

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

## “Percorsi nel Blu” (“Blue Paths”): a long-lasting project to integrate ocean literacy and marine citizen science into school curricula

Erika MIONI

Istituto Comprensivo Statale ISA2, Viale Aldo Ferrari, 19122 La Spezia, Italy

Corresponding author: Erika MIONI; [erika.mioni@gmail.com](mailto:erika.mioni@gmail.com)

Contributing Editor: Athanasios MOGIAS

Received: 29 May 2021; Accepted: 08 January 2022; Published online: 01 April 2022

### Abstract

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

**Keywords:** Ocean literacy; marine citizen science; Blue School; global citizenship; interdisciplinary skills; environmental education; STEM; 2030 Agenda.

### Introduction

#### The context

Over the past decade, the publication rate on public knowledge and perception of marine issues has steadily grown, starting from an almost non-existent level in the early 2000s, as shown by the European Marine Board report (Garcia-Soto *et al.*, 2017). This great increase is probably due to modern technologies that have allowed researchers to reach unexplored areas and to experiment with new scientific approaches, thus attracting the interest of an increasing number of people in sciences such as biology, chemistry and oceanography, and contributing to the dissemination of ocean literacy (OL) (Merlino *et al.*, 2019). However, despite the significant progress in marine science, the field of research in marine education is still sparse, and most publications are descriptions of teaching activities that do not involve the study of the

learning process or its outcomes at all (Fauville, 2019). In fact, only 91 publications addressing OL, marine education and ocean education have been published online since 2000 (Fauville, 2019).

Moreover, while several scholars around the world agree on the need to develop marine literacy as a key factor for the conservation of the aquatic and oceanic environment, in Italy, the debate is still far from being fully taken into account, despite its 7,500 kilometres of coastline and the urgent need to save the environment of the Mediterranean Sea (Squarcina & Pecorelli, 2017). In order to fill this gap, in 2012, the European Marine Science Educators Association (EMSEA) (2021) focused its efforts on transforming European marine education by promoting stronger international connections to make teachers and educators feel more supported and equipped for the educative task of making European citizens more ocean literate (Copejans *et al.*, 2012; Fauville *et al.*, 2013). Studies conducted by the EMSEA work-

group highlighted that the growing interest in OL and its dissemination are not accompanied by a consequent enrichment of school curricula through the integration of marine science themes (Merlino *et al.*, 2019). In Italy, in accordance with the “Indicazioni Nazionali per il curricolo” ministerial programmes (MIUR, 2012), marine science is already part of school curricula. Nevertheless, Italian students, as well as Europeans, do not acquire a deeper knowledge in this field while advancing in their studies, since programmes are limited only to a few topics which are repeated at different school levels (Lin *et al.*, 2020). For this reason, schools need an enhancement of marine science teaching that engages students more actively in the learning process through a participatory approach (Dupont & Fauville, 2017). The reasons for the lack of practical activities are to be found in the overloaded school curricula and the interdisciplinary nature of marine themes, which require specific skills in several scientific fields and are not often supported by the teachers’ basic professional knowledge (Merlino *et al.*, 2019; Lin *et al.*, 2020). Another reason may be the overly fragmented school curriculum into many disciplines, which does not encourage extra-curricular activities, interdisciplinary projects and collaborative work among teachers (Wang *et al.*, 2020). Ideally, teachers should receive specific training to acquire interdisciplinary skills as well as the support of practical teaching guidelines (Merlino *et al.*, 2019) on the seven principles of OL (Ocean Literacy, 2005). A practical educative training could indeed lead students to a deep understanding of their shared civic responsibility, expressed through a sustainable commitment to the safeguard of the marine environment (Cava *et al.*, 2005; Dupont & Fauville, 2017; Fauville, 2017; Lin *et al.*, 2020).

Citizens need to be ocean literate to be able to make well-informed choices in their everyday lives and contribute to the public debate in participatory democracy; these are the key factors of change (Dupont & Fauville, 2017). In consideration of these concepts, marine science education can be seen as a significant cross-disciplinary stimulus for the development of OL, starting from the definition of the fundamental environmental education skills, the promotion of a critical and conscious attitude towards environmental issues (Dupont & Fauville, 2017) and also the push towards the development of free and motivated personalities (Cortellini & Mazzoni, 2001). A significant input for the inclusion and expansion of OL into school curricula took place in Italy in 2015, when the Italian Ministry of Education, University and Research (MIUR) and the Italian Ministry of Environment (MATM) promoted the “Linee guida per l’Educazione Ambientale” (MATM, 2015). These guidelines are addressed to educational institutions to provide innovative recommendations on environmental education and sustainable development, promote an educative approach through the implementation of vertical curricula and support school education towards the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda (Sustainable Agenda Goals, 2021). Additionally, marine topics such as biodiversity conservation, sea protection, climate changes, ecologic

services and marine pollution are included in the 13<sup>th</sup> and 14<sup>th</sup> goals of the United Nations Sustainable Development Goals (UN SDGs), related to climate action and life below water, respectively. Since 2019, the introduction of civic education teaching in schools has allowed students to experience marine science from a more practical and participative point of view. The updating and experimentation of teacher training in classrooms provide, in turn, innovative tested tools and educational materials in the field of participatory citizenship, digital citizenship and sustainable development (MIUR, 2019). This can still be implemented through educational practice by harmonising the themes of OL and marine citizenship within ministerial curricula, in agreement with the “Linee guida per l’Educazione Civica”, the guidelines for civic education (MIUR, 2019).

The enhancement of marine science into school programmes is aimed at promoting individual and collective eco-sustainable actions and behaviours in young students (Lin *et al.*, 2020). This innovation responds positively to the challenges that schools face to develop meaningful curricula that present real-world problems, thus enabling young people to understand the links between their own lives and those of people in other countries and motivating them to act for a more sustainable world (Myers, 2006). How teachers convert marine education curricula into teaching strategies is the key factor in how effectively marine education can be implemented into school programmes (Lin *et al.*, 2020). Thus, if the key task of citizenship education is to provide students with an incentive to participate in actions that push local or global communities towards global citizenship education (Davies *et al.*, 2004), success can be achieved by fostering the Blue School (Blue Schools, 2019). The Blue School project is an innovative ministerial educational programme whose mission is to promote OL in the school community and to create more responsible and participatory generations that will contribute to the sustainability of the ocean. This programme helps schools create a community that brings together schools, the maritime sector, industries, municipalities, NGOs, universities and other institutions that play an active role in OL (Merlino *et al.*, 2019).

