# Trend oceanography research for enhancing ocean literacy to support sustainable development goals (SDGs): A systematic literature review

*Nurul* Asikin[1,2*], *Hadi* Suwono[2], *Agus* Dharmawan[2], *Annisa* Qadri Tanjung[3]

[1]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Maritim Raja Ali Haji, Tanjungpinang 29411, Indonesia
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang 65111, Indonesia
[3]Graduate School of Elementary Education, Universitas Negeri Malang, Malang 65111, Indonesia

**Abstract.** The ocean, as the most extensive ecosystem on the planet, holds significant importance in environmental sustainability. This study aims to review and compare research investigations into articles regarding oceanography research through a systematic literature review (SLR). This SLR follows the five-step procedures Denyer and Tranfield (2009) proposed. A search was conducted in the Scopus database using the terms "oceanography, ocean literacy (OL), and the Sustainable Development Goals (SDGs)" in the disbursement menu, resulting in the retrieval of 145 articles. In addition, 20 papers satisfied the established criteria for analysis. The findings of this observation article are in the form of research trends regarding oceanography research. Most oceanography research is in the distribution year category 2022 (5 articles). Most prominent authors originate from the United Kingdom (9 articles) and America (8 articles). Collaborative research is more common (85%). Most research articles are published in the journal Marine Policy. The dominant fields of study are Social Sciences (45%) and Environmental Sciences (30%). Oceanography research has a very important role in increasing OL and Supporting the attainment of SDGs, especially SDG 14, which emphasizes the need to protect and utilize marine resources sustainably.
**Keywords:** oceanography, ocean literacy, sustainable development goals, systematic literature review

## 1 Introduction

The ocean is a significant ecosystem that plays a crucial part in maintaining the balance of the Earth and sustaining life across the globe [1–3]. Marine biodiversity creates complex food webs and maintains rich biodiversity, from microorganisms to giant mammals [4,5]. The oceans also provide important human resources, including fish and seafood, and nonfood

*Corresponding author: nurul_asikin@umrah.ac.id

resources, such as petroleum and minerals [6,7]. In addition, the ocean's role in regulating global climate through the absorption of carbon dioxide and its influence on world weather cannot be ignored [8]. Protecting and managing the ocean in a sustainable way is essential to preserving the delicate ecological balance on this planet. This ensures that future generations will be able to reap the advantages of the ocean and benefit from its vital functions. One way to protect and sustainably manage the sea is by conducting oceanography research [9,10].

Oceanography research is urgently needed because the ocean is vital to our planetary system [11]. Oceans not only cover most of the Earth's surface but also have a significant impact on our lives [12]. Oceanography research allows us to understand the dynamics of the ocean better, the biodiversity within it [4], ongoing climate change [13], and the effect that human activities have on ecosystems found in marine environments [14]. Research in the field of oceanography has a crucial role in increasing ocean literacy [15]. Through this research, we understand the ocean and its ecosystem more deeply, uncover the mysteries hidden in ocean depths, and identify the effect of human activities and climate change on marine ecosystems [3,16]. The information and findings obtained from this research are not only for scientific circles but are also used to educate and make the wider community aware of the importance of protecting and caring for the sea. Research data fill knowledge gaps, enrich the general understanding of the oceans, and provide the basis for educational programs to increase ocean literacy [17,18].

Ocean literacy is defined as "an understanding of the influence of the ocean on you and your influence on the ocean" [3,10], which means "people who are marine literate can understand important principles about the ocean so that they can communicate about the ocean in a meaningful and capable way. Take decisions and be responsible regarding the sea and the resources therein" [19–21]. Ocean literacy consists of seven principles [20,21]: 1) the Earth has one large ocean with many features; 2) the ocean and life in the ocean shape the features of Earth; 3) the ocean has 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; and 7) the ocean is largely unexplored. The main aim of ocean literacy, as a means of promoting the SDGs, is to provide individuals with knowledge and empowerment to make well-informed and responsible choices regarding marine resources and sustainability [20,22].

The field of oceanography significantly contributes to the advancement of the SDGs because the ocean is an integral component in maintaining global environmental balance [1,4]. SDG 14, in particular, emphasizes the need to safeguard and sustainably utilize marine resources and marine ecosystems. Through oceanography research, we can deepen our understanding of marine ecosystems, understand the changes that occur in them, and identify ways to protect and care for them. In addition, oceanography research plays a crucial role in acquiring the essential data required for the sustainable management of marine resources while fostering public awareness of the need to safeguard the maritime environment [1]. Increasing ocean literacy through oceanography research also provides understanding. It creates public awareness about protecting the marine environment and contributes to education and training (SDG 4) that supports sustainable development [18,20]. This study also contributes to the comprehension of the influence of climate change on marine ecosystems and their potential as a mitigating factor for climate change (SDG 13) [1,23]. International collaboration in oceanography research strengthens global efforts to achieve the SDGs. In contrast, technological innovations from this research can be used for better monitoring and managing marine resources (SDG 9) [1]. Thus, oceanography research has a profound impact on supporting efforts toward sustainable development and preserving marine ecosystems for future generations.

This research is based on an investigation conducted using the Scopus database, with the keywords "oceanography research, ocean literacy, and Sustainable Development Goals"

from 2013 to September 2023; 145 articles (all years) were obtained. A comprehensive analysis of these articles is required to identify prevailing publication trends during that period. This analysis should encompass several factors such as the distribution year and keywords, the nationality of the authors and their involvement in international collaborations, as well as the categorization of journals and subject areas. In addition to examining publication patterns, we also assess the significance of oceanography research in promoting ocean literacy and its contribution to the SDGs. Conducting a SLR is often regarded as one of the most highly recommended strategies for study and analysis [24].

To date, several SLR-based articles related to oceanography research have been published. The first article is about the framework system of marine sustainable development assessment [25]. The second article focuses on examining gaps, problems, and options pertaining to advancing social sustainability within the context of marine spatial planning (MSP). This examination is based on a comprehensive evaluation of the scientific literature published between 2005 and 2020 [26]. The third article concerns the challenges and opportunities of the blue economy and the UN's SDGs. This analysis is based on an extensive literature survey spanning 1998 to 2018 [27]. However, no SLR is focused on oceanography research that can accommodate ocean literacy in supporting the SDGs.

Therefore, the objective of this SLR is to critically evaluate and analyze a range of scholarly publications published in journals in oceanography research. Specifically, this study examines the connection between ocean literacy and its contribution to achieving the SDGs. The expectation is that this SLR will make a valuable contribution to the advancement of oceanography research investigations, thereby establishing itself as a reputable source of information for researchers and readers. Our primary objective is to disseminate original scholarly publications on oceanography research and its consequential impact, particularly in promoting ocean literacy and its role in supporting the SDGs. This unique endeavor distinguishes our research from previous studies and establishes a foundational framework for further investigations. The scope of information considered in this review is limited to research publications and original studies. This approach allows for examining the breadth and consistency of researchers' perspectives and interests within the chosen theme. This study establishes a correlation between oceanography research and ocean literacy principles and SDGs. Consequently, it has the potential to serve as a valuable resource for researchers, educational practitioners, and the general public in recognizing the significance of oceanography research in sustainably safeguarding the oceans going forward. We hope our SLR will contribute to the existing body of research, serving as a reference point for academics and readers interested in the issues we have reviewed.

