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Supporting Sustainability through Maritime Literacy and Valuable Reflections for the Future: A Systematic Literature Review

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Abstract: This study investigates Scopus-indexed articles to identify literacy trends that support maritime sustainability and derive key insights for future research and development. Using a PRISMA-based systematic literature review (SLR) combined with thematic analysis, the findings reveal an increasing trend in publications, primarily in the fields of environmental sciences, social sciences, and biology. Highly cited works, such as those by Kelly et al. and Gutierrez and Thornton, highlight dominant research contributions from the United States, the United Kingdom, and the European Union, with the European Union emerging as a key funding source. Six interrelated keywords were identified: sustainability, literacy, education, students, knowledge, and Sustainable Development Goals (SDGs). The review identifies five critical themes: marine sustainability and literacy, education, collaboration and stakeholder engagement, challenges and opportunities in marine resource management, and social awareness. In conclusion, the study underscores the growing importance of publications on maritime sustainability, driven by international collaborations and thematic focus on six central keywords.

INTRODUCTION

The word "literacy" is now a hot topic of discussion all over the world. This word concerns human ability to live life (Osborne & Allchin, 2024). Types of literacy have also evolved, so that they are more multiliteracies rather than single-meaning (Walsh, 2017). Literacy has now targeted the maritime aspect and its relationship to the spirit of sustainability mandated by the United Nations through the Sustainable Development Goals. Various studies collectively argue that maritime literacy is very important to foster a society in particular and maritime professionals in general who are aware of the importance of the sustainability of maritime functions and are technically competent (Gerhardinger et al., 2024; Lin et al., 2020; Emma McKinley et al., 2024). Maritime literacy is not just about understanding the ocean and its resources, but also about building awareness and a sense of ownership of the ocean (Buchan et al., 2023), and encourage active community participation in preserving and utilizing it sustainably (Freitas et al., 2024). The urgency of maritime literacy lies in its ability to build a society that has the knowledge, attitudes and skills to

maximize the potential of the sea as an economic resource, maintaining the sustainability of marine ecosystems (Kelly et al., 2022), and play an active role in maintaining maritime sovereignty (Odgaard, 2024).

The relationship between maritime, literacy and sustainability is interesting to study. The interest and concern of world experts towards these three things - shown by their publication trail - needs to be studied. In this regard, a very possible step is to analyze the articles in the Scopus database - as a representation of the world's largest reputable database. One of the most recommended techniques for study and analysis is Systematic Literature Review (SLR).

Systematic literature review about "maritime/ocean/marine sustainability and literacy" is still very rare. In the Scopus database, there are only two review articles since this theme attracted the interest of experts (start from 1992). Both articles are reviews by experts, who focus their studies on ocean assessment and ocean knowledge (Evans et al., 2021) and ocean science for sustainable development (Claudet et al., 2020). So far there is only one SLR related to ocean literacy studies with the range of articles analyzed being 2017-2021 (Cavas et al., 2023) but does not link it specifically to sustainability issues.

Therefore, this study aimed to analyze articles published in Scopus to obtain literacy trends to realize maritime sustainability and formulate valuable reflections from each article as an urgency for future research and development. This SLR is expected to contribute in three ways, namely (1) helping to identify and summarize existing research findings for four decades comprehensively so that researchers can understand the development (trend) and direction of the study (scope); (2) through systematic analysis, this SLR can reveal research gaps, providing a basis for future studies that are more focused and relevant; (3) the results of this SLR can function as a credible resource for the government as policy makers, and academics in producing holistic policies to realize maritime sustainability. Thus, this SLR certainly not only contributes to enriching theoretical knowledge, but also has significant practical implications for implementing policies that are pro-maritime sustainability.

The contributions of this SLR are (1) This SLR maps research trends and collaboration patterns, making it valuable for researchers and policymakers to understand the evolving research landscape, prioritize funding, and build strategic partnerships. (2) The review highlights key thematic areas and interconnected concepts, providing a basis for future research to explore under-researched areas and build a more holistic approach to maritime sustainability. (3) The SLR also provides recommendations for future research and policy development that are important for researchers, educators, and policymakers seeking to advance the field and achieve sustainable management of marine resources.

METHOD

Research Question (RQ)

In order to achieve the stated objectives, namely finding the urgency of literacy to realize maritime sustainability and formulating valuable reflections for Southeast Asia, we set the following research questions (RQ): RQ 1: What is the temporal distribution and growth rate of publications? RQ 2: What subject areas are dominant as the starting point for researchers in studying the theme? RQ 3: What articles are included in the category of most globally cited documents? RQ 4: Which countries are dominant and how is the collaboration between countries in publishing the theme? RQ 5: Which institutions have high concern in funding research and publications? RQ 6: What is the trend of keywords that are dominantly

used? RQ 7: How is the development of the theme in the study? RQ 8: What valuable reflections can be given to Southeast Asian countries regarding the issue?

Search Article and Inclusion Criteria

The search was focused on the phrase "maritime OR ocean OR marine AND sustainability AND literacy" in the search within "all fields", where the articles found were 4532. Because the search was too broad, the search was changed to search within "title, abstracts, and keywords" so that fewer articles were found, namely 77 (article status is 1992-2024). The search was carried out using the official subscription account owned by the Universitas Muhammadiyah Malang. Data simulation uses "Analyze search results" which is available on the Scopus system. To enrich data and analysis, the data was exported to *CSV format (for visualizing data process with VOSviewer and RStudio) and *RIS (for synchronized with Mendeley). The search yielded 77 articles, so they needed to be filtered (inclusion and exclusion) to focus the analysis. We use Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), consisting of four stages, namely identification, screening, eligibility, and inclusion (Selcuk, 2019). The sequence of inclusion and exclusion is shown in Figure 1. The final result of this process was 39 articles that met the criteria and were worthy of analysis.