The “Percorsi nel Blu” project operates in this field and harmonises the above-discussed topics in a wider context.

### **The Project**

“Percorsi nel Blu” is an innovative model of Blue School in which the themes of OL and marine citizen science (MCS) are well integrated into school curricula. The project has been promoted by a science teacher and independent researcher of the project’s leading school, the ISA2 School Institute (ISA2) of La Spezia, Italy. Since 2011, the project has been setting up a network among schools, institutions and citizens, along with cooperation with research centres, marine parks and universities for coastal monitoring activities within the “Pelagos” Mammal Sanctuary in the Ligurian and Tyrrhenian seas (Mi-

oni *et al.*, 2016). The project focuses on the key points of OL and MCS, promoting the gradual development of scientific literacy in marine biology and coastal monitoring techniques in school curricula. Through a long-term incremental vertical training, from kindergarten up to university, the project harmonises the existing ministerial school programmes and improves the teaching of science, technology, engineering and mathematics (STEM) disciplines, following the recommendations of the UN SDGs of the 2030 Agenda (Sustainable Development Goals, 2021).

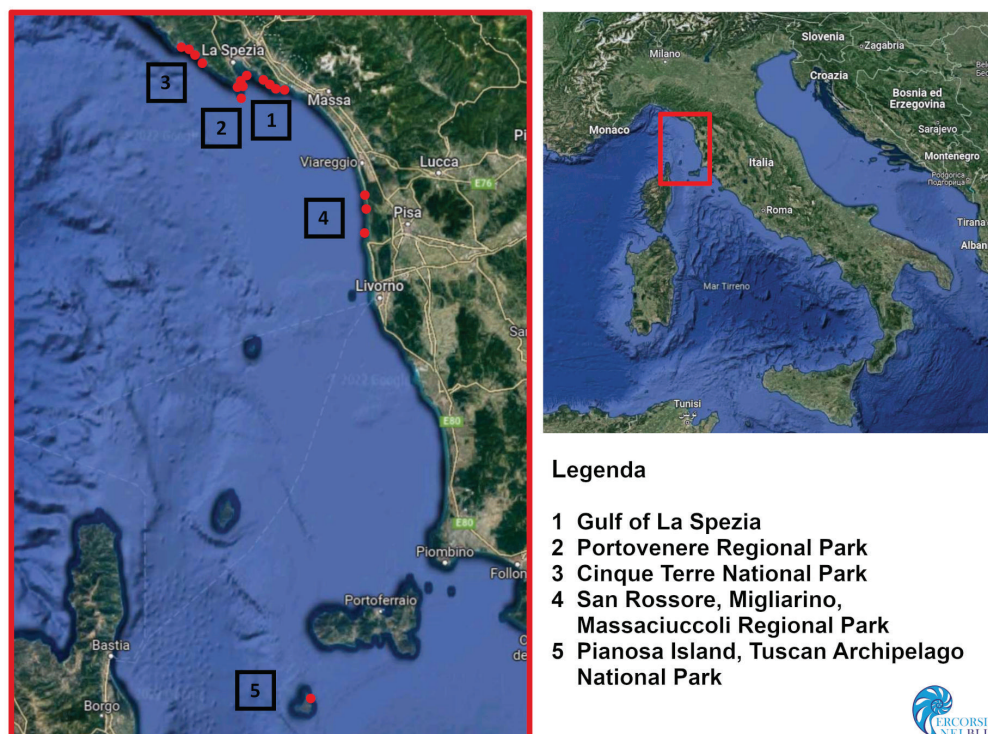
### ***Social challenges for a long-lasting scientific school training***

The ISA2 institute reflects the typical Italian school organisation promoted by MIUR and is composed of schools of different levels (from kindergarten to secondary middle school) located in different adjacent areas. Since initially, not all students can find adequate stimuli to improve their skills or identify their personal goals in the marine field, the learning process of OL has to be inclusive, provide opportunities for non-formal teaching and simplify the language of communication. To involve the students' families as much as possible within extra-curricular scientific public events, such as the BIOBlitz, surveys were organised at weekends. In this scenario, the learning process of OL and the introduction of MCS promoted by the project stimulated students through practical and technical training, which gave them the input to test themselves and overcome their limits. Offering the opportunity to minimise differences between peers is a fundamental aspect for the process of teambuilding in "Percorsi nel Blu" and can facilitate integration paths

in the school community. During the project, passionate students who had acquired and improved their skills were involved in tutoring activities with their peers and beginner adults, thus strengthening the partnership within the "BIOTeam", a heterogeneous group of student scientists composed of both beginners and experts.

During its ten years of activity, "Percorsi nel Blu" has been setting up a tested and replicable vertical format of teaching and research while disseminating activities of marine flora and fauna coastal monitoring. This format has involved more than 18,000 participants, including students, teachers and citizens of the project's network. The network was principally composed by the ISA1 and ISA4 school institutes and the scientific, technological, nautical and linguistic high schools involved in the Percorsi per le Competenze Trasversali e per l'Orientamento (PCTO) school-work training course, which had been defined by the "Linee guida PCTO" (MIUR, 2018). Since 2014, the project has been promoting a one week-long campaign of MCS research in Pianosa Island (in the Tuscan Archipelago) and BIOBlitz events at the Regional Park of San Rossore, in cooperation with CNR ISMAR of La Spezia. At the National Park of Cinque Terre and the Regional Park of Portovenere (Fig. 1), the project's surveillance programme has involved tutor students in data collection, besides beginner students and their parents. Before the COVID-19 pandemic in 2019, "Percorsi nel Blu" created a specific educative and operative surveillance plan for the coastal monitoring of fouling marine organisms at marinas of La Spezia, in accordance with the programme named "*Fantastic creatures and where to find them*" (Fig. 2).

The project's activities took place according to a calendar of meetings throughout the school year which provided monthly intensive workshops of 1 or 2 hours held



**Fig. 1:** Italian coastal sites monitored by the "Percorsi nel Blu" project in the Ligurian and Tyrrhenian seas.





**Fig. 2:** Pupils involved in the educative and operative surveillance plan for the coastal monitoring activities at marinas of La Spezia, named “*Fantastic Creatures and where to find them*”.

by an expert teacher. The educative programme has been defined in partnership with an interdisciplinary team of teachers under the project’s methodological format and guidelines. “Percorsi nel Blu” has promoted long-lasting training in OL, starting from 5-year-old children up to university students and adult citizens, and in the MCS literacy process, starting from 8-year-old children onwards.