## 2 Method

The main aim of an SLR is to comprehensively gather all available information in order to address a specific research inquiry pertaining to a certain subject matter. The process entails conducting a replicable and comprehensive literature review and rigorous assessment of relevant studies [28,29]. SLR is a rigorous approach to reviewing and reflecting on existing scholarly works. It encompasses several strategies to discover, disseminate, and analyze the most recent and pertinent information available in the literature and references. The primary objective of an SLR is to address research topics comprehensively and examine them in a meticulous manner [30,31]. This SLR follows the five-step recommendations proposed by Denyer and Tranfield [32] (Figure 1); these methods have also been employed by other researchers, including Han et al. [29] and Husamah et al. [33].

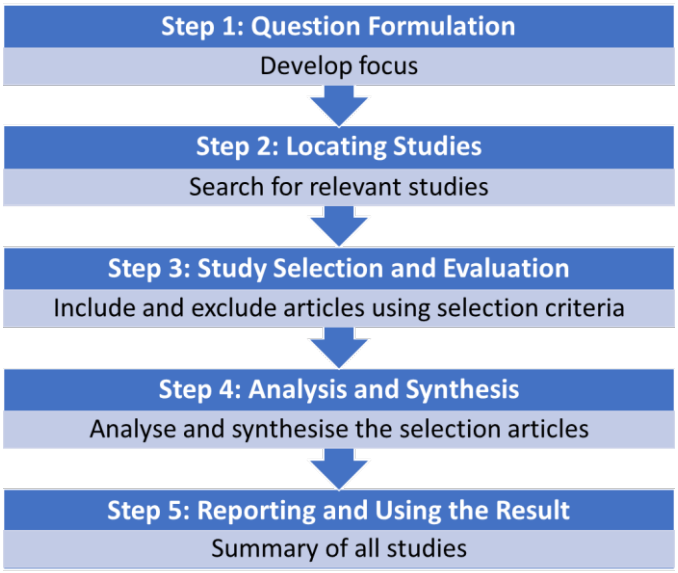


**Fig. 1.** Five steps of an SLR, adapted from Denyer and Tranfield (2009) [32]

### 2.1 Step 1: question formulation

The first step in SLR is to determine a clear scope and focus of research so that the research carried out is more focused and systematic [29,30,32]. This research aims to identify trends in oceanography research publications to increase ocean literacy in supporting SDGs. Therefore, this study posits and endeavors to address inquiries pertinent to the subject matter. The formulation of this question was derived from the specific requirements of the chosen subject matter, namely:

- Q1: What are the publication trends with the theme of oceanography research and ocean literacy to support the SDGs based on distribution years and keywords?
- Q2: What are the publication trends surrounding oceanography research and ocean literacy in support of the SDGs, based on the nationality of the author and international collaboration?
- Q3: What are the publication trends with the theme of oceanography research and ocean literacy to support the SDGs based on Journal and subject areas?
- Q4: How is oceanography research linked to enhancing ocean literacy to support the SDGs?

### 2.2 Step 2: Locating studies

The second step in SLR is finding, selecting, assessing, and creating a list of core contributions related to the research question [29,32]. This research's main source and information comes from the Scopus database. The selection of these databases was predicated upon their availability within academic institutions and ease of accessibility. Furthermore, these databases have been previously examined in comparable studies [29]. The target of this research is the keywords "oceanography, ocean literacy, and Sustainable Development Goals." These keywords are used to search for articles in the Scopus database search menu from 2013 to September 2023. The collected data is stored in both CSV and RIS file formats and then synchronized with the reference management software Mendeley. The VOS-viewer

software enables the visual representation of data, improving its comprehensibility and communicative effectiveness.

### 2.3 Step 3: study selection and evaluation

The study selection process involved the inclusion and exclusion of published publications deemed pertinent to the investigation. Using the vocabulary above and the search criteria, 145 scholarly papers were successfully identified. A total of 20 papers were identified as meeting the inclusion and exclusion criteria outlined in Figure 2 for this SLR investigation. The subsequent significant factors serve as the foundation for the inclusion and exclusion criteria employed in this SLR, specifically:

(1) publications, including research/original articles;
(2) articles published in English;
(3) articles published in the last 11 years, from 2013 to 2023;
(4) only open-access articles;
(5) articles only related to research on "oceanography, ocean literacy, and sustainable development goals."

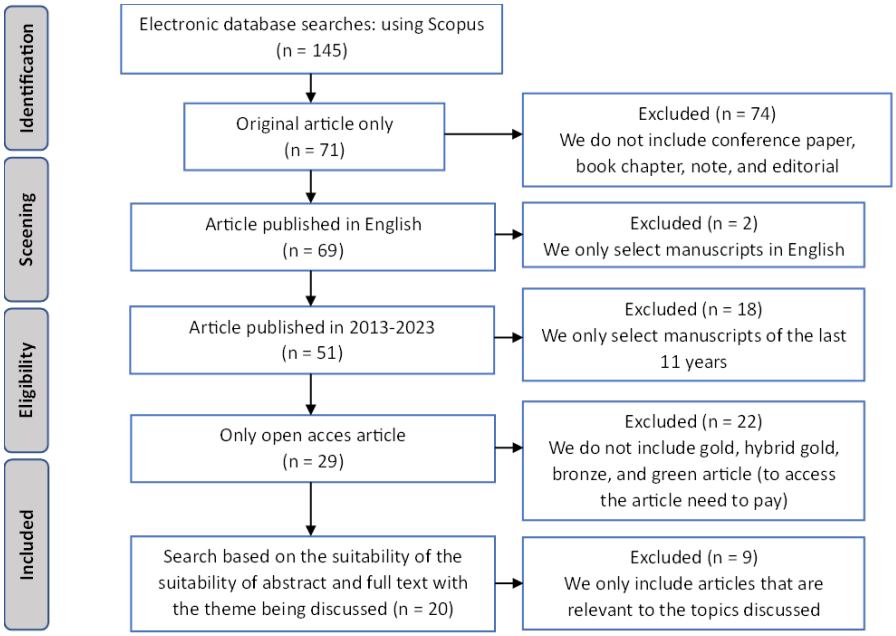


**Fig. 2.** Flowchart of the search and selection process.

## 3 Finding

### 3.1 Publication trends oceanography research

Publication trends regarding oceanography research can be identified based on the categories distribution year and keywords, Author's nationality and international collaboration, journal, and subject areas. Here are some ways to identify publication trends in oceanography research based on the categories mentioned.