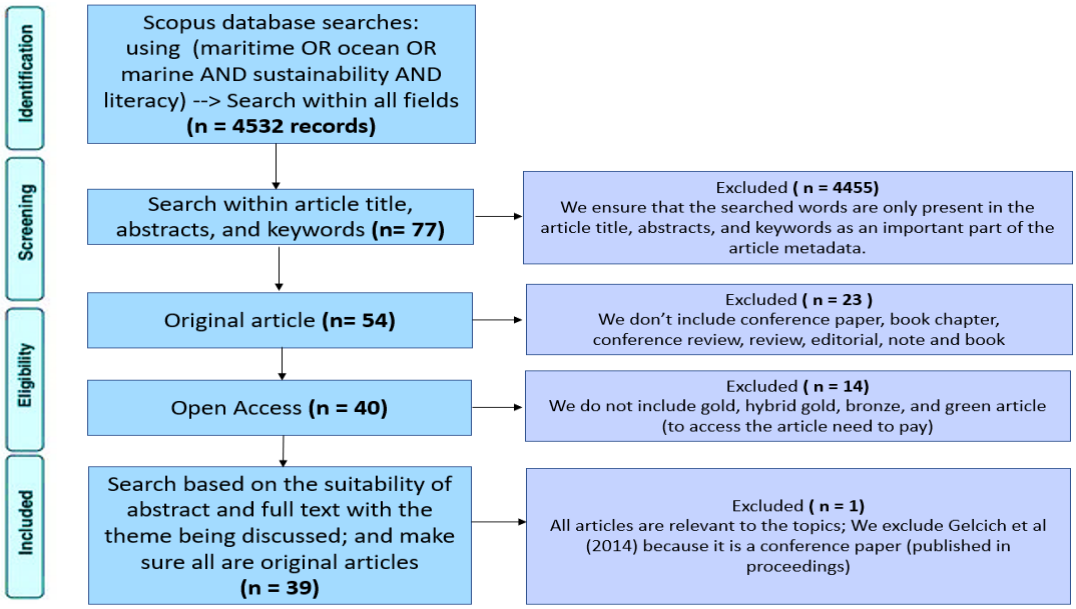

Figure 1. PRISMA Flow Diagram.

RESULT AND DISCUSSION

Temporal Distribution

Figure 2 shows the number of articles in teh Scopus database, annually from 2014 to 2024. Based on Figure 3, it can be seen that the trend of publications on martime, sustainability, and literacy in the Scopus database peaked in 2023. This data cannot be fully used to conclude that in previous years the number of publications was low, because we only focused on original articles. It could be that other publications are in the form of books, conference papers, and others. This is also very likely to happen in 2024 because the number is approaching 2023, even though there is still six months.

The increase in publications in Scopus on the maritime, sustainability and literacy linkages can be analyzed through several key factors. Global awareness of environmental issues, such as climate change and marine pollution, makes research linking maritime to sustainability

increasingly relevant, especially with support from international initiatives such as the Decade of Ocean Science for Sustainable Development (Guan et al., 2023). Marine literacy is considered essential to prepare society to face ocean-related challenges, making education in this area a priority (Freitas et al., 2024). In addition, innovations in research and education methodologies (Husamah et al., 2023, 2024), including the use of digital technologies, increase access to and understanding of marine biodiversity, coservation, and sustainability issues (Rahardjanto et al., 2020). Policy and funding support from governments, donor agencies and research institutions also encourage more research in the field of marine sustainability and education (Rowan, 2023). Multidisciplinary collaborations between environmental science, education and economics create a dynamic research environment, while demands from industry and society for sustainable practices in the marine sector further strengthen the need for research in this area (Purba & Simanjuntak, 2024). With the combination of these factors, publications in reputable international journals on the maritime, sustainability and literacy linkages continue to increase.

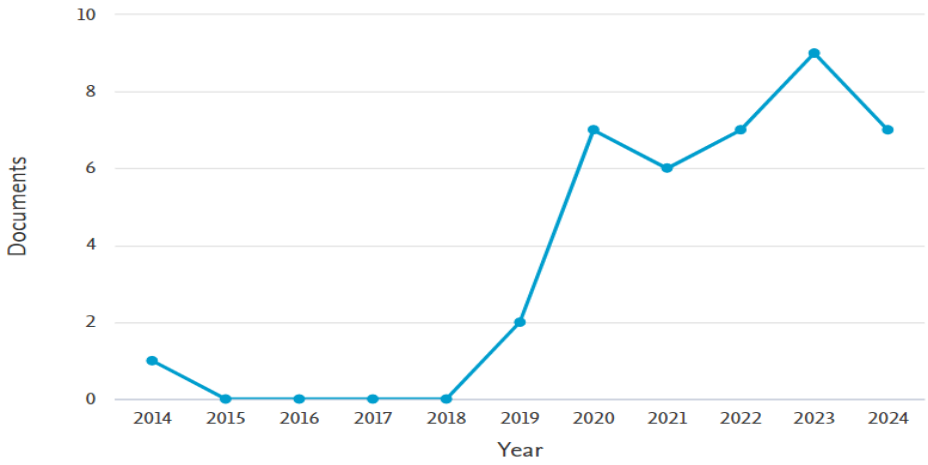

Figure 2. Documents by Year.

