



A Scientometric Analysis of Biodiversity Conservation in Marine Parks: Trends, Gaps, and Future Directions

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ABSTRACT

This scientometric analysis investigates the evolving trends, existing gaps, and prospective directions in the realm of biodiversity conservation within marine parks. The findings indicate a notable surge in research publications since the early 2000s, with a peak observed from 2018 to 2020. This surge appears to be driven by escalating ecological concerns, particularly exacerbated during the COVID-19 pandemic. The predominance of journal articles underscores the field's reliance on original research and scholarly discourse. Esteemed journals such as "Marine Policy" and "Frontiers in Marine Science" play a critical role in disseminating pioneering research. Keyword analysis reveals "marine protected areas," "biodiversity conservation," and "fisheries" as prominent terms, highlighting the interdisciplinary nature of the research focus. Influential works, including those by Defeo et al. (2009) and Gray (1997), have significantly shaped the field. Notably, leading research outputs emanate from institutions in Australia and the United States. The study underscores the necessity for comprehensive and standardized reporting that integrates social, economic, and ecological dimensions to formulate holistic conservation strategies. Emphasizing stakeholder involvement, robust enforcement, and adaptive management is imperative for the effective conservation of marine biodiversity.

Keywords: *Biodiversity Conservation, Marine Parks, Scientometric Analysis, Marine Ecosystems, Conservation Strategies.*

Introduction

Marine parks, also known as Marine Protected Areas (MPAs), play a crucial role in safeguarding marine ecosystems and biodiversity. They aim to address the severe degradation caused by overexploitation and various threats, including overfishing, habitat destruction, ocean warming, and plastic pollution (Bergseth, 2023). However, the effectiveness of MPAs can be hindered by factors such as poor governance, insufficient resources, and conflicts with local communities. This often results in the existence of "paper parks," which are protected areas in name only (Di Cintio et al., 2023; Jacquet et al., 2023). To enhance the success of MPAs, several key factors need to be considered. These factors include stakeholder involvement, effective communication, and robust enforcement and monitoring strategies (Church et al., 2023). Achieving the goals of marine parks requires a shift towards governing for compliance, integrating social influence, equity principles, and aligning incentives through market-based instruments (Casimiro et al., 2023). Recent global efforts to establish high seas marine protected areas beyond national jurisdictions highlight the importance of multilateral agreements and effective governance in protecting marine biological diversity.

Biodiversity conservation is crucial for marine parks as it supports ecosystem stability, species preservation, and economic value. MPAs play a vital role in preserving marine biodiversity, with studies emphasizing the importance of factors like stakeholder involvement, enforcement, and monitoring (Abdullah, 2021). MPAs have been shown to stabilize fish diversity over time, supporting ecosystem resilience and species retention (Abdullah et al., 2022). Additionally, features supporting marine mammal foraging contribute to high biodiversity within MPAs, highlighting the significance of habitat protection for diverse marine communities (Pettersen et al., 2021). Furthermore, the economic value of marine biodiversity, including species, genetic, and phylogenetic diversity, underscores the need for global conservation efforts to protect these valuable resources (Hodge et al., 2022). Therefore, biodiversity conservation in marine parks is essential for ecosystem health, species survival, and sustainable economic benefits.

Research indicates that higher levels of biodiversity in marine ecosystems can have a substantial mitigating effect on the adverse impacts of ocean acidification on key organisms that constitute habitats. This can augment their resilience to acidification and deter detrimental occurrences of opportunistic microbes, resulting in reductions ranging from 50% to over 90% (Masud, 2019). In Malaysia, the establishment of MPAs has aimed to address diverse threats to marine ecosystems, including the loss of biodiversity. These MPAs also make significant contributions to the sustainability of livelihoods, financial advantages, and the restoration of ecosystems (Herbert-Read et al., 2022). Furthermore, the growth of Malaysia's socio-economic sector is influenced by the marine park islands that attract tourists. Consequently, it is imperative to preserve the natural allure of marine parks, despite

the negative impacts of tourism (Wong Abdullah et al., 2020). Therefore, the conservation of biodiversity in marine park ecosystems is crucial for ameliorating environmental deterioration and ensuring sustainable development, both at a global level and specifically in Malaysia.