### 3.1.1 Distribution year and keywords

Analysis of publication trends can be started by looking at the distribution of publication years. This will explain whether oceanography publications have increased or decreased over time. There is an increasing trend in research on oceanography from 2013 to 2023, with a total of 20 articles. In 2013 and 2014, only 1 article was published. In 2015-2017, there was no research related to oceanography. In 2018-2021, there were fluctuations in article publication. 2022, there will be an increase, and the most articles will be published compared to the previous year, namely, 5 articles. In 2023, 4 articles were found to be published. This could increase article publications because the search for articles was carried out until September 2023. Thus, there is an increasing research trend in oceanography research. Figure 3 illustrates the annual publication count of articles.

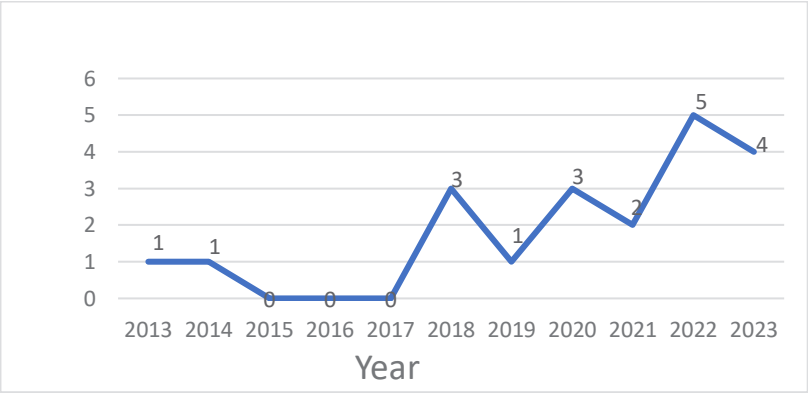


**Fig. 3.** Distribution year of articles

The results of trend keyword analysis from oceanography research and ocean literacy to support SDGs show that the keywords used are sustainable development, ocean science, and ocean literacy. The keyword "sustainable development" shows that this topic is the main focus of oceanography research. Figure 4 shows the VOSViewer output results regarding trend keywords from oceanography research.

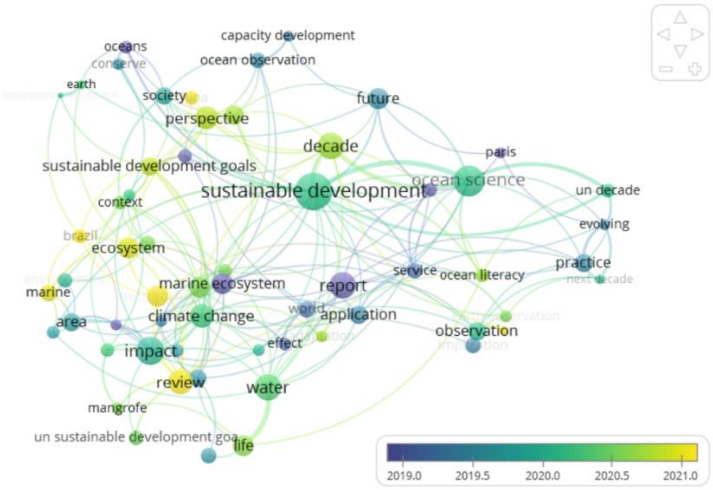


**Fig. 4.** The VOS viewer shows the "Co-occurrence → keywords" type of research

### 3.1.2 Author's nationality and international collaboration

Based on the author's nationality trend in oceanography study themes, the author is from 19 different countries. The United Kingdom, the United States of America, Japan, Switzerland, and France are the top five countries in the number of publications on oceanography research themes. The United Kingdom leads with nine articles, followed closely by the United States of America with eight articles. Japan, Switzerland, and France each have two articles published in this field. Europe is the primary contributor of authors in oceanographic research, accounting for the majority share of 50% based on continental distribution, followed by America at 30% and Asia at 10%. Meanwhile, Australia and Africa only account for 5%. The national trends of research authors related to the "oceanography research" theme are presented in Table 1.

**Table 1.** Country of the author and continental on oceanography research topics

| Country | Continent | Amount |
|---|---|---|
| United Kingdom | Europe | 9 |
| USA | America | 8 |
| Japan | Asia | 2 |
| Switzerland | Europe | 2 |
| France | Europe | 2 |
| Canada | America | 1 |
| Mexico | America | 1 |
| Norway | Europe | 2 |
| Belgium | Europe | 1 |
| German | Europe | 1 |
| Australia | Australia | 2 |
| Venezuela | Europe | 1 |
| South Africa | Africa | 2 |
| Brazil | America | 1 |
| Oman | Asia | 1 |
| Denmark | Europe | 1 |
| Netherlands | Europe | 1 |
| Russia | Asia | 1 |
| Uruguay | America | 1 |

The analysis of the trend in international collaboration within the field of oceanography reveals a notable increase in the number of articles published through collaborative efforts, with 10 articles identified. Collaboration within one country (7 articles). Only 3 articles did not collaborate in research related to oceanography themes. Figure 5 illustrates the extent of collaboration among authors in the publication of articles, encompassing cross-country collaboration, collaboration between colleges within a single nation, and instances when no collaboration occurred.

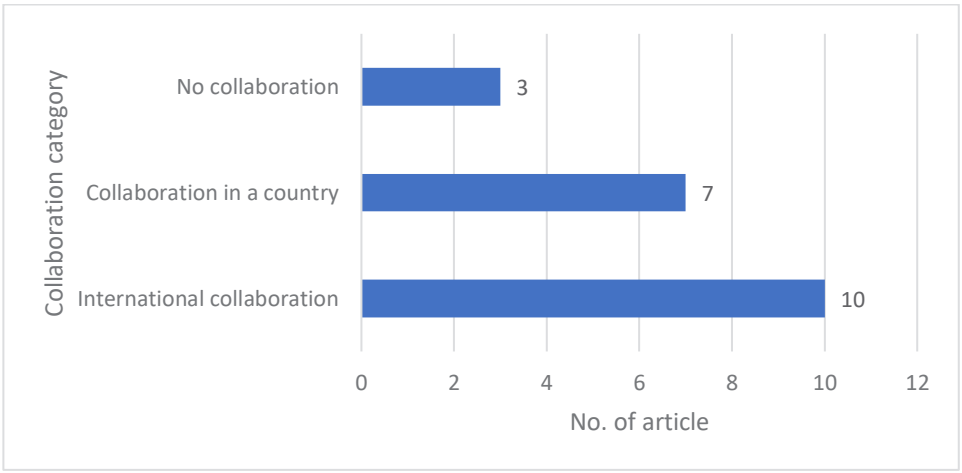


**Fig. 5.** Author collaboration in writing articles

If we review the 20 articles found (as presented in Figure 6), we will conclude that the majority (85%) of the articles were written collaboratively with more than one author. Articles written by more than 5 authors are more dominant (50%). Only 15% are written by a single Author.