Subject Area

Figure 3 shows the percentage of subject areas of documents published in Scopus. It can be seen that the dominant subject areas are environmental science, social, and agricultural-biology. Publications on the maritime, sustainability and literacy themes are more widely approached within the environmental sciences subject area because the main focus of these issues relates to the environmental impacts of human activities in the ocean. Environmental sciences provide a theoretical and methodological framework for understanding how sustainable practices can be integrated into marine resource management, including aspects such as pollution, sustainable fishing and habitat protection (Penca et al., 2024).

On the other hand, the social sciences as well as agricultural and biological subject areas also contribute significantly to this research because human involvement and social interactions in marine resource management are essential. Social sciences examine the behaviors, values and norms of society that influence how individuals and communities understand and interact with the marine environment (Luzyawati et al., 2025; Nurwidodo et al., 2023; Ramdiah et al., 2018; Yayuk & Husamah, 2020). By studying the social and cultural context, researchers can identify barriers

and opportunities for increasing marine literacy and the adoption of sustainable practices (Emma McKinley et al., 2022). Meanwhile, agricultural and biological sciences focus on the technical and scientific aspects of sustainability in the context of marine resource utilization, such as aquaculture and marine-based agriculture (Khademi-Vidra et al., 2024).

The integration of environmental sciences, social sciences, and agriculture and biology allows for a holistic and interdisciplinary approach to understanding and addressing the challenges faced by marine ecosystems. Of course, this makes the theme of maritime links, sustainability, and literacy a growing focus of research.

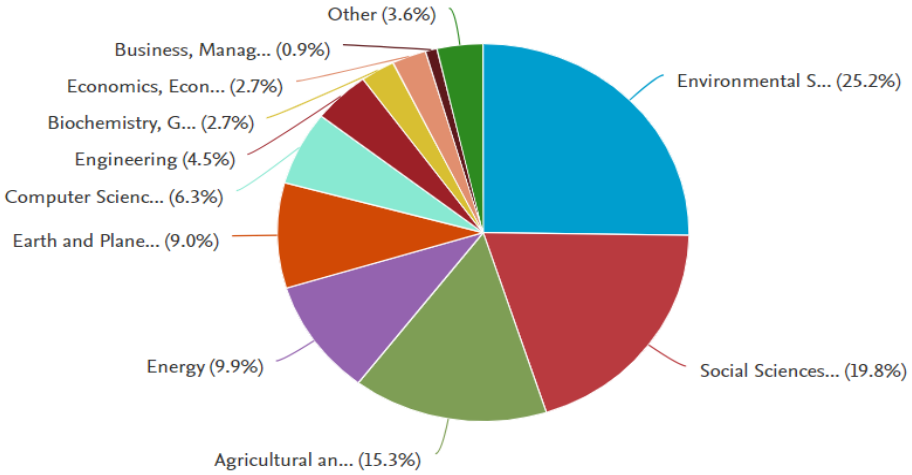

Figure 3. Subject Area.

Most Globally Cited Documents

Table 1 presents the data of most globally cited documents. Based on Table 1, it can be seen that there are two dominant articles, namely the article entitled "Connecting to the oceans: supporting ocean literacy and public engagement"(Kelly et al., 2022) and Can consumers understand sustainability through seafood eco-labels? A U.S. and UK case study (Gutierrez & Thornton, 2014).

Table 1. Most Globally Cited Documents.

No	Title	Authors	Journal	Year	citation
1	Connecting to the oceans: supporting ocean literacy and public engagement	Kelly, R., Evans, K., Alexander, K., ... Wood, G., Pecl, G.T.	Reviews in Fish Biology and Fisheries, 32(1), pp. 123–143	2022	72
2	Can consumers understand sustainability through seafood eco-labels? A U.S. and UK case study	Gutierrez, A., Thornton, T.F.	Sustainability (Switzerland), 6(11), pp. 8195–8217	2014	69
3	Evolving the narrative for protecting a rapidly changing ocean, post-COVID-19	Laffoley, D., Baxter, J.M., Amon, D.J., ... Woodall, L.C., Andersen, N.F.	Aquatic Conservation: Marine and Freshwater Ecosystems, 31(6), pp. 1512–1534	2021	29
4	Life below water; challenges for tourism partnerships in achieving ocean literacy	Garcia, O., Cater, C.	Journal of Sustainable Tourism, 30(10), pp. 2428–2447	2022	25
5	A framework for mixed reality free-choice, self-determined learning	Aguayo, C., Eames, C., Cochrane, T.	Research in Learning Technology, 28, 2347	2020	21

Kelly, Evans, et al. (2022) is widely cited for addressing global challenges like climate change, marine resource sustainability, and ecosystem protection. By integrating education, culture, technology, and policy, it appeals to researchers across disciplines. The article provides a clear framework for improving marine literacy, emphasizing policy support and stakeholder engagement, and aligns with the UN Decade of Ocean Science for Sustainable Development 2021–2030, enhancing its international relevance. Its practical toolkit for educators and policymakers and focus on societal behavioral change further increase its applicability in ocean conservation efforts.

Gutierrez and Thornton (2014) is notable for examining sustainability in the seafood industry, exploring producer-consumer dynamics, and highlighting the role of eco-labels in promoting sustainable choices. Using case studies from the US and UK, it provides robust empirical evidence on consumer awareness of eco-labels like "dolphin-safe" and "organic," linking these insights to marine literacy and consumer education. This interdisciplinary approach makes it a key reference for academics, policymakers, and practitioners in sustainability and marine resource management (Luzyawati et al., 2025; Yayuk & Husamah, 2020).

