

Assessing Ocean Literacy in a sample of Italian primary and middle school students

Giulia Realdon (1, 2, 3), Athanasios Mogias (2, 4), Sandra Fabris (3), Giuliana Candussio (3),
Chiara Invernizzi (1) & Eleonora Paris (1)

(1) School of Science and Technology, Geology division - UNICAMearth group, University of Camerino, Italy.

(2) EMSEA – European Marine Science Educators Association.

(3) Associazione Scienza under 18 Isontina, Italy.

(4) Laboratory of Environmental Research and Education, Department of Elementary Education Democritus University of Thrace, Alexandroupolis, Greece.

Corresponding author e-mail: giulia.realdon@unicam.it

Document type: Short note.

Manuscript received 14 January 2019; accepted 07 May 2019; editorial responsibility and handling by F. Cifelli.

ABSTRACT

Despite the rise of Ocean Literacy (OL) movement at the beginning of 2000s, ocean sciences remain a neglected topic in school curricula of many countries, including Italy. This study investigates ocean-related knowledge and opinions in a sample of 351 primary and secondary school students of North Eastern Italy (4th, 5th and 8th grades) by means of structured questionnaires, before and after a teaching intervention aimed at promoting higher education and careers in the maritime sector. Students demonstrated a moderate level of knowledge and positive opinions about their relationship with the marine environment, as well as some misconceptions about the connectedness of all seas, the origin of half of atmospheric oxygen from the sea and the global dimension of water cycle. After the teaching intervention, primary school students' scores evidenced a significant improvement, while secondary school results showed minimal change. This difference could possibly be attributed to differences in teaching organisation between primary and secondary schools. This is the first investigation on OL among Italian students, and is part of a larger project carried out by EMSEA (European Marine Science Educators Association) in three Mediterranean countries.

KEYWORDS: Ocean Literacy (OL), primary and secondary school students, EMSEA (European Marine Science Educators Association), ocean misconceptions.

INTRODUCTION

THE HISTORY OF OCEAN LITERACY

Covering about 70% of Earth surface and providing countless ecosystem services, only in recent years the ocean gained the attention of media due to threats impending on it, namely overexploitation of marine resources, plastics and microplastics pollution, water warming and acidification. Due to these emerging issues, the United Nations specifically addressed the ocean in one of the 17 goals included in the Agenda 2030 for Sustainable Development - i.e. Sustainable Development Goal 14 - (United Nations, 2015), declaring 2021-2030 a Decade of Ocean Science for Sustainable Development (UNESCO, 2017). In fact, understanding and awareness of ocean-related issues are essential for the protection of our planet, and to sustainability in general (Cava et al., 2005).

In spite of the worldwide spread of environmental education, ocean sciences were neglected in most school curricula and even university programs over the past decades. As a reaction to this critical situation, at the beginning of 2000s, a global movement was born within United States universities, research institutions and environmentalist NGOs to overcome the general lack of knowledge and awareness of ocean-related issues in the schools and among citizens. More recently, this movement expanded in other continents and countries, including Europe by initiative of EMSEA (European Marine Science Educators Association). Within EMSEA, a group of researchers and educators from the Mediterranean countries established a Regional Group (EMSEA Med) to promote the diffusion of Ocean Literacy and of educational research on OL in this region. The movement eventually created a definition of Ocean Literacy (OL) by developing 7 OL Principles, the "Big Ideas" at the base of OL, and the OL Scope and Sequence, including the pedagogical tools for OL teaching (NMEA, 2010; NOAA, 2013). Ocean Literacy goes further than marine sciences: very synthetically it means "*an understanding of the ocean's influence on you and your influence on the ocean*" (Cava et al., 2005).

OL AROUND THE WORLD: EVIDENCE FROM PUBLISHED RESEARCH

Even before the birth of the OL movement, several investigations had addressed knowledge of, and attitudes and behaviour towards marine-related issues among citizens, school and university students.