Effective educational strategies were also applied to make adult citizen scientists (scuba operators, volunteers, parents and expert teachers) passionate about CS research; this has been achieved through the promotion of practical training in informal situations (Collins, 2004).

The project’s educative approach has been tested with a hands-on teaching methodology that was diversified according to the needs of different school levels (Mioni *et al.*, 2016). This approach promotes education through participation (Cerrano *et al.*, 2012) using:

1. surveys on the field for monitoring marine litter, fouling species at marinas, marine specimens on the beach (e.g., dead sponges, algae and molluscs) and marine flora and fauna on rocky seabed;
2. surveys by snorkelling or scuba diving for monitoring the distribution of indigenous and alien species on rocky seabed;
3. experimental laboratories;
4. coastal monitoring activities: CS BIOBlitz events involving students, passionate teachers, families and citizens.

Students and young pupils who participated in “Percorsi nel Blu” became part of a research team, received new stimuli and took part in scientific investigations. Furthermore, field experiences had a great emotional impact on students facilitating the acquisition of deep concepts and skills (emotion-based learning) (Damasio, 1994; Mioni *et al.*, 2016).

### ***Project’s format: Ocean literacy and marine citizen science for different school levels, teacher training and marine science dissemination***

#### *Didactic activities at different school levels*

1. Didactic activities at kindergarten for 5-year-old children (introduction to OL): a) educational and recreational activities for introducing marine biology; b) surveys on the beach by free exploration of marine specimens on the beach followed by tactile, ludic and sensorial analysis; c) marine samples’ drawing and modelling activities to stimulate observation.
2. Didactic activities at primary school for 6 to 7-year-old pupils (OL schooling) and 8 to 10-year-old pupils (introduction to MCS): a) experimental activities introducing the scientific method; b) simulation of surveys on the beach by using digital tools to stimulate curiosity; c) surveys on the beach: basic taxonomic recognition of marine samples, data recording using scientific tools and microscopic analysis on the field; e) survey reports for editing kid-friendly bio-guides.
3. Didactic activities at secondary school (gradual development of OL and MCS) for 11 to 18-year-old students, including students of the PCTO school-work training course: a) workshops on the field for the acquisition of coastal monitoring techniques for benthos recognition; b) use of technical working tools (e.g., ROV, drones, tablets and camp microscopes) and survey planning; c) field activities and data recording by snorkelling and scuba diving or on the beach and at marinas; d) statistic data processing and report writing for school websites; g) tutoring activities on the occasion of scientific dissemination events.

4. Citizen Science research campaigns for 11 to 18-year-old students in Pianosa Island (Fig. 3): in 2019, the project defined the “Advanced BIOTeam”, a team formed by passionate students, scuba instructors, teachers and parents who were able to apply coastal monitoring protocols and techniques. During research activities, the team provided data collection through monthly monitoring campaigns in the same georeferenced monitoring stations. Surveys were realised along linear transects by using sampling squares of 50x50 cm to estimate the qualitative and quantitative presence of specimens on the beach, anthropogenic marine litter and benthic species’ distribution on rocky seabed. The distribution of relevant species, such as alien and bioindicator species, was analysed using protocols which had been adapted for the involvement of students and citizens in surveys by snorkelling and scuba diving or on the beach (Mioni *et al.*, 2017). Data collection and results were validated through the cooperation with researchers and then shared with the scientific community on the occasion of international congresses.
5. Practical training for students of the DISAT department of Milan Bicocca University in CS research for their degree thesis.

#### *Project’s best practices for professional training on the UN SDGs of the 2030 Agenda*

Marine topics such as biodiversity protection and climate change are addressed in relation to the 13<sup>th</sup> and 14<sup>th</sup> goals of the UN SDGs. Since 2019, in line with the teacher training courses organised by the Regional School Office, “Percorsi nel Blu” is a benchmark for best practices for teachers who have to update their knowledge in marine biodiversity and should receive stimuli for enhancing marine topics of the UN SDGs in school programmes. The project’s format also helps teachers to innovate their teaching methods of STEM disciplines for

promoting skills related to scientific citizenship, in compliance with the “Scienza & Tecnologia” research programme of MIUR (Piano S & T MIUR, 2021).

#### *Marine science dissemination*

1. BIOBlitz events: “Percorsi nel Blu” organised public coastal monitoring surveys to actively engage its participants and promote their long-lasting involvement in the project’s events. BIOBlitz activities were supported by expert students who had to verify the correct application of protocols (Fig. 4).
2. Marine science events in the province of La Spezia, in partnership with the Research-Network for Outreach and Education in marine sciences: “Percorsi nel Blu” promoted scientific events which contributed to the dissemination of marine science. This goal has been pursued through scientific workshops organised for schools that involved students in tutoring activities with their peers, as shown in Figure 5.

#### *The importance of Technology in ocean literacy*

Technology plays an important role and represents an effective stimulus for the emotional involvement of students and the maintaining of a long-lasting commitment to scientific activities (Fauville, 2017). Moreover, digital technologies have the potential to support the process of learning about the ocean, as they can virtually guide students into the depths of the ocean and help them visualise complex interactions between different factors over time and space (Fauville, 2017). During the project’s activities, students have learned how to use common tools such as smartphones and tablets for surveys and to operate with different digital microscopes and GPS applications. They have also learned how to use remotely operated vehicles (ROV) and air-drones, which do not only report the behaviour of monitored species but also witness students’ activities.



**Fig. 3:** The Advanced BIOTeam of students involved in the research campaign in Pianosa Island.





**Fig. 4:** BIOBlitz events: students tutoring their parents at the San Rossore Regional Park.



**Fig. 5:** Students disseminating ocean literacy during public scientific events for schools.

## Results

“Percorsi nel Blu” highlights how important the contribution of passionate students and citizens can be for CS research (Fig. 6). The importance of CS in the achievement of significant scientific goals can be fully understood through the observation of the results of this study which can be classified into scientific, didactic, social and educative results.

### Scientific results

Since 2014, Citizen Science research activities have allowed for the achievement of relevant scientific results in registering the first records of indigenous and alien species in the Ligurian and Tyrrhenian seas.