Author's Country and Collaboration

The trend of author's country or territory of research related to "biology and literacy" themes are presented in Figure 3 and collaboration between countries is presented in Figure 4.

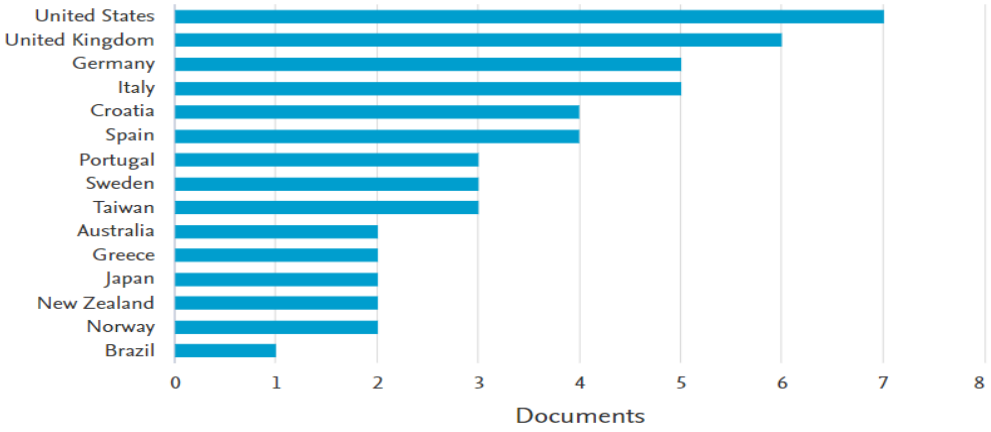

Figure 4. Author's Country or Territory.

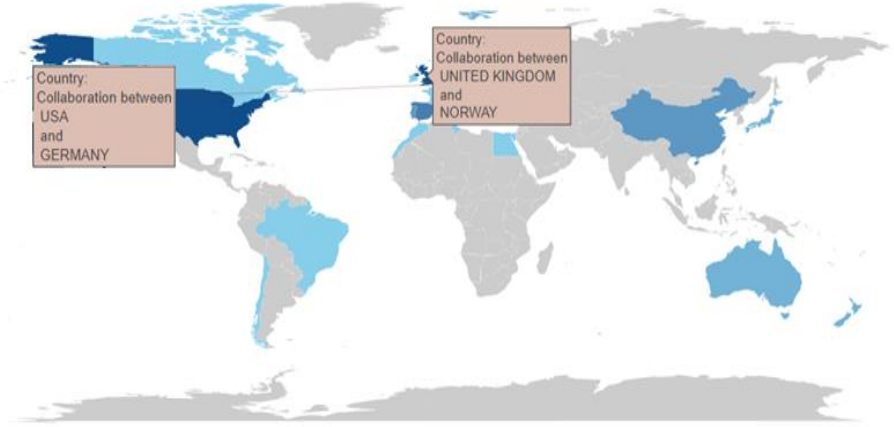

Figure 5. Collaboration between Countries.

Researchers from the US and UK are highly active in maritime, sustainability, and literacy research due to their strong research traditions, significant funding, and supportive environmental policies (Dawodu et al., 2022; Zhou, 2024; E McKinley et al., 2023). With leading programs in environmental and marine sciences, universities in these countries provide resources and collaboration opportunities, fostering impactful research and publications. Public awareness and political support further drive research aimed at addressing knowledge gaps and offering practical solutions for sustainability policies (Buchan et al., 2023; Han & Ahn, 2020; Shellock et al., 2024).

Collaboration between researchers from the US, UK, Germany, and Norway leverages strong traditions and infrastructure in marine science and sustainability. These partnerships enable the exchange of knowledge, access to resources, and multidisciplinary approaches essential for tackling global marine challenges. Germany and Norway's technological innovations and environmental policies complement the expertise of US and UK researchers, enhancing research quality and advancing global maritime sustainability efforts (Baker et al., 2023; Pace et al., 2023).

Funding Sponsor

Figure 6 shows that the European Commission (EC) has funded six research and publications. There are 14 other sponsoring institutions, with fewer numbers.

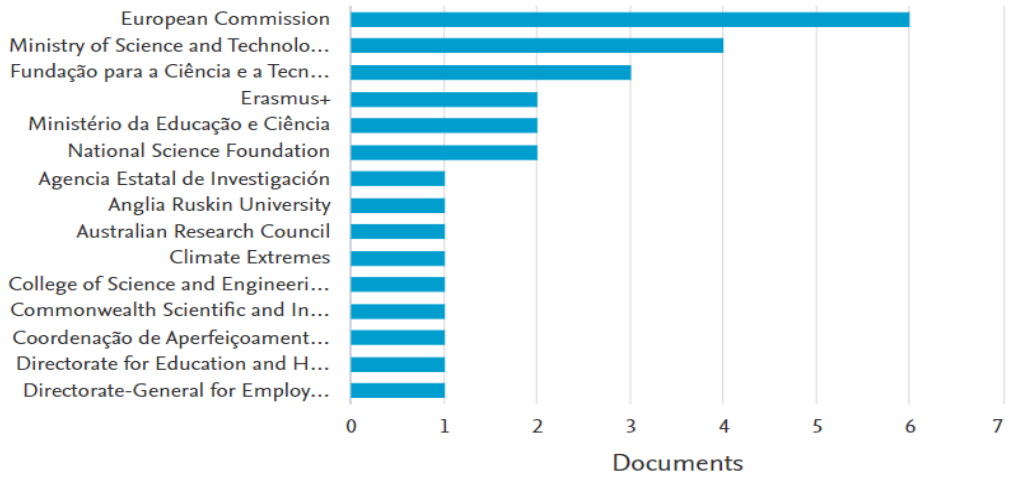

Figure 6. Funding Sponsor.

