# Bibliometric analysis of ocean literacy: An underrated term in the scientific literature

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## ARTICLE INFO

## ABSTRACT

Since the term "ocean literacy" (OL) was proposed in 2004 by a group of professionals dedicated to ocean sciences, marine education, and general education policies, its principles have spread worldwide. In order to better understand OL-related research a bibliometric analysis was performed with data from databases obtained from Scopus and Web of Science (WoS). Fifty-two publications matched the search criteria (articles and conference papers with OL as part of title, keywords and/or abstract). Analysed parameters included the document types, publishing outlets, authors, countries, institutes, author keywords and title words. The term OL in scientific publications has been quantitatively dominated by the United States of America (USA), followed by the United Kingdom (UK) and Canada. The UK and Italy were the countries with the most international collaborative publications on this theme. In addition, the UK was the country that established the most international collaborations. National Oceanic and Atmospheric Administration (NOAA) was the most productive institution and the Proceedings of the MTS/IEEE OCEANS 2005 was the publishing outlet containing the most publications. The analysis has also revealed the intrinsic link between science and OL, the use of questionnaires to evaluate the level of citizens' knowledge, values and awareness about marine issues, and the emphasis placed on educational approaches to improve OL.

## 1. Introduction

The term ocean literacy (OL) is defined as the understanding of the ocean's influence on humans and of our influence on the ocean [1]. The initial discussions around this idea began in the United States of America (USA) in 2004, with the engagement of representatives from several ocean-related areas (educators, researchers and policymakers) [2,3]. The participants were concerned with the lack of public awareness about the importance of oceans and with the absence of ocean topics in the American school curriculum. A series of workshops were organised to discuss what should be understood by Americans about the ocean by the end of high school [3]. The result was the development of a framework comprising a guide entitled "Ocean Literacy – The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages" (1st version published in 2005 and 2nd version in 2013) [4] and the start of a national campaign in the USA aimed at achieving an ocean-literate society. The guide identifies seven essential principles (Table 1) and 44 fundamental concepts that students should know by the end of Grade 12. A more detailed document, named "Ocean Literacy Scope and Sequence for Grades K-12″, was also produced in order to detail how educators could help learners build their understanding of the seven Ocean Literacy Principles [5]. Those guidelines, developed to help implement an ocean-dedicated curriculum in the USA, are now largely accepted and have been an inspiration for several initiatives worldwide. Some countries adopted the OL principles and developed new approaches adapted to their reality. Portugal was one of the first countries to adopt the USA OL guides through the initiative "Conhecer o Oceano" ("Knowing the Ocean"), engaging scientists and educators alike (http://www.cienciaviva.pt/oceano/home/). Also, museums, aquariums, and science centres have been restructuring their programs, exhibitions, and activities to incorporate the OL guidelines [6–8].

**Table 1**
The essential principles of ocean literacy.

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|---|
| 1. The Earth has one big ocean with many features |
| 2. The ocean and life in the ocean shape the features of Earth |
| 3. The ocean is a major influence on weather and climate |
| 4. The ocean makes 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 |

To achieve an ocean-literate society, the OL principles and concepts should be integrated not only into educational practice, curricula, and textbooks but also in regulations and scientific research [2,9–11]. Some regulations which are essential to implementing responsible ocean policies and management strategies, are currently embedding OL and are aligned with its core principles, although not always explicitly using the term (e.g. Marine Framework Strategy Directive; Blue Growth Strategy; Marine Spatial Planning Directive; Common Fisheries Policy; Birds Directive; and Habitats Directive), as discussed in [10]. Furthermore, at European policy level, the European Union (EU), USA, and Canada signed a transatlantic ocean research alliance that explicitly identified OL as one of the key areas for cooperation among marine scientists [12]. EU awareness of OL is also evident in the recent calls for OL-dedicated projects. For instance, in 2013 it was included in the "Research and Innovation Funding Program – Horizon 2020". In fact, a specific call was dedicated to the topic "Ocean literacy – Engaging with Society" [13]. One of the funded initiatives was the Sea Change project, which targeted its intervention at three main societal groups: the general public, formal educators, and policy makers [14] (http://www.seachangeproject.eu/).