In the Marine Protected Area of Pianosa Island, Italy (42,3515° N, 10,0604° E), from 2014 to 2019, the following results were obtained (Mioni *et al.*, 2017; Mioni *et al.*, 2018; Mioni *et al.*, 2020), as shown in Figure 7:

- First record of the cryptogenic species *Aplysia dacty-*

*lomela* (Rang, 1828) on December 5, 2015

- Exceptional record of black sponges’ die-off: *Spongia officinalis* (Linnaeus, 1759) and *Ircinia* spp. Nardo, 1833 on September 11, 2017
  - First record of the cryptogenic species *Percnon gibbesi* (H. Milne Edwards, 1853) on October 2, 2019
- Concerning marinas in the Gulf of La Spezia (SP), Italy (44,0532° N, 9,5023° E), from 2019 to 2021, the following results were achieved through the surveillance plan “*Fantastic Creatures and where to find them*” (Mioni *et al.*, 2021), as shown in Figure 8:
- First record for the Italian coasts of the alien species *Favorinus ghanensis* Edmunds, 1968, at Fezzano (SP) on November 17, 2020
  - First record for the Ligurian Sea of the native species *Okenia* cf. *longiductis* Pola, Paz-Sedano, Macali, Minchin, Marchini, Vitale, Licchelli & Crocetta, 2019, at Fezzano (SP) on October 23, 2019.
  - First record for the Ligurian Sea of the native species *Runcina brenkoae* T. E. Thompson, 1980, at Fezzano (SP) on November 9, 2019
  - First record for the Ligurian Sea of the native species

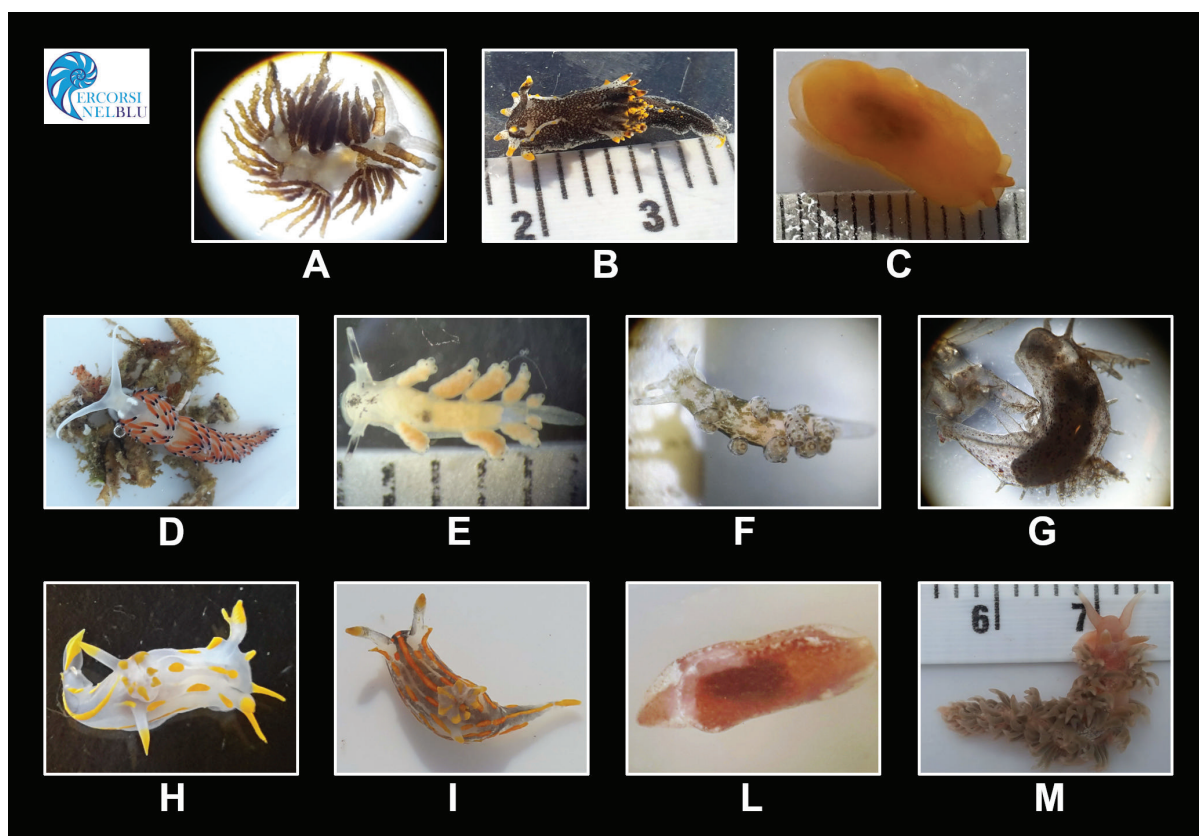




**Fig. 6:** Students and citizens involved in data collection during CS research activities.



**Fig. 7:** Citizen Science Research campaign at Pianosa Island: first records of the cryptogenic species *Aplysia dactylomela* (A) and *Percnon gibbesi* (B) and exceptional black sponges' die-off (C).



**Fig. 8:** Check list of Marine Heterobranchia (Mollusca; Gastropoda) recorded at marinas of La Spezia. A: *Favorinus ghanensis*; B: *Polycera hedgpethi*; C: *Berthella* cf. *aurantiaca*; D: *Caloria quatrefagesi*; E: *Doto cervicenigra*; F: *Eubranchius exiguus*; G: *Okenia* cf. *longiductis*; H: *Polycera quadrilineata*; I: *Polycera quadrilineata*; L: *Runcina brenkoae*; M: *Spurilla neapolitana*.