The European Commission (EC) likely has several key considerations in funding research and publications on the maritime, sustainability and literacy nexus. The focus on sustainability and environmental protection is an integral part of the EC's strategic agenda, especially in the context of the European Green Deal. By funding research in this area, the EC can encourage innovation and the development of solutions that can help achieve sustainability and marine resource conservation goals. This is in line with the EU's commitment to mitigate the impacts of climate change, preserve ecosystems and support a circular economy (Kirchherr et al., 2023).

Funding for maritime research and literacy also supports the EC's efforts to raise public awareness and citizen participation in marine issues. By increasing marine literacy, the EC seeks to empower citizens to understand and engage in marine resource management, which in turn can influence more

sustainable policies and practices (Freitas et al., 2024). Supporting research that involves collaboration between EC member states can strengthen scientific and innovation networks across Europe, promote knowledge exchange and build the capacity needed to collectively address maritime challenges (Gautier, 2023). This will certainly have an impact on efforts that not only support environmental goals but also promote economic growth and social equity in the region.

Dominant Keywords

Dominant keywords in the study of maritime, sustainability, and literacy in the Scopus database are presented in the form of co-occurrence keyword simulation results from VOSviewer (Figure 7) and Wolcloud results from Rstudio simulation (Figure 8). There are six main words that are dominant and interrelated, namely sustainability, literacy, education, students, knowledge, and sustainable development goals.

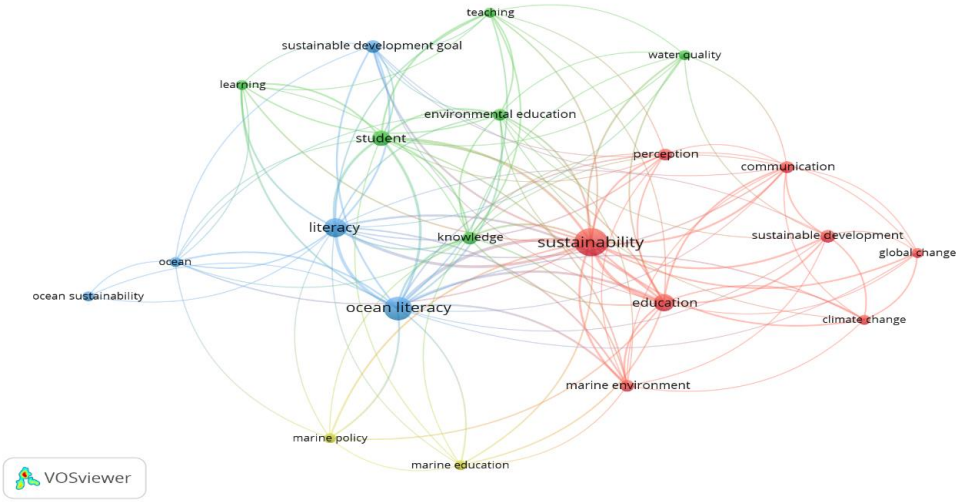

Figure 7. Dominant Keywords.

Figure 8. Worldcloud.

The relationship between keywords such as "sustainability, literacy, education, students, knowledge, and sustainable development goals" in maritime issues is critical and interdependent. Sustainability in marine resource management involves responsible practices to maintain healthy ecosystems for future generations, addressing challenges like climate

change and overfishing (Macpherson et al., 2023). Marine literacy underpins understanding the impact of human actions on oceans, highlighting their role in global climate balance and biodiversity. It fosters awareness and responsibility, essential for sustainable resource use and environmental protection (Choi et al., 2024).

Students play a pivotal role in maritime sustainability as future leaders and decision-makers. Equipping them with knowledge about sustainability and marine issues prepares a generation to drive societal change and sustainable practices locally and globally (Hou, 2024). Education provides foundational knowledge on marine ecosystems, policies, and resource management (Yang et al., 2024).

These elements align with SDG 14, emphasizing marine ecosystem sustainability. Research and education tied to SDGs promote global responsibility for ocean conservation (Shayan et al., 2022). Therefore, marine education and literacy are vital for achieving sustainability and ensuring a better future for ecosystems and dependent communities.

The Development of the Theme

Figure 9 shows the development or evolution of themes in maritime, sustainability, and literacy publications in the Scopus database.