A few surveys investigated large citizen samples in the United States and in 11 European Countries (The Ocean Project 2009, Gelcich et al. 2014). Both surveys evidenced widespread concern for pollution, industrial toxic waste and overfishing, but little awareness and poor knowledge of other marine criticalities (e.g. ocean acidification), and scarce trust in individual action, despite positive attitude towards behavioural changes for the good of sea environment.

The majority of existing literature, though, investigated primary and secondary school students in individual countries (USA, Canada, South Africa, Taiwan, UK, Mexico). With very few exceptions, these studies, too, evidenced low/moderate knowledge level, with concern and positive attitudes towards marine environment.

Students from Mediterranean countries have not been investigated about OL until 2018, when a research study involving primary school students in Greece, Italy and Croatia was developed within the EMSEA - Mediterranean Sea regional workgroup (EMSEA Med). Part of the research discussed in this paper was developed within this international collaboration (Realdon et al., 2018; Mogias et al., 2019).

OL IN ITALY: AN INTERESTING CASE STUDY

The level of OL among Italian students was largely unknown prior to the implementation of our study (January 2018): to our knowledge, the only relevant reference on the matter is a research study on “Ocean Citizenship”, based on a survey of primary school textbooks and on interviews to a small teacher sample (Squarcina & Pecorelli, 2017). This study found a substantial absence of the sea in geography and environmental education, worsened by the *“banality and the rhetoric used by school books to represent the sea”*, leading to an educational neglect of the sea, and particularly of high seas, likely to remain an *“unknown space”* for many Italian students. As a matter of fact, in the *“Indicazioni Nazionali per il curricolo”* (Italian Ministry of Education Guidelines) there is no mention of the sea in primary school science curriculum, but *“the characteristics of water and its role in the environment”* are mentioned, with the suggestion to *“observe the characteristics of soil and water through field trips”*. Seas and oceans, though, are addressed within geography syllabus, among the *“main geographical objects”*. In lower secondary school, sea-related topics are not mentioned both in geography and in science curricula, but possibly included in the topic *“Earth’s structure”*, with some hints about fresh-water and hydro-geological hazard. In high school hydrosphere is a prescribed science topic, addressed within geomorphology in *Liceo* high school: *“surface structures of the Earth (rivers, lakes, glaciers, seas...)”*, with more details for technical and vocational high schools, whose curriculum includes: *“seafloor, physical and chemical characteristics of water, sea movements: waves, currents”*.

Nevertheless, sea related topics are always addressed, even if concisely, in primary and middle school textbooks, and more extensively in high school.

It must be added that Ministry of Environment/Ministry of Education guidelines for Environmental Education – even if not compulsory – include sea-related topics and that some particularly motivated teachers, participating in different projects proposed by research institutes, universities and environmentalist NGOs, regularly involve their students in sea-related activities.

In consideration of the described state of marine education in Italy, and of the research on OL carried out in other countries, we investigated how ocean literate our students are, starting from a convenience sample of primary and middle school students participating in a project aimed at promoting “Blue Careers” (careers in

marine and maritime sectors) developed by MARE FVG - Maritime Technology Cluster FVG, a regional public-private partnership in the maritime technologies domain (<https://www.marefvg.it/en/home.htm>).

The aim of this study is twofold:

1. To investigate the level of ocean-related knowledge and opinions according to the OL framework in a sample of students not necessarily exposed to specific teaching;
2. To investigate if (and how much) the basic level of OL varies after a teaching intervention not specifically aimed at OL, but aligned with some of the OL principles.

MATERIALS AND METHODS

In the following paragraphs synthetic information is provided about the students’ sample, the questionnaires used for data collection, the teaching activities object of the interventional study and the statistical methods applied to data treatment.

PARTICIPANTS

The study sample included 12 primary school classes (4th and 5th grades) and 9 secondary school classes (8th grade) located in Friuli Venezia Giulia region, North-Eastern Italy. The total number of participants was 351.