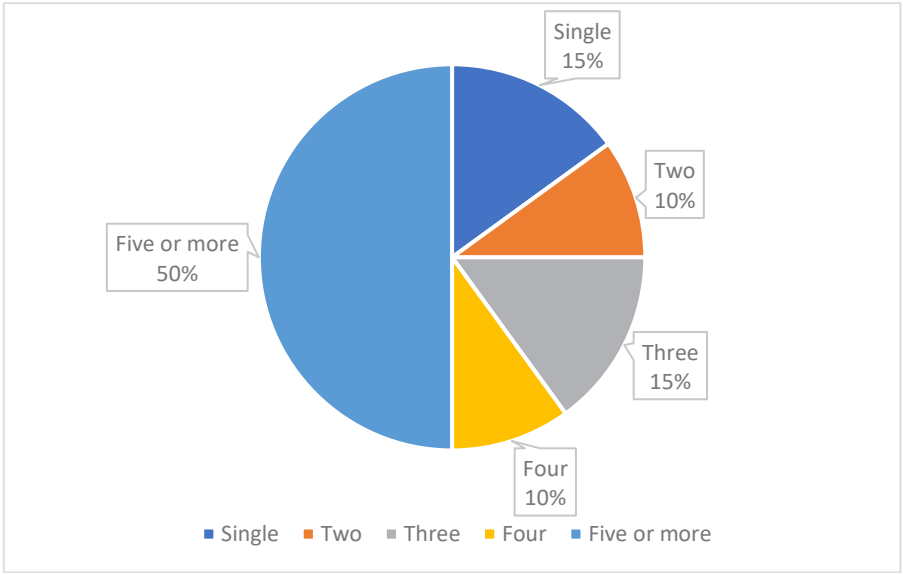


**Fig. 6.** Distribution of scientist collaboration

### 3.1.3 Journal and subject areas

Table 2 presents the trend of scholarly journals that disseminate research articles about oceanography. According to the data presented in Table 2, it is evident that the Journal of Marine Policy and the Journal of Ocean & Coastal Management have published the highest number of articles about oceanography. Specifically, the Journal Marine Policy has published six articles, while the Journal Ocean & Coastal Management has published two on this theme.

Most journals fall into the Quartile 1 (Q1) category, two are in the Quartile 2 (Q2) category, and only 1 journal is in the Non-Q category.

**Table 2.** Distribution of articles published in journals

| No | Journal | Quartiles | N |
|---|---|---|---|
| 1 | Marine Policy | Q1 | 6 |
| 2 | Ocean & Coastal Management | Q1 | 2 |
| 3 | Arabian Journal of Chemistry | Q1 | 1 |
| 4 | Climate Risk Management | Q1 | 1 |
| 5 | One Earth | Q1 | 1 |
| 6 | Environmental Science and Policy | Q1 | 1 |
| 7 | Water-Energy Nexus | Non-Q | 1 |
| 8 | Aquaculture Reports | Q1 | 1 |
| 9 | Global Environmental Change | Q1 | 1 |
| 10 | Continental Shelf Research | Q2 | 1 |
| 11 | Energy Research & Social Science | Q1 | 1 |
| 12 | Earth System Governance | Q1 | 1 |
| 13 | Marine Pollution Bulletin | Q1 | 1 |
| 14 | Oceanologia | Q2 | 1 |

Research findings based on subject areas related to the theme "oceanography" show that there are 6 categories: Social Science, Environmental Science, Earth and Planetary Science, Agricultural and Biological Science, Energy, and Engineering. The three most frequently found subject areas were Social Science 9 articles (45%), Environmental Science 6 articles (30%), and Earth and Planetary Science 2 articles (10%). Trends in research subject areas related to the theme "oceanography" are presented in Table 3.

**Table 3.** Distribution of subject areas in research

| No | Subject Areas | N | Percentage |
|---|---|---|---|
| 1 | Social Science | 9 | 45% |
| 2 | Environmental Science | 6 | 30% |
| 3 | Earth and Planetary Science | 2 | 10% |
| 4 | Agricultural and Biological Science | 1 | 5% |
| 5 | Energy | 1 | 5% |
| 6 | Engineering | 1 | 5% |

### 3.2 The connection between oceanography research enhancing ocean literacy to support SDGs

The selected publications were examined based on selection studies, utilizing the model given in this technique. Consequently, a total of 20 articles were collected. This aligns with the veracity of the data or information utilized. We meticulously examined each publication, comprehensively analyzing them to identify significant insights about the correlation between oceanography research and its contribution to ocean literacy in support of the SDGs. Table 4 presents the significant information extracted from these articles. The articles demonstrate a correlation between oceanography research and ocean literacy principles in their contribution to the SDGs. The sixth principle (P6) of ocean literacy asserts that there exists an inseparable and intricate connection between the ocean and human beings. Oceanography research plays a crucial role in facilitating the attainment of the SDGs, particularly SDG 14 (Life Below Water). SDG 14 underscores the imperative of safeguarding and responsibly sustainably harnessing marine resources.

**Table 4.** Important information regarding oceanography research is linked to increasing ocean literacy to support the SDGs

| No | Important information from each article | Linkage to OL Principles* | Linkage to SDGs |
|---|---|---|---|
| 1 | The Marine Life Protection Act (MLPA) in California is implemented. The goal was to create a network of marine protected areas (MPAs) across the state. The MLPA implementation process, the involvement of many agencies and stakeholders, the difficulties encountered, and the accomplishment of building a sizable network of MPAs [34] | P4, P5, P6 | SDG 14: Life Below Water |
| 2 | Chemists are responsible for engaging in discussions and taking action to reduce climate change's impacts [35] | P3 | SDG 13: Climate Action |
| 3 | The importance of monitoring and conservation efforts to protect deep-sea ecosystems from the impact of marine litter [36]. | P4, P6 | SDG 14: Life Below Water |
| 4 | The need for the concept of "other effective area-based conservation measures" (OECMs) in the context of marine protected areas (MPAs) and their linkage to the SDGs [4]. | P5, P6, P7 | SDG 14: Life Below Water |
| 5 | Setting up a climate-related information network will help Pacific islands learn more about environmental change and find better ways to deal with it. The network aims to bring together environmental leaders, resource managers, teachers, and other interested parties to make it easier for people to share knowledge and help each other adapt to climate change [37]. | P3, P6 | SDG 13: Climate Action SDG 14: Life Below Water, SDG 4: Quality Education |
| 6 | The importance of California's marine protected areas (MPAs) network and the efforts made to monitor, manage, and enforce these areas. The positive impact of MPAs on fish populations, California's comprehensive approach, and the importance of effective management and enforcement in achieving global ocean protection targets [38]. | P4, P5, P6 | SDG 14: Life Below Water |
| 7 | The critical state of the ocean's health and the need for action to address challenges such as overexploited fish | P2, P4, P5, P6 | SDG 14: Life Below Water, |