*Doto cervicenigra* Ortea & Bouchet, 1989, at Lerici (SP) on February 5, 2020

- First record for the Gulf of La Spezia of the native species *Berthella* cf. *aurantiaca* (Risso, 1818), at Santa Teresa -Lerici (SP) on September 20, 2019
- First record for the Gulf of La Spezia of the native species *Eubbranchus exiguus* (Alder & Hancock, 1848), at Fezzano (SP) on February 14, 2020
- First record for the Gulf of La Spezia of the native species *Caloria quatrefagesi* (Vayssière, 1888), at Fezzano (SP) on October 23, 2019
- First record for the Gulf of La Spezia of *Polycera quadrilineata* (Müller, 1776), at Santa Teresa – Lerici (SP) on February 22, 2020
- First record for the Gulf of La Spezia of *Spurilla neapolitana* (Delle Chiaje, 1841), at Portovenere (SP) on February 23, 2020
- New record for the Gulf of La Spezia of *Polycera hedgpethi* Er. Marcus, 1964, at Fezzano on November 9, 2019 and Santa Teresa - Lerici (SP) on February 22, 2020

### ***Didactic results: best practices in the innovation of the learning process***

Since learning is a process activated by a combination of didactic and emotive stimuli that encourage the acquisition of knowledge and new skills, only an effective didactic approach can lead to the acquisition of long-lasting skills (Castoldi, 2013). The project's best practices for developing skills related to the UN SDGs, STEM disciplines, and global citizenship were peer learning, learning by doing and intergenerational and cooperative learning (Fig. 9). In collaboration with various schools, research institutes and universities, "Percorsi nel Blu" won the "Global Citizenship Skills" project, obtaining a National Operative Programme (PON) fund established by MIUR (PON Homepage MIUR, 2021) and funded by the European Structural Funds (FSE), thus becoming a training model focused on the UN SDGs of the 2030 Agenda.

In "Percorsi nel Blu", the innovation in the learning process is related to a non-formal teaching methodology



**Fig. 9:** Intergenerational learning on the field.

(Mioni *et al.*, 2016) that crosses classroom boundaries to reach the whole community. The project implements spontaneous learning of technicalities in marine biology and other scientific subjects, such as mathematics, physics and chemistry, by enabling students to gain new experiences as researchers. This increases the pleasure of working in marine research to find solutions for environmental issues in such a way that secondary school students are encouraged to choose scientific careers.

### ***Social results: inclusive impact on the community***

The impact on the whole community is an integral part of this project since extracurricular activities allow students, parents and citizens to participate in monitoring campaigns, establish personal relationships and share experiences. BIOBlitz activities scheduled on the weekends were aimed at bringing students, citizens and families closer to the school community. Considering the project's social impact, it is important to note that the most passionate students were sometimes those who were living in a difficult social context or had disabilities; the project also supported sensitive students in the promotion of inclusive peer tutoring, thereby fostering empathy among the group of peers. Moreover, the use of instruments to facilitate the learning process provided new opportunities for the participants to gain self-confidence and test their inner abilities.

### ***Educative results: acquiring interdisciplinary skills to pursue the UN SDGs of the 2030 Agenda***

Research and outreach experiences represent useful stimuli for the acquisition of important cognitive skills. In fact, at the end of the school training, all the students were able to recognise marine species, create tables and graphs, organise and manage technological tools, co-design their work in a team, disseminate their experiences and share them with professional biologists. Field activities were found to be effective for increasing students' interest in marine environmental issues, as they stimulate tangible emotions and actions for preserving the coastal marine habitat. In particular, field activities improved students' behaviour and attendance as well as increased their self-esteem and ability to build relationships with peers.

Following the guidelines for environmental education for the fulfilment of the UN SDGs of the 2030 Agenda, the school training in OL and MCS for 5 to 18-year-old students led to the acquisition of the following main transversal skills:

#### ***Kindergarten:***

- a) establishing a positive emotional relationship with the natural environment;
- b) acquiring the ability to observe the natural world and the awareness of one's own identity as an integral part of the natural context;
- c) understanding the importance of variety and diversity in nature, formulating a hypothesis and seeking



solutions to problematic situations

*Primary school:*

- a) developing attitudes in recognising the main characteristics of the marine environment; b) becoming aware of the naturalistic and cultural value of one's territory while enhancing a sense of belonging to it

*Secondary middle school:*

- a) recognising the value of ecological and cultural diversity according to one's territory as well as its naturalistic peculiarities; b) learning key concepts related to pollution and the irreversible impact of environmental damage

*Scientific and technological high schools:*

- a) developing the ability to devise, promote and implement responsible and eco-sustainable actions and behaviours, both individual and collective; b) evaluating the relationship between science, technology and the natural environment; c) gaining awareness of the fundamental role that actions play in the protection and conservation of nature and developing the ability to implement conscious choices capable of modifying behaviours

## Achievements

The tangible results achieved through the project's activities allowed us to value its impact on the community, as shown by the data presented below:

- Approximately 300 students were involved in the coastal monitoring twinning between marine parks in Ancona and La Spezia, which took place in the 2014–15 school year.
- A total of 175 students took part in research campaigns in Pianosa Island from May 2014 to October 2019.
- Since 2014, more than 1,000 citizens per year have been directly or indirectly involved thanks to the echo effect of coastal surveys.
- Nearly 200 teachers have participated in the project each year together with their students.
- A total of 35 students from the Advanced BIOTeam worked together on the first records of alien species during the monitoring research campaigns in Pianosa Island in 2017 and 2019.
- A total of 53 students were selected as talented attendees for the PON-FSE “Global Citizenship Skills” project since “Percorsi nel Blu” was awarded a PON fund by MIUR in 2018–2019.
- Almost 1,700 students and families from ISA2 were involved in marine biodiversity dissemination in La Spezia (the 2011–2013 school years) having taken part in a project that was awarded the Saint Raphaël, Monaco, Genova (RAMOGE) “Alain Vatricain” special prize by the Principality of Monaco in 2013.
- A total of 235 high school students who participated in “Percorsi nel Blu” were selected for the PCTO school-work training course from 2016 to 2018;
- A total of 87% of the Advanced BIOTeam students chose to attend scientific high schools or pursue sci-

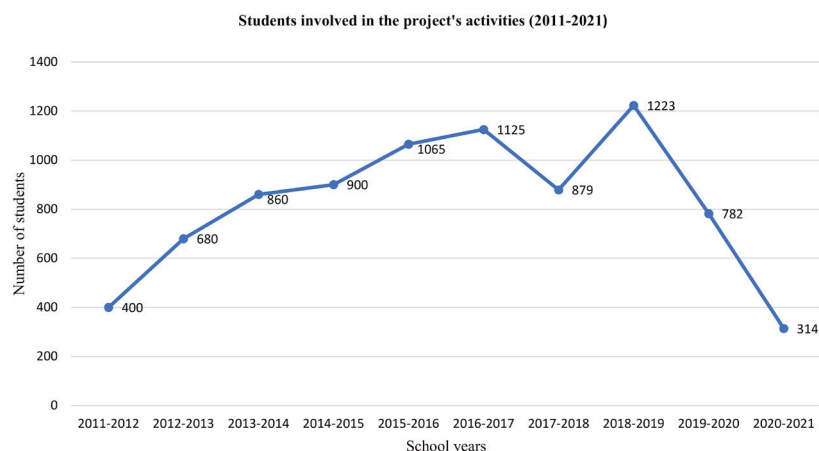
entific careers in STEM disciplines (2014–2021);

- A remarkable progression in the number of students involved in project activities has been recorded throughout the years (progression in Fig. 10). From 2011–12 to 2016–17, the number of participants has steadily grown, leading to an increase in coastal monitoring activities and events aimed at disseminating the project's results. During the 2017–18 school year, the intensification of research activity in collaboration with universities and institutions resulted in a slight decrease in the number of participants, but it enlarged and strengthened the school network. In fact, in the following school year (2018–19), “Percorsi nel Blu” managed to involve 1,223 students, the highest value ever registered since the beginning of the project. In the last two years, the COVID-19 pandemic has strongly impacted these activities: some of them were carried out online and only subsequently resumed in person with a limited number of students, but this has inevitably affected the number of students involved (782 in 2019–20 and 314 in 2020–21).