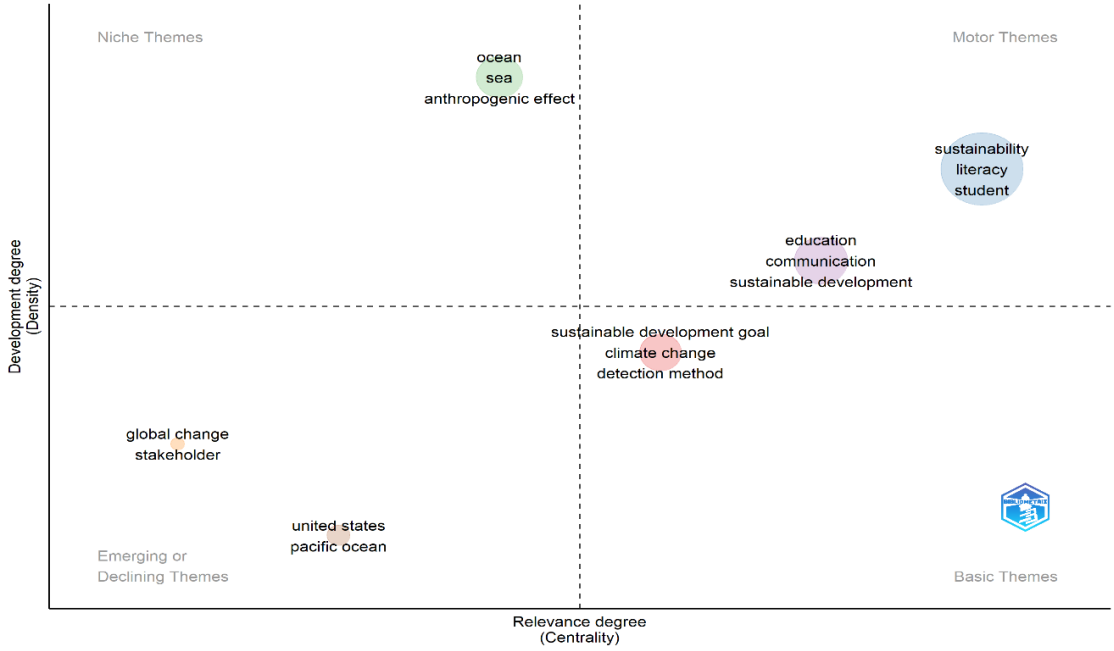

Figure 9. Evolution of Research Direction.

The bibliographic analysis reveals a dynamic map of research themes, showcasing the evolution of knowledge, trending areas, and potential future directions. Understanding these relationships aids researchers in formulating new questions, tracking literature trends, and identifying opportunities for impactful contributions.

From the data (Figure 9), several key insights emerge regarding maritime sustainability and literacy research dynamics. First, Basic Themes. Foundational topics such as SDGs, climate change, and detection methods emphasize addressing global challenges. The prominence of sustainability and climate change underscores their priority in international agendas, highlighting the

relevance of these studies (Sorooshian, 2024).

Second, Motor Themes. Key topics like education, communication, and sustainable development, as well as sustainability, literacy, and students, emphasize the critical role of education in promoting awareness of sustainability and climate change. These themes also highlight the need for effective communication among stakeholders to foster collaborative efforts (Ramírez Suárez et al., 2023).

Third, Niche Themes. Focus areas such as oceans, seas, and anthropogenic effects reflect a growing interest in marine ecosystems and the impact of human activities. This targeted focus presents opportunities for deeper exploration in under-researched areas, emphasizing the urgency of ocean conservation (Murray et al., 2023).

Fourth, Emerging or Declining Themes. Emerging topics like global change, stakeholder involvement, the Pacific Ocean, and the United States indicate new research directions. For instance, "global change" reflects concern for broad climate impacts, while "stakeholder" highlights the necessity of multi-stakeholder engagement in sustainability efforts (Bolan et al., 2024; Kismartini et al., 2023). Declining themes may point to areas losing research momentum or relevance in the current context (Snyder, 2019).

Overall, research on marine sustainability and literacy is experiencing rapid and transformative growth. This development spans fundamental issues, enhanced education, and literacy, as well as innovative approaches to addressing human impacts on marine ecosystems. The attention to emerging themes suggests new opportunities for collaboration between researchers, policymakers, and communities to achieve sustainability goals effectively (Baidya & Saha, 2024).

Important Reflections

Important reflections from each article as presented in Table 2.

Table 2. Important Reflections from Each Article.

No	Important Reflections	Reference
1	This paper discusses the idealized model of seafood eco-labelling in promoting sustainability and presents results of US and UK case studies based on consumer interviews and surveys.	(Gutierrez & Thornton, 2014)
2	The geological exploration of the Grand Canyon reflects the development of geoscientific understanding over the past 150 years, while also providing a time-sensitive perspective on understanding geological change and its implications for society, the ocean, and the environment in the future.	(Karlstrom & Crossey, 2019)
3	Achieving sustainability requires a deep understanding of the complex interactions between planetary boundaries and social foundations, including synergies and trade-offs that must be accounted for in effective policymaking.	(Capmourteres et al., 2019)
4	A theoretical framework for self-paced mixed reality (MR/XR) learning can enhance ecological literacy through the integration of mobile technologies in free-choice educational environments, such as visitor centers and museums, to support sustainability learning outside the classroom.	(Aguayo et al., 2020)
5	Board-based role-playing games such as “Ocean Limited” can be effective educational tools to enhance understanding of ocean sustainability, teach systemic thinking skills, and foster collaboration in addressing socio-ecological challenges related to ocean use.	(Koenigstein et al., 2020)
6	Marine literacy is essential for the sustainability of marine resources, and enhancing students’ knowledge through non-formal educational approaches suggests that integrating ocean topics into school curricula from an early age is critical to achieving greater marine literacy.	(Mokos et al., 2020)
7	The introduction of course modules focused on safety management and social sustainability in a naval architecture program can change the way students view ship design, emphasizing that discipline-specific sustainability teaching is more	(Liwång, 2020)