| No | Important information from each article | Linkage to OL Principles* | Linkage to SDGs |
|---|---|---|---|
| | stocks, climate change, and ocean acidification. It emphasizes the importance of integrating science and policy, establishing new partnerships, improving ocean literacy, and implementing innovative finance systems to promote ocean sustainability [39]. | | SDG 4: Quality Education |
| 8 | Everyone needs to make marine social science study easier around the world, make sure that all kinds of people can join the research community, and make marine social science data and evidence more important for global ocean policy and management [40]. | P5, P6 | SDG 14: Life Below Water |
| 9 | Ocean science, data, and services are important in achieving the United Nations' SDGs. The statement underscores the importance of adopting a comprehensive approach that combines sustainable ocean management with the utilization of the most reliable scientific knowledge and data [1]. | P5, P6 | SDG 14: Life Below Water |
| 10 | Impact of climate change on the water-energy-food relationship and propose a database system using the Unified Modeling Language (UML). Interconnected water-energy-food relationships and sustainable management in dry areas [41]. | P3 | SDG 6: Clean Water and Sanitation<br>SDG 13: Climate Action<br>SDG 7: Affordable and clean energy |
| 11 | The challenges and opportunities in the aquaculture industry include the need for sustainable production systems and the potential for growth and development [42]. | P5, P6 | SDG 14: Life Below Water |
| 12 | The implementation of the Plastic Drawdown (PD) framework in the Maldives to address plastic waste and leakage. The framework combines data on plastic waste generation and leakage with policy analysis to identify strategies for reducing plastic pollution [43]. | P6 | SDG 14: Life Below Water |
| 13 | The development and implementation of Smartfin, a surfboard fin equipped with oceanography sensors for citizen science, outreach, and education. The technology has been successful in scientific research, education, and community engagement [44]. | P3, P6 | SDG 14: Life Below Water<br>SDG 13: Climate Action |
| 14 | The study analyses the key issues of contention, actors involved, and tactics used to oppose these experiments, aiming to provide insights into the governance and perception of these experimental climate technologies [45]. | P3, P6 | SDG 14: Life Below Water<br>SDG 13: Climate Action |
| 15 | The Importance of Earth System Governance (ESG) research can help achieve the goals and challenges of the Decade by identifying problem frames, informing stakeholder engagement, and supporting effective governance solutions. Collaboration, integration of | P5, P6 | SDG 14: Life Below Water<br>SDG 17: Partnerships for the Goals |

| No | Important information from each article | Linkage to OL Principles* | Linkage to SDGs |
|---|---|---|---|
| | various scientific disciplines, and a transformative approach to marine governance are needed [46]. | | |
| 16 | Connectivity, ecosystem functions, and cumulative impacts in deep-sea ecosystems are important. A proposed roadmap is presented to close these scientific gaps through collaboration and strategic planning [47]. | P1, P2, P5, P6, P7 | SDG 14: Life Below Water SDG 17: Partnerships for the Goals |
| 17 | Promoting ocean literacy through various non-formal education programs for marine environments is significant. In order to enhance educational curriculums and encourage a higher level of ocean literacy, there is a requirement for collaboration between formal and informal education [48]. | P1, P2, P3, P4, P5, P6, P7 | SDG 14: Life Below Water, SDG 4: Quality Education |
| 18 | The importance of transdisciplinary efforts, improved communication, and the role of the arts in conveying scientific findings. The article discusses the need to change human behavior towards the ocean and explores initiatives [49]. | P5, P6 | SDG 14: Life Below Water |
| 19 | It highlights how important imagination, originality, and the ability to tell a good tale are in molding the future of the high seas. Additionally, the need for various approaches and incorporating indigenous and local knowledge into ocean management is emphasized [50]. | P4, P6 | SDG 14: Life Below Water |
| 20 | Due to the role that foresight plays in linking disciplinary viewpoints and industry sectors, In order to develop a blue economy that is both sustainable and competitive, interdisciplinary research and collaboration are both required [51]. | P4, P6 | SDG 14: Life Below Water |

* Ocean literacy is based on these seven principles [20,21]:
P1: The Earth has one large ocean with many features;
P2: The ocean and life in the ocean shape the features of Earth;
P3: The ocean is a major influence on weather and climate;
P4: The ocean made earth habitable;
P5: The ocean supports a great diversity of life and ecosystems;
P6: The ocean and humans are inextricably interconnected;
P7: The ocean is largely unexplored.

# 4 Discussion

## 4.1 Publication trends oceanography research

Publication trends can be identified through various categories, including distribution year and keywords, author nationality and international collaborations, and the selection of particular journals and subject areas. By analyzing these aspects, we can gain deeper insight into the development of oceanography research, changes in interests, and collaborations supporting this science's development. An explanation of publication trends in oceanography research based on these categories is explained as follows.

### *4.1.1 Distribution years and keywords*

Publication trends in oceanography research can provide valuable insight into scientific developments. Analysis of publication trends is an important tool in understanding the development of oceanography research over time. Observing the distribution of publications per year can reveal whether oceanography research is experiencing growth, stability, or decline. Data on the distribution of publication years clearly show how research interest in this area has developed. Our findings show that oceanography research has experienced significant development from 2013 to 2023. The increase in articles from only 1 in 2013 and 2014 to 20 in 2023 strongly indicates that this field is increasingly receiving attention from researchers. The 2015-2017 period was low in oceanography research, but fluctuations in publications from 2018 to 2021 indicate a changing interest in this topic. In 2022, we should expect a dramatic increase in the total number of articles produced.

This may reflect increased awareness of oceanography's importance in climate change and planetary well-being and increased international collaboration in this research [1,4,35,37]. With knowledge of these trends, we can understand how the research focus on oceanography has evolved and identify areas that may require further attention [52]. Analyzing publication trends in oceanography research is important to stay informed about emerging priorities and challenges in this field [24]. It can also guide researchers, institutions, and policymakers in making informed decisions and investments in oceanography research [9,10].

The results of keyword trend analysis from oceanography and ocean literacy research to support the SDGs show that several keywords are highlighted in the literature, namely "sustainable development," "marine science," and "ocean literacy." The keyword "sustainable development" indicates that this issue has become a major focus in oceanography research, in line with global efforts to achieve SDGs [4,26]. This keyword analysis is important in identifying research trends, changes in research interests, and the potential contribution of oceanography research in achieving broader SDGs. Additionally, analyzing keywords mentioned in the titles and abstracts of publications can help identify emerging areas of research interest and focus in oceanography [26,52].

### *4.1.2 Author's nationality and international collaboration*

Trends in author nationality in oceanography research reflect the diversity of collaborations internationally in contributing to knowledge about the oceans. A review of 20 articles shows that 19 countries play a role in writing articles about oceanography. The five countries with the most publications are England, with 9 articles; the United States, with 8 articles; and Japan, Switzerland, and France, with 2 articles. The United Kingdom and the United States are major contributors to the number of publications, demonstrating their commitment to ocean exploration and research. In addition, contributions from countries such as Japan, Switzerland, and France reflect the diversity in oceanography research perspectives.