## Discussion

### *“The Percorsi nel Blu” project: global citizenship moving towards the Blue School model*

The outcomes of “Percorsi nel Blu” highlighted the effectiveness of an innovative educational approach to marine science education that integrates OL and MCS into school curricula and promotes the achievement of new skills in STEM disciplines in compliance with the goals of the 2030 Agenda. This educational format has enabled schools to develop many interdisciplinary connections between different subjects that are not strictly related to marine science, such as geography, Italian language, history, art, music and technology. This project also plays a key role in the development of global citizenship skills, which are fundamental for the next generation of students who will become citizens of the world and be called upon to promote sustainable interventions for the management of cultural and environmental heritage. In particular, the preservation of the coastal heritage of the Mediterranean Sea requires specific professional skills. That is because there is a need to overcome certain critical issues related to the fact that coastal areas suffer not only from depopulation, marine pollution and overloaded tourism (European Commission, 2021c) but also from the inadequacy of school education, which focuses only on theoretical learning without considering the acquisition of experience through field activities, thus leading to a lack of confidence in the marine environment (Blue Schools, 2019). These issues reveal the urgency of a profound innovation in education systems that can create the Blue School (Blue Schools, 2019), a new model for operating a school. This new model originated from the need to introduce the blue economy into school education in order to train and encourage future generations to protect the marine and coastal environment and foster economic



**Fig. 10:** 5–18-year-old students involved in the project from 2011 to 2021.

growth in coastal areas.

In Europe, the Blue School project is promoted by the European Ocean Coalition, a coalition that connects different organisations, projects and people and coordinates the Network of European Blue Schools with the support of the European Commission (European Commission, 2021a, b). At the moment, the European countries participating in the coalition are developing activities in accordance with their conception of the blue economy.

The “Escola Azul” (Escola Azul, 2021) in Portugal led by the Ministry of the Sea was one of the first schools that joined the Blue School network. It is supported by universities, governmental and non-governmental organisations, municipalities and companies. It promotes an integrated political strategy for marine education that is capable of engaging all sea sectors to improve the level of OL in the short and long term while focusing on the implementation of the 4<sup>th</sup>, 14<sup>th</sup> and 17<sup>th</sup> UN SDGs (quality education, life below water and partnerships for the goals) (Costa *et al.*, 2021). Additionally, the technological high school of Cannizzaro, a school in Italy, joined the Blue School programme in 2019. It focuses on the development of STEM disciplines and their application in practical contexts, such as biotechnology, electronics, computer science, mechanics and mechatronics. It aims to raise students’ awareness about the importance of marine protection and the blue economy and introduce them to professional and entrepreneurial opportunities in this field.

The Blue School project not only develops marine topics into school programmes but also requires that all school subjects focus on marine topics through a vertical and interdisciplinary approach. Furthermore, all schools participating in the project must define a well-trained team of teachers on the issues associated with the blue economy in order to set up projects for students that involve local actors and promote activities in partnership with other local and national institutions.

The Blue School encourages students to participate actively in society and engage with local institutions for the development of global citizenship. The “Percorsi nel Blu” project perfectly meets these criteria since its main goal is to develop global citizenship as a shared task

by involving the whole community inside and outside school, engaging students, parents and volunteers and encouraging them to learn more about marine environmental issues. Due to their advanced abilities, the participants have acquired a sense of responsibility over time and received stimulus and recognition for their efforts. This has enabled them to help their peers, both children and adults, as well as develop entrepreneurial and empathetic skills in a team based on co-planning and interpersonal cooperation. As a part of this project, students had the opportunity to move between cities to study different marine habitats and share their experiences. These activities made them aware of the fact that their studies and practices did not consist only of data collection but also represented a way to actively participate in society, thereby supporting the change towards a sustainable environment and blue economy according to the 13<sup>th</sup> and 14<sup>th</sup> SDGs. Students have grown together with the project and developed transversal skills that can be valuable in future along with a sense of commitment to research activities and responsibility towards the community. This has been promoted through mutual understanding between individuals and cultures in accordance with the 4<sup>th</sup>, 5<sup>th</sup> and 10<sup>th</sup> SDGs of the 2030 Agenda (education quality, gender equality and the reduction of inequalities). Due to the efforts of the students from the Advanced BIOTeam, who have been engaging citizens year after year, the project had a direct impact on the school community, led to better integration of STEM disciplines into school curricula and promoted the creation of professional scientific profiles in the marine sciences. It also had an indirect impact due to its echo effect: starting from students, this project reached parents, families, teachers, researchers and institutions.

Unlike other MCS projects, “Percorsi nel Blu” aims at preserving the human resources involved over time, allowing participants to intervene in the research phases. This approach allows all students and the entire community involved to feel like they are a part of a sustainable system that can effectively act to safeguard the environment and fight for the defence of its fragility. The acquisition of this powerful and innovative awareness enables students to strengthen their commitment as citizen scientists both inside and outside the team as well



as apply scientific transversal skills in everyday life and the working environment. “Percorsi nel Blu” constantly involves large numbers of participants who remain connected to the project over time, thereby contributing to the maintenance of a scholastic-scientific community. Such a community attests to the achievements of the project at the national and international level in a meaningful and tangible way and enhances its role as the model Italian Blue School. Thus, “Percorsi nel Blu” develops the Blue School principles through the investigation of ocean issues, encourages students to actively participate in the creation of a more sustainable future and involves local and national institutions. However, for further improvement of the project, a few challenges need to be addressed, such as ensuring greater support for teams of teachers and promoting their skills through an interdisciplinary approach. Finally, it should be mentioned that future scenarios will multiply the project’s effects on the community by strengthening partnerships with schools and involving more and more actors.

