44.8
14	In the Mediterranean region, **phytoplankton** produces a significant amount of oxygen	24.0
15	The Mediterranean climate is mainly the result of the **heat transfer and water circulation of the Mediterranean Sea**	29.2
16	**The wide ranges of climate and hydrological characteristics** contribute to the co-occurrence and survival of both temperate and subtropical organisms in the Mediterranean Sea	40.9
17	The Mediterranean Sea is characterized by **high biodiversity and high endemism**	50.6
18	**Kelp forest** habitats are not present in the Mediterranean Sea	13.6
19	**Mangrove swamp** wetlands cannot be found in the Mediterranean region	43.5
20	Mediterranean ecosystems are defined by certain unique abiotic characteristics such as **the relatively high temperature of the deep-sea waters**	19.5
21	Productive nursery areas for many marine and aquatic species in the Mediterranean Sea are **deltas and estuaries**	50.6
22	Non-indigenous species are introduced in the Mediterranean Sea through **escapes from aquaculture and aquaria and the opening of the Suez Canal**	31.2
23	The Mediterranean Sea and its climate affect the **history and culture of its region, health, well-being, and lifestyle of its inhabitants**	70.8
24	The Mediterranean Sea provides **food, medicines, minerals, and energy resources**	51.9
25	Major human impacts on the Mediterranean Sea are due to **marine pollution from land and sea-based sources, over-fishing, and degradation of habitats**	57.8
26	Rising CO_2 levels in the atmosphere are responsible for the warming of the surface waters of the Mediterranean Sea and its acidification, leading to an **increase in harmful algal and jellyfish blooms**	45.5
27	**Erosion** is the most important threat to the Mediterranean coasts	43.5
28	Citizen science projects **help researchers to collect scientific data**	52.6
29	Biodiversity in the Mediterranean Sea **is less known than that of the mainland in the Mediterranean region**	39.0
30	**Liberalizing the access of tourists to marine protected areas** is not leading to the protection of the Mediterranean resources	66.9
Mean frequency		**40.1**

due to marine pollution from land and sea-based sources, over-fishing, and degradation of habitats, respectively (Table 2).

On the other hand, the hardest items to answer were found to be:

- Q.4 (with only 9.1% of correct responses), referring to the Mediterranean Sea evaporation which greatly exceeds precipitation and river run-off;
- Q.18 (13.6%) concerning the absence of kelp forest habitats from the basin;
- Q.20 (19.5%), the relatively high temperature of the deep-sea waters;
- Q.14 (24.0%), phytoplankton as a producer of significant amounts of oxygen;
- Q.6 (25.3%) referring to typical Mediterranean cultivations which flourish in soils of marine formation;
- Q.9 (26.0%) concerning the storage of carbon in the Mediterranean seagrass meadows (Table 2).

Moreover, in order to better portray the knowledge level of the respondents, it is also worth mentioning the high percentage of "I don't know" answers where the mean frequency value was 23.6%. Finally, an expected knowledge level increase from grade 11, presenting a mean score of 10.47 to grade 12, with a mean score of 14.07 was also detected, revealing a statistically significant difference ($p<0.001$).

Discussion

In this pilot study, MSL was investigated for the first time in the Mediterranean Sea region by using a new research tool focusing on the unique features of the Mediterranean marine ecosystems. By measuring the reliability of the instrument, high internal consistency was revealed, while its content validity was assessed by experts. As far as construct validity is concerned, the MSL survey was designed and developed based on existing and already validated OL surveys (e.g., Greely, 2008; Markos *et al*., 2017). In addition, construct validity of the instrument is also verified by our results revealing that the easiest and hard questions to answer were similar to previous research on OL issues (Mogias *et al*., 2015; 2019; Cheimonopoulou *et al*., 2019a, b; Realdon *et al*., 2019a, b; Mokos *et al*., 2020a; Koulouri *et al*., 2021d; 2022).

High school students from the Mediterranean region were found to possess only a low to moderate level of content knowledge concerning Mediterranean Sea issues. Up to now, similar previous studies have been focused only on general ocean sciences issues in several Mediterranean countries (e.g., Croatia, Cyprus, Egypt, Greece, Italy, Malta, Spain, Turkey). Results of these studies have revealed a moderate level of content knowledge of students of different education levels from primary to tertiary education (Mogias *et al*., 2015, 2019; Cheimonopoulou et al., 2019a, b; Realdon *et al*., 2019a, b; Mokos *et al*., 2020a; Koulouri *et al*., 2021c, d; 2022), while similar results have also been found in studies from other countries worldwide (i.e., United States, Canada, Portugal, Japan, Taiwan) (Plankis & Marrero, 2010; Chen & Tsai, 2015; Danielson & Tanner, 2015; Guest *et al*., 2015; Umuhire & Fang, 2016; Leitão *et al*., 2018; Sakurai *et al*., 2019; Lin *et al*., 2020).

The respondents' low level of knowledge can be attributed to the fact that the ocean/sea sciences constitute only a minor part of national curricula in the Mediterranean Sea region (Pocze *et al*., 2020; Mokos *et al*., 2021; Mogias *et al*., 2022), while scientific information focusing on region-specific marine issues such as the specificities of the Mediterranean Sea are even scarcer (e.g., Spoors *et al.*, 2021). In addition, the questions that were difficult to answer concerned topics such as water and carbon cycles, marine resources, prevailing winds, climate, abiotic characteristics, factors shaping the coasts, origin of the largest amount of oxygen, biological invasions. Several of these topics and incorrect answers are related to incorrect perceptions and are not simple mistakes due to ignorance, i.e., misconceptions which have also been reported in other studies (e.g., Boubonari *et al*., 2013; Mogias *et al*., 2019). Other factors that may affect levels of knowledge are awareness, attitude, communication, behaviour, and activism that have not yet been sufficiently explored worldwide (Brennan *et al.*, 2019; Paredes *et al*., 2022). However, further research is required in order to provide tools and approaches to transform knowledge into behaviour change and actions, and in this way to promote the sustainable use of the ocean in general and the Mediterranean Sea in particular.

Although the present study constitutes a pilot approach and therefore cannot represent the whole student population of the respective countries surveyed or the Mediterranean Sea region in general, the results have potential implications in different directions. The progress of OL beyond English-speaking countries can be a challenge for the Mediterranean's large linguistic and cultural diverse populations. The emerging national and regional initiatives and/or networks can make a significant contribution towards enabling translations into national languages and using existing resources through national channels. In this context, communities can develop a stronger sense of identity with the Sea through local and traditional ecological knowledge (e.g., Kelly *et al*., 2021). It remains critical, however, that these initiatives should work together in pursuit of effective multi- and trans-disciplinary collaboration (Marrero *et al*., 2019). This is particularly important in a region such as the Mediterranean where multi-cultural experiences and unbalances co-exist.

To this end, it will be of the utmost importance for the organizations and networks working on marine issues in the Mediterranean Sea to develop synergies and coordinate research programmes to broaden engagement with human societies in the region. Towards this direction and within the Ocean Decade Action Programme led by the Italian Oceanographic Commission, the EMSEA Med group can serve as a basis for the Mediterranean Sea Literacy of institutions and organizations, especially those coming from the southern part of the basin. In addition, the European Blue Schools Network can be proposed as a model for non-European Mediterranean countries, after having assessed ways to adapt it to different specific contexts.

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Supplementary Data

The following supplementary information is available online for the article:
S1: Mediterranean Sea Literacy (MSL) Questionnaire (correct answers are indicated in bold).