From a continental perspective, Europe is the largest contributor, with 50% of total publications, followed by the Americas with 30%, and Asia with 10%. Meanwhile, Australia and Africa each only contributed 5%. These data reflect the significant role of different countries in oceanography research, with the dominance of Europe as the center of research activities, and show that international cooperation in understanding and conserving the ocean is key to achieving sustainable goals in the oceanography context [1,4]. The presence of contributors from various continents, such as Europe and America, emphasizes the international nature of this discipline. However, considering their wealth of marine resources, Asia, Australia, and Africa have great potential to play a more active role in oceanography research. In the context of the SDGs, cooperation across countries and continents in

oceanography research will be key to achieving global goals related to oceans and the marine environment [1,17,39]

Trends in oceanography research based on international collaboration show that cross-border cooperation is becoming a significant factor in developing knowledge about the oceans [17]. Of the total articles published, 10 involved international collaboration, indicating that oceanography research is often the result of joint efforts from various countries. Meanwhile, 7 articles result from research collaboration within one country, reflecting strong collaboration between researchers at the national level. There are only 3 articles that do not involve international or national research collaboration in an oceanography context. This shows that collaboration is important in facing the complexity of research challenges in the ocean and that understanding the ocean is becoming increasingly global by involving various expertise and perspectives from various countries [27,53]. This collaboration will continue to be key in developing relevant solutions and policies for preserving marine ecosystems and achieving the SDGs related to oceans and the marine environment [4,53].

Most research in oceanography involves collaboration between researchers, with 85% of the total articles reviewed. More interestingly, articles involving more than 5 authors are the dominant trend, accounting for 50% of all analyzed articles. However, approximately 15% of articles are still written independently or by a single author. These findings reflect that international collaboration and cross-disciplinary working teams are common in oceanography research. Illustrates the complexity of the challenges involved in understanding and exploring the ocean, which requires a combination of expertise from different disciplines and geographic locations [25]. Meanwhile, single authors still have an important role in developing innovative ideas and producing valuable contributions to the field.

### *4.1.3 Journal publications and subject areas*

Trends in journals publishing research articles on oceanography provide an idea of where this research is often published. Two journals are the main choice for researchers in publishing their research results: the Marine Policy Journal with 6 articles and the Ocean & Coastal Management Journal with 2 articles. These two journals highlight oceanography and ocean literacy issues in supporting the SDGs. Additionally, it is interesting to note that these journals fall significantly into the quartile 1 (Q1) category, indicating that research in oceanography is often published in high-quality journals with greater impact in the scientific world. However, there are also 2 journals included in the Q2 category, which also have important contributions to oceanography research. Finally, one Journal falls into the Non-Q category, which remains a valid channel for sharing knowledge but may have a lower level of influence in the scientific community. The selection of journals appropriate to the research focus is an important step in amplifying the impact of scientific findings, and understanding journal trends can help researchers make informed decisions [54,55]. This provides insight into relevant journals in oceanography, which can help researchers choose the best place to publish research results [24,56].

Research findings by subject area related to the oceanography theme provide an interesting picture of how broad and multidisciplinary this field is. Social Sciences dominate, showing that social, policy, and economic aspects are very important in oceanography, especially in marine resource management [1,40]. Furthermore, Environmental Science emphasizes the importance of preserving the marine environment and the impact of climate change on marine ecosystems [44,57,58]. Earth and Planetary Sciences also have an important role in understanding geological and geophysical processes in the oceans [34,47]. These findings illustrate the importance of cross-disciplinary approaches in oceanography

research to understand and maintain the health and sustainability of complex marine ecosystems [25,59,60].

Thus, oceanography research requires complex interdisciplinary collaboration involving scientists and researchers from various fields. This reflects the importance of a holistic approach to understanding the ocean because these various aspects are interrelated and impact the balance of the marine ecosystem. In the context of the SDGs, oceanography research in various subjects is highly relevant in achieving goals related to oceans and the marine environment, food security, social justice, and sustainable economic growth [17,46,61–64].

### 4.2 The linkage of oceanography research increases ocean literacy to support the SDGs

Oceanography research is related to increasing ocean literacy to support the SDGs. The seven principles of ocean literacy are met in the research articles that were evaluated, and this demonstrates a thorough awareness of the link between people and the ocean in the context of sustainable development. However, what is more interesting is that the sixth principle, namely, "Oceans and humans are interconnected and cannot be separated," emerged as the most dominant principle in these articles. This shows a strong emphasis on the importance of understanding that human activities and the sustainability of marine ecosystems are interrelated and inseparable entities [3,20,65].

The scientific community is developing a heightened awareness of the significance of the complicated link between people and oceans. This is consistent with the view that the ocean is an integral part of our lives and that human actions significantly impact the balance of marine ecosystems. The emphasis on this principle underscores that oceanography research efforts are concerned with scientific understanding and awareness of its impact on sustainability and human well-being [44,65,66].

This principle highlights that the ocean is a natural resource and an environment supporting human life [15]. What we do on land can have a major impact on the ocean and its ecosystems, and in turn, ocean health greatly impacts human well-being. It includes aspects such as sustainable management of marine resources, climate change, marine pollution, and the impact of other human activities on the marine environment [67,68].

Oceanography research has a crucial role in supporting the achievement of the SDGs. The results of the analysis and review of oceanography research articles show that the contribution of oceanography science includes several SDGs that directly relate to oceans and the marine environment. SDG 14, which focuses on "Life Below Water," emerged as the most dominant goal in this research, reflecting the urgency of maintaining balance in marine ecosystems and caring for marine resources. SDG 14 (life below water), the main focus of oceanography research, emphasizes the need to protect marine biodiversity, reduce marine pollution, and maintain healthy marine ecosystems [4,10,23,69]. Stable marine ecosystems are key for various marine species that provide food and employment resources for communities worldwide [1,2].

However, the role of oceanography is not limited to SDG 14 alone. This research also supports SDG 4 (Quality Education) by providing knowledge about marine ecosystems that can be integrated into education, applied to the curriculum, and disseminated knowledge about marine ecosystems to future generations to realize quality education. In addition, SDG 6 (Clean Water and Sanitation) and SDG 7 (Affordable and Clean Energy) also receive support from an oceanography understanding of seawater quality and marine energy potential [6,41]. SDG 13 (Climate Action) is also supported by understanding climate change and its impact on the oceans [34,36,43]. Furthermore, collaboration in oceanography research reflects the spirit of SDG 17 (Partnerships for the Goals) to achieve SDGs through cross-

sector and cross-country cooperation [46,47]. Thus, oceanography research provides an understanding of the ocean and shapes concrete actions to protect and utilize marine resources sustainably, supporting the larger SDG agenda [4].

In other words, oceanography research is about understanding the oceans and maintaining a global balance that greatly depends on ocean health [4,40]. As a result, the significance of oceanography in attaining the SDGs is paramount in ensuring our planet's long-term viability and humanity's welfare in future generations. Therefore, oceanography research that strengthens ocean literacy and deepens this understanding has a crucial role in achieving global SDGs [22,62]. These results can be a strong basis for demonstrating the importance of oceanography research as a tool for increasing ocean literacy to support the SDGs. It can also help clarify how understanding the interconnections between oceans and humans can significantly contribute to achieving SDGs [20,62,70,71].

## 5 Conclusion

Through the use of SLR, which used the five-step guidelines developed by Denyer and Tranfield (2009), we could locate 20 articles suitable for evaluation. Based on the analysis and review of articles, there is a trend of increasing research regarding oceanography research enhancing ocean literacy to support SDGs in the last 11 years. In 2022, there will be an increase and the highest number of articles published compared to the previous year. Thus, there is an increasing research trend in oceanography research. We found that the keywords in the spotlight were "sustainable development," "marine science," and "ocean literacy." The keyword "sustainable development" indicates that this issue has become a major focus in oceanography research, in line with global efforts to achieve SDGs. The authors who publish papers originate from 19 nations, with a prominent representation from Europe and America. The United Kingdom and the United States of America are the leading contributors to publication output. In particular, in Asian countries, only Japan and Oman publish oceanography research. The trend of international research collaborations related to oceanography themes shows more articles published through international collaborations. The journals that publish the most research articles on "oceanography" are Marine Policy and Ocean & Coastal Management. Most journals are in the Quartile 1 (Q1) category.

Research trends based on subject areas show that the three most frequently found subject areas are Social Sciences, Environmental Sciences, and Earth and Planetary Sciences. Every article we look at connects oceanography research and the fundamentals of ocean literacy that contribute to the SDGs. The articles under consideration adhere to all seven of the ocean literacy principles. However, the sixth principle (P6) is the most dominant: "The ocean and humans are interconnected and cannot be separated." Oceanography research plays a very significant part in helping to attain the SDGs. Oceanography research provides support for several SDGs, including SDG 4 (Quality Education), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 17 (Partnerships for the Goals), as determined by the findings of the analysis and review of the articles. On the other hand, SDG 14, "Life Below Water," is currently the target that receives the most attention in oceanography research.

Research in the field of oceanography will be required indefinitely in the future. Research in oceanography substantially contributes to our understanding of marine environments and resources, as well as their preservation and the development of methods for their responsible use. In addition, oceanography research helps increase ocean literacy, which is important for comprehending the intricate link between humans and the ocean. By enhancing the comprehension of the ocean, society will be more proficient in facilitating the achievement of the SDGs, specifically SDG 14, which pertains to the conservation and sustainable use of marine resources. Therefore, oceanography research is essential in

accomplishing global SDGs, particularly those that center on maintaining healthy and viable oceans.

## 6 Limitations

This study has certain limitations. Firstly, the scope of this study is limited to literature published within the past 11 years, specifically sourced from the academic database Scopus. Furthermore, the chosen publications exclusively pertain to study subjects within oceanography, ocean literacy, and SDGs. Furthermore, the publications chosen for review and analysis were restricted exclusively to scholarly journal articles. Our analysis does not consider conference papers and book chapters, which provide a more comprehensive insight into the subject matter.

## References

1. K. von Schuckmann, E. Holland, P. Haugan, and P. Thomson, Mar Policy **121**, 104154 (2020)
2. N. V Veríssimo, Green Chemistry **23**, 9377 (2021)
3. T. Zielinski, I. Kotynska-Zielinska, and C. Garcia-Soto, Sustainability (Switzerland) **14**, (2022)
4. D. Diz, D. Johnson, M. Riddell, S. Rees, J. Battle, K. Gjerde, S. Hennige, and J. M. Roberts, Mar Policy **93**, 251 (2018)
5. F. E. Muller-Karger, Front Mar Sci **5**, (2018)
6. C. Constant, Progress in Energy **3**, (2021)
7. S. Zunino, D. Melaku Canu, F. Marangon, and S. Troiano, Front Mar Sci **6**, (2020)
8. G. Calzolari, M. Casari, and R. Ghidoni, J Environ Econ Manage **92**, 169 (2018)
9. L. C. Schaffner, T. W. Hartley, and J. G. Sanders, Oceanography **29**, 36 (2016)
10. M. J. Fogarty, Oceanography **26**, 116 (2013)
11. J. Virdin, Sci Adv **7**, (2021)
12. N. Heck, K. Lykkebo Petersen, D. C. Potts, B. Haddad, and A. Paytan, Science of the Total Environment **639**, 785 (2018)
13. M. M. C. Muelbert, M. Copertino, L. Cotrim da Cunha, M. N. Lewis, A. Polejack, A. D. C. Peña-Puch, and E. Rivera-Arriaga, Frontiers in Climate **3**, (2021)
14. L. E. Fleming, N. McDonough, M. Austen, L. Mee, M. Moore, P. Hess, M. H. Depledge, M. White, K. Philippart, P. Bradbrook, and A. Smalley, Mar Environ Res **99**, 16 (2014)
15. R. Kelly, K. Evans, K. Alexander, S. Bettiol, S. Corney, C. Cullen-Knox, C. Cvitanovic, K. de Salas, G. R. Emad, L. Fullbrook, C. Garcia, S. Ison, S. Ling, C. Macleod, A. Meyer, L. Murray, M. Murunga, K. L. Nash, K. Norris, M. Oellermann, J. Scott, J. S. Stark, G. Wood, and G. T. Pecl, Rev Fish Biol Fish **32**, 123 (2022)
16. D. Eparkhina, Mar Technol Soc J **56**, 114 (2022)
17. E. Paredes-Coral, M. Mokos, A. Vanreusel, and T. Deprez, Front Mar Sci **8**, (2021)
18. M. C. Uyarra and Á. Borja, Mar Pollut Bull **104**, 1 (2016)
19. S. Schoedinger, F. Cava, C. Strang, and P. Tuddenham, *Ocean Literacy Through Science Standards* (2005)
20. S. Francesca, S. Selvaggia, G. Scowcroft, G. Fauville, and P. Tuddenham, *Ocean Literacy for All: A Toolkit (IOC Manuals and Guides, 80)* (IOC/UNESCO & UNISCO Venice Office, Paris, 2017)
21. NOAA, *Ocean Literacy The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages Version 3: February 2020* (2020)