THE RESEARCH TOOLS

The research tools were developed within the EMSEA Med workgroup based on previous research (Greely, 2008; Mogias et al., 2015; Fauville et al., 2018) and following the pedagogical guidelines of OL Scope and Sequence for Grades K-12 (NMEA, 2010). The tools consisted of structured questionnaires for two grade ranges: “elementary” (3rd-6th grades) and “secondary” (7th-8th grades). The original questionnaires were developed in English, translated into the different national languages and pilot tested with small student samples (in Italy N = 40). They were then revised by a panel of marine education experts and teachers and psychometrically validated through Rasch analysis (Rasch, 1960), before final implementation for the needs of this study.

The questionnaires were comprised of a section about demographics and informal education background, followed by a number of multiple-choice knowledge questions and of Likert scale opinion questions (Likert, 1932). Both questionnaires addressed – with one or more questions – the 7 OL Principles:

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

TEACHING INTERVENTIONS AND QUESTIONNAIRE TIMING

The teaching intervention for primary school students, run by experts of MARE FVG, consisted in an introduction to ships and maritime transportation, followed by a practical lab in the classroom with assemblage and testing of model-ships for stability and buoyancy in a small tank. The activity took 2 hours in the same day. The secondary school intervention consisted in an introductory lesson given by experts on ships and shipping, followed by instruction for building model-ships of fixed dimensions and weight, aimed at participating in a school context. The models were designed and built from the scratch by student teams with the guide of their schoolteachers. Finally, model-ships were hydrodynamically tested in a real portable towing tank during a regional school context (total duration: 1 two-hour session per week for about 2 months).

The same questionnaires were used as a pre-test before the teaching intervention (February-March 2018) and as a post-test at the end of the school year (May-June 2018).

DATA TREATMENT

Descriptive statistics (percentages, means, SD-Standard Deviation, SE-Standard Error) were used for data describing the sample and test results. Inferential statistics (paired sample Student's t-test, McNemar's Chi Square test) were used to assess the outcome of the teaching interventions (Student, 1908; McNemar, 1947).

RESULTS

PRIMARY SCHOOL SAMPLE PRE-TEST

The primary school sample included 198 students from 7 schools located within 30 km from the coast of the Adriatic Sea. Thirty one per cent of students belonged to 4th grade and 69% to 5th grade classes (mean age 9.94 ± 0.60 SD years). Females were 42%. Eighty six per cent of the students declared to have attended school activities on nature/environment and 76% affirmed to watch TV documentaries on naturalistic issues.

The average percentage of correct answers to knowledge questions was $56.9 \pm 14.4\%$ SD, evidencing a positive level of information on issues not included in official curricula. Knowledge level, though, varied in relationship to the different OL Principles: the average number of correct answers on Principles 2 (ocean shapes Earth), 6 (ocean/human connection), 5 (ocean biodiversity) and 4 (ocean and life) was $>50\%$, while on the other Principles it was $<50\%$ (Fig. 1)

Analysing each specific question, we found heterogeneity about students' knowledge of different concepts referring to the sea. Where the percentage of correct answers was low, students' choices clustered around specific incorrect ideas, which were widely shared in our sample, suggesting their role as true misconceptions.

When asked to express their views about ocean-related issues, 77% of students agreed on the need of studying the sea for its protection and 54% acknowledged the link between their behaviour and marine environment. On the contrary, a question on the influence of the sea on