No	Important Reflections	Reference
	effective than a general sustainability literacy approach.	
8	Social media contextual awareness competency is an emerging skill involving social media literacy, understanding of communication processes, awareness of content impacts, and self-confidence, which is essential in the digital era to support social sustainability.	(Rad et al., 2020)
9	Marine literacy among high school students in Taiwan is still at a basic level, with some common misconceptions, so more efficient marine education is needed to improve marine literacy among the younger generation.	(Lin et al., 2020)
10	Fashion brand ECOALF effectively uses digital media to convey environmental awareness messages through responsible corporate practices, inspiring consumers to play an active role in environmental conservation through interactive communication on social media.	(Serrano et al., 2020)
11	To protect our only ocean and maintain the health of the planet as a whole, a global narrative that combines climate and ocean action with a "One Health" approach must be realized urgently, as ocean damage directly impacts human well-being and the future of the earth.	(Laffoley et al., 2021)
12	Recreational activities in marine spaces, such as surfing, can improve users' marine literacy, thereby supporting marine sustainability strategies through coastal community engagement and awareness of human-ocean interactions.	(Fox et al., 2021)
13	UNESCO Marine World Heritage management and communication have not fully facilitated public engagement in human-nature interactions and marine literacy, so a more integrated strategy is needed to support sustainability and the achievement of the Sustainable Development Goals (SDGs).	(Kenterelidou & Galatsopoulou, 2021)
14	Logistics management needs to adopt sustainable performance that includes standardized measurements to reduce negative impacts, such as decarbonization, through the development of internal capabilities that can support the achievement of the Sustainable Development Goals (SDGs).	(Dovbischuk, 2021)
15	Marine literacy is a key topic in marine environmental sustainability, and this study shows that curriculum standards in the US are superior to those in India, providing recommendations for curriculum developers in India to improve the concept of marine literacy in education.	(Chang et al., 2021)
16	Developing critical environmental agents (CEAs) among teachers can empower them to teach deeper environmental awareness and contribute to a more sustainable future for students and communities, despite the barriers to doing so.	(Huffling & Scott, 2021)
17	Marine ecotourism, such as scuba diving, has the potential to improve place-based marine literacy, but this can only be achieved through effective stakeholder collaboration, which is currently lacking in the sector in Mallorca, Spain.	(Garcia & Cater, 2022)
18	Effective science communication and non-formal educational approaches are needed to raise global awareness of marine issues, with engaging methods to support sustainable development goals and address environmental change.	(Zielinski et al., 2022)
19	Successful communication initiatives in Interreg projects such as AdSWiM and WATERCARE are critical to improving marine literacy among students, as they will be the next generation of influencers of environmental decisions and attitudes.	(Baldrighi et al., 2022)
20	Increasing ocean literacy through education, cultural connections, technological development, and knowledge exchange is essential to building a better public understanding of the ocean, which in turn can drive the behavioral changes needed to achieve global ocean sustainability by 2030 and beyond. The use of digital storytelling as a teaching tool in informal learning can effectively increase environmental awareness and scientific literacy of secondary school students regarding marine pollution, especially the issue of plastic waste, thereby encouraging sustainable behavior and attitudes.	(Kelly et al., 2022)
21	Marine literacy is a key topic in marine environmental sustainability, and this study shows that curriculum standards in the US are superior to those in India, providing recommendations for curriculum developers in India to improve the concept of marine literacy in education.	(Andriopoulou et al., 2022)
22	Despite progress in marine turtle conservation efforts, illegal fishing, use, and trade remain a serious threat, and evidence-based strategies that include law	(Lopes et al., 2022)

No	Important Reflections	Reference
	enforcement, increased environmental literacy, and stakeholder engagement are needed to effectively address this issue.	
23	Although educational curricula cover more topics on the marine environment than other countries, marine literacy is still hampered by uneven distribution and a concentration in limited publications, so expanding marine-related content in curricula is essential to improve public understanding of the importance of marine conservation and ocean sustainability.	(Pazoto et al., 2022)
24	Transdisciplinary research methods, through creative activities such as cooking classes and coastal explorations, can effectively improve students' understanding of marine literacy and sustainable seafood consumption, and contribute to the development of more effective educational programs and policy frameworks.	(Cretella et al., 2023)
25	The use of biology-inspired robotics-based educational toolkits can improve students' marine literacy and environmental awareness, while supporting STEM learning from primary to secondary education, in a way that is engaging and relevant to sustainability issues.	(D. Costa et al., 2023)
26	The concept of maritime citizenship needs to be expanded to include collective and public political action, as well as civil rights, rather than just individual pro-environmental behavior, so that it can more effectively influence marine policy and management for sustainability.	(Buchan et al., 2023)
27	To achieve more effective ocean sustainability, ocean literacy must integrate diverse cultural histories and perspectives, with regional approaches involving collaboration between different types of knowledge and actors, rather than relying solely on static, universal frameworks.	(Schwerdtner Manez et al., 2023)
28	The game-based educational experience developed for the promotion of artisanal fisheries not only enhances students' knowledge of marine biodiversity and conservation, but also empowers them as responsible fish consumers, in line with the broader Sustainable Development Goals (SDGs).	(Torralba-Burrial & Dopico, 2023)
29	Concepts such as sustainability and community engagement in efforts to protect and understand the ocean, which can support the development of marine literacy-based policies, are essential.	(Cavas et al., 2023)
30	There is an urgent need to realign science, policy and public interest in the context of fisheries sustainability, with an emphasis on the development of marine literacy among a wider range of stakeholders, in order to achieve better outcomes during the UN Decade of Ocean Science.	(Sugimoto et al., 2023)
31	The storydoing advertising communication model has the potential to raise social and environmental awareness, but its success depends on the clarity and consistency of companies in developing strategies based on social causes, so that they can effectively contribute to the transformation of social realities.	(Rodríguez-Ríos & Lázaro Pernias, 2023)
32	Assessment of marine literacy among maritime vocational high school students in Indonesia showed significant differences by grade level and gender, with grade 11 and 12 students and female students showing better understanding, highlighting the need for a more focused teaching approach to improve overall marine literacy.	(Chang et al., 2023)
33	Although teachers have a general awareness of marine literacy, the lack of integration of marine-related themes into pedagogical practices indicates the need for curriculum updates and the provision of easily accessible learning materials to support marine environmental sustainability.	(A. C. Costa et al., 2024)
34	Achieving a just, equitable and sustainable ocean future requires the development of new transdisciplinary competencies for scientists and researchers, as well as systemic shifts in organisations and education that support the effective implementation of this competency framework.	(Penca et al., 2024)
35	Practical activities involving students in the construction of constructed wetlands not only enhance their understanding of nature-based solutions and water quality, but also strengthen marine literacy and awareness of the importance of environmental sustainability and the protection of aquatic ecosystems.	(Bruno et al., 2024)
36	Although the principles of marine literacy are already present in basic education curricula, there are many gaps in the integration of marine concepts that need to be addressed, so collaboration between marine scientists, education	(Almeida et al., 2024)