This study aims to conduct a scientometric analysis to assess publishing trends and research advancements related to the conservation of biodiversity in marine parks. Undertaking a scientometric analysis of biodiversity conservation in marine parks is crucial for gaining a comprehensive understanding of this field of study. Furthermore, this analysis enables the identification of key works, enhances our understanding, fosters collaboration, and provides guidance for future research efforts in advancing biodiversity conservation in marine parks and promoting environmental awareness.

The following research questions are crucial for improving the understanding of previous research on the conservation of biodiversity in marine parks:

1. What trends and patterns have been identified regarding the quantity and characteristics of publications related to investigating the conservation of biodiversity in marine parks?
2. Which sources have been the most productive in publishing research on the conservation of biodiversity in marine parks?
3. What are the dominant research themes or subjects that have emerged in the investigation of biodiversity conservation in marine parks?
4. Which academic publications have had the most significant impact on the conservation of biodiversity in marine parks?
5. Which research institutions have made significant contributions to the study of biodiversity conservation in marine parks?

Materials And Methods

This study aims to conduct a comprehensive review and analysis of existing research on biodiversity conservation in marine parks, examining their applications, capabilities, roles, and effects. To accomplish this objective, various techniques were employed, including mapping analysis using VOSviewer and research trend measurement using ScientoPy. The review gathered relevant datasets from Scopus and Web of Science (WoS) pertaining to biodiversity conservation in marine parks. The datasets were populated using resilient keywords outlined in Table 1. The search was conducted without any temporal restrictions until June 12, 2024. Scopus and WoS databases were selected for this study due to their widespread usage in academia and research institutions for scientometric analysis (Abdullah & Sofyan, 2023). These databases are renowned for their comprehensive coverage, high-quality data, detailed metadata, advanced analytical tools, and global accessibility (Hafiar et al., 2024).

For analysis and visualization, the present investigation utilized ScientoPy and VOSviewer. ScientoPy is a scholarly-scientometric analysis software platform that assesses the significance of key subjects, authors, countries, and associated publications in a study (Abdullah & Sofyan, 2023). ScientoPy is also acknowledged as a publicly available and open-source Python-based program for scientometric analysis. A notable feature of the system is its pre-processing component, which effectively eliminates any biases present in individual articles (Ruiz-Rosero et al., 2019). This pre-processing phase enhances the readability, accuracy, organization, comprehensiveness, and representativeness of the findings derived from a substantial volume of Scopus and WoS data. In this study, VOSviewer was employed to construct a co-occurrence map of authors' terms related to biodiversity conservation. It is essential to provide accurate information on various themes or issues that have been previously studied and have influenced research on biodiversity conservation in marine park contexts worldwide (Abdullah, 2022b).

Table 1

Search strategy for extracting data from the Web of Science and Scopus databases.

Database	Search Strategy	Records
Web of Science	Topic: ("marine parks" OR "Marine protection zone" OR "Marine reserve area" OR "Ocean parks" OR "Marine protected areas") AND ("biodiversity conservation" OR "Ecosystem protection" OR "Environmental conservation" OR "Biosphere protection" OR "Biodiversity safeguarding" OR "Biodiversity protection")	507
Scopus	Article Title, Abstract, Keywords: ("marine parks" OR "Marine protection zone" OR "Marine reserve area" OR "Ocean parks" OR "Marine protected areas") AND ("biodiversity conservation" OR "Ecosystem protection" OR "Environmental conservation" OR "Biosphere protection" OR "Biodiversity safeguarding" OR "Biodiversity protection")	576

Pre-processing of Retrieved Datasets

The datasets currently in use underwent pre-processing to eliminate duplicate entries and consolidate significant data using ScientoPy. Figure 1 presents the initial findings of the data collection process, revealing a total of 1083 unprocessed data items obtained from publications in Scopus and WoS. Based on these findings, 57 articles, representing 5.30% of the datasets, were excluded due to their utilization of the automatic document-type filtering technique. Initially, 1026 papers were identified, but subsequent removal of duplicate datasets revealed 323 cases of duplication within the Scopus database, accounting for 31.50% of the dataset. Ultimately, 703 papers were deemed suitable for inclusion in the current study. Of these, 493 papers (70.10%) were sourced from the WoS, while the remaining 210 publications (29.90%) originated from Scopus. The inclusion of datasets containing over 100 components facilitated the execution of scientometric analysis.

