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Identifying Ocean-Related Literature Using the UN Second World Ocean Assessment Report

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Abstract

In recent years, ocean governance has called for strategic action and science-informed policy to work towards the sustainable development of the ocean, most notably as part of the UN Decade of Ocean Science for Sustainable Development (2021–2030). This common framework identifies the integration of scientific knowledge in governance as a key process to deliver solutions responding to the current challenges, opportunities, and transformations posed by global change in the oceans. This article presents a methodological approach for identifying ocean-related research outputs and documenting research-based knowledge integration in documents that inform ocean governance. Specifically, this study builds on an analysis of the references included in the *UN Second World Ocean Assessment* report to (a) identify and describe the research outputs cited in the distinct chapters of the report, (b) identify research outputs relevant to ocean governance through the analysis of citations from and to references included in the *UN Second World Ocean Assessment* report, (c) compare both datasets to examine the position of the literature cited in the report within a broader ecosystem of ocean-related research, and (d) present a method to identify topically relevant research that could be integrated in future ocean assessments. Our findings show distinct referencing practices across chapters and expert groups and a higher reliance on high-profile sources in the report compared to a broader dataset of ocean research outputs. Moreover, this study highlights an innovative approach to identifying ocean research based on knowledge syntheses and considers discussion points about integrating research-based knowledge in documents informing ocean governance.

Keywords

knowledge mobilization; ocean governance; ocean research; scholarly communication; science-policy interface; scientific knowledge; UN

1. Introduction

Global ocean governance can be understood as a "holistic, integrated, and/or cross-sectoral approach to the management of the oceans, its resources, and the human activities occurring within it or affecting it" (Molenaar, 2019, p. 419). Recently, the UN Decade of Ocean Science for Sustainable Development (2021–2030) and the UN 2030 Agenda for Sustainable Development provided frameworks to direct the trajectory of ocean governance toward strategic action and science-informed policy (Gerhardinger et al., 2024; UN, 2015; UNESCO, 2017; UNESCO-IOC, 2023). As these frameworks specifically call for the integration of research-based knowledge in ocean governance, they invite to consider the identification of research relevant to ocean governance and examine its integration in documents such as the *Second World Ocean Assessment* (WOAII) report knowledge synthesis (UN, 2021). This study presents a process for the identification of ocean-related research outputs through the analysis of the references included in the WOAII report as a recent and global state of knowledge about oceans dedicated to informing ocean governance.

The integration of scientific knowledge into policy decisions is a key process for delivering evidence-based and actionable solutions (Karcher et al., 2024). Reports such as the WOAII leverage the efforts of hundreds of experts across the globe and effectively create tools for policy and decision-makers to use as credible and authoritative sources (Evans et al., 2021). They also present an opportunity for critical engagement: What knowledge is mobilized in the WOAII and other seminal reports, and what is excluded? How does the literature cited in such assessments compare to the broader existing body of knowledge about oceans? How can we identify relevant research outputs—literature identified by DOIs and indexed in bibliographic databases, including peer-reviewed articles, books, book chapters, datasets, and grey literature—that could inform the development of ocean-related policy and action? This study uses a bibliometric approach to explore the potential of analyzing official assessments to identify ocean-related research outputs, examine the broader field of ocean research, and document the integration of knowledge in documents informing ocean governance. We first present a review of the literature on the WOAII report, the science-policy interface, and the contribution of bibliometrics to capturing ocean research. We then present the methodology used to identify ocean-related research and examine both the set of literature cited in the WOAII report and that included in a broader dataset of documents related to ocean research. We finally describe and compare the datasets, guiding a discussion around the potential of our approach to identify ocean-related research and to examine what research is integrated into documents informing ocean governance.

2. Literature Review

2.1. The WOAII as a Science-Policy Interface

The translation and transfer of information from knowledge generators to decision-makers to society occurs in many forms (Evans et al., 2021). These bridges between the realms of scientific research, governance, and public understanding can be understood as the science-policy interface, encompassing the multiple and complex pathways by which decision-making should be informed by scientific evidence (MacDonald et al., 2016). Interactions at the science-policy interface represent both the mechanisms and interactions through which scientific activities may influence decision-making and governance, and the mechanisms through which policy may, in turn, impact the advancement of scientific knowledge and research priorities. For example, the UN Decade of Ocean Science for Sustainable Development highlights the crucial role that

science should play in informing ocean governance, thus promoting the creation of mechanisms and frameworks to facilitate the production and dissemination of ocean research (McKinley et al., 2023). Scientific information is thus a key vector for ocean governance to address related issues, such as articulating the needs of fisheries and conservation, through evidence-based decision-making (Bogenschneider & Corbett, 2021; Karcher et al., 2024; MacDonald et al., 2016).

Scientists disseminate useful evidence stemming from research to inform decision-making (MacDonald et al., 2016), but there remain questions about the mechanisms by which policymakers access scientific evidence (Wellstead et al., 2018). There are also socio-topical and information retrieval dynamics at play that may favor the inclusion of certain types, topics, and clusters of knowledge in ocean governance (Toupin et al., 2023). Knowledge syntheses, reports, and grey literature typically play an important role at the ocean science-policy interface by synthesizing relevant knowledge into digestible formats that are more readily accessible for decision-making (Cossarini et al., 2014). Nevertheless, divergence has been found between scientists and policymakers regarding their respective roles at the science-policy interface, as well as in broader knowledge mobilization processes ranging from passive knowledge transfer to high levels of engagement, influencing the availability and use of scientific evidence by policymakers (Rudd, 2015). The UN, among other global organizations, supports this interface by producing comprehensive and integrated syntheses of scientific and grey literature through public-facing reports such as the WOAII, a work akin to the reports produced by the Intergovernmental Panel on Climate Change (IPCC) in the case of climate change (IPCC, 2021). These documents provide valuable knowledge brokering of complex, technical topics that are presented in usable, accessible formats and contain information that is at times not directly available to policymakers and the public (Evans et al., 2019, 2021).