“Percorsi nel Blu” is a dynamic project which engages students and citizens in the analysis of different scenarios in coastal monitoring activities, thereby facilitating and accelerating the development of the awareness about climate change due to the creation of a wider and deeper body of knowledge on the related issues. The key role of the project in relation to marine science dissemination lies in its power to encourage students to respect their commitment as citizen-scientists, leading to a domino effect on the whole community.

## Acknowledgements

I would like to thank all the volunteers who participated in the project: students, families, and passionate teachers from the BIOTeam, the Advanced BIOTeam, scuba operators and assistants (Roberto Traverso, Daniele Moggia, Fabrizio Maramotti, Mario Scimone, Emanuela Casella, Silvio Guani and Anna Canepa). Their commitment and perseverance have supported the progress of the project and the achievement of its goals. I would like to express my gratitude to the godmothers of “Percorsi nel Blu”, the headteachers Antonella Minucci and Sandra Fabiani, who allowed the project to take its first steps and encouraged its rapid development. Further, I am thankful to teachers Maria Grazia Taliercio, Orsola Velo, and Antonella Ranieri as well as the entire community of which the project is a part: headteachers, teachers and tutors of PCTO, Silvia Merlino (National Research Council - Institute of Marine Science, CNR-ISMAR of La Spezia), Anna Maria Mannino (STEBICEF department of the University of Palermo), Giulia Furfaro (DiSTeBA department of the University of Salento), Marina Locritani (National Institute of Geophysics and Volcanology, INGV of La Spezia), Paolo Balistreri, Mascha Stroobant and the other researchers who contributed to this in partnership along with MIUR institutions, the R-NOEMS, marine parks and the “Life on the Sea” and “Amici dell’Isola del Tino” voluntary associations. I would also like to thank

the two reviewers for their valuable comments, Anna Maria Mannino for her final review of the references and Stefano Federici for the photo editing. Finally, I am especially thankful to Alessia Del Santo for the English language revision.

## References

- Blue Schools, 2019. <http://www.blue-schools.eu/en/the-blue-schools-concept/> (Accessed 16 September 2021)
- Castoldi, M., 2013. *Curricolo per competenze: percorsi e strumenti*. Carocci, Roma, 276 pp.
- Cava, F., Schoedinger, S., Strang, C., Tuddenham, C., 2005. *Science content and standards for ocean literacy: a report on ocean literacy*. [http://www.coexploration.org/oceanliteracy/documents/OLit200405\\_Final\\_Report.pdf](http://www.coexploration.org/oceanliteracy/documents/OLit200405_Final_Report.pdf). (Accessed 26 September 2021)
- Cerrano, C., Di Camillo, C.G., Milanese, M., Previati, M., Rossi, G. *et al.*, 2012. Education through participation: The role of citizen science in marine habitat conservation. In: *PIXEL New Perspectives in Science Education International Conference, 1<sup>st</sup> edition, Florence, Italy, March 8-9*. Simonelli Ed., University Press. [https://conference.pixel-online.net/conferences/science/common/download/Paper\\_pdf/204-SEP14-FP-Cerrano-NPSE2012.pdf](https://conference.pixel-online.net/conferences/science/common/download/Paper_pdf/204-SEP14-FP-Cerrano-NPSE2012.pdf) (Accessed 15 October 2021)
- Collins, J., 2004. Education techniques for lifelong learning. *RadioGraphics*, 24 (5), 1483-1489.
- Copejans, E., Crouch, F., Fauville, G., 2012. The European marine science educators association (EMSEA): towards a more ocean literate Europe. *The Journal of Marine Education*, 28 (2), 43-46.
- Cortellini, G., Mazzoni, A., 2001. *L'insegnamento delle Scienze verso un Curricolo verticale. Un approccio costruttivista nella scuola di base. I fenomeni biologici*. Istituto Regionale Sperimentazione ed Aggiornamento Educativi -IRSAE Abruzzo. Editoriale Eco srl, S. Gabriele (TE), 2, 233 pp.
- Costa, R.L., Mata, B., Silva, F., Conceição, P., Guimarães, L., 2021. Fostering ocean-literate generations: the Portuguese Blue School. p. 241-273. In: *Ocean Literacy: understanding the Ocean*. Koutsopoulos, K.C., Stel, J.H. (Eds). Key Challenges in Geography (EUROGEO Book Series). Springer, Cham.
- Damasio, A.R., 1994. *Descartes' error: emotion, reason and the human brain*. Grosset / Putnam, New York, NY, 331 pp.
- Davies, L., Harber, C., Yamashita, L., 2004. *The needs of teachers and learners in global citizenship*. University of Birmingham, Centre for Educational Research, Edgbaston, Birmingham, UK, Report of DFID funded project, 189 pp.
- Dupont, S., Fauville, G., 2017. Ocean literacy as a key toward sustainable development and ocean governance. p. 519-537. In: *Handbook on the Economics and Management of Sustainable Oceans*. Nunes, P., Svensson, L.E., Markandya, A. (Eds). Edward Elgar Publishers & UNEP, Cheltenham, UK.
- EMSEA, 2021. *European Marine Science Educators Association*. <http://www.emsea.eu/> (Accessed 2 May 2021)
- Escola Azul, 2021. Blue School. Ministério do Mar. Lisboa, Portugal. <https://escolaazul.pt/en> (Accessed 2 May 2021)