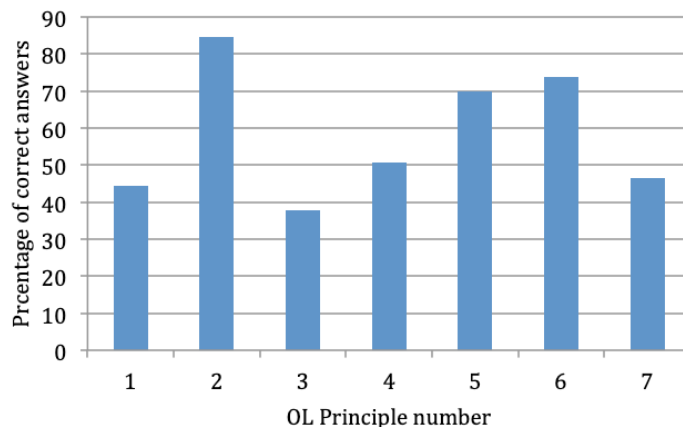


Fig. 1 - Primary school: pre-test scores per OL Principle (N = 198).

people living far from it split our sample into three nearly equivalent groups agreeing, disagreeing or having no opinion on this issue.

SECONDARY SCHOOL SAMPLE PRE-TEST

Secondary school sample included 153 students, 49% of which were females. All attended 8th grade classes in schools located within 15 km from the coast of the Adriatic Sea; their mean age was 13.2 ± 0.5 SD years. Sixty five per cent of the students declared having attended environmental education activities at school. When asked about their sources of information about nature and environment, 96% mentioned the Internet and 60% their family. Teachers, books, friends and TV scored lower as information sources in this field. (40%, 40%, 24% and 22% respectively)

The average score of this sample in knowledge questions was $55.9 \pm 11.5\%$ SD, evidencing a moderate information level on OL issues. Students' knowledge appeared higher on OL Principles 5 (ocean biodiversity, 83 % correct answers), 6 (ocean/human connection, 69 %), 7 (unexplored ocean, 63 %) and 4 (ocean and life, 52 %). Lower percentages of correct answers were found on OL Principles 2 (ocean shapes Earth, 48 %), 3 (ocean and

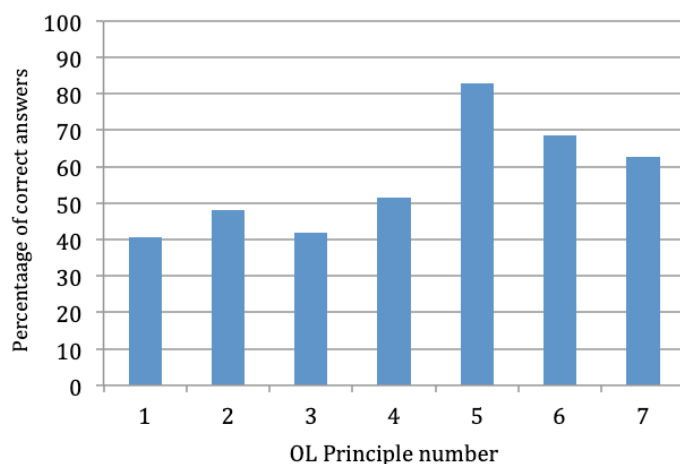


Fig. 2 - Secondary school: pre-test scores per OL Principle (N = 153).

climate/weather, 42 %) and 1 (one ocean, 41 %) (Fig. 2).

Analysing each specific question, also this sample evidenced heterogeneity in the knowledge level about different concepts referring to the same OL Principle. For instance, with regards to Principle 4 (ocean and life), students knew that life originated in the sea, but failed to recognize the sea as the main source of oxygen gas. Similarly, when assessed on Principle 1 (one ocean), students displayed knowledge that most of Earth water is in the ocean but seemed to ignore that all seas are connected in one ocean. Knowledge heterogeneity was also evidenced for Principles 2 (ocean shapes Earth), and 3 (ocean and climate/weather). It is worth noticing that, when students chose wrong answers, their choices clustered around specific statements, revealing shared misconceptions, acquired in school or maintained through it.

Secondary school students' opinions were similar to primary school students' views in our sample about the need to study the sea in order to protect it (79% agreement) and about the connection between individual behaviour and marine environment (63%); older students appeared more convinced of the influence of the sea on people living far from it (63%). Older students were also asked about "blue economy", wealth and jobs in maritime sector: the majority (60%) recognized its importance (Fig. 3).