2.2. The Production of the WOAII Report

The WOAII report, an integrated assessment of the environmental, economic, and social aspects of the Earth's oceans, was produced through the second cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects to provide a scientific foundation for policymaking (UN, 2021). Produced by interdisciplinary writing teams comprising 300 authors drawn from a pool of over 780 experts (scientists, policymakers, volunteer experts, and other actors) from across the globe (UN, 2021), the report provides a public and official state of knowledge on ocean matters. The expert teams outlined a report structure informed by a workshop series, the outcomes of the *First World Ocean Assessment*, and regional assessments and priorities (UN, 2021). Members of the writing teams synthesized scientific information on key topics; leads and co-leads of each chapter provided guidance on acceptable types of information and were expected to, as much as possible, rely on the "best available data and information" to produce sound and well-supported conclusions (UN, 2021, p. 44). Information gathering and content development were also informed by wider groups of stakeholders through workshops, dialogue, peer review processes, and input from the member states of the UN (Evans et al., 2021).

The WOAII usefully synthesizes relevant information but is not a comprehensive systematic review of all available ocean literature. Rather, it is a curated document produced through a collaborative yet selective information-gathering process, resulting in a structured report that refers to a limited set of literature that naturally favors certain types of knowledge and may provide uneven topical or regional coverage (Feary et al., 2014; Mendenhall & Helm, 2024; Turnhout, 2024). As Evans et al. (2021, p. 5) state:

> Writing teams contributing to both the *First* and *Second World Ocean Assessment* have often been uneven in their disciplinary and regional coverage. An outcome of unbalanced contributions to writing teams is that chapters have varied in their scope, the degree to which they have covered the diverse range of topics and the extent to which complex scientific information was integrated across disciplines and delivered.

This study uses the WOAII report as an entry point to identify a broader body of ocean research literature, thus taking an opportunity to develop a method to document the field of ocean research and examine the integration of research outputs in ocean governance. This case study contributes, on the one hand, to the development of new bibliometric approaches to capture research outputs about socially relevant issues, and, on the other hand, provides an empirical assessment of the knowledge integrated into an official document informing ocean governance.

2.3. Capturing and Analyzing Oceans Research

Following a recent shift in bibliometric studies to investigate the dissemination of research outputs outside of academia, many studies have explored methods to identify research outputs about socially relevant topics, such as ocean affairs or Sustainable Development Goals (SDGs). For instance, Kashnitsky et al. (2024) assessed extant approaches to mapping literature to the SDGs and found most involved Boolean methods. Among other studies that aimed to map literature about SDGs, Armitage et al. (2020) also compared bibliometric approaches to better map research outputs to corresponding goals, while Purnell (2022) examined methods specifically identifying literature related to SDG13 "climate action." Methods based on large language models and search queries were also developed by Bergeron et al. (2023) and Bordignon (2021). However, both machine learning and query-based approaches pose challenges around diverse understandings of topics, search precision and accuracy, and interpretations of the results of automated processes (Kashnitsky et al., 2024).

More closely related to ocean-related literature, Lercari (2021) analyzed marine science research institutionally affiliated with Uruguay, using Scopus, to provide insights on publication trends, research topics, and collaboration. Picone et al. (2021) conducted a bibliometric analysis of Marine Protected Areas research retrieved from Scopus and Web of Science to show a temporal evolution of its conceptual focus. In another study focusing on rhodolith bed research, Rendina et al. (2022) recognized that using Scopus for a bibliometric assessment excluded grey literature on the topics. More recently, Potter and Pearson (2023) analyzed ocean basin research trends and collaboration patterns using a title-abstract approach rather than relying on Web of Science subject categories. In another approach, 169 SDG queries were developed by Vanderfeesten et al. (2020) to identify relevant research outputs, while Guyot-Téphany et al. (2024) conducted a bibliometric analysis on multi-use ocean research using Scopus to create a corpus that then underwent manual review. Toupin et al. (2023) used citation analysis to identify and document shark-related research clusters and examine the distribution of citations, tweets, media, and policy mentions, while Costa and Caldeira (2018) conducted a similar analysis about the concept of ocean literacy. Finally, Lübker et al. (2023) performed latent Dirichlet allocation topic modeling on 8,580 cross-disciplinary scientific articles collected through Scopus about the high seas to structure their dataset and discover topical themes in the literature which they used to create narratives. These approaches illustrate the opportunities and challenges arising in the development of methodological frameworks to identify ocean research outputs. Therefore, they inspired the development of the framework presented in this study that focuses on

capturing outputs through the citation links of works referenced by a knowledge synthesis report about ocean matters.

2.4. Purpose of the Study

This article presents both an empirical examination of the literature cited in the WOAII report and a methodological contribution to the identification of ocean research outputs stemming from the citation links to and from the literature mentioned in the report. Both contributions aim to improve our understanding of the integration of research-based knowledge in a document informing ocean governance. Our approach uses the WOAII as a case study to leverage the report's unique structure to locate and capture an expanded set of ocean research literature. We used the WOAII report as it is one of the most recent global knowledge syntheses of ocean-related topics, thus providing foundations to look at a broad body of ocean research. This broader body of literature is then used to describe the references included in the WOAII report and to provide keys for the identification of other relevant ocean research outputs that could contribute to future knowledge synthesis regarding oceans. Our research questions are as follows:

> RQ1: What literature is cited in the WOAII report?
> RQ2: How can we identify research outputs that are or could be integrated into knowledge syntheses informing ocean governance?
> RQ3: How does the literature referenced in the WOAII report compare to a broader dataset of ocean-related research?

This article also provides a proof of concept regarding the use of knowledge assessments published by official bodies, such as the UN and the IPCC, to identify outputs about complex socioenvironmental issues. As an official assessment of the state of oceans, the WOAII provides a window to examine the knowledge integrated into ocean governance, but also to investigate how this knowledge is connected to a broader body of literature about oceans.

3. Methods

3.1. Collecting Works Cited in the WOAII Report

The WOAII report includes two volumes, separated into 28 chapters, with Chapters 6, 7, and 8 further divided into subchapters that were considered separate chapters for data collection, resulting in 51 distinct chapter entries. Excluding Chapter 1 ("Overall Summary") and Chapter 2 ("Approach to the Assessment"), the analysis was conducted on 49 topical chapters written by distinct expert groups. A total of 4,723 references were manually extracted from the report, segmented by chapter, and copied in the UN style into a spreadsheet. For each entry, we added the chapter, volume, chapter title, and document type per the APA reference style. The resulting dataset, separated by chapter, included 3,927 documents with DOIs. All references were sent through the Simple Text Query form at Crossref to obtain DOIs, returning 3,516 unique DOIs. We found 70 more DOIs using a Levenshtein distance title-matching process of OpenAlex data, resulting in 3,586 unique DOIs. Documents without DOIs mostly included reports (n = 571), data entries (n = 70), websites (n = 53), and news pieces (n = 37); 96.51% of journal articles had DOIs. Using the DOIs obtained for the core dataset of references in WOAII, the metadata for these works was retrieved from OpenAlex, an open bibliometrics

database offering the largest coverage of research outputs, using custom R scripts and the OpenAlexR library (Aria et al., 2024; Priem et al., 2022). The 3,586 distinct DOIs returned a list of 3,809 total references and 3,532 unique works with metadata present in OpenAlex (hereafter the core dataset).

3.2. Collecting Works Related to the Core Dataset

Records for works either citing or cited by the core dataset were then retrieved, resulting in a list of 419,079 works (hereafter the full dataset), including the core dataset, and 740,613 citation links (citing or cited by) between records in the core and full datasets. Authors were extracted from the records, producing a list of 693,770 distinct authors (based on their OpenAlex IDs), and nearly two million authorship records (links between authors and papers). Datasets built through the course of this study, including the list of all works in the full dataset, WOAII chapter details, core works referenced per chapter, citations, authors, and authorship links, were stored in a PostgreSQL database. The database entity relationship diagram is available in Figure 1 of the Supplementary File, illustrating how information was organized to connect data and metadata relevant to both the core dataset of references included in the report and the full dataset of all documents connected to the references in the report.

3.3. Identifying Ocean Literature

Upon collecting all documents connected to the references included in the report, we developed a process to identify relevant ocean research literature based on five document-level criteria: (1) being cited by or (2) citing a core document, (3) co-authorship links, (4) keywords relevant to the chapter topics of the report, and (5) publication in a journal topically related to oceans. We then checked how well combinations of these criteria contributed to capturing ocean-related research outputs. On a per-chapter basis, the number of incoming citations from the core works (1 Cg [citing core]), the number of outgoing citations to these works (2 Cd [cited by core]), and the number of author co-occurrences (3 Ca [coauthorship relationship]) with the core works from the chapter were calculated for each work in the full set. Multiple papers in the core dataset with a shared author (multiple papers for one author) and individual papers with multiple shared authors (one paper with multiple authors) both contributed to the co-authorship numbers. As part of the identification process, we also identified keywords related to oceans by reading the keynote points of each chapter of the report, resulting in a list of 687 keywords (4 Kw). This list was further cleaned by stemming, removing, and adapting keywords based on the following criteria:

1. Concept is related to the chapter and oceans
2. We favor precise terms (sea ice) vs. generic terms that can generate semantic ambiguity (ice).
3. When a word is ambiguous (e.g., banks) but not generic (it is topical—alternate definitions relate to specific objects or themes), it is included. For example, banks is a topical word as it relates to either marine topography or financial institutions.
4. When a word is ambiguous but also general (not topical; e.g., population, current, and slope), it is excluded.

After cleaning, the resulting list included 232 keywords specific to the oceans and related topics (see Table 1 in the Supplementary File). Though coded on a per-chapter basis, the keywords were used to check for ocean-related research in general. Thus, generic keywords ("ocean," "sea," "marine," and "coast") were added

to the list as well. Finally, going through the list of sources for the full dataset, two authors of this study manually identified 791 journals closely related to ocean research (5 Jo [journal of publication]). At the document level, each criterion was given a present/absent score (either the criteria are present or absent from the document) as part of the identification process. This process resulted in 24 combinations of the five criteria categorizing the works included in the full dataset, excluding those from the core dataset. The list of all document-level combinations can be found in Table 2 of the Supplementary Files.

3.4. Qualitative Assessment of the Performance of the Ocean Literature Identification Process

For each of the 24 combinations of the five criteria used in the identification process, a random sample of 100 works was extracted with only the OpenAlex ID, the title, and the abstract, resulting in a total of 2,384 works. This sample dataset was randomly sorted and manually coded by two coders, without knowledge of the associated combination, to assess the relationship of the documents to oceans and related topics based on the title and abstract. In addition to a direct relationship to oceans (Code 2) and no relationship (Code 0), works could also be indirectly related (Code 1), for example, literature about related issues, such as climate research. A first intercoder reliability test was performed after coding 500 works (Krippendorff's alpha = 0.73; Cohen's kappa = 0.55) and a second one after 800 works (Krippendorff's alpha = 0.75; Cohen's kappa = 0.60) to adjust the coding scheme and come to a better agreement between the two coders (Krippendorff, 2004). The intercoder reliability tests were performed in R using the standard parameters of the test_icr function from the Tidycomm package (Unkel, n.d.). Differences in coding categorization were discussed between tests to improve agreement on the best categorization by the coders. After the series of 800 works, 169 documents with differing categorizations were again recoded separately, and the resulting intercoder reliability test on the updated set of 800 works indicated a strong agreement (Krippendorff's alpha = 0.93; Cohen's kappa = 0.86). Further discussions between the two coders contributed to an agreement on the best categorization for the remaining 60 works still coded differently. The remaining 1,584 works were separated and coded independently by the two coders. The results of the coding process were subsequently matched back to the documents' metadata, including the criteria combination, to compare the performance of the different combinations in capturing ocean-related research. A performance score in identifying ocean-related research was calculated for each combination based on the sum of all individual work classifications divided by the number of works sampled in a specific combination times 50, which gave a score out of 100%. We describe three datasets of ocean-related literature based on the combinations that performed above the performance thresholds of 90%, 75%, and 60%.

4. Results

4.1. What Literature Is Cited in the WOAII Report

Altogether, the WOAII report includes 4,723 references across 51 chapters and subchapters. Among the most cited types of publications in the report, references to journal articles are the most common (n = 3,527), followed by reports (n = 649), books and open educational resources (n = 250), and data and databases (n = 134). Among documents indexed in OpenAlex, the most prevalent type of research literature is the article (works = 3,088; references = 3,338), followed by book chapters (works = 176; references = 181), reviews (works = 93; references = 104), books (works = 58; references = 61), and datasets (works = 58; references = 59). These results indicate that most references to grey literature were

not captured in OpenAlex, reflecting instead research-based types of literature. The document most cited by the WOAII report is its predecessor, the *UN First Global Integrated Marine Assessment: World Ocean Assessment* (n = 39). Outside of this, the most cited document is the journal article "Ecosystem Function and Services Provided by the Deep Sea" (Thurber et al., 2014), with 5 references. The 4 most cited journals are *Frontiers in Marine Science* (155 references; 130 distinct documents), *PLOS ONE* (106 references; 94 distinct documents), *Scientific Reports* (100 references; 90 distinct documents), and *Science* (109 references; 79 distinct documents). Except for *Frontiers in Marine Science*, these results indicate a trend toward high-profile multidisciplinary journals to document the knowledge recorded in the report. The document referenced in the report with the most total citations overall, based on the OpenAlex citations count, is the *Summary for Policymakers of the IPCC 5th Assessment Report*, published in 2014, with 12,275 citations at the time of data collection (IPCC, 2014). The mean number of citations for works referenced in the WOAII report is 247 and the median is 72 with a standard deviation of 711.96, indicating a heavily skewed distribution of citations among the references of the report. References cited in the report were published between 1874—a book by Charles Darwin titled *The Structure and Distribution of Coral Reefs* (Darwin, 2013/1874)—and 2021, with about 60% of the works published between 2016 and 2019.

Referencing practices vary significantly between chapters (Figure 1). Excluding Chapters 1 "Overall Summary" (n = 0) and 2 "Approach to the Assessment" (n = 7), the minimum number of references in a chapter is 17 (Chapter 7A "Intertidal Zone") and the maximum is 225 (Chapter 7J "Continental Slopes and Submarine Canyons") with a mean of 97, a standard deviation of 45.3, and a median of 92 references (Figure 2). These variations are also reflected in the references with DOIs (minimum = 9 for Chapter 17 "Changes in Seaweed Harvesting and Use," maximum = 209 for Chapter 6A "Planktons," mean = 76; standard deviation = 44.4; median = 67) and the references in OpenAlex (minimum = 8 for Chapter 17; maximum = 206 for Chapter 6A; mean = 75; standard deviation = 43.8; median = 65). The proportion of references with open OpenAlex records also varies significantly across chapters, with a maximum of 94.50% for Chapter 6A and a minimum of 20% for Chapter 19 "Changes in Hydrocarbon Exploration and Exploitation." The mean proportion of references included in OpenAlex is 73.86% with a standard deviation of 16.07. In the case of Chapter 19, most citations appear to be made to reports or news documents, which are not typically indexed in OpenAlex. These results reflect the choices made by the various writing groups in selecting the most relevant information for their respective chapters, which may be more oriented toward grey literature and reports for certain topics, compared to research outputs in the case of others. In the case of chapters 6A and 19 for example, the citation choices are dominantly for journal articles in 6A (170 articles; 24 reviews; 15 books; 2 reports; 1 thesis; 8 as other), whereas in 19 reports and websites are preferred (10 articles; 17 websites; 14 reports; 4 magazine articles; 2 books; 1 review; 1 standard). A summary of the descriptive analysis for each chapter is available in Tables 3 and 4 of the Supplementary File.

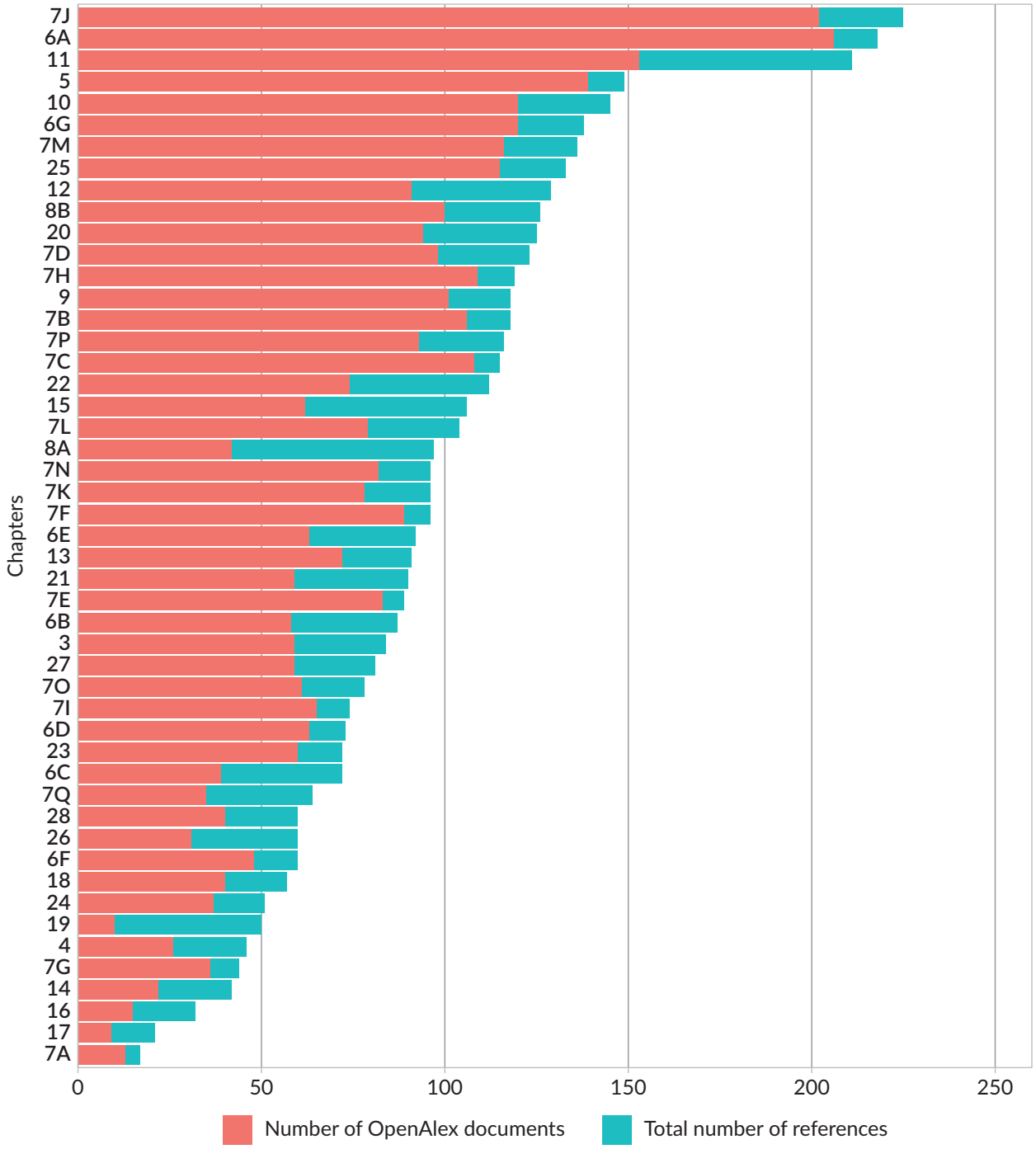

Figure 1. The number of references and OpenAlex documents per chapter entry in the WOAII report.

4.2. The Broader Body of Literature Connected to the WOAII Report

The references included in the core dataset feature 740,613 citation links, resulting in a full dataset of 419,079 documents. Among these, 528 documents of the core dataset are neither citing nor cited by other core documents; 823 are citing; 499 are cited by; and 1,692 are both citing and cited by documents in the core dataset (Figure 2). A total of 304,624 documents have only a citing relationship to documents from the core dataset, whereas 90,475 have only a cited-by relationship. A total of 20,438 documents outside the

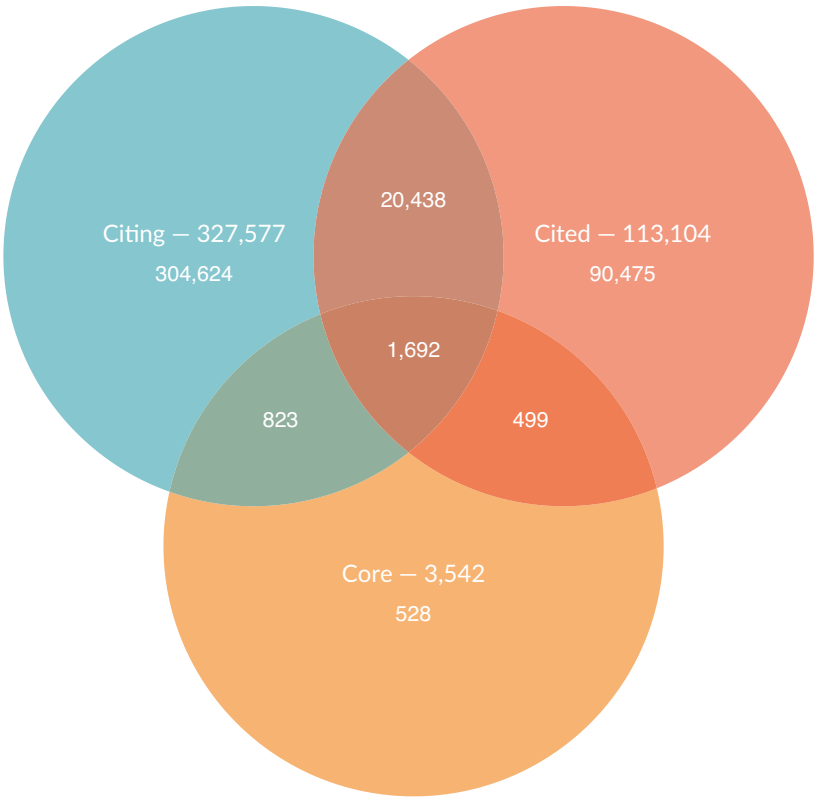

Figure 2. Venn diagram of the citation relationships between the documents from the core and full dataset based on references from the WOAII report.

core dataset also have a citing and cited-by relationship to other documents in the full dataset. The full dataset features 15,932 distinct sources (journals, book series, etc.). The most prevalent OpenAlex document type is the article (n = 361,282), followed by book chapters (n = 25,129), preprints (n = 13,383), reviews (n = 6,948), and dissertations (n = 4,268). The sources in the full dataset reflect a higher representation of specialized journals, such as *Science of the Total Environment* (n = 7,888), *Marine Pollution* (n = 5,918), *Frontiers in Marine Science* (n = 5,602), and *Marine Ecology Progress Series* (n = 5,457). Springer eBooks (n = 6,426) and Elsevier eBooks (n = 4,856) also occupy important positions, as do the preprint repository bioRxiv (n = 4,751) and the multidisciplinary journals *PLOS ONE* (n = 4,659) and Scientific Reports (n = 3,656).

4.3. The Identification of Ocean-Related Literature

Figure 3 highlights the findings of the process to identify ocean-related literature through the qualitative assessment performed on a random sample of 100 documents fitting each of the 24 possible combinations of the five criteria, for a total of 2,384 documents. The inclusion of several or all criteria (journals of publication, keywords, cited by, citing, and coauthorship) appears to have the most impact on helping the identification of research outputs, as all combinations that fit four or more of these criteria have a performance score above 90%. Keywords and journals are the factors that contributed the most to the identification of key research outputs, with performance higher for all combinations that included at least one of two compared to none, and combinations fitting both typically among the top in terms of performance score. Being cited by a core document also contributed slightly better than citing a core document in identifying relevant literature.

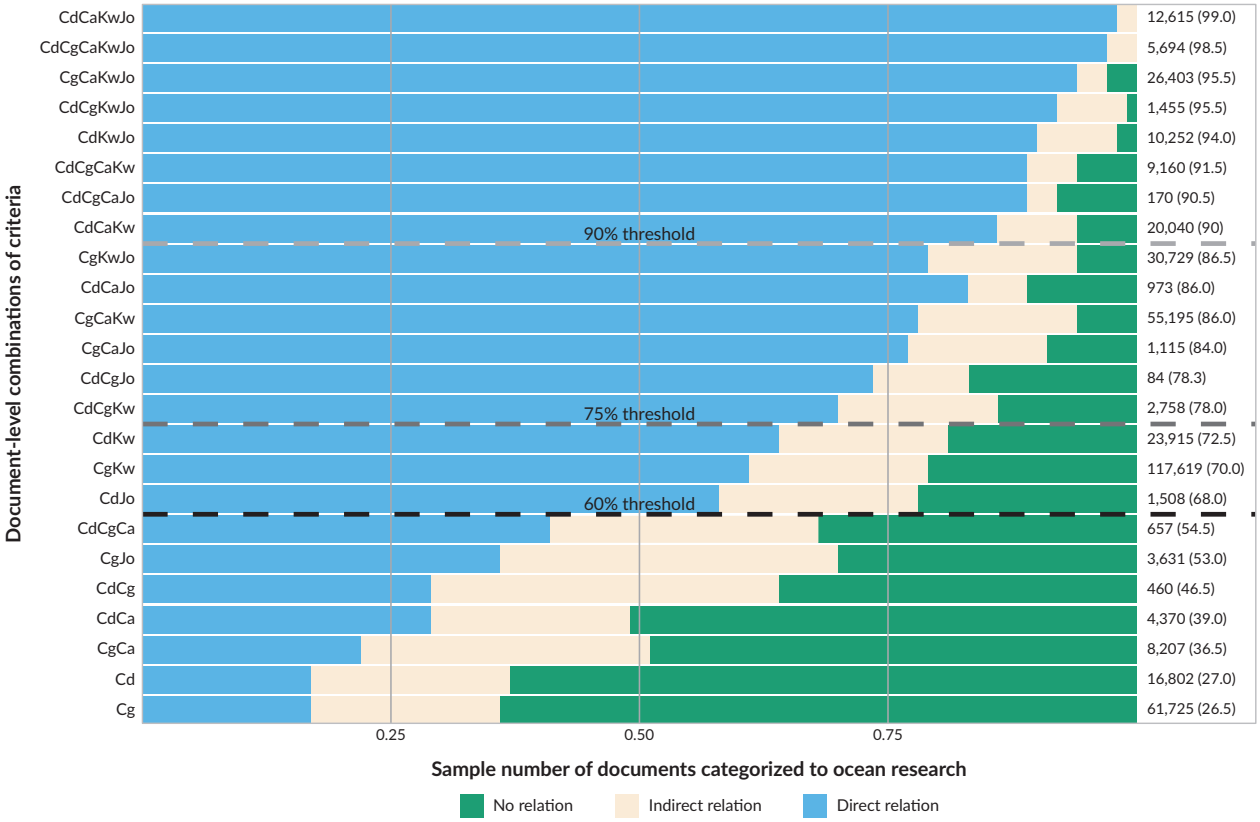

Figure 3. Results of the manual sampling of articles of all 24 possible combinations of criteria for ocean relation matching the documents in the full dataset. Notes: CdCaKwJo means that these papers were cited by the core dataset, had a Ca with papers from the core dataset, including at least one relevant keywords from the list established for this study, and were published in a journal related to oceans; each bar represents the % of papers (out of 100 for each category) that were coded based on the relation of the paper to oceans; the numbers on the right indicate the number of papers fitting a given combination as well as the performance score of the combination to capture relevant ocean research outputs.

We then compared three performance score thresholds at 60% (Figure 3, above the black line), 75% (Figure 3, above the dark grey line), and 90% respectively (Figure 3, above the light grey line). The threshold of 60% includes 319,685 documents from the full dataset excluding core documents, whereas the threshold of 75% includes 176,643 documents, and the 90% threshold includes 85,789 documents. However, the probability of them being ocean-related research papers diminishes significantly with lower thresholds. Looking at the prevalence of document types between the three thresholds datasets, we observe that articles (n = 81,793), book chapters (n = 1,621), and reviews (n = 997) are the most present in the 90% dataset, compared to articles (n = 162,006 and 281,101), book chapters (n = 5,804 and 16,148), and preprints (n = 4,640 and 9,784) in the 75% and 60% datasets respectively. The identification of documents other than research articles appears to diminish drastically with a stricter threshold, likely due to the inclusion of the source or journal name as part of the identification process.

4.4. Assessing the Position of the Literature Cited in the WOAII Report

Comparing datasets, observations of the core dataset indicate that research outputs cited in the WOAII report stem more from open access and high-profile journals, such as *PLOS ONE*, *Scientific Reports*, *PNAS*, *Science*,

and *Nature*, whereas the top sources in the full dataset appear to be more topical, such as *Science of the Total Environment*, *Marine Pollution Bulletin*, *Marine Ecology Progress Series*, and *Geophysical Research Letters* (Figure 4). In both datasets, *Frontiers in Marine Science* occupies a central place among the cited sources, whereas *Marine Policy*, a topic journal in ocean social sciences, also ranked among the most cited journals of the core dataset. The International Union for the Conservation of Nature Red List of Threatened Species, an authoritative source produced by the International Union for the Conservation of Nature documenting the status of endangered species, also occupies a central role among the references used in the WOAII report. Looking at the sources included at various thresholds, we observe that the number of distinct publication sources diminishes from 10,992 at the 60% threshold to 4,361 at 75% and 2,398 at 90%. Across the three thresholds, the journals *Marine Pollution Bulletin* (n = 3,540, 90%; n = 5,860, 75%; and n = 5,880, 60%), *Frontiers in Marine Science* (n = 3,585, 90%; and n = 5,574, 75% and 60%), and *Marine Ecology Progress Series Bulletin* (n = 4,339, 90%; n = 5,385, 75%; and n = 5,443, 60%) are typically among the most prevalent sources, although *Science of the Total Environment* (n = 7,045) has the most references at the 60% threshold. As shown in Figure 4, the most

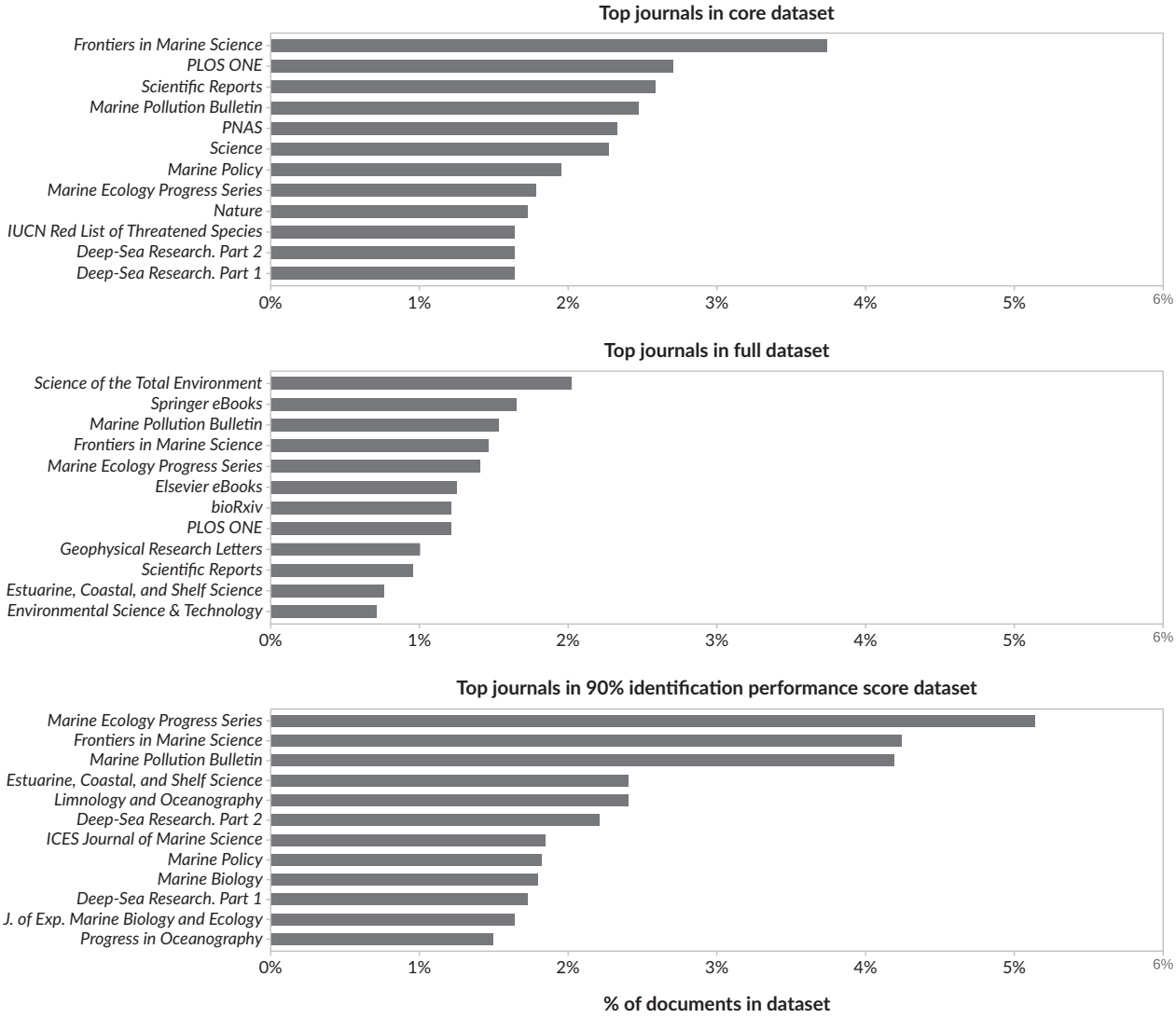

Figure 4. Sources with the most publications in the core dataset, full dataset, and full dataset after filtering the articles that matched the combinations with a performance score above 90%. Note: Sources are plotted based on the relative proportion (%) of articles in the dataset.

central sources included at a 90% performance threshold are more topically oriented toward ocean-related research, mostly due to the inclusion of topical keywords and journals in the identification process. A table with the segmentation of relevant references by chapter is available in Table 5 of the Supplementary File.

5. Discussion

The WOAII report acts as an authoritative document for ocean decision-making and a brokering channel synthesizing critical up-to-date knowledge about the state of oceans worldwide. As stated by Evans et al. (2021), the assessment aims to be a central point of convergence for the collective understanding of oceans, with the objectives of shaping ocean governance, ocean literacy, and ocean action. Therefore, the WOAII and similar seminal knowledge syntheses present a unique opportunity to investigate the construction of and engagement with scientific knowledge outside of academia, especially in processes informing decision-making. Our findings show that this second version of the assessment presents a partial synthesis of the research literature. Despite being the result of a careful and thorough collaborative information-gathering process, the selection of sources in each chapter is dependent upon the strategy and perspective of the group of experts. When it comes to the use of research-based knowledge, our findings show significant differences in the number of references to research outputs cited in each chapter of the report, as well as a reliance on other document types. As an example, Chapter 19 "Changes in Hydrocarbon Exploration and Extraction" cites more reports and grey literature than research articles, likely the result of the specific information practices related to this topic. Therefore, research outputs may be more or less mobilized to address certain topics, especially when other types of knowledge may act as the foundational blocks of expert communities, such as in the case of Chapter 19. These findings also corroborate a point raised by Evans et al. (2021) that future assessments should increase engagement with research and researchers, especially from social sciences disciplines. They also highlight potential gaps in the coverage of selected topics. Nevertheless, the research paper is the main type of document cited in the report, thus indicative of a strong reliance on traditional research outputs in the production of the report.

A second empirical finding of this study relates to the high reliance on papers published in high-profile, multidisciplinary sources when it comes to citing ocean-related research literature in the WOAII. Despite specialized journals, such as *Marine Pollution Bulletin* or *Marine Ecology Progress Series*, appearing as key sources in the full dataset of this study, articles published in *PLOS ONE*, *Scientific Reports*, *PNAS*, *Science*, and *Nature* occupy a central role among the top cited sources in the report, alongside other specialized sources like *Frontiers in Marine Science* and *Marine Policy*. These findings highlight the central role that high-profile journals, like *Nature* and *Science*, play at the science-policy interface; as authoritative sources both in and outside the scientific community, referencing material from these journals could foster credibility by relying on their reputations as high-impact research sources to demonstrate the current state of knowledge about oceans (Alperin et al., 2024). This elicits questions about the unique roles of both high-profile journals and more specialized sources in shaping the collective understanding of research knowledge on certain topics. Research published in high-profile, multidisciplinary journals may be authoritative for decision-making as these journals typically have high scientific publishing standards while benefitting from mechanisms favoring engagement outside of academia, such as historical public reputation or mechanisms that encourage open access publication and broader public outreach. Papers published in specialized journals can also generate significant public interest but may traditionally be less visible than those published in public-facing, high-profile sources. Future research could look at the topics published in either type of source and consider

how the articulation of research published in multidisciplinary and specialized journals may facilitate the mobilization of knowledge in decision-making processes.

The goal of this study is also to present methodological considerations about the use of knowledge synthesis reports for scholarly communication studies and bibliometric assessment about topical objects, such as oceans. As official documents produced by experts in their field, these documents present opportunities for a critical examination of the structure of research knowledge about said topics. Our objective was to link the literature cited in the WOAII report to other research outputs to build a dataset about ocean-related research, thus using the report as an anchor point to build a comprehensive understanding of ocean research. However, as not all research outputs citing or cited by the references included in the report necessarily dealt with oceans, we crafted a process to identify papers based on a combination of five criteria that could indicate a socio-topical relationship, that is a relationship that is informed both by the social and thematic ties between documents, with ocean research (Mongeon, 2018). Through this process, we observed that keywords and journals were the best indicators to identify relevant papers about oceans, with a combination of multiple criteria yielding even better results. Building on previous scholarly communication studies, the findings associated with the development of this process may facilitate the identification of research linked to other policy documents or socially relevant topics (Armitage et al., 2020; Kashnitsky et al., 2024; Purnell, 2022). They also inform future approaches by highlighting how a series of criteria—citing relationships, cited by relationships, co-authorship relationships, keywords, and journals—contribute to the identification of research outputs.

On top of these methodological considerations, our study highlights how a comprehensive dataset of ocean research would help achieve the goals of the UN Decade of Ocean Science for Sustainable Development (UNESCO, 2017) in facilitating the integration of scientific knowledge in processes informing ocean governance. This dataset and related tools could facilitate the access of relevant information for future assessments, as well as for targeted audiences involved in ocean literacy and ocean action (Evans et al., 2021). Such a database could eventually help identify coverage differences between topics, regions, and cultural settings, helping interested audiences find the relevant knowledge outputs they need. Using this approach, further questions could be asked, such as whether factors exist that make some research outputs less likely to be mobilized, how the WOAII might impact science communication, and what is the nature of the information practices of those who contributed to the report. The development of this kind of dataset would nevertheless require significant consideration for data quality and access to scholarly databases to maintain a continuous and exhaustive input of new research (Riddle et al., 2024).

5.1. Limitations and Future Research

While multiple types of outputs are cited in the WOAII report, this research focused specifically on research outputs as indexed in OpenAlex, an open bibliographic database for scholarly communication. Despite covering a broad body of research, the full dataset of papers we collected is not an exhaustive representation of ocean research but rather reproduces a partial and selective view of ocean literature on a larger scale, built upon the knowledge that served as foundations of the WOAII report. Further citation analyses incorporating natural language processing techniques to analyze the text contained in the report could improve this representation by discovering linkages and text similarities between papers. This representation of ocean research literature is also partial in that it builds on the information made available by scholarly information platforms, in this case, OpenAlex. Different platforms, such as Web of Science,

Scopus, or Google Scholar provide a distinct coverage of research outputs and related metadata (Culbert et al., 2024). The advantages of using OpenAlex reside in it being an open platform designed by scholars, thus more accessible and in line with research needs, rather than a proprietary platform. Data quality nevertheless remains an important issue for bibliometrics analysis, as metadata entry is usually performed at the publishing level, with different standards between publishing platforms (Schares, 2024). In that regard, OpenAlex offers a wide coverage of research outputs while also benefiting from the continuous output of a team of scholars to maintain data quality standards. However, certain pieces of information, such as publication year or number of citations, are dependent on the data entry process performed through the publishing process and, therefore, should be subject to caution and careful data processing (Besançon et al., 2024; Delgado-Quirós & Ortega, 2024). While performing better than other indexing platforms, such as the Web of Science or Scopus, research not published in English or region-specific research outputs may also lack coverage in OpenAlex (Céspedes et al., 2024). Therefore, this study provides a partial view of ocean-related research outputs as indexed in OpenAlex and collected through the use of DOIs and Crossref data, thus focusing on a specific set of research publications compared to other types of documents.

Future research will aim to improve the current methodological framework presented in this study by integrating clustering and natural language processing techniques into citation analysis, thereby producing maps of the structure of knowledge in ocean research (Colavizza et al., 2021). It will also focus on expanding and improving the dataset presented in this study toward an exhaustive representation of the field of ocean-related research. Among empirical studies to be conducted, future detailed assessments of document types by chapters would also help critically examine information practices related to specific topics. For example, future studies could assess the role reviews play in producing a state of knowledge about oceans, as well as the prevalence of grey literature to inform certain topics. Through the clustering of research outputs, we also aim to identify socio-topical structures that could provide information on the topics and groups involved in ocean research, as well as examine eventual attention gaps through citations and mentions outside of academia (Toupin et al., 2023). This will create an opportunity to look at the knowledge trends and discrepancies in research literature about oceans, for example by examining whether certain topics are more or less discussed through various mediums. On top of these future research paths, the process developed in this study could also be applied to other policy documents, for example, to identify ocean research outputs that are mobilized to inform policymaking. Finally, we aim to leverage interactive visualization tools to facilitate the discovery of relevant literature about oceans.

6. Conclusion

This research looked at the integration of research outputs in the UN WOAII report. Through the analysis of citations to and from the research outputs included at the end of each chapter of the report, we examined the references used across chapters, specifically the distinct reliance on research outputs in the preparation of the chapters about specific topics. We also observed that the outputs cited in the report occupy a distinct position compared to a broader ecosystem of ocean research, relying mostly on research published in high-impact journals compared to more specialized sources that frame the field of ocean science. This finding corroborates the role that high-profile sources may play at the science-policy interface. As historically authoritative sources, journals like *Nature* or *Science* may provide critical public credibility to the research they publish. We also took the WOAII report as an opportunity to look at a proof-of-concept and a methodological framework to use these knowledge syntheses as a basis to identify a broader set

of research outputs about a specific topic, specifically oceans in this case, as well as to examine the engagement with research related to oceans.

Existing research applies useful methodological tactics for capturing and analyzing research on specific topics, yet much of the literature is missed, and existing structures are subsequently reinforced rather than transgressed. Further research on the science of science is needed to critically examine how the production and selection of research may inhibit its own transformation (Turnhout, 2024). This article presented a methodological approach that leverages the expertise, purposeful selections, and dynamic, collaborative processes that produced the WOAII to capture a broader range of knowledge than query-based or automated processes used in isolation could produce.

The integration of research outputs in ocean policymaking and management is key to achieving the targets of the UN Decade for Ocean Science and to better inform ocean governance. The findings reported in this study could help authors of future WOAs identify relevant literature and improve the coverage of existing knowledge on topical issues related to oceans in an interdisciplinary fashion, a key issue raised by Evans et al. (2021). A broad and exhaustive picture of ocean research could facilitate the communication of relevant knowledge to decision-makers and other audiences, thereby improving our understanding of oceans and fostering ocean action.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

All scripts created for this study are available at: https://github.com/toupinr/ocean_research. The data related to the project can be found at: https://doi.org/10.5281/zenodo.14082108

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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