- European Commission, 2021a. *EU4 Ocean Coalition, European Union*. <https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1482> (Accessed 1 October 2021)
- European Commission, 2021b. *Network of European Blue Schools*. <https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1485> (Accessed 1 October 2021)
- European Commission, 2021c. *The EU Blue Economy Report*. Publications Office of the European Union. Luxembourg, 178 pp. [https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/the-eu-blue-economy-report-2021\\_en.pdf](https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/the-eu-blue-economy-report-2021_en.pdf) (Accessed 3 October 2021)
- Fauville, G., Copejans, E., Crouch, F., 2013. European marine educators, unite! Europe's quest for a more ocean-oriented society and economy. *The Marine Biologist*, 1, 30-31.
- Fauville, G., 2017. *Digital technologies as support for learning about the marine environment: Steps toward ocean literacy*. Doctoral Thesis. University of Gothenburg, Sweden, 167 pp.
- Fauville, G., 2019. Ocean literacy in the twenty-first century. p. 3-11. In: *Exemplary practices in marine science education. a resource for practitioners and researchers*. Fauville G., Payne, D., Marrero, M., Lantz-Andersson, A., Crouch, F. (Eds). Springer, Cham.
- Garcia-Soto, C., van der Meeren, G.I., Busch, J.A., Delany, J., Domegan, C. et al., 2017. *Advancing Citizen Science for Coastal and Ocean Research. Position Paper 23*. French, V., Kellett, P., Delany, J., McDonough, N., (Eds). European Marine Board, European Science Foundation, Ostend, Belgium. 112 pp.
- Lin, Y.-L., Wu, L.-Y., Tsai, L.-T., Chang, C.-C., 2020. The beginning of marine sustainability: preliminary results of measuring students' marine knowledge and ocean literacy. *Sustainability*, MDPI, 12 (17), 1-18.
- MATTM, Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2015. *Linee guida per l'Educazione ambientale*. [https://www.minambiente.it/sites/default/files/archivio/allegati/LINEE\\_GUIDA.pdf](https://www.minambiente.it/sites/default/files/archivio/allegati/LINEE_GUIDA.pdf) (Accessed 2 May 2021)
- Merlino, S., Locritani, M., Mioni, E., Vignali, L., 2019. Shortening the distance between students and ocean challenges. *The Journal of Ocean Technology*, 14 (2), 43-56.
- Mioni, E., Merlino, S., Giovacchini, A., 2016. Engaging way to help students develop skills, interest and methodological research approaches in marine and environmental science. p. 400-408. In: *Advances in higher education*. de la Poza, E., Domènech, J., Lloret, J., Vincent-Vela, M.C., Zuriaga, E. (Eds). Editorial Universitat Politècnica de València, València.
- Mioni, E., Stroobant, M., Locritani, M., Merlino, S., Traverso, R., 2017. Blue Paths: 5 years motivating the participation of citizens in research activities for coastal monitoring of the Benthos. p. 64. In: *First Citizen Science Conference, Rome, 23-25 November 2017*. Italy.
- Mioni, E., Mannino, A.M., Merlino, S., 2018. First record of *Aplysia dactylomela* (Rang, 1828) (Heterobranchia, Aplysiidae) from the island of Pianosa (Alto Tirreno). p. 224. In: *Conference of the Italian Society of Marine Biology SIBM*, Cesenatico, 4-8 June 2018. Italy.
- Mioni, E., Merlino, S., Balistreri, P., Mannino, A.M., 2020. First record of the invasive crab *Percnon gibbesi* (H. Milne Edwards, 1853) at Pianosa Island: the second goal reached by the innovative Marine Citizen Science Literacy Project "PERCORSI NEL BLU" ("BLUE PATHS"). p. 150. In: *11th International Conference on Biological Invasions*, Vodice, 15-18 September 2020. Croatia.
- Mioni, E., Furfaro, G., Merlino, S., Mannino, A.M., 2021. Project "Percorsi nel Blu": Ocean Literacy & Citizen Science as a valid tool to monitor Marine Heterobranchia. the case study of the first records of the alien species *Favorinus ghanensis* and the Mediterranean *Okenia* cf. *longiductis*, as updating records for the Italian coast. In: *EMSEA Virtual Conference 2021*, Gdynia, 7-8 October 2021. Poland.
- MIUR, Ministero dell'Istruzione, dell'Università e della Ricerca, 2012. Indicazioni nazionali per il curricolo della scuola dell'infanzia e del primo ciclo d'istruzione, *Annali della Pubblica Istruzione, Numero Speciale*. Anno LXXXVIII. Le Monnier, Firenze, 97 pp. [http://www.indicazioninazionali.it/wp-content/uploads/2018/08/Indicazioni\\_Annali\\_Definitivo.pdf](http://www.indicazioninazionali.it/wp-content/uploads/2018/08/Indicazioni_Annali_Definitivo.pdf) (Accessed 17 September 2021)
- MIUR, Ministero dell'Istruzione, dell'Università e della Ricerca, 2018. *Percorsi per le Competenze Trasversali e per l'Orientamento (PCTO). Linee Guida*. <https://www.miur.gov.it/documents/20182/1306025/Linee+guida+PC+TO+con+allegati.pdf> (Accessed 5 March 2021)
- MIUR, Ministero dell'Istruzione, dell'Università e della Ricerca, 2019. *Linee guida per l'Educazione civica*. [https://www.miur.gov.it/documents/20182/0/ALL.+Linee\\_guida\\_educazione\\_civica\\_dopoCSPI.pdf/8ed02589-e25e-1aed-1afb-291ce7cd119e?t=1592916355306](https://www.miur.gov.it/documents/20182/0/ALL.+Linee_guida_educazione_civica_dopoCSPI.pdf/8ed02589-e25e-1aed-1afb-291ce7cd119e?t=1592916355306) (Accessed 2 May 2021)
- Myers, J.P., 2006. Rethinking the social studies curriculum in the context of globalization: education for global citizenship in the U.S. *Theory and Research in Social Education*, 34 (93), 370-394.
- Ocean Literacy, 2005. *The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages*. <https://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf> (Accessed 5 May 2021)
- Piano S & T MIUR, 2021. <https://www.miur.gov.it/piano-s-t> (Accessed 1 April 2021)
- Pola, M., Paz-Sedano, S., Macali, A., Minchin, D., Marchini, A. et al., 2019. What is really out there? review of the genus *Okenia* Menke, 1830 (Nudibranchia: Goniadorididae) in the Mediterranean Sea with description of two new species. *PLoS ONE*, 14 (5): e0215037.
- PON Homepage MIUR, 2021. <https://www.istruzione.it/pon/> (Accessed 25 September 2021)
- Squarcina, E., Pecorelli, V., 2017. Ocean citizenship. the time to adopt a useful concept for environmental teaching and citizenship is now. *Journal of Research and Didactics in Geography (J-READING)*, 2, 45-53.
- Sustainable Development Goals, 2021. <https://www.un.org/sustainabledevelopment/development-agenda/> (Accessed 17 October 2021)
- Wang, H.H., Charoenmuang, M., Knobloch, N.A., Tormoehlen, R.L., 2020. Defining interdisciplinary collaboration based on high school teachers' beliefs and practices of STEM integration using a complex designed system. *IJ STEM Ed*, 7 (3).