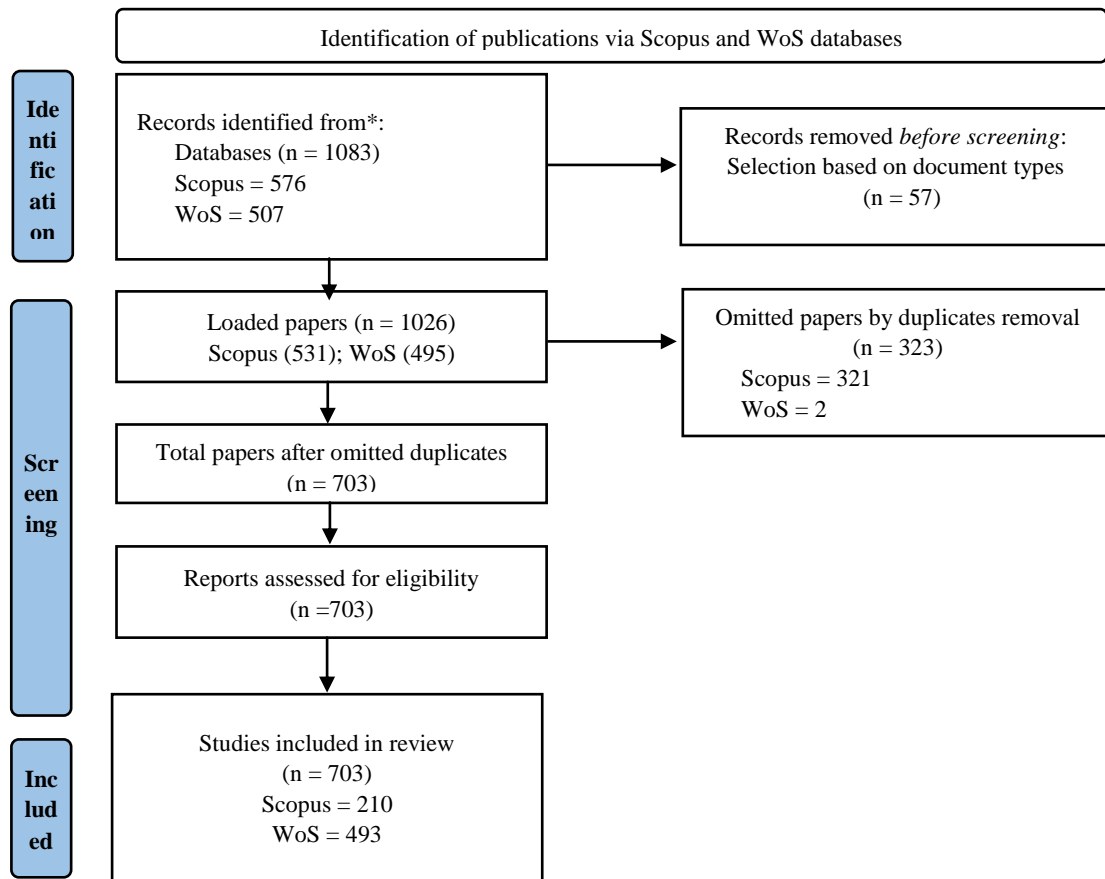


Diagram 1. Flow diagram of research of databases and registers

Results

The results of the present investigation sufficiently answer each of the research inquiries delineated in the methodology segment. The results also presented using graphical visualisations generated by ScientoPy and VOSviewer.

Trends and Patterns in Publishing

Figure 1 presents a depiction of the progression of publications pertaining to the conservation of biodiversity in marine parks, spanning the years 1992 to 2024. The data used for this analysis is derived from the WoS and Scopus databases. The key findings of this study indicate a substantial upsurge in research output over the course of the examined period, with a particularly noticeable increase occurring from the early 2000s onward. The WoS database exhibits a consistent upward trajectory in the number of publications, reaching its zenith around the years 2018 to 2020, with over 40 documents being produced annually. This trend signifies a growing academic interest in and recognition of the importance of conserving marine biodiversity. In contrast, the Scopus data, while generally displaying an upward trend, demonstrates more variability, with notable peaks and troughs. This variability could be attributed to inconsistent research activity or divergent indexing practices. Both datasets ultimately underscore a positive trend, thereby emphasizing the significance and expanding scope of research on biodiversity conservation in marine parks. Nevertheless, the disparities in publication counts between the two databases highlight the necessity for comprehensive and standardized reporting, which would allow for a more comprehensive understanding of global research efforts in this critical field.

The increasing volume of literature on biodiversity conservation in marine parks indicates a growing interest among scholars in comprehending and tackling the challenges associated with preserving marