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Review

The nature and use of Ocean Literacy in achieving sustainable ocean futures: A Systematic Map

R.J. Shellock [a,b,*], L. Fullbrook [b,c], E. McKinley [d], C. Cvitanovic [e,f], R. Kelly [b,g], V. Martin [h,i]

[a] Centre for Sustainable Development Reform, Faculty of Law, University of New South Wales, Sydney, NSW, 2052, Australia
[b] Centre for Marine Socioecology, University of Tasmania, Hobart, Tasmania 7004, Australia
[c] School of Social Sciences, College of Arts, Law and Education, University of Tasmania (UTAS), Tasmania, Australia
[d] School of Earth and Environmental Sciences, Cardiff University, Park Place, Cardiff, CF10 3AT, UK
[e] School of Business, University of New South Wales, Canberra, Australian Capital Territory, Australia
[f] Centre for Marine Science and Innovation, University of New South Wales, Australia
[g] Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania 7004, Australia
[h] Mosaic Insights, Queensland, Australia
[i] Centre for Biodiversity & Conservation Science, The University of Queensland, Australia

A B S T R A C T

Ocean Literacy (OL) is essential for changing human behaviours and practices to improve ocean sustainability. Recently, the concept has become a focal topic in ocean and coastal research, including as a key pillar of the United Nations Decade of Ocean Science for Sustainable Development. As the concept and practice of OL continues to evolve, it is timely to synthesise the existing evidence base to ensure that future research, practice and policy is informed by robust and up-to-date evidence. To this end, we undertook a Systematic Map addressing the following research questions: (i) where has OL work been undertaken, (ii) which OL dimensions have been discussed and measured, (iii) what methods have been used to measure OL, (iv) what populations have been studied in OL research, (v) what is the rationale or purpose of OL research and (vi) what are the recommendations for future OL research and practice? The review included 298 articles, 181 from peer-reviewed literature and 117 from grey literature. Results show a growing body of literature on OL research and practice, but also highlight several evidence gaps. Most research identified has been published by first authors from the USA, Canada, UK, Ireland and Portugal, accounting for over 50% of articles included in the Systematic Map. Evidence suggested that primary data studies have measured all 10 currently recognised dimensions of OL, albeit to varying degrees. However, assessing knowledge remains the predominant focus, indicating that the field still relies on the knowledge-deficit approach to OL. To date, studies have measured OL in 25 different target populations; however, over 50% focused on OL in students and teachers. Most of the studies employ quantitative approaches, particularly surveys, to collect OL data with limited use of other methods. We identified that OL research is driven by four core rationales or purposes: (i) defining and conceptualising OL, (ii) educational design and programming, (iii) evaluating OL, and (iv) increasing OL (tools and improvements). We also captured future priorities and recommendations for OL research and practice, including evaluation of OL initiatives and projects, diversity, equity and inclusion and partnerships and collaboration. The Systematic Map brings coherence to the existing OL evidence base, identifies gaps, and provides a way forward for OL research and practice and its implications for ocean and coastal management.

1. Background

Our ocean is experiencing unprecedented pressures from increasing anthropogenic impacts and as such is exhibiting change at an accelerating rate. The main forces of ocean change are land-based and include population growth, increasing urbanisation, rising individual consumption and climate change (Nash et al., 2017). The impacts of these have severely degraded oceanic ecosystems and the goods and services they provide for human well-being and prosperity. These impacts, and their consequential effects on society, are projected to continue (Halpern et al., 2015, 2019; Jouffray et al., 2020), with some describing the next decade as critical for ocean management (Hobday and Cvitanovic, 2017; Salinger et al., 2016).

Proposed solutions to many problems facing the ocean are largely connected to social values, societal environmental behaviour (Gifford, 2014; Wynveen et al., 2015) and social and marine governance (United Nations Environment Programme, 2021; Veríssimo, 2013)- all of which require individuals to have Ocean Literacy (hereafter abbreviated to "OL"). The concept of OL was first defined by marine educators in the USA in the 2000s as an "understanding of the ocean's influence on

* Corresponding author. Centre for Sustainable Development Reform, Faculty of Law, University of New South Wales, Sydney, NSW, 2052, Australia.
E-mail address: r.shellock@unsw.edu.au (R.J. Shellock).

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humans and of our influence on the ocean" (Cava, 2005). It emerged through recognition of the lack of ocean-related subjects in formal education and the need for a more comprehensive framework to encourage the inclusion of ocean sciences into national and state curricula (Santoro et al., 2017; UNESCO, 2018). However, OL models have since evolved from the knowledge-deficit framing. OL is now seen as a process and an outcome resulting in a society that understands, values and cares for the ocean (Glithero et al., 2024). Recent studies have proposed several additional dimensions of OL: (i) awareness, (ii) attitude, (iii) behaviour, (iv) activism, (v) communication, (vi) emotional connections, (vii) access and experience, (viii) adaptive capacity and (IX) trust and transparency (Brennan et al., 2019; McKinley et al., 2023).

Increasing recognition of the potential practical role and value of OL has seen it become a central component of international frameworks and policy goals (McKinley and Burdon, 2020). OL is increasingly being seen as a panacea for ocean sustainability policy and will lead to societal behaviour change. For example, "Ocean Literacy as a concept and approach is radically evolving from being a tool to be applied in formal education and training contexts to a tool and an approach for society as a whole, aimed at triggering actions towards Ocean sustainability" (UNESCO, 2020) (p1). For example, the principles and fundamental concepts of OL are now embedded into various European regulations (e.g., Marine Framework Strategy Directive, Blue Growth Strategy, Marine Spatial Planning Directive, Common Fisheries Policy and the 2013 Galway Statement on Atlantic Ocean Cooperation; Costa and Caldeira, 2018; Fernández Otero et al., 2019; French et al., 2015). Further, OL is a key pillar of the United Nations Decade of Ocean Science for Sustainable Development (hereafter Ocean Decade; Claudet et al., 2020; Ryabinin et al., 2019). In April 2024, the Barcelona Statement identified OL as a key and strategic mechanism for ensuring that the Ocean Decade succeeds. The UN highlighted the need to "continue to expand efforts in ocean literacy to address all sectors of society including policy makers, resource managers, and industry (UNESCO, 2024, p3).

Despite this progress, limitations to the evolution of OL remain (McKinley et al., 2023). First, due to the origin and interdisciplinary nature of OL, there are disparities regarding its conceptualisation and application. In just the last 5 years there have been a range of papers outlining different frameworks and approaches to OL, including Brennan et al. (2019), Kopke et al. (2019), McKinley et al. (2023) and more recently Fauville et al. (2024). This can provide ambiguity and complexity for those wanting to operationalise OL. Second, this rapidly evolving field lacks an evidence synthesis of work and progress achieved to date. Whilst studies have explored bibliographic analyses of OL, these focus purely on trends in the peer-reviewed literature (Costa and Caldeira, 2018; Paredes-Coral et al., 2021; Cavas et al., 2023; Salazar-Sepúlveda et al., 2023). These studies omitted the grey literature which may be important since OL originated outside of academic research and has progressed largely through the marine education. As a result, there is a lack of coherence and shared vision of OL which hinders the extent to which the potential of OL can be delivered in practice and incorporated within diverse decision-making contexts.

The aim of this study is to examine the existing evidence base for OL. We adopt a Systematic Map ("SM") methodology to gather and categorise relevant articles, describe broad trends and synthesise peer-reviewed and grey literature research on OL. This collation of evidence allows us to develop a comprehensive understanding of the evolving field and identify gaps in knowledge and directions for future research and exploration (Pullin et al., 2022). The SM uses high-quality and stringent methods to synthesise the best available evidence on OL. Hence, it can provide a go-to resource for practitioners and decision-makers expected to develop policy principles and operational procedures based on the most current and best available information (Kelly et al., 2022).

This study was guided by an overarching research question, drawing together more specific sub-questions.

- *What is the existing evidence base for OL?*
  - *Where has OL work been undertaken?*
  - *Which OL dimensions have been discussed and measured?*
  - *What methods have been used to measure OL?*
  - *What populations have been studied in OL research?*
  - *What is the rationale or purpose of OL research?*
  - *What are the recommendations for future OL research and practice?*

2. Methods

We developed a SM of the OL literature guided by the Collaboration for Environmental Evidence (CEE) (Pullin et al., 2022) and RepOrting standards for Systematic Evidence Synthesis (ROSES) (Haddaway et al., 2018). SMs (also known as "scoping reviews") synthesise existing literature on a specific topic and categorise it according to predefined keywords. They provide an overview of the distribution and abundance of evidence and create a coded database of literature (Bates et al., 2007). This database provides "meta-data" which details information about each study included in the SM (i.e. bibliographic, geographic and study-specific information). The database can be used by various stakeholders (e.g. policymakers, service-users, practitioners and researchers) for the purpose of: (i) improving understanding of a specific topic, (ii) providing a transparent evidence base from which to highlight practice and policy issues, (iii) identifying a breadth of science needed for policy-relevant questions, (iv) highlighting knowledge gaps and (v) understanding knowledge clusters (James et al., 2016). SMs have 7 main stages: (i) planning of the review, (ii) search execution, (iii) screening and selection of studies, (iv) data extraction, (v) data coding and data extraction, (vi) data synthesis and (vii) interpretation and reporting of the findings (Pullin et al., 2022). Supplementary Materials 1 provides further detail on the reasons for selecting the Systematic Map approach for this study.

2.1. Search strategy

2.1.1. Scoping

Initial scoping was undertaken to ensure appropriateness of the keyword search string before systematic searching began and involved testing search strategies and keyword strings (Pullin et al., 2022). This search string was developed to comprehensively cover the phenomenon and outcomes outlined in the eligibility criteria (see 2.3). Supplementary Materials 2 and 3 details all the searches conducted and includes the date, database searched and results for data collection for the scholarly and grey literature, respectively.

2.1.2. Keyword string

A Boolean search string was developed through a rigorous process, including a 'naïve' scoping search and identification of benchmark articles to strengthen the search strategy. A proximity operator was used to improve the precision of the search string (Livoreil et al., 2017). Further details are provided in Supplementary Materials 4. The initial search was undertaken in 2022 (June 19, 2022). Then an additional search was undertaken in 2023 (June 21, 2023) to capture literature from June 2022–June 2023.

The final keyword search using in this SM was:

TITLE-ABS-KEY ((“literacy”) W/5 (“Marine*" OR “coast*" OR “ocean*" OR “sea”)).

2.1.3. Databases and searches

Academic literature was searched in the Scopus database (http://www.scopus.com/home.uri;) and Web of Science (http://webofscience.com/), as they comprehensively cover both natural and social sciences (Norris and Oppenheim, 2007). Grey literature was also collected due to the origin of OL outside of the academic literature and to reduce publication bias (Haddaway et al., 2015; Haddaway and Bayliss, 2015). Grey literature has previously been defined as: "… a field

in library and information science that deals with the production, distribution, and access to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing i.e., where publishing is not the primary activity of the producing body" (GreyNet, 2013). Examples include reports, theses, book chapters, conference proceedings, technical notes and white papers (Livoreil et al., 2017). Grey literature was sourced through three databases: (i) Google Scholar, (ii) Bielefeld Academic Search Engine (BASE) and (iii) Open Access Theses and Dissertations (OATD), as using more than one database increases coverage of the literature (Bramer et al., 2016; Livoreil et al., 2017). A modified keyword search string was developed, recorded and appended to the SM, when the full string was not accepted (e.g., due to different Boolean functions and character limits).

2.2. Exported results and duplicate removal

Search results from Scopus, Web of Science and Google Scholar were exported from the database using Publish or Perish (https://harzing.com/resources/publish-or-perish). Exports were done manually for BASE and OATD. They were then imported into Covidence (https://www.covidence.org/), a platform for managing Systematic Review and Map processes (Kellermeyer et al., 2018). Literature was collected from multiple online sources, resulting in duplicated records. Duplicate records were removed (see Supplementary Materials 5).

2.3. Article screening and inclusion criteria

Screening was conducted at the title, abstract and full text level. Inclusion/exclusion was determined through the Population, Phenomenon and Outcome design (see Table 1). The *Population* to be considered for this SM is the body of academic and grey literature focused on OL., the *Phenomenon* is the concept of OL and the *Outcome* of interest is the marine environment. Articles were included if they met the following criteria: (i) published peer-reviewed and grey literature, (ii) examined the concept of OL and (iii) focused on the use of OL in the context of marine environments.

Articles were only included if they referred to OL. While we recognise associated and analogous terms (e.g., marine literacy, coastal literacy, aquatic literacy, marine citizenship, ocean citizenship, marine connectedness), we only considered variations of OL, as we were looking at the evolution and trends in relation to this specific concept. Journal articles, theses, book chapters, conference proceedings, technical notes and white papers were included within the search. In line with previous studies, due to language limitations only English language literature was searched for and retained. Some articles were inaccessible (e.g., citation only or behind an inaccessible paywall) and were excluded from the study.

2.4. Consistency checking

Screening consistency was conducted by RJS and EMCK to ensure that there was alignment amongst the authors. 15% of papers were randomly selected for the internal consistency check (N = 236). Following screening, the results were compared, and a kappa statistic was calculated. There is no consensus around an 'adequate' level of agreement (Pullin et al., 2022). However, due to our narrow search criteria (i.e., a focus on OL as a concept), we deemed it necessary to aim for almost perfect agreement (i.e. above 0.81; Viera and Garrett, 2005). Kappa was calculated to be 0.87 (93.64% agreement; see Supplementary Materials 6) meaning no further screening or refining of PHO criteria was required. Screening of all articles was then conducted by the first author (RJS) and discussed with EMCK when there was uncertainty regarding inclusion (as per Frampton et al., 2017).

Table 1
Population, Phenomenon and Outcome elements for assessing inclusion/exclusion.

PHO element	Description	Inclusion criteria
Population	The body of OL literature	Is it a defined piece of academic or grey literature?
Phenomenon	The concept of OL	Is the article about OL?
Outcome	The use of OL in the context of the marine environment.	Is the article about the use of OL in the context of marine environments?

2.5. Data coding

Data coding is the recording of relevant characteristics (meta-data) of the study such as when and where the study was conducted and by whom and aspects of the study design and conduct (Pullin et al., 2022). Key data from the articles was extracted and entered into Microsoft Excel. A draft coding strategy was developed by two authors and a pilot test was undertaken on five papers selected at random and piloted by two of the authors (RJS and EMCK). The authors compared their codes to identify any differences, discuss any challenges they had with coding and put forward suggestions for changes to the coding strategy. The following changes were made: (i) additional coding categories: scale and the county/state to gain some more-detailed geographical data and (ii) adding a coding category related to the OL dimension studied. The coding strategy was then piloted for the second time (n = 5), after which it was agreed that the coding strategy (Table 2 and Supplementary Materials 7) was collecting suitable data to answer the research questions. A third co-author (LF) was brought on to code the documents so a third round of piloting was undertaken to ensure consensus. The third co-author completed coding for the full sample of articles.

3. Results and discussion

Here, we report the results of the SM together with our narrative interpretation, to avoid repetition and aid accessible discussion (following previous SMs, e.g. Eales et al., 2021).

3.1. Search results and screening

In total, 4605 references were imported. Two thousand and fourteen duplicates were removed, leaving 2591 articles. The first stage of screening (at the title and abstract level) excluded 1798 articles and left 794 articles. Full-text screening excluded a further 495 articles, leaving 298 articles. Fig. 1 presents a summary of the search process and results. A total of 298 studies met all search criteria up to and including those published before June 23, 2023 and were included in the review.

3.2. Dates and journals

The earliest articles on OL were published in 2002 in the "Our Fragile Oceans: California Journal of Science Education" (Cava, 2002a, 2002b). This was part of the grass roots movement for OL in the USA with scientists, and educators highlighting the need to include ocean sciences in the school curriculum (Fauville et al., 2019; Schoedinger et al., 2005).

Table 2
Coding strategy used for collecting data from each study.

Code category	Data
Bibliographic	Title, author(s), year, type of document, type of study, journal.
Geographic	Location of first author, location of study, scale, county/state
Study-specific	Study approach[a], study rationale, type of method[a], Ocean Literacy dimension(s)[a], sample population(s)[a], recommendations

[a] Information collected for primary data studies only (observational and experimental studies).

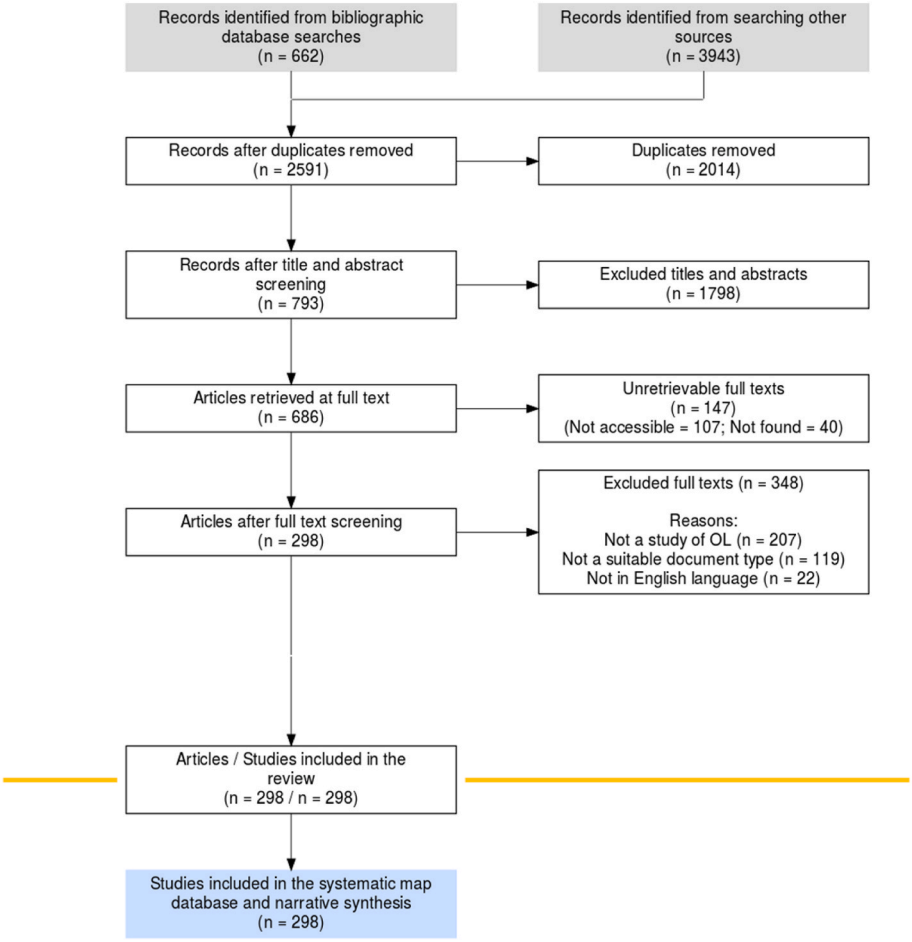

Fig. 1. ROSES flow diagram showing the stages of the SM process (Haddaway, 2020).

The number of publications increased during this period but stayed relatively steady until 2017. Publications on OL then became more numerous from 2017, peaking in 2021 (Fig. 2) with most of the literature published over the last six years (2018–2023). This is likely as a result of various key events which are likely to have raised the profile of OL and potential for knowledge sharing; including (i) a special issue in Frontiers of Marine Science in 2019 which published 12 articles on OL (Borja et al., 2020), (ii) the launch of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030; Claudet et al., 2020; Ryabinin et al., 2019) and (iii) the development of the Intergovernmental Oceanographic Commission's OL action plan (2018–2021; International Governmental Oceanographic Commission 2020).

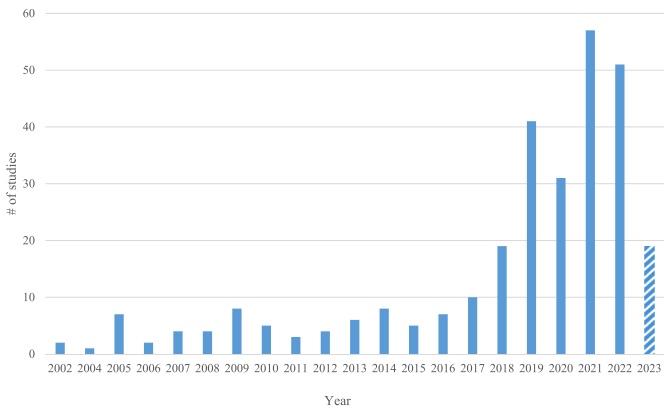

Fig. 2. Publication dates for all articles (total n = 298). Note: 2023 is an incomplete record, as the last search was undertaken in June 2023.

The scholarly articles were published in 74 journals. One hundred and eighty-one articles (60.74% of all articles) were published in journals. Over a third of the peer-reviewed literature was published in six journals (n = 67; 37.43%), including Frontiers in Marine Science (n = 20; 11.17%) and Mediterranean Marine Science (n = 11; 6.15%). Other popular journals included Marine Policy, Ocean and Coastal Management, Sustainability and the Journal of Marine Education, each of which published 9 articles (5.0%). Forty-eight journals each published one article each, which collectively equated to 26.82% of the published literature. Theses (n = 36; 12.08%), book chapters (n = 28; 9.40%), reports, (n = 34; 11.41%), conference proceedings (n = 17; 5.70%), and working papers (n = 2; 0.67%) made up the remaining 39.26% of the literature base.

3.3. *Where has Ocean Literacy work been undertaken?*

The majority of first authors came from the USA (n = 73; 25.50%), Canada (n = 33, 11.54%), the UK (n = 19; 6.64%), Ireland (n = 17; 5.94%) and Portugal (n = 16; 5.59%; see Fig. 3). The location of the study aligned relatively closely with the first author location and some studies had multiple case study locations. The most frequently studied location (i.e., where participants originated from) was the USA (n = 53; 18.73%), followed by Canada (n = 27; 9.54%), UK (N = 17; 6.00%), Portugal (n = 15; 5.30%), Ireland (n = 15; 5.30%) and Indonesia (n = 15; 5.30%; Fig. 4).

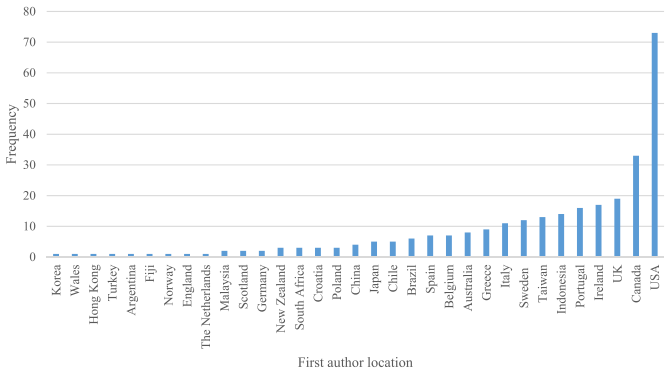

Fig. 3. The first author location for each of the articles (n = 286).

Our findings align with bibliometric analyses which have examined the OL literature base between 2017 and 2022 (Cavas et al., 2023; Costa and Caldeira, 2018; Paredes-Coral et al., 2021; Salazar-Sepúlveda et al., 2023). This predominance and activity from the USA could be attributed to the following factors: (i) the geographic origins of the concept of OL (Schoedinger et al., 2005, 2010), (ii) the presence of the National Marine Educators Association (NMEA) in the USA and (iii) 7 out of 8 OCEANS conferences being held in the USA, which have contributed to the literature.

Despite the dominance of the USA, other countries are active contributors to the peer-reviewed and grey literature on OL. Canada, for example, has a national OL Strategy developed by the Canadian Ocean Literacy Coalition (COLC) as well as the Canadian Network for Ocean Education (CaNOE). Research from Canada has explored OL in various regions, including inland Canada, Inuit Nunangat, Pacific and the Atlantic (Ammendolia, 2020; Ammendolia et al., 2020; Hoover, 2022; Yumagulova, 2020). European countries including the UK, Portugal and Ireland have also made large contributions to the literature. This may be due to Horizon 2020 projects such as Sea Change and ResponSEAble which focus on OL, the European Marine Science Education Association (EMSEA) and co-operation with various countries on OL (Cavas et al., 2023; Costa and Caldeira, 2018).

Our study highlights the strong focus of OL in the Global Minority (i.e. the smaller population of the world that live in wealthier nations, often described as the "West" or the "Global North"; Oxfam, 2023). There may be numerous reasons for the gaps in distribution of studies. For example, the trends could be attributed to the Global Minority bias in terms of publication (e.g., English language publication) which has been observed previously in marine science (Ahmadia et al., 2021). Another reason for these geographic gaps in the literature may be that the language and terminology of OL may not be perceived as accessible or appropriate for all communities and contexts (MacNeil et al., 2021; Spalding et al., 2023; Worm et al., 2021). For example, work published in 2021, argued that the term OL was insufficient to capture the scope of potential experiences people may have with the ocean, is inadequate for encapsulating different worldviews across diverse linguistic communities and emphasise how OL might be perceived as an instrument of power, colonialism and oppression (MacNeil et al., 2021). An exception to the location bias identified in this SM is Indonesia, where researchers have published 15 studies on OL representing 5.30% of the total study locations. This bias highlights the infancy of the OL field, outside of the Global Minority. It also emphasises that there may be not enough context-specific information to understand global variations and patterns of OL if most data collection has been concentrated in the USA, Canada, UK, Portugal, Ireland and Indonesia. This presents challenges for informing marine and coastal policy, management, planning, monitoring, evaluation and learning and marine education. It also suggests that there is limited transcendence across geographical boundaries and an inequitable approach to OL, decision-making, communication and education. Rectification of this disparity will require a change in how funding for OL work is administered and regional and international cooperation, joint efforts, and knowledge exchange (e.g. capacity building and sharing data and information on methods, tools and assessments) between countries and stakeholders (e.g. researchers, decision-makers, industry). This has been called for by the UN Ocean Decade (e.g. UNESCO, 2020) and researchers in the OL field (Cavas et al., 2023; Paredes-Coral et al., 2021).

3.4. *Which Ocean Literacy dimensions have been discussed and measured?*

The dimensions were coded according to McKinley et al. (2023) (see Fig. 5). Our analysis of primary data studies in this SM showed that most OL studies measured more than one type of dimension of OL. In keeping with the origin of OL, the most popular dimension of OL was knowledge (n = 142; 20.91%). Knowledge refers to what an individual knows about ocean-related topics, including features of the ocean (e.g. biological, physical, chemical processes), the importance and role of the ocean (e.g.

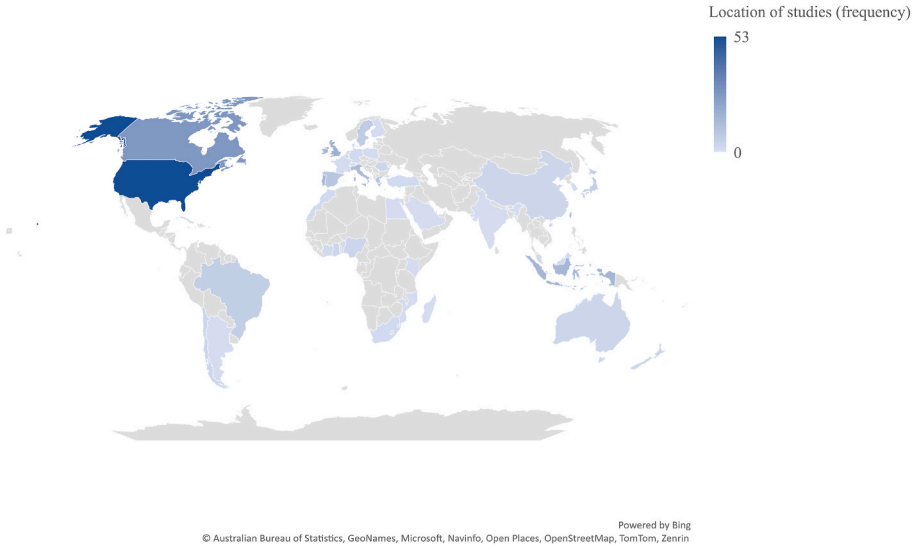

Fig. 4. The geographical location in which OL studies were carried out. This includes articles that collected primary data (n = 222). In some instances studies had multiple study locations, therefore, max n = 283.

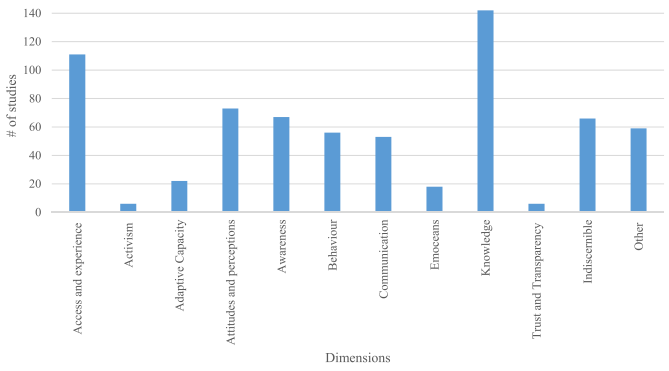

Fig. 5. The main dimensions of OL which have been discussed in the literature (max n = 679).

for food, transportation, jobs, culture, well-being) and the types of anthropogenic impacts affecting the ocean (e.g. invasive species, overfishing, and marine pollution; Cheimonopoulou et al., 2022; Chiashi and Sasaki, 2012; Fauville et al., 2019; Leitao et al., 2018; Markos et al., 2017), ocean decision-making, opportunities to participate and engage in ocean decisions and behaviours (Marrero and Mensah, 2010) and where and how to get information about ocean issues (Leitao et al., 2018). We acknowledge that the concept of knowledge has changed since the conceptualisation of OL and the OL principles. However, it has still predominantly relied on the knowledge deficit approach.

The SM found that studies are measuring broader measures of OL, drawing on more contemporary models which have expanded the original education-based framing of OL. The second most popular dimension was access and experience (n = 111, 16.35%). This refers to a person's physical or virtual experiences with and engagement with the ocean and the ways in which they can access these experiences. For example, relating to their visits to the ocean, beaches, citizen science, activities and exhibitions in museums and aquariums and virtual reality (Baldrighi et al., 2022; Boaventura et al., 2021; Cahyadi et al., 2021; Childress et al., 2021). Other popular dimensions included: attitudes and perceptions (n = 73; 10.75%) and awareness (n = 67; 9.87%). The other dimensions were mentioned, albeit to a lesser extent: (i) behaviour (n = 56; 8.25%), (ii) communication (n = 53; 7.81%), (iii) adaptive capacity (n = 22; 3.24%), (iv) emoceans (n = 18; 2.65%) and (v) trust and transparency (n = 6; 0.88%). It was not always clear which, if any, of the ten dimensions were examined in some of the articles and hence they were coded as "indiscernible" (N = 66; 9.72%). Some responses were also coded as "other" (n = 53; 7.81%), as they did not fall into the OL typology (McKinley et al., 2023). Miscellaneous topics included imagination, collaboration and competencies and employment.

3.5. What methods have been used to measure Ocean Literacy?

Of the primary data studies (n = 218), over half of the articles used purely quantitative approaches (n = 104; 50.98%). Just under a third used mixed method approaches (n = 63; 30.88%). Finally, the remainder of studies used purely qualitative methods (n = 37; 18.14%). We were unable to identify the type of approach for 14 studies.

A total of 22 different types of data collection method were discussed in the OL evidence base (see Fig. 6). Some studies employed multiple data collection methods (n = 412). Surveys were the most popular data collection method used to assess OL (n = 98; 23.79%). This was followed by interviews (n = 54; 13.11%). Although mentioned less frequently, other methods included student tests and content analysis (e.g. of social media, lesson plans and other documents). Overall, our results suggest that whilst there is a diversity of approaches and methods being used to measure OL within the literature, quantitative methodologies are the most commonly applied.

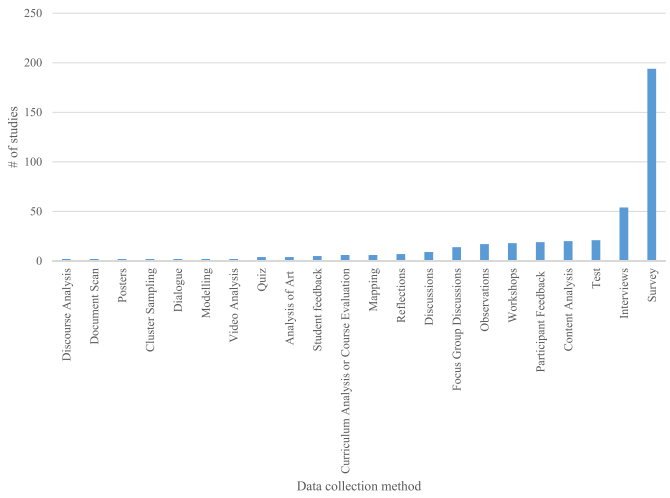

Fig. 6. Types of data collection methods used in OL primary data studies (max n = 412).

3.6. Which populations have been studied in Ocean Literacy research?

Twenty-five different populations (or participant groups) were mentioned within the articles (see Fig. 7). Some studies focused on more than one population type; hence the number # of data points (n = 237) are greater than the number of studies (n = 218). Most articles focused on understanding OL levels of students and teachers; representing over half of the total (n = 134; 56.54%) which aligns with the history of OL (Schoedinger et al., 2005, 2010). For 33 studies, we were unable to identify the target group and they were labelled as indiscernible (13.92%). Albeit fewer, other groups included stakeholders (n = 13; 5.49%), the public (n = 6; 2.53%), online participants (n = 6; 2.53%) and residents (n = 5; 2.11%).

The remaining groups were mentioned by fewer than five articles and made up just over a quarter of the articles (n = 40; 16.88%). These findings suggest that the groups included within OL studies are not overly diverse, and many groups are missing (e.g. indigenous communities). To ensure the inclusion of different world views, ontologies and ways of being (Moon and Blackman, 2014), it will be important to have a more diverse range of participants in studies (and involved in co-designing research), particularly as they may have differing factors influencing their OL.

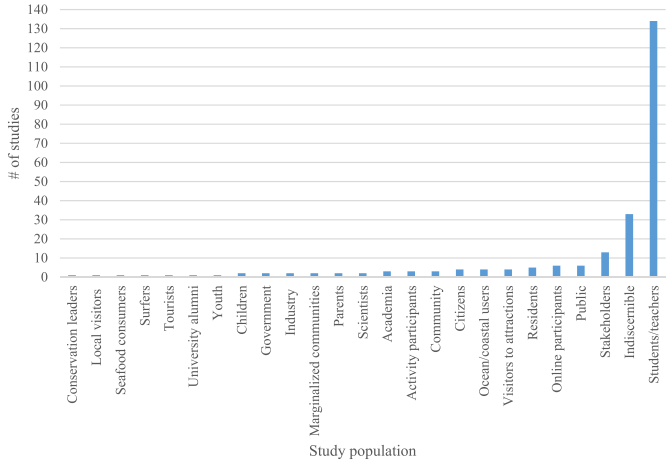

Fig. 7. Target population in OL studies (max n = 237).

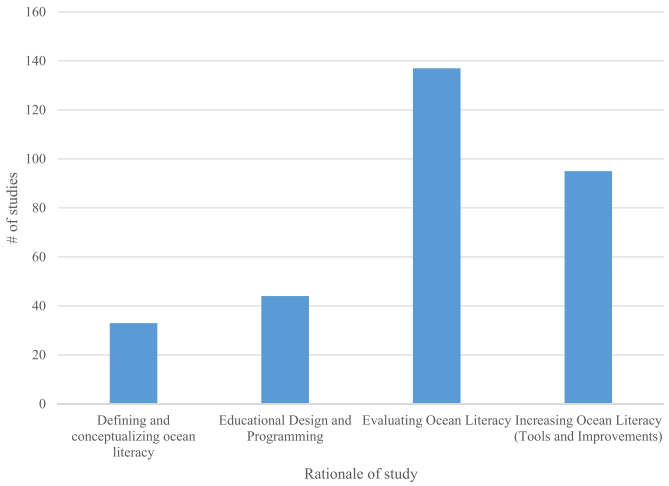

Fig. 8. The rationale and purpose of OL studies (n = 298).

3.7. What is the rationale or purpose of Ocean Literacy research?

From the synthesis of the literature, OL research appears to be driven by four core rationales or purposes. Defining and conceptualising OL, educational design and programming, evaluating OL, and increasing OL (tools and improvements; see Fig. 8).

Defining and conceptualising OL (n = 33, 11.07%) primarily revolves around scholarly deliberations and conversations regarding the fundamental aspects, principles, and significance of OL. The discussion of OL concentrates on defining and conceptualising this concept, evolving beyond its initial scope in formal education to a broader tool for societal engagement (Cavas et al., 2023; McKinley et al., 2023). Educational design and programming (n = 44, 14.77%) focuses on formulating effective educational strategies, curricula, and programs aimed at fostering OL among diverse demographics (O'Brien et al., 2023). These involve designing engaging and informative educational tools and methodologies to enhance understanding and awareness of the ocean's influence. These studies also delve into structuring effective educational initiatives, highlighting the need for integrated and early-grade approaches in teaching OL (Mokos et al., 2020).

Evaluating OL (n = 137, 45.97%) involves assessing the levels of OL among different groups, evaluating existing educational programs' efficacy, and measuring the impact of various interventions (McKinley

Table 3
Types of intervention studied in primary data studies (max n = 333).

Category	Frequency	Description	Examples
Education and learning	126	Activities/interventions involved in formal and informal education.	• Curriculum • Resources (e.g. textbooks and online resources) • Learning styles (e.g. place-based learning, co-operative learning, role play and inquiry-based learning) • Activities (e.g. experiments in laboratories)
Engagement and connection	46	Engaging with or connecting with other individuals, groups, organisations, sectors.	• Traditional knowledge • Collaboration • Engagement • Partnership
Media	42	Interventions which involve exposure to a type of visual media.	• Social media • Film • Art (e.g. murals and photos) • Videos • Posters • Visualisations • Books
Physical exposure to marine and coastal environments	22	Having access to and making physical visits to the marine and coastal environment.	• Leisure and recreation (e.g. scuba diving) • Field trips (e.g. to marine reserves and fish markets) • Expeditions • Proximity to the coast
Attending events	20	Attending events which focus on marine and coastal environments.	• Conventions • Meetings • Workshops
Training and development	18	Training and development programs and activities	• Teacher development • Capacity building • Professional development
Visits to attractions	18	Visits, outreach, field trips and study visits to environmental and scientific attractions and organisations.	• Museums • Aquariums • Exhibitions
Technology	16	Exposure to machinery and equipment that uses the application of scientific knowledge in the context of the marine and coastal environment	• Games • Underwater cameras • Robotics • Virtual reality
Citizen science	11	Projects which actively involve citizens in scientific endeavour that generates new knowledge or understanding of the ocean (including natural and social science).	• Sampling plastics • Collecting data from videos • Reporting sightings of marine species (e.g. seagrass)
Storytelling	5	The activity of writing, telling or reading stories about marine and coastal environments.	• Digital storytelling • Storytelling in person
Other	9	Miscellaneous topics described by respondents.	• Research methods (e.g. horizon scanning, mapping, ethnography) • Policy initiatives • Seafood eco labels

Table 4
Recommendations for future OL research and practice from the literature.

Theme	Description	Example recommendations from the literature	Example references
Dimensions of OL	Includes all topics related to the conceptualisation of and dimensions and components of OL.	• Study interconnectedness between ocean knowledge, values and actions. • Broaden dimensions (e.g., political visibility of the ocean) • Promote multiple dimensions of OL, going beyond knowledge. • Explore how dimensions can be modified, re-framed and contextualised for different geographical and sociocultural contexts.	(McKinley et al., 2023; Mokos et al., 2022; Si and Chen, 2021)
Assessment of OL	Includes all topics relating to the measurement and assessment of OL.	• Use common and universal processes to assess OL globally and track progress. • Conduct cross-cultural comparison of OL. • Use longitudinal methods to assess OL (e.g., student competencies at different time points). • Use of regional surveys with national frameworks to amplify rural and coastal communities. • Widen survey sample populations, e.g. to include groups beyond just school children and teacher, but also policymakers, indigenous groups and industry groups.	(Ahmad-Kamil et al., 2022; Chang et al., 2023; Gonçalves, 2022; Markos et al., 2017; Spoors et al., 2022)
Evaluation	Includes all topics relating to the evaluation of the effectiveness of OL programs, activities, strategies (e.g., using pre-post surveys and experiments).	• Repeat interventions and surveys to obtain more generalisable and reliable findings. • Improve tools for evaluating the impact and effectiveness of interventions on OL (e.g., activities, programs, and initiatives). • Understand the influence of interventions on behaviour change. • Undertake more long-term evaluations of interventions.	(Alvisi et al., 2022; Aurélio et al., 2022; Chiashi and Sasaki, 2012; Wulff and Johannesson, 2018)
Diversity, equity and inclusion	Includes all topics related to the consideration and maximisation of diversity, equity and inclusion within OL (e.g., equity, equality, justice).	• Consider diversity of languages, cultures, and societies. • Give special attention to inclusiveness, accessibility and equity in OL. • Recognise the importance of indigenous knowledge and traditional knowledge for OL. • Provide partnership support for locally relevant, place-based ocean education and training.	(Hoover, 2022; MacNeil et al., 2021; Mokos et al., 2022; Yumagulova, 2020)
Partnerships and collaboration	Includes all topics related to partnerships and collaborations within OL, between different disciplines, groups and sectors.	• Co-ordinate organisations and networks to develop synergies and co-ordinate research programs. • Establish cross-institutional and cross-disciplinary cooperation among research institutions, marine education networks and industry to support OL movement. • Develop more open dialogue and collaboration between ocean and water literacy experts and practitioners. • Develop partnerships, particularly in relation to the UN Ocean Decade to identify where operators already provide OL education and how it can be advanced within their own programme(s) would be advantageous. • Establish partnerships and collaboration which go beyond education - include private sector, stakeholders, policy/decision makers, local communities, etc.	(Ammendolia et al., 2020; Lyth, 2021; Mokos et al., 2022; Paredes-Coral et al., 2021)
Resources and investment	Includes all topics related to resourcing, capacity and investment in OL strategies, actions, programs, and activities (e.g., budgets, personnel, expertise).	• Develop regionally specific resources that tie into an overarching national water/ocean narrative. • Identify scope of work, personnel and ensuring adequate financial resources for OL strategies and actions to achieve goals.	(Cava, 2005; Hoover, 2022; Mokos et al., 2022; Schubel et al., 2005)
Formal education	Includes all topics relevant to formal education programs used to increase OL (i.e., in primary, secondary and higher education).	• Integrate of ocean education and OL principles and concepts into the higher education curricular framework. • Focus OL learning on topics that are likely to personally affect students (e.g., climate change, coastal hazards and climate adaptation). • Develop and make accessible professional development for teachers on OL and education techniques. • Expand the use of cross curricula links that recognise and build upon the importance of outdoor learning within the marine environment. • Establish international school partnerships to promote effective teaching about OL (e.g. that are relevant to the young people and the area in which they live).	(Attard, 2020; Boaventura et al., 2021; de la Vega, 2021; Freitas et al., 2022; Gebbels, 2018; Leitner, 2022; Lyth, 2021)
Informal education	Includes all topics relevant to informal education- i.e., takes place outside of schools/classrooms (e.g. in museums, aquariums)	• Include OL in formal and informal education. • Develop close and functional cooperation and intersectional collaborations between formal education (e.g., teachers) and educators from informal settings (i.e. non-formal education). • Champion the role of museums and aquariums in informal education (i.e. in experiential learning).	(Andriopoulou et al., 2022; Chang et al., 2023; Childress et al., 2021; Mokos et al., 2022; Ostertag et al., 2021; Sims et al., 2021)

(*continued on next page*)

Table 4 (*continued*)

Theme	Description	Example recommendations from the literature	Example references
Technology and innovation	Includes all topics relevant to the use of technology and innovation in relation to building OL (e.g., for use in formal and informal education or broader).	• Use new approaches and digital technology in formal and informal learning (e.g. underwater cameras, robots, apps, games, virtual reality, and laboratories, live connections to research expeditions). • Use social media to inform formal and informal learning, as well as creating interest and connections with the ocean (e.g., Facebook and X).	(Fauville, 2013; Hoeberechts et al., 2016; Roy, 2020; Salazar et al., 2019)
Other	Miscellaneous topics described by respondents.	• Develop strategic OL professional development. • Establish improved communication around the connections between ocean, climate change, biodiversity, sustainable economies, and health • Establish undergraduate science training opportunities that can broaden student participation in conservation- related marine STEM.	(Linsky, 2020; Rivera et al., 2022; Yumagulova, 2020)

et al., 2023). These studies explore methodologies to assess the efficacy of educational programs and individuals' understanding, emphasizing the importance of robust evaluation tools. Researchers utilise assessments and metrics to gauge individuals' knowledge and understanding of ocean-related concepts. Increasing OL (tools and improvements; n = 95, 31.88%) concentrates on developing tools, methodologies, and innovative approaches to augment OL levels (Kelly et al., 2022). These studies broadly aim to improve existing educational frameworks, technologies, and resources to elevate the public's understanding of the ocean's significance (Cavas et al., 2023).

As a component of the rationale, we also explored the interventions which had been studied in primary data studies (n = 218). Some studies examined multiple types of intervention, leading to a frequency of n = 333. There were 11 main types of intervention (see Table 3). Education and learning (i.e. change to curriculum, education activities, the use of resources and applying different learning styles) were the most common (n = 126; 37.84%), which aligns to our findings that knowledge is the most common dimension of OL (section 3.5). This was followed by engagement and connection (n = 46; 13.81%), which focused on people gaining OL through engaging and connecting with other individuals, groups, organisations and sectors to gain OL (e.g. collaborations, partnerships and cultural connections-such as traditional knowledge). In addition to media (n = 42; 12.61%) which involved gaining OL through being exposed to visual media, in the forms of social media, film, art, videos, posters, visualisations and books. The other types of intervention included: (i) physical exposure to marine and coastal environments, (ii) attending events, (iii) training and development, (iv) visits to attractions, (v) technology, (vi) citizen science, (vii) storytelling and (viii) other.

3.8. What are the recommendations for future Ocean Literacy research and practice?

Numerous articles provided future priorities or recommendations for OL. Collectively this set of recommendations captured both research-focused and operational priorities. Our analysis produced ten themes of recommendations (see Table 4 for definitions, examples, and references).

Three themes were more explicitly related to research priorities. For example, research into: (i) dimensions of OL, (ii) assessment of OL and (iii) evaluation of OL. These priorities potentially highlight the specific challenges relating to the measurement and operationalisation of OL, perhaps emphasizing the urgent need for this work. The complexity of these issues will necessitate true interdisciplinarity, transdisciplinarity and global efforts, building on the progress and status of research, disciplines, sectors and networks that work in this space. This will require systemic change to funding calls, design and implementation of OL research, as has been discussed previously in Marine Social Science (McKinley et al., 2022; van Putten et al., 2021) and topics such as public perception research and marine conservation (Jefferson et al., 2021; Parsons et al., 2014). The remaining seven themes were cross-cutting but more explicitly related to OL practice: (i) diversity, equity and inclusion, (ii) partnerships and collaboration, (iii) resources and investment, (iv) formal education, (v) informal education, (vi) technology and innovation and (vii) other.

3.9. Implications for research and policy

This SM of OL outlines the first updatable, interrogable and comprehensive source of evidence on this topic. It is intended as a first step at bringing coherence to the evidence base, identifying the gaps and providing a way forward by focusing on synthesised understandings of OL (Badullovich et al., 2020; Eales et al., 2021), which will support researchers, practitioners and decision-makers. We highlight the main implications of the findings for research and policy below. We note that the SM assesses the amount of evidence on OL and the types of

approaches used but does not detail the direction or strength of effect, nor quality of individual studies included (Eales et al., 2021). We encourage the use of the SM database, available as an excel file in the Supplementary Materials to support research and decision-making.

3.9.1. Research

These findings have implications for future research by highlighting areas that require further investigation, such as the dimensions of emoceans and trust and transparency. Researchers could focus on developing appropriate methods and measures to address these underexplored aspects of OL. We also identified the main rationale and purpose behind OL work to date as: (i) defining and conceptualising OL and (ii) educational design and programming. This indication of the trends in OL research can help to identify popular topics and guide the design and implementation of future work (e.g., OL surveys and evaluations). We also identified a range of recommendations for future research and practice to provide much-needed direction for the continued development and expansion of OL globally. We encourage discussion and action around the priorities identified in the SM, along with further investigation by research institutions, industry and NGOs (McKinley et al., 2022; Wisz et al., 2020).

3.9.2. Policy

Policymakers and practitioners can use the evidence synthesised in this SM to inform the development and implementation of OL initiatives and strategies. The identified knowledge gaps and recommendations can guide the prioritization of efforts and resource allocation to address critical areas effectively. In addition, there are risks of bias when gathering evidence, especially when using information from individual studies, policy briefs and less-structured discussions of existing literature (e.g., narrative reviews and perspective pieces; Boyd, 2013; Thomas-Walters et al., 2021). This SM aims to overcome this barrier by using high-quality and stringent methods to synthesise the best available evidence on OL. This is particularly pertinent in 2024, following the UN Barcelona Statement, which highlighted OL as a priority area for the delivery of the Ocean Decade. Hence, this SM will be useful for decision-makers working on ocean policy initiatives and drivers connected with OL. These include international initiatives, such as the Ocean Decade (Claudet et al., 2020; Ryabinin et al., 2019) and national, regional and local policy directives and legal and policy developments that address, for example, the sustainable use of marine areas (e.g., Marine Protected Areas and Marine Protected Areas and Marine Spatial Planning) and marine conservation and climate change (Kelly et al., 2022). The review may also help to raise the profile of OL amongst policy and decision-makers and help facilitate more useful discussions between researchers, practitioners and decision-makers. OL is "a key tool to engage society and to leverage actions on the ground, needs to be more efficiently and widely promoted" (Claudet et al., 2020; p40).

The SM reveals important governance insights related to the application of OL in decision-making processes. The findings indicate a need for greater collaboration between researchers, policymakers, and stakeholders to develop practical guidance on integrating OL into marine policy and management frameworks. This collaborative approach can help bridge the gap between scientific knowledge and governance, facilitating the translation of OL concepts into actionable strategies for sustainable ocean and coastal management.

To better leverage OL for policymaking and decision-making, future research should prioritize examining the direct links between OL and policy outcomes, as well as developing practical guidance on how to integrate OL into marine policy processes. Collaboration between researchers, policymakers, and stakeholders will be crucial in addressing these knowledge gaps and enhancing the policy relevance of OL. From a governance perspective, addressing the appropriateness and inclusivity of OL terminology is crucial. Collaborative efforts involving diverse stakeholders, including indigenous communities and underrepresented groups, can help reframe OL in a more inclusive and culturally sensitive manner. This could enhance the acceptance and effective implementation of OL initiatives, fostering greater participation and ownership among coastal communities in ocean and coastal management processes.

3.10. Limitations

This SM provides an overview of the OL literature to observe the evolution and trends in relation to this specific concept. However, as highlighted by the review, there are issues with the term OL, including calls to redefine OL. For example, to "recognise tacit and practical wisdom and local and Indigenous knowledge that, where applicable, is also in concert with the dominant scientific paradigm" (Spalding et al., 2023) (p8). Further, some papers may be discussing OL but use different terms in the title or abstract and therefore would be more difficult to pick up in the SM process. For example, using terms such as "marine literacy", "coastal literacy", "aquatic literacy" and "environmental literacy". Furthermore, we did not examine associated terms such as marine stewardship or marine citizenship (Buchan et al., 2023; McKinley and Fletcher, 2010, 2012), which are often used in conjunction with OL.

Only English language articles were included in this SM which means that potential research in other languages was excluded from our database. This limitation could be readdressed by conducting updates on this SM to include a range of languages and accessing different literatures. This is important because scientists from the Global Majority are underrepresented in marine conservation (Ahmadia et al., 2021; Shellock et al., 2022, 2023) and associated fields (Maas et al., 2021). English-language focused searches may further exacerbate these trends and result in gaps in understanding of research and practice. Lastly, some of the articles were inaccessible, however, this number was low and hence unlikely to affect the overall trends in our SM. Despite these limitations, the SM provides a comprehensive overview of the current state of OL research and highlights areas that warrant further attention from both researchers and policymakers. Addressing the identified gaps and recommendations can advance the field and enhance the practical application of OL in supporting sustainable ocean management.

4. Conclusions

The field of OL has grown since its inception in 2002 and our SM demonstrates that OL as a concept and practice is likely to continue evolving rapidly. We have used a SM methodology to examine the existing evidence base on OL. This SM is a first step at bringing coherence to the evidence base, identifying opportunities, and providing a way forward by focusing on synthesised understandings of OL. We encourage and invite future primary research and evidence synthesis to ask new questions of the literature base and to use our SM as a starting point. This SM underscores the importance of adopting a governance approach that recognizes the multidisciplinary and cross-sectoral nature of OL. Effective ocean and coastal management requires a holistic understanding of the social, cultural, and economic dimensions of human-ocean interactions. By bringing together diverse perspectives and knowledge systems, OL can serve as a platform for fostering inclusive and participatory governance processes, ultimately contributing to more sustainable and equitable management of marine resources and ecosystems.

CRediT authorship contribution statement

R.J. Shellock: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **L. Fullbrook:** Writing – review & editing, Writing – original draft, Validation, Formal analysis. **E. McKinley:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization. **C. Cvitanovic:** Writing – review & editing, Validation, Methodology, Conceptualization. **R. Kelly:** Writing – review & editing, Validation, Methodology,

Conceptualization. **V. Martin:** Writing – review & editing, Validation, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors have shared the Systematic Map database which displays the data used in the article.

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Appendix A. Supplementary data

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References

Ahmadia, G.N., Cheng, S.H., Andradi-brown, D.A., Baez, S.K., Barnes, M.D., Bennett, N. J., Campbell, S.J., Darling, E.S., Gill, D., Gress, E., Gurney, G.G., 2021. Limited progress in improving gender and geographic representation in coral reef science. Front. Mar. Sci. 8, 1–15. https://doi.org/10.3389/fmars.2021.731037.

Ahmad-Kamil, E.I., Zakaria, S.Z.S., Othman, M., 2022. What teachers should know for effective marine litter education: a scoping review. Sustainability. https://doi.org/10.3390/su14074308.

Alvisi, F., Baldrighi, E., Merlino, S., Locritani, M., Panfili, M., Colella, S., Bronco, S., Cicogna, F., Coiai, S., King, E., 2022. Walking on the sea traces: developing a platform to bring Ocean Literacy and citizen science at home. Mediterr. Mar. Sci. 23, 389–404. https://doi.org/10.12681/mms.26931.

Ammendolia, J., 2020. Understanding Ocean Literacy in Canada Atlantic Regional Report Hydrostatic Pressure as a Biotic Stressor View Project Plastic Ingestion View Project.

Ammendolia, J., Glithero, L., Macneil, S., Monk, S., 2020. Understanding Ocean Literacy in Canada "Inland Canada" Regional Report.

Andriopoulou, A., Giakoumi, S., Kouvarda, T., Tsabaris, C., Pavlatou, E., Scoullos, M., 2022. Digital storytelling as an educational tool for scientific, environmental and sustainable development literacy on marine litter in informal education environments (Case study: hellenic Center for Marine Research). Mediterr. Mar. Sci. 23, 327–337. https://doi.org/10.12681/mms.26942.

Attard, A., 2020. The role of formal education in shaping first-year student knowledge, awareness and risk perceptions of coastal hazards : a study of first-year undergraduate students at UNSW Sydney Australia. https://doi.org/10.26190/unsworks/22654.

Aurélio, L., Sequeira, V., França, S., Amoroso, S., Boaventura, D., Cardoso, I., Amorim, A., Cabral, H.N., 2022. Bridging the gap between formal and non-formal science education: traditional fish markets as a tool to promote ocean literacy. Appl. Environ. Educ. Commun. Int. J. 21, 238–253. https://doi.org/10.1080/1533015X.2022.2043207.

Badullovich, N., Grant, W.J., Colvin, R.M., 2020. Framing climate change for effective communication: a systematic map. Environ. Res. Lett. 15 https://doi.org/10.1088/1748-9326/aba4c7.

Baldrighi, E., Muzlovic, P., Annibaldi, A., Penna, A., Manini, E., Rosetti, E., Renzoni, E.E., Grilli, F., Giacomini, G., Kristovic, I., Marini, M., Susmel, S., 2022. ADSWIM and WATERCARE projects meet kids and youth: the challenge of bringing the world of research to school to merge research, education and communication. Water (Switzerland) 14. https://doi.org/10.3390/w14121843.

Bates, S., Clapton, J., Coren, E., 2007. Systematic maps to support the evidence base in social care. Evidence & Policy 3, 539–551.

Boaventura, D., Neves, A.T., Santos, J., Pereira, P.C., Luís, C., Monteiro, A., Cartaxana, A., Hawkins, S.J., Caldeira, M.F., Ponces de Carvalho, A., 2021. Promoting Ocean literacy in elementary school students through investigation activities and citizen science. Front. Mar. Sci. 8 https://doi.org/10.3389/fmars.2021.675278.

Borja, A., Santoro, F., Scowcroft, G., Fletcher, S., Strosser, P., 2020. Editorial: connecting people to their oceans: issues and options for effective Ocean Literacy. Front. Mar. Sci. 6 https://doi.org/10.3389/fmars.2019.00837.

Boyd, I., 2013. A standard for policy-relevant science. Nature 501, 159–160.

Bramer, W.M., Giustini, D., Kramer, B.M.R., 2016. Comparing the coverage, recall, and precision of searches for 120 systematic reviews in Embase, MEDLINE, and Google Scholar: a prospective study. Syst. Rev. 5, 1–7.

Brennan, C., Ashley, M., Molloy, O., 2019. A system dynamics approach to increasing ocean literacy. Front. Mar. Sci. 6 https://doi.org/10.3389/fmars.2019.00360.

Buchan, P.M., Evans, L.S., Pieraccini, M., Barr, S., 2023. Marine citizenship: the right to participate in the transformation of the human-ocean relationship for sustainability. PLoS One 18, e0280518.

Cahyadi, F.D., Tarigan, D.J., Sasongko, A.S., Prakoso, K., Widiyanto, K., 2021. Virtual scuba diving activities for elementary student to enhance their ocean literacy. In: Journal of Physics: Conference Series. IOP Publishing Ltd. https://doi.org/10.1088/1742-6596/1987/1/012054.

Cava, F., 2005. Science Content and Standards for Ocean Literacy: A Report on Ocean Literacy.

Cava, F., 2002a. Enhancing the national geographic standards with ocean content. Our Fragile Oceans: Calif. J. Sci. Educ.

Cava, F., 2002b. Promoting Ocean Literacy in the Classroom Excerpt from Our Fragile Oceans: California Journal of Science Education, Fall 2002. Our Fragile Oceans: California Journal of Science Education.

Cavas, B., Acik, S., Koc, S., Kolac, M., 2023. Research trends and content analysis of Ocean Literacy studies between 2017 and 2021. Front. Mar. Sci. 10, 1200181.

Chang, C.C., Tsai, L.T., Meliana, D., 2023. The concept of Ocean Sustainability in high school: measuring the Ocean Literacy of vocational high school students in Indonesia. Sustainability 15. https://doi.org/10.3390/su15021043.

Cheimonopoulou, M.T., Koulouri, P., Previati, M., Realdon, G., Mokos, M., Mogias, A., 2022. Implementation of a new research tool for evaluating Mediterranean Sea Literacy (MSL) of high school students: a pilot study. Mediterr. Mar. Sci. 23, 302–309. https://doi.org/10.12681/mms.29712.

Chiashi, K., Sasaki, T., 2012. Trainer's views of indicators comprising Ocean Literacy. Japan Outdoor Education Journal 15, 139–19.

Childress, M.J., Tallapragada, M., Prosser, K.L., 2021. Something Very Fishy: an ocean literacy STEAM exhibit impacts how children, teachers, and university students think about science. Integr. Comp. Biol. 61 (MA-S), E137–E138.

Claudet, J., Bopp, L., Cheung, W.L., Devillers, R., Escobar-Briones, E., Haugan, P., Heymans, J.J., Masson-Delmotte, V., Matz-Lück, N., Miloslavich, P., Mullineaux, L., Visbeck, M., Watson, R., Zivian, A.M., Ansorge, I., Araujo, M., Aricò, S., Bailly, D., Barbière, J., Barnerias, C., Bowler, C., Brun, V., Cazenave, A., Diver, C., Euzen, A., Gaye, A.T., Hilmi, N., Ménard, F., Moulin, C., Muñoz, N.P., Parmentier, R., Pebayle, A., Pörtner, H.-O., Osvaldina, S., Ricard, P., Santos, R.S., Sicre, M.-A., Thiébault, S., Thiele, T., Troublé, R., Turra, A., Uku, J., Gaill, F., 2020. A roadmap for using the UN decade of Ocean science for sustainable development in support of science, policy, and action. One Earth 2, 34–42. https://doi.org/10.1016/j.oneear.2019.10.012.

Costa, S., Caldeira, R., 2018. Bibliometric analysis of ocean literacy: an underrated term in the scientific literature. Mar. Pol. 87, 149–157. https://doi.org/10.1016/j.marpol.2017.10.022.

de la Vega, A.G., 2021. Design-based implementation research for exploring the Ocean: a geographical perspective. In: Koutsopoulos, K.C., Stel, J.H. (Eds.), Ocean Literacy: Understanding the Ocean, pp. 115–147.

Eales, J., Bethel, A., Fullam, J., Olmesdahl, S., Wulandari, P., Garside, R., 2021. What is the evidence documenting the effects of marine or coastal nature conservation or natural resource management activities on human well-being in South East Asia? A systematic map. Environ. Int. https://doi.org/10.1016/j.envint.2021.106397.

Fauville, G., 2013. How Can Facebook Contribute to the Creation of a More Ocean Literate Society?.

Fauville, G., Strang, C., Cannady, M.A., Chen, Y.F., 2019. Development of the international Ocean Literacy survey: measuring knowledge across the world. Environ. Educ. Res. 25, 238–263. https://doi.org/10.1080/13504622.2018.1440381.

Fauville, G., Voşki, A., Mado, M., Bailenson, J.N., Lantz-Andersson, A., 2024. Underwater virtual reality for marine education and ocean literacy: technological and psychological potentials. Environ. Educ. Res. 1–25.

Fernández Otero, R.M., Bayliss-Brown, G.A., Papathanassiou, M., 2019. Ocean literacy and knowledge transfer synergies in support of a sustainable blue economy. Front. Mar. Sci. 6, 1–8. https://doi.org/10.3389/fmars.2019.00646.

Frampton, G.K., Livoreil, B., Petrokofsky, G., 2017. Eligibility screening in evidence synthesis of environmental management topics. Environ. Evid. 6 https://doi.org/10.1186/s13750-017-0102-2.

Freitas, C., Bellgrove, A., Venzo, P., Francis, P., 2022. Towards a 2025 national Ocean Literacy strategy: current status and future needs in primary education. Front. Mar. Sci. 9 https://doi.org/10.3389/fmars.2022.883524.

French, V., Chu, N.-C., Santoro, F., Sousa-Pinto, I., Borges, D., McDonough, N., 2015. Review of Ocean Literacy in European maritime policy. EU Sea Change Project.

Gebbels, S., 2018. Using international school partnerships to promote ocean literacy, exemplary practices in marine science education: a resource for practitioners and researchers. https://doi.org/10.1007/978-3-319-90778-9_14.
Gifford, R., 2014. Environmental psychology matters. Annu. Rev. Psychol. 65, 541–579. https://doi.org/10.1146/annurev-psych-010213-115048.
Glithero, D., Bridge, N., Hart, H., Mann-Lang, J., McPhie, R., Paul, K., Peebler, A., Wiener, C., Yen, C., Kelly, R., McRuer, J., Callon, M., Curtin, F., 2024. Restoring Society's Relationship with the Ocean. United Nations Educational, Scientific and Cultural Organization (UNESCO).
Gonçalves, A.M.M., 2022. Ocean literacy for sustainable use of Oceans globally. In: Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Wall, T. (Eds.), Life below Water, Encyclopedia of the UN Sustainable Development Goals. Springer International Publishing. https://doi.org/10.1007/978-3-319-98536-7.
GreyNet, 2013. GreyNet: grey literature network service [WWW Document]. http://www.greynet.org/.
Haddaway, N.R., 2020. ROSES_flowchart: an R package and ShinyApp. https://doi.org/10.5281/zenodo.4294810.
Haddaway, N.R., Bayliss, H.R., 2015. Shades of grey: two forms of grey literature important for reviews in conservation. Biol. Conserv. 191, 827–829. https://doi.org/10.1016/j.biocon.2015.08.018.
Haddaway, N.R., Collins, A.M., Coughlin, D., Kirk, S., 2015. The role of google scholar in evidence reviews and its applicability to grey literature searching. PLoS One 10. https://doi.org/10.1371/journal.pone.0138237.
Haddaway, N.R., Macura, B., Whaley, P., Pullin, A.S., 2018. ROSES Reporting standards for Systematic Evidence Syntheses: pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. Environ. Evid. 7, 4–11. https://doi.org/10.1186/s13750-018-0121-7.
Halpern, B.S., Frazier, M., Afflerbach, J., Lowndes, J.S., Micheli, F., O'Hara, C., Scarborough, C., Selkoe, K.A., 2019. Recent pace of change in human impact on the world's ocean. Sci. Rep. 9, 1–8. https://doi.org/10.1038/s41598-019-47201-9.
Halpern, B.S., Frazier, M., Potapenko, J., Casey, K.S., Koenig, K., Longo, C., Lowndes, J. S., Rockwood, R.C., Selig, E.R., Selkoe, K.A., Walbridge, S., 2015. Spatial and temporal changes in cumulative human impacts on the world's ocean. Nat. Commun. 6, 1–7. https://doi.org/10.1038/ncomms8615.
Hobday, A.J., Cvitanovic, C., 2017. Preparing Australian fisheries for the critical decade: insights from the past 25 years. Mar. Freshw. Res. 68, 1779–1787.
Hoeberechts, M., Owens, D., Riddell, D.J., Robertson, A.D., 2016. The Power of Seeing: experiences using video as a deep-sea engagement and education tool. In: OCEANS 2015 - MTS. Institute of Electrical and Electronics Engineers Inc, IEEE Washington. https://doi.org/10.23919/oceans.2015.7404592.
Hoover, C., 2022. Understanding Ocean Literacy in Canada: Inuit Nunangat Regional Report.
International Governmental Oceanographic Commission (of UNESCO), 2020. Revised Draft IOC Ocean Literacy Plan of 2018-2021. Paris.
James, K.L., Randall, N.P., Haddaway, N.R., 2016. A methodology for systematic mapping in environmental sciences. Environ. Evid. 5, 1–13. https://doi.org/10.1186/s13750-016-0059-6.
Jefferson, R., McKinley, E., Griffin, H., Nimmo, A., Fletcher, S., 2021. Public perceptions of the Ocean: lessons for marine conservation from a global research review. Front. Mar. Sci. https://doi.org/10.3389/fmars.2021.711245.
Jouffray, J.-B., Blasiak, R., Norström, A.V., Österblom, H., Nyström, M., 2020. The blue acceleration: the trajectory of human expansion into the Ocean. One Earth 2, 43–54. https://doi.org/10.1016/j.oneear.2019.12.016.
Kellermeyer, L., Harnke, B., Knight, S., 2018. Covidence and rayyan. J. Med. Libr. Assoc. https://doi.org/10.5195/JMLA.2018.513.
Kelly, R., Evans, K., Alexander, K., Bettiol, S., Corney, S., Cullen-Knox, C., Cvitanovic, C., de Salas, K., Emad, G.R., Fullbrook, L., Wood, G., Pecl, G.T., 2022. Connecting to the oceans: supporting ocean literacy and public engagement. Rev. Fish Biol. Fish. 32, 123–143. https://doi.org/10.1007/s11160-020-09625-9.
Kopke, K., Black, J., Dozier, A., 2019. Stepping out of the ivory tower for Ocean Literacy. Front. Mar. Sci. 6 https://doi.org/10.3389/fmars.2019.00060.
Leitao, R., Maguire, M., Turner, S., Guimaraes, L., Arenas, F., 2018. OCEAN LITERACY and information sources: comparison between pupils in Portugal and the UK. 12TH INTERNATIONAL TECHNOLOGY, EDUCATION AND DEVELOPMENT CONFERENCE (INTED).
Leitner, C., 2022. Ocean Literacy in the Swedish Curriculum. University of Gothenburg, Gothenburg.
Linsky, L., 2020. School administrator influences on classroom ocean-based curricula: lessons from a professional development program in Hawaii. Curr. J. Mar. Educ. 34, 36–45. https://doi.org/10.5334/cjme.37.
Livoreil, B., Glanville, J., Haddaway, N.R., Bayliss, H., Bethel, A., De Lachapelle, F.F., Robalino, S., Savilaakso, S., Zhou, W., Petrokofsky, G., Frampton, G., 2017. Systematic searching for environmental evidence using multiple tools and sources. Environ. Evid. 6, 1–14. https://doi.org/10.1186/s13750-017-0099-6.
Lyth, L.E., 2021. Sail training has set sail on a course towards Ocean Literacy. In: Koutsopoulos, K.C., Stel, J.H. (Eds.), Ocean Literacy: Understanding the Ocean, pp. 160–194.
Maas, B., Pakeman, R.J., Godet, L., Smith, L., Devictor, V., Primack, R., 2021. Women and Global South strikingly underrepresented among top-publishing ecologists. Conserv Lett 1–9. https://doi.org/10.1111/conl.12797.
MacNeil, S., Hoover, C., Ostertag, J., Yumagulova, L., Glithero, L., 2021. Coming to terms with Ocean Literacy. Can. J. Environ. Educ. 24, 233–252.
Markos, A., Boubonari, T., Mogias, A., Kevrekidis, T., 2017. Measuring ocean literacy in pre-service teachers: psychometric properties of the Greek version of the Survey of Ocean Literacy and Experience (SOLE). Environ. Educ. Res. 23, 231–251. https://doi.org/10.1080/13504622.2015.1126807.
Marrero, M.E., Mensah, F.M.M., 2010. Socioscientific decision making and the Ocean: a case study of 7th grade life science students. Electron. J. Sci. Educ. 14.
McKinley, E., Burdon, D., 2020. Understanding Ocean literacy and ocean climate-related behaviour change in the UK- work package 1: evidence synthesis. Final Report Produced for the Ocean Conservation Trust and Defra.
McKinley, E., Burdon, D., Shellock, R.J., 2023. The evolution of ocean literacy: a new framework for the United Nations Ocean Decade and beyond. Mar. Pollut. Bull. 186 https://doi.org/10.1016/j.marpolbul.2022.114467.
McKinley, E., Fletcher, S., 2012. Improving marine environmental health through marine citizenship: a call for debate. Mar. Pol. 36, 839–843. https://doi.org/10.1016/j.marpol.2011.11.001.
McKinley, E., Fletcher, S., 2010. Individual responsibility for the oceans? An evaluation of marine citizenship by UK marine practitioners. Ocean Coast Manag. 53, 379–384. https://doi.org/10.1016/j.ocecoaman.2010.04.012.
McKinley, E., Kelly, R., Mackay, M., Shellock, R., Cvitanovic, C., van Putten, I., 2022. Development and expansion in the marine social sciences: insights from the global community. iScience 25. https://doi.org/10.1016/j.isci.2022.104735.
Mokos, M., De-Bastos, E.S.R., Realdon, G., Wojcieszek, D., Papathanasiou, M., Tuddenham, P., 2022. Navigating Ocean literacy in europe: 10 years of history and future perspectives. Mediterr. Mar. Sci. 23, 277–288. https://doi.org/10.12681/mms.26989.
Mokos, M., Realdon, G., Čižmek, I.Z., 2020. How to increase ocean literacy for future ocean sustainability? The influence of non-formal marine science education. Sustainability 12, 1–12. https://doi.org/10.3390/su122410647.
Moon, K., Blackman, D., 2014. A guide to understanding social science research for natural scientists. Conserv. Biol. 28, 1167–1177. https://doi.org/10.1111/cobi.12326.
Nash, K.L., Cvitanovic, C., Fulton, E.A., Halpern, B.S., Milner-Gulland, E.J., Watson, R.A., Blanchard, J.L., 2017. Planetary boundaries for a blue planet. Nat Ecol Evol 1, 1625–1634. https://doi.org/10.1038/s41559-017-0319-z.
Norris, M., Oppenheim, C., 2007. Comparing alternatives to the Web of Science for coverage of the social sciences' literature. J Informetr 1, 161–169.
O'Brien, M., Freitas, C., Venzo, P., Francis, P., 2023. Fostering ocean literacy through informal marine education programs. Mar. Pollut. Bull. 193 https://doi.org/10.1016/j.marpolbul.2023.115208.
Ostertag, J., Ammendolia, J., Vance, A., McPherson, K., Hamelin, K.M., Cousineau, M., Daoud, D., Morissette, L., Orren, K., Hill, A., VanderKloet, E., Whoriskey, F., Iverson, S., Sutherland, M., Denny, S., Beland, J., Syliboy, A., Stokesbury, M., Porter, D., 2021. Community-based Ocean Literacy: four examples of Ocean optimism from mi'kma'ki/atlantic Canada. Can. J. Environ. Educ. 24, 136–160.
Oxfam, 2023. Inclusive Language Guide. Oxford. https://doi.org/10.21201/2021.7611.
Paredes-Coral, E., Mokos, M., Vanreusel, A., Deprez, T., 2021. Mapping global research on Ocean Literacy: implications for science, policy, and the blue economy. Front. Mar. Sci. 8, 1–12. https://doi.org/10.3389/fmars.2021.648492.
Parsons, E.C.M., Favaro, B., Aguirre, A.A., Bauer, A.L., Blight, L.K., Cigliano, J.A., Coleman, M.A., C, I.M., Draheim, M., Fletcher, S., Foley, M.M., Jefferson, R., Jones, M.C., Kelaher, B.P., Lundquist, C.J., Mccarthy, J.B., Nelson, A., Patterson, K., Walsh, L., Wright, A.J., Sutherland, W.J., 2014. Seventy-one important questions for the conservation of marine biodiversity. Conserv. Biol. 28, 1206–1214. https://doi.org/10.1111/cobi.12303.
Pullin, A., Frampton, G.F., Livoreil, B., Petrokofsky, G., 2022. Guidelines and Standards for Evidence Synthesis in Environmental Management [WWW Document], Version 5.1.
Rivera, M.A.J., Ambrosino, C.M., Manning, M.M., Soon, S.L., Rii, Y.M., Gorospe, K.D., 2022. Broadening participation through research experiences in marine science: an early-admit immersive college course provides experiential, place-based scientific training for Hawai'i high school students. Oceanography 35, 60–71. https://doi.org/10.2307/27166140.
Roy, N., 2020. Youth and Ocean Literacy in Canada: Key Findings &recommendations.
Ryabinin, V., Barbière, J., Haugan, P., Kullenberg, G., Smith, N., McLean, C., Troisi, A., Fischer, A., Aricò, S., Aarup, T., Pissierssens, P., Visbeck, M., Enevoldsen, H.O., Rigaud, J., 2019. The UN decade of Ocean science for sustainable development. Front. Mar. Sci. 6 https://doi.org/10.3389/fmars.2019.00470.
Salazar, J., Dominguez-Carrió, C., Gili, J.M., Ambroso, S., Grinyó, J., Vendrell-Simón, B., 2019. Building a new ocean literacy approach based on a simulated dive in a submarine: a multisensory workshop to bring the deep sea closer to people. Front. Mar. Sci. 6 https://doi.org/10.3389/fmars.2019.00576.
Salazar-Sepúlveda, G., Vega-Muñoz, A., Contreras-Barraza, N., Castillo, D., Torres-Alcayaga, M., Cornejo-Orellana, C., 2023. Bibliometric analysis on Ocean Literacy studies for marine conservation. Water 15, 2095.
Salinger, J., Hobday, A.J., Matear, R.J., O'Kane, T.J., Risbey, J.S., Dunstan, P., Eveson, J. P., Fulton, E.A., Feng, M., Plaganyi, E.E., Poloczanska, E.S., Marshall, A.G., Thompson, P.A., 2016. Decadal-scale forecasting of climate drivers for marine applications. Adv. Mar. Biol. 74, 1–68.
Santoro, F., Selvaggia, S., Scowcroft, G., Fauville, G., Tuddenham, P., 2017. Ocean Literacy for All: a Toolkit. UNESCO Publishing, Italy.
Schoedinger, S., Cava, F., Strang, C., Tuddenham, P., 2005. Ocean literacy through science standards. In: Proceedings of MTS/IEEE OCEANS, pp. 736–740. https://doi.org/10.1109/OCEANS.2005.1639840.
Schoedinger, S., Tran, L.U., Whitley, L., 2010. From the Principles to the Scope and Sequence: A Brief History of the Ocean Literacy Campaign.
Schubel, J.R., Monroe, C., Lau, A., 2005. Energizing networks of free-choice learning organizations around the USCOP report and one ocean. In: Proceedings of MTS/IEEE OCEANS, pp. 127–129. https://doi.org/10.1109/OCEANS.2005.1639749, 2005.