22. M. Mokos, G. Realdon, and I. Z. Čižmek, Sustainability (Switzerland) **12**, 1 (2020)
23. D. C. Major, M. Lehmann, and J. Fitton, Ocean Coast Manag **163**, 205 (2018)
24. S. Stoll-Kleemann, Front Mar Sci **6**, (2019)
25. F. Chen, Y. Jiang, Z. Liu, R. Lin, and W. Yang, Mar Policy **154**, 105689 (2023)
26. M. Gilek, A. Armoskaite, K. Gee, F. Saunders, R. Tafon, and J. Zaucha, Ocean Coast Manag **208**, (2021)
27. K. H. Lee, J. Noh, and J. S. Khim, Environ Int **137**, (2020)
28. R. B. Briner and D. Denyer, *The Oxford Handbook of Evidence-Based Management: Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool* (Oxford University Press, New York, 2012)
29. Y. Han, W. K. Chong, and D. Li, Int J Prod Res 4541 (2020)
30. H. Snyder, J Bus Res **104**, 333 (2019)
31. Y. Xiao and M. Watson, J Plan Educ Res **39**, 93 (2019)
32. D. Denyer and D. Tranfield, in *In The SAGE Handbook of Organizational Research Methods (Pp671-689)* (Sage, London, 2009)
33. H. Husamah, H. Suwono, H. Nur, and A. Dharmawan, Eurasia Journal of Mathematics, Science and Technology Education **18**, em2103 (2022)
34. J. Kirlin, M. Caldwell, M. Gleason, M. Weber, J. Ugoretz, E. Fox, and M. Miller-Henson, Ocean Coast Manag **74**, 3 (2013)
35. B. Z. Shakhashiri and J. A. Bell, Arabian Journal of Chemistry **7**, 5 (2014)
36. S. Chiba, H. Saito, R. Fletcher, T. Yogi, M. Kayo, S. Miyagi, M. Ogido, and K. Fujikura, Mar Policy **96**, 204 (2018)
37. I. W. Bolden, S. K. Seroy, E. A. Roberts, L. Schmeisser, J. Z. Koehn, C. H. Rilometo, E. L. Odango, C. Barros, J. P. Sachs, and T. Klinger, Clim Risk Manag **21**, 1 (2018)
38. S. Murray and T. T. Hee, Ocean Coast Manag **182**, 104920 (2019)
39. J. Claudet, L. Bopp, W. W. L. Cheung, R. Devillers, E. Escobar-Briones, P. Haugan, J. J. Heymans, V. Masson-Delmotte, N. Matz-Lück, P. Miloslavich, L. Mullineaux, M. Visbeck, R. Watson, A. M. Zivian, I. Ansorge, M. Araujo, S. Aricò, D. Bailly, J. Barbière, C. Barnerias, C. Bowler, V. Brun, A. Cazenave, C. Diver, A. Euzen, A. T. Gaye, N. Hilmi, F. Ménard, C. Moulin, N. P. Muñoz, R. Parmentier, A. Pebayle, H.-O. Pörtner, S. Osvaldina, P. Ricard, R. S. Santos, M.-A. Sicre, S. Thiébault, T. Thiele, R. Troublé, A. Turra, J. Uku, and F. Gaill, One Earth **2**, 34 (2020)
40. E. McKinley, T. Acott, and K. L. Yates, Environ Sci Policy **108**, 85 (2020)
41. A. Boluwade, Water-Energy Nexus **4**, 54 (2021)
42. W. C. Valenti, H. P. Barros, P. Moraes-Valenti, G. W. Bueno, and R. O. Cavalli, Aquac Rep **19**, 100611 (2021)
43. J. Royle, B. Jack, H. Parris, T. Elliott, A. C. Castillo, S. Kalawana, H. Nashfa, and L. C. Woodall, Global Environmental Change **72**, 102442 (2022)
44. P. Bresnahan, T. Cyronak, R. J. W. Brewin, A. Andersson, T. Wirth, T. Martz, T. Courtney, N. Hui, R. Kastner, A. Stern, T. McGrain, D. Reinicke, J. Richard, K. Hammond, and S. Waters, Cont Shelf Res **242**, 104748 (2022)
45. S. Low, C. M. Baum, and B. K. Sovacool, Energy Res Soc Sci **90**, 102594 (2022)
46. B. Hofmann, Earth System Governance **12**, 100139 (2022)
47. D. J. Amon, S. Gollner, T. Morato, C. R. Smith, C. Chen, S. Christiansen, B. Currie, J. C. Drazen, T. Fukushima, M. Gianni, K. M. Gjerde, A. J. Gooday, G. G. Grillo, M. Haeckel, T. Joyini, S.-J. Ju, L. A. Levin, A. Metaxas, K. Mianowicz, T. N. Molodtsova, I. Narberhaus, B. N. Orcutt, A. Swaddling, J. Tuhumwire, P. U. Palacio, M. Walker, P. Weaver, X.-W. Xu, C. Y. Mulalap, P. E. T. Edwards, and C. Pickens, Mar Policy **138**, 105006 (2022)
48. M. O'Brien, C. Freitas, P. Venzo, and P. Francis, Mar Pollut Bull **193**, 115208 (2023)

49. A. Omstedt, Oceanologia **65**, 20 (2023)
50. L. M. Pereira, G. Ortuño Crespo, D. J. Amon, R. Badhe, S. Bandeira, F. Bengtsson, M. Boettcher, G. Carmine, W. W. L. Cheung, B. Chibwe, D. Dunn, M. A. Gasalla, G. Halouani, D. E. Johnson, J.-B. Jouffray, S. Juri, P. W. Keys, H. M. Lübker, A. S. Merrie, F. Obaidullah, J. Palacios-Abrantes, L. J. Shannon, U. R. Sumaila, E. Superchi, N. Terry, C. C. C. Wabnitz, M. Yasuhara, and W. Zhou, Mar Policy **153**, 105644 (2023)
51. L. A. Pace, O. Saritas, and A. Deidun, Mar Policy **148**, 105433 (2023)
52. S. Costa and R. Caldeira, Mar Policy **87**, 149 (2018)
53. R. Chambers, N. Hart, S. Ranger, A. Birney, C. Angheloiu, J. Loring, S. Williams, and L. Hooper, Front Mar Sci **6**, (2019)
54. R. Venkatesan, Mar Technol Soc J **55**, 34 (2021)
55. O. Garcia and C. Cater, Journal of Sustainable Tourism **30**, 2428 (2022)
56. R. E. Short, Environ Int **146**, (2021)
57. G. Fauville, Digital Technologies as Support for Learning about the Marine Environment: Steps toward Ocean Literacy, Doctoral Thesis in Education, University of Gothenburg, 2018
58. S. Gelcich, P. Buckley, J. K. Pinnegar, J. Chilvers, I. Lorenzoni, G. Terry, M. Guerrero, J. C. Castilla, A. Valdebenito, and C. M. Duarte, Proc Natl Acad Sci U S A **111**, 15042 (2014)
59. N. Pinardi, Front Mar Sci **6**, (2019)
60. W. Rickels, Environmental Research Letters **9**, (2014)
61. B. Zhang, Big Earth Data **5**, 557 (2021)
62. J. C. Ferreira, L. Vasconcelos, R. Monteiro, F. Z. Silva, C. M. Duarte, and F. Ferreira, Educ Sci (Basel) **11**, 1 (2021)
63. E. Gissi, J Clean Prod **330**, (2022)
64. R. M. Fernández Otero, G. A. Bayliss-Brown, and M. Papathanassiou, Front Mar Sci **6**, (2019)
65. R. Kelly, A. Fleming, G. T. Pecl, A. Richter, and A. Bonn, Ecology and Society **24**, (2019)
66. D. Boaventura, A. T. Neves, J. Santos, P. C. Pereira, C. Luís, A. Monteiro, A. Cartaxana, S. J. Hawkins, M. F. Caldeira, and A. Ponces de Carvalho, Front Mar Sci **8**, (2021)
67. J. Brito, Ocean Coast Manag **244**, (2023)
68. M. Mokos, E. S. R. De-Bastos, G. Realdon, D. Wojcieszek, M. Papathanasiou, and P. Tuddenham, Mediterr Mar Sci **23**, 277 (2022)
69. N. Heck, A. Paytan, D. C. Potts, and B. Haddad, Mar Policy **68**, 178 (2016)
70. M. Andriamahefazafy, Ocean Coast Manag **227**, (2022)
71. K. C. Koutsopoulos and J. H. Stel in (Switzerland, 2021)