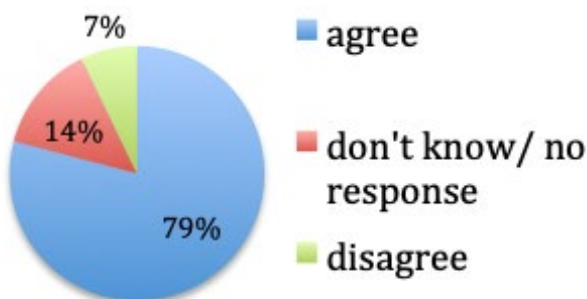
PRIMARY SCHOOL SAMPLE POST-TEST

The same questionnaire was administered to the students at the end of the school year and a paired sample t-test was performed on the students who had filled in both questionnaires (159 students). In spite of the short duration of the classroom intervention, students' average score raised from 56.5 ± 1.0 % SE to 60.7 ± 1.2 % SE of correct answers. Students' improvement was evident for some but not all questions (Fig. 4). The overall improvement resulted statistically significant ($p < 0.001$). Awareness of the ocean's influence on people improved from 34% to 43% of the sample, while remained stable on the other assessed issues. The recorded improvement resulted in statistically significant difference (McNemar's Chi Square test $\chi^2 = 4.54$, $p < 0.05$).

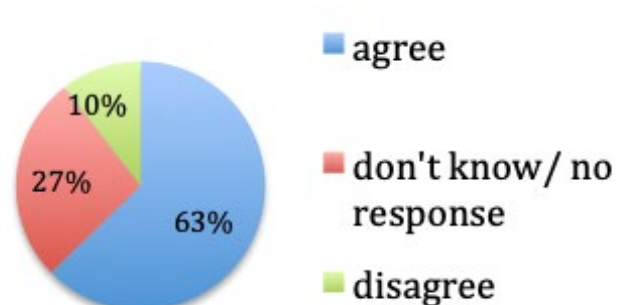
SECONDARY SCHOOL SAMPLE POST-TEST

Students were probed with the same questionnaire at the end of the school year: of 121 students who participated in both assessments, test results were analysed by means of a paired sample t-test. Students' average score changed from 56.2 ± 1.0 % SE in the pre-test to 57.0 ± 1.3 % SE in the post-test. In the opinion questions, post-test evidenced

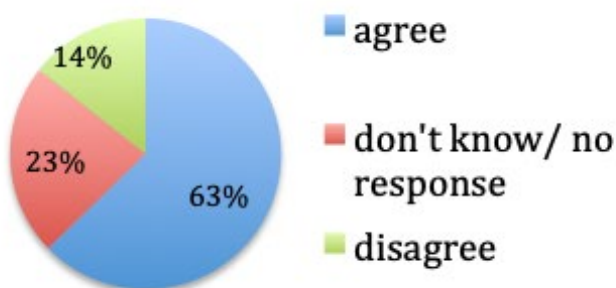
We need to study and know the sea to protect



What I throw in the sink has an influence on the sea



The sea influences my life, even if I live far from the coast



The sea provides little wealth and few jobs

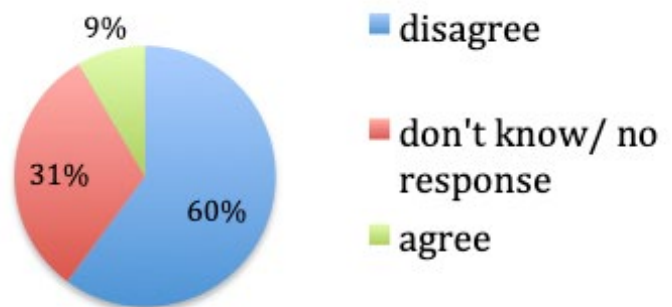


Fig. 3 - Secondary school: pre-test opinions (percentages, N = 153).