No	Important Reflections	Reference
	specialists and policy makers is essential to improve students' understanding of marine sustainability and conservation.	
37	Environmental sustainability education, through activities conducted both face-to-face and online, can significantly increase students' knowledge of sustainable fish consumption and change their consumption behaviour, even though many of them are initially unaware of many aspects of the topic.	(Ezgeta-Balić & Balić, 2024)
38	While the development of marine tenure rights has provided economic and social opportunities, including the empowerment of women in the aquatic sector, challenges such as weak market positions and low prices threaten the sustainability of aquaculture livelihoods, highlighting the need for further steps to achieve gender equality in this male-dominated industry.	(Gutierrez & Thornton, 2014)
39	Developing environmental literacy and professional training for teachers is key to improving the quality of STEM teaching, as well as creating sustainability in education through efficient use of resources.	(Bruno et al., 2024)

Based on Table 2, we can draw several important points by combining reflections from the articles based on similar themes. First, Sustainability and Marine Literacy. Many articles emphasize the importance of marine literacy as a basis for achieving marine environmental sustainability. Increasing knowledge about marine ecosystems and the impacts of human behavior on them is needed to empower communities in making more responsible decisions (Ward et al., 2022). Education integrated with marine and sustainability topics should be included in the curriculum from an early age to form a strong environmental awareness among the younger generation (Sihvonen et al., 2024).

Second, Education and Competency Development. Education is a key tool in increasing sustainability literacy (included marine) and awareness. Innovative approaches, such as game-based learning, digital storytelling, and practical activities, have proven effective in improving students' understanding (Yakar-Pritchard et al., 2024). In addition, developing transdisciplinary competencies for educators and researchers is needed to address the complex challenges faced in managing marine resources and the environment (Ciannelli et al., 2014).

Third, Collaboration and Stakeholder Engagement. Many studies have shown the need for collaboration between scientists, educators, policy makers, and communities to improve the effectiveness of marine and sustainability literacy programs (Ardoin et al., 2020; O'Brien et al., 2023). Broad stakeholder engagement in policy formulation and implementation of education programs is essential to achieve better outcomes and to support overall environmental sustainability (Lucrezi et al., 2019; Lukambagire et al., 2024).

Fourth, Challenges and Opportunities in Marine Resource Management. The articles also note the challenges faced in marine resource management, such as the weak market position in the aquatic sector, as well as gaps in the integration of marine literacy concepts in education. Despite progress in various initiatives, much remains to be done to ensure that all aspects of sustainability and literacy are effectively integrated into existing policies and practices (Shellock et al., 2024).

Fifth, Social Awareness and Reality Transformation. A more holistic and social approach to marine literacy is needed to support social and environmental transformation (Penca et al., 2024). Effective communication, including the use of digital media and story-based advertising, can raise public awareness of marine and sustainability issues, encouraging broader collective action to protect and understand the ocean (Reamer, 2022). These important

reflections provide emphasis and awareness to all of us of the importance of marine and sustainability literacy in the context of education, collaboration, and policy to ensure a more sustainable future for marine ecosystems and the communities that depend on them.

CONCLUSION

This systematic literature review highlights several key findings: (1) an increasing trend in publications from 2014 to 2024; (2) dominant subject areas including environmental sciences, social sciences, and agriculture and biology; (3) globally influential works by Kelly et al. and Gutierrez and Thornton; (4) the dominance of researchers from the US and UK, driven by strong research traditions and significant funding for environmental issues; (5) the European Commission's leading role in funding research; (6) the interrelation of six dominant keywords: sustainability, literacy, education, students, knowledge, and sustainable development goals; (7) the dynamic development of research on maritime sustainability and literacy; and (8) key thematic reflections categorized into sustainability and marine literacy, education and competency development, stakeholder collaboration, challenges in resource management, and social transformation. Based on these findings, several recommendations are proposed: strengthening international collaboration to enhance maritime sustainability research; integrating sustainability and marine literacy into educational programs to increase awareness; ensuring sustainable funding from donor agencies; incorporating sustainability themes into curricula to foster environmentally conscious generations; conducting public awareness campaigns to influence policy and resource management; and exploring niche themes to provide fresh insights into marine resource management. These efforts are expected to advance understanding, practices, and contributions toward preserving marine ecosystems and achieving sustainability goals.

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