Individual behaviour changes are also essential to ensuring the sustainable use of the ocean and its resources [15]. Anthropogenic pressures demand an urgent change of human behaviours that is only possible if each citizen understands the ocean's vital role, i.e., if each citizen becomes ocean-literate [13,16]. Additionally, enhancing public knowledge and awareness will lead to increased public support for ocean restoration and/or conservation efforts [7,10].

Twelve years after the original OL proposal, it is important to review what has been published as well as to determine what progress has been made. To this end, the present study aims to perform a bibliometric analysis on the term OL, thus providing an overview of the research works' features. It also attempts to identify trends and gaps that could orient future studies. The main objectives were: a) to analyse the OL literature growth over time; b) to identify the countries, institutions, publishing outlets, and authors publishing on OL; c) to identify the collaborations established among countries and among institutions to implement OL initiatives and/or to publish OL studies; d) to identify research trends and gaps on this topic.

## 2. Materials and methods

### 2.1. Data collection

The study was conducted during February 2017 through a bibliographic survey using the Scopus and Web of Science (WoS) multidisciplinary databases. Publications were searched from the databases' custom data (from 1900 to 2016 in WoS and from 1960 to 2016 in Scopus) using OL as search criteria. The documents where OL appeared in the title, keywords, and/or abstract were included in the study.

The search resulted in 93 records, all written in English. After removing duplicates in our in-house database, 62 records belonging to different document types remained: 32 articles (61.5%), 20 conference papers (38.5%); 3 notes (5.8%); 3 editorial materials (5.8%); 1 book (1.9%); 1 book chapter (1.9%); 1 conference review (1.9%); and 1 meeting abstract (1.9%). Taking into consideration the

representativeness of different publication types, 52 records belonging to the article and conference paper categories were selected for further analysis.

### 2.2. Data management and analysis

Bibliometric approaches have been widely accepted for evaluating several research topics (e.g. methods, trends, preeminent authors) in most areas of expertise, from natural (e.g. [17,18,19]) to social sciences (e.g. [20–22]. In the present bibliometric study, performance analysis and science mapping [23] were used as procedures to evaluate the publications' characteristics and to display some content features. The focus was placed in the document types, publishing outlets, authors, countries, institutions, author keywords, and title words.

The contributions of institutions and countries were estimated using author affiliations and addresses. Each journal's Impact Factor (IF) was obtained from InCites™ Journal Citation Reports® (Thomson Reuters, Philadelphia, PA) and refers to the year 2015. The term "single country publication" was assigned to outputs of authors from the same country and "single institutional publication" was assigned when the researchers' addresses were from the same institution, even though they belonged to different departments. "National inter-institutional collaborative publication" was used to designate works co-authored by researchers from multiple institutions, but all from the same country, and "international collaborative publication" was assigned for publications with authors from multiple countries. Pairs of collaborative countries and pairs of collaborative institutions were identified through maps based in co-occurrences and drawn in Pajek software.

Pajek is an open source program used for analysis and visualisation of large networks [24]. The data inserted into Pajek was previously obtained with Bibexcel, a free software frequently used to perform bibliometric analysis and to prepare data for mapping in other appropriate software [25]. Further visual improvements were made in Pajek maps.

Title word and author keyword analysis is a relatively simple method to perform content studies to reveal the main topics and trends emerging from the research data. In the present study, the list of words used in the publications' titles and the frequency of their presence (prepositions and other stop words removed) was obtained using the Bibexcel software. First Bibexcel separates the titles into single words and then ranks them according to their frequency. The list obtained was further examined in order to identify and group similar words (ex. engage/engagement, impact/impacts). Author keywords (available only in 24 of the 52 publications) were also obtained with Bibexcel. The same software was used to extract author, institution, and country frequencies from our database.

## 3. Results and discussion

### 3.1. Publication characteristics through time

Searching by OL on Scopus and WoS returned 52 publications meeting our criteria (32 articles and 20 conference papers, duplicates excluded). The first records were found in the year 2005 (2 articles and 6 conference papers) (Fig. 1). This finding was expected because the concept was initially proposed in late 2004 with a subsequent OL campaign initiated thereafter.

Assuming that journals and conferences are the main tools in disseminating scientific research results, it may be posited that the pattern of publication in those diffusion media could give us an indication of the themes' importance within the academic research community. Additionally, it could be an indicator of the funding allocated to the research theme, since the number of publications, and their impact, are widely regarded as a useful method of demonstrating the investment return of research and institutional funding [26]. In this case, the number of publications was considerably low and widely variable