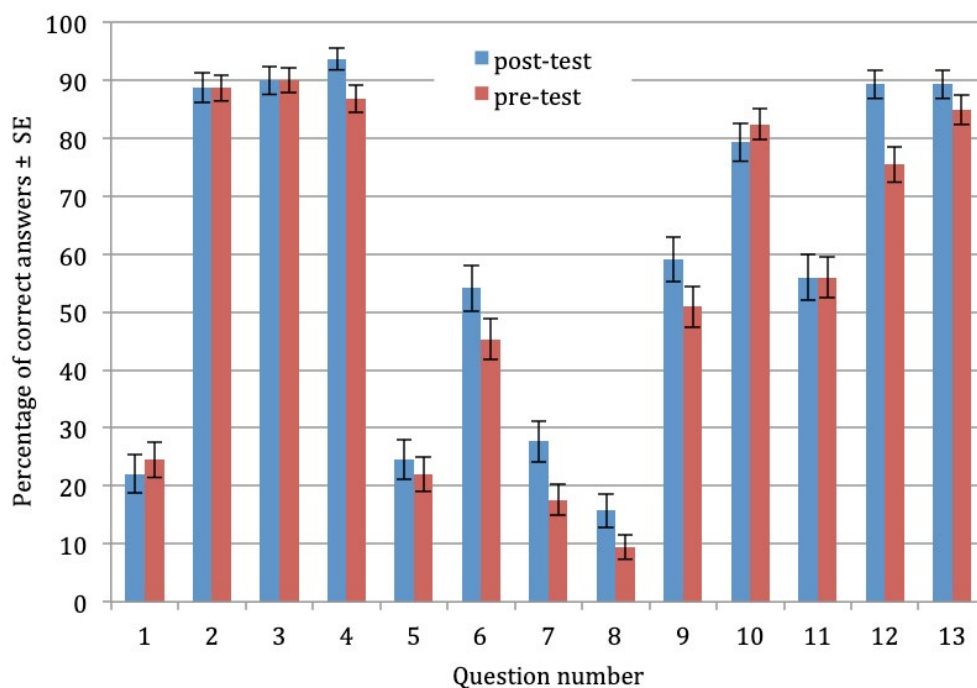


Fig. 4 - Primary school: paired sample pre- and post-test scores per question (N = 159).

an improvement from 63% to 69% in the awareness of the impact of individual behaviour on marine environment, with little or no change on the other tested issues. No statistically significant difference was recorded in both knowledge and opinion questions.

DISCUSSION

From pre-test results we can affirm that the basic knowledge of ocean issues in our sample of Italian students appears moderate, ranging above 50% of correct questions in both age ranges. Our results seem to be in line with the results on students of similar age from other countries, as evidenced by previous research, even with the limitations due to the different research tools and the different school contexts. In studies that used quantitative knowledge assessment, mean scores ranged from 38% to 57% of correct answers (Fortner & Mayer, 1983; Brody & Koch, 1986; Brody, 1996; Cummins & Snively, 2000; Greely, 2008; Hartley et al., 2015; Guest et al., 2015), with higher scores reported only in a Taiwanese research (Wen & Lu 2013). Some studies also reported a number of ocean-related misconceptions (Brody & Koch, 1983; Brody, 1996; Ballantyne, 2004). Considering the lack of ocean sciences in official curricula, our findings exceeded our expectations, and are possibly linked to the prevalence, in our sample, of environmental education activities and out-of-school opportunities (e.g. TV documentaries watching for primary school students), as emerged from background questions on prior informal education. The positive influence of such information sources was also found in other studies (Fortner & Lyon, 1985; Wen & Lu 2013; Guest et al., 2015).