Shellock, R.J., Cvitanovic, C., Mackay, M., McKinnon, M.C., Blythe, J., Kelly, R., van Putten, I.E., Tuohy, P., Bailey, M., Begossi, A., Crona, B., Fakoya, K.A., Ferreira, B.P., Ferrer, A.J.G., Frangoudes, K., Gobin, J., Goh, H.C., Haapasaari, P., Hardesty, B.D., Häussermann, V., Hoareau, K., Hornidge, A.-K., Isaacs, M., Kraan, M., Li, Y., Liu, M., Lopes, P.F.M., Mlakar, M., Morrison, T.H., Oxenford, H.A., Pecl, G.T., Penca, J., Robinson, C., Selim, S., Skern-Mauritzen, M., Soejima, K., Soto, D., Spalding, A.K., Vadrot, A., Vaidianu, N., Webber, M., Wisz, M.S., 2022. Breaking down barriers: the identification of actions to promote gender equality in interdisciplinary marine research institutions. One Earth 5, 687–708. https://doi.org/10.1016/j.oneear.2022.05.006.

Shellock, R.J., Cvitanovic, C., McKinnon, M.C., Mackay, M., van Putten, I.E., Blythe, J., Kelly, R., Tuohy, P., Maltby, K.M., Mynott, S., 2023. Building leaders for the UN Ocean Science Decade: a guide to supporting early career women researchers within academic marine research institutions. ICES (Int. Counc. Explor. Sea) J. Mar. Sci. 80, 56–75.

Si, L., Chen, Y., 2021. Developing an Ocean Literacy Framework: Lesson from an Analysis of Ocean Week Canada.

Sims, R.J., Tallapragada, M., Payton, T.G., Noonan, K., Prosser, K.L., Childress, M.J., 2021. University experiences of marine science research and outreach beyond the classroom. In: Integrative and Comparative Biology. Oxford University Press, pp. 1078–1088. https://doi.org/10.1093/icb/icab104.

Spalding, A.K., Grorud-Colvert, K., Allison, E.H., Amon, D.J., Collin, R., de Vos, A., Friedlander, A.M., Johnson, S.M., Mayorga, J., Paris, C.B., 2023. Engaging the tropical majority to make ocean governance and science more equitable and effective. npj Ocean Sustainability 2, 8.

Spoors, F., Leakey, C.D.B., James, M.A., 2022. Piloting a regional scale Ocean Literacy survey in fife. Front. Mar. Sci. 9 https://doi.org/10.3389/fmars.2022.858937.

Thomas-Walters, L., Nyboer, E.A., Taylor, J.J., Rytwinski, T., Lane, J.F., Young, N., Bennett, J.R., Nguyen, V.M., Harron, N., Aitken, S.M., Auld, G., Browne, D., Jacob, A.L., Prior, K., Smith, P.A., Smokorowski, K.E., Alexander, S.M., Cooke, S.J., 2021. An optimistic outlook on the use of evidence syntheses to inform environmental decision-making. Conserv Sci Pract 3. https://doi.org/10.1111/csp2.426.

UNESCO, 2024. Ocean Decade Conference - Barcelona Statement.

UNESCO, 2020. Ocean Literacy for the UN Decade of Ocean Science for Sustainable Development (Draft Strategy).

UNESCO, 2018. Ocean literacy portal [WWW Document]. URL. https://oceanliteracy.unesco.org/, 8.29.22.

United Nations Environment Programme, 2021. Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity and Pollution Emergencies. Nairobi.

van Putten, I., Kelly, R., Cavanagh, R.D., Murphy, E.J., Breckwoldt, A., Brodie, S., Cvitanovic, C., Dickey-Collas, M., Maddison, L., Melbourne-Thomas, J., Arrizabalaga, H., Azetsu-Scott, K., Beckley, L.E., Bellerby, R., Constable, A.J., Cowie, G., Evans, K., Glaser, M., Hall, J., Hobday, A.J., Johnston, N.M., Llopiz, J.K., Mueter, F., Muller-Karger, F.E., Weng, K.C., Wolf-Gladrow, D., Xavier, J.C., 2021. A decade of incorporating social sciences in the integrated marine biosphere research project (IMBeR): much done, much to do? Front. Mar. Sci. 8, 1–14. https://doi.org/10.3389/fmars.2021.662350.

Veríssimo, D., 2013. Influencing human behaviour: an underutilised tool for biodiversity management. Conservation Evidence 10, 29–31.

Viera, A.J., Garrett, J.M., 2005. Understanding interobserver agreement: the kappa statistic. Fam. Med. 37, 360–363.

Wisz, M.S., Satterthwaite, E.V., Fudge, M., Fischer, M., Polejack, A., St John, M., Fletcher, S., Rudd, M.A., 2020. 100 opportunities for more inclusive ocean research: cross-disciplinary research questions for sustainable ocean governance and management. Front. Mar. Sci. https://doi.org/10.3389/fmars.2020.00576.

Worm, B., Elliff, C., Fonseca, J.G., Gell, F.R., Serra-Gonçalves, C., Helder, N.K., Murray, K., Peckham, H., Prelovec, L., Sink, K., 2021. Making ocean literacy inclusive and accessible. Ethics Sci. Environ. Polit. 21, 1–9. https://doi.org/10.3354/esep00196.

Wulff, A., Johannesson, K., 2018. Bring the ocean to the classroom- introducing experimental studies to teachers with fair or no science knowledge. In: Exemplary Practices in Marine Science Education: A Resource for Practitioners and Researchers. Springer International Publishing, pp. 363–376. https://doi.org/10.1007/978-3-319-90778-9_20.

Wynveen, C.J., Wynveen, B.J., Sutton, S.G., 2015. Applying the value-belief-norm theory to marine contexts: implications for encouraging pro-environmental behavior. Coast. Manag. 43, 84–103. https://doi.org/10.1080/08920753.2014.989149.

Yumagulova, L., 2020. Understanding Ocean Literacy in Canada: Pacific Regional Report.