Despite demonstrating good knowledge on issues such as ocean and life, biodiversity, human/ocean connections, students revealed the presence of diffused

misconceptions when answering our questionnaires. Specifically, misconceptions emerged about the connectedness of all seas, the origin of atmospheric oxygen from the sea, the global dimension of the water cycle and, for the secondary school sample, about sea levels in the past. While most of these misconceptions can be found in the literature (Phillips, 1991; Henriques, 2000; Ben-zvi-Assaraf & Orion, 2005; Cook, 2008), the misconception regarding sea connectedness is a novel finding and therefore worth further investigation.

Considering the outcome of the teaching activities, we found a statistically significant knowledge improvement in the primary school sample, but not among older students. This finding could possibly be attributed to the different teaching organization in primary and secondary school. Unlike secondary school, in primary school teaching is organized in "subject areas" (multiple-subject blocks) managed by the same teacher. From informal feedback comments received by some participating teachers, we hypothesize that, in our sample, primary school teachers may have been inspired by the activity and may have taken the opportunity to address other ocean issues. In secondary school, the division between the teaching subjects involved in the project (science and technological education) probably did not foster this kind of approach.

CONCLUSIONS

This study is the first one of its kind in Italy, but it has been limited, so far, to a specific area of the country. For this reason, it cannot give a reliable picture of OL in the rest of the country and in other age groups. Further research is needed to obtain more data about Italy and other Mediterranean countries, scarcely investigated until now.

The recent interest for the ocean, generated by emerging environmental problems, like plastics/microplastics pollution, could also promote a novel interest for Ocean Literacy, both in the educational practice and at the research level. We hope that this research will be followed and widened by many others, leading to better knowledge and awareness levels in the education community and better teaching practices in schools and, consequently, to more ocean-literate citizens.

ACKNOWLEDGMENTS

G. Realdon acknowledges the kind persons who helped her to realise this study: teachers and students participating in the activity, colleague fellows of EMSEA Med and of Scienza under 18 Isontina, experts of MARE FVG, colleagues of UNICAMearth group at University of Camerino.

REFERENCES

- Ballantyne R. (2004) - Young students' conceptions of the marine environment and their role in the development of aquaria exhibits. *Geo J.*, 60, 159-163.
- Ben-zvi-Assaraf O. & Orion N. (2005) - A study of junior high students' perceptions of the water cycle. *J. Geosci. Educ.*, 53, 366-373.
- Brody M. (1996) - An assessment of 4th-, 8th-, and 11th-grade students' environmental science knowledge related to Oregon's marine resources. *J. Environ. Educ.*, 27, 21-27.
- Brody M. & Koch H. (1986) - An assessment of 4th-, 8th-, and 11th-grade students' knowledge related to marine sciences and natural resource issues. University of Maine, Orono: College of Education. ED273502.
- Cava F., Schoedinger S., Strang C. & Tuddenham P. (2005) - Science content and standards for ocean literacy: A report on ocean literacy. Retrieved from http://coexploration.org/oceanliteracy/documents/OLit200405_Final_Report.pdf
- Cook B. (2018) - Ten forest myths. MSU (Michigan State University). Retrieved from www.canr.msu.edu/news/ten_forest_myths.
- Cummins S. & Snively G. (2000) - The effect of instruction on children's knowledge of marine ecology, attitudes toward the ocean, and stances toward marine resource issues. *Canadian J. Environ. Educ.*, 5, 305-324.
- Fauville G., Strang C., Cannady M. & Chen Y.F. (2018) - Development of the international ocean literacy survey: measuring knowledge across the world. *Environ. Educ. Res.* doi.org/10.1080/13504622.2018.1440381.
- Fortner R.W. & Lyon A.E. (1985) - Effects of Cousteau Television Special on viewer knowledge and attitudes. *J. Environ. Educ.*, 16, 12-20.
- Fortner R.W. & Mayer, V.J. (1989) - Marine and aquatic education - A challenge for science educators. *Sci. Educ.*, 73, 135-154.
- Gelcich S., Buckley P., Pinnegar J.K., Chilvers J., Lorenzoni I., Terry G. et al. (2014) - Public awareness, concerns, and priorities about anthropogenic impacts on marine environments. *PNAS*, 111, 15042-15047.
- Greely T. (2008) - Ocean literacy and reasoning about ocean issues: The influence of content, experience and morality. PhD diss., University of South Florida.
- Guest H., Lotze H.K. & Wallace D. (2015) - Youth and the sea: Ocean literacy in Nova Scotia, Canada. *Mar. Policy*, 58, 98-107.
- Hartley B., Thompson R.C. & Pahl S. (2015) - Marine litter education boosts children's understanding and self-reported actions. *Mar. Poll. Bull.*, 90, 209-217.
- Henriques L. (2000) - Children's misconceptions about weather: A review of the literature. Abstract presented at the Annual meeting of the National Association of Research in Science Teaching, New Orleans, LA, April 29, 2000.
- Likert R. (1932) - A Technique for the Measurement of Attitudes. *Arch Psychol.*, 140, 1-55.
- McNemar Q. (1947) - Note on the sampling error of the difference between correlated proportions or percentages. *Psychometrika*, 12 (2), 153-157.
- Mogias A., Boubonari T., Markos A., Kevrekidis T. (2015) - Greek pre-service teachers' knowledge of ocean sciences issues and attitudes toward ocean stewardship. *J. Environ. Educ.*, 46, 251-270.
- Mogias A., Boubonari T., Realdon G., Previati M., Mokos M., Koulouri P. & Cheimonopoulou M.T. (2019) - Evaluating Ocean Literacy of Elementary School Students: Preliminary Results of a Cross-Cultural Study in the Mediterranean Region. *Front. Mar. Sci.* 6, 396. <https://doi.org/10.3389/fmars.2019.00396>.
- NMEA - National Marine Educators Association (2010) - Ocean Literacy Scope and Sequence for Grades K-12, NMEA, U.S.A. Special Report #3. Retrieved from http://www.coexploration.org/oceanliteracy/NMEA_Report_3/NMEA_2010.pdf
- NOAA - National Oceanic and Atmospheric Administration (2013) - Ocean Literacy: The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages Version 2. Retrieved from <http://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf>
- Phillips W. (1991) - Earth science misconceptions. *Sci. Teach.*, 58, 21-23.
- Rasch G. (1960) - Studies in mathematical psychology: I. Probabilistic models for some intelligence and attainment tests. Oxford, England: Nielsen & Lydiche.
- Realdon G., Cheimonopoulou M., Koulouri P., Mokos M., Mogias A., Boubonari, T. et al. (2018) - EMSEA Med: birth and development of an initiative aimed at fostering Mediterranean Sea Literacy. *Geophysical Research Abstracts*, Vol. 20, EGU2018-17617.
- Squarcina E. & Pecorelli V. (2017) - Ocean citizenship. The time to adopt a useful concept for environmental teaching and citizenship education is now. *J. Res. and Didact. In Geograph.*, 2, 45-53. <https://doi.org/10.4458/9446-04>
- Student (1908) - The probable error of a mean. *Biometrika*, 6 (1): 1-25.
- The Ocean Project (2009) - America, the ocean, and climate change: New research insights for conservation, awareness, and action. Retrieved from https://theoceanproject.org/wp-content/uploads/2017/08/America_the_Ocean_and_Climate_Change_KeyFindings_1Jun09final.pdf
- United Nations (2015) - Transforming our World: The 2030 Agenda for Sustainable Development. Retrieved from <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>
- UNESCO (2017) - Education for Sustainable Development Goals. Learning objectives. Paris: United Nations Educational and Cultural Organization. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000247444>
- Wen W-C. & Lu S-Y. (2013) - Marine environmental protection knowledge, attitudes, behaviors, and curricular involvement of Taiwanese primary school students in senior grades. *Environ. Educ. Res.*, 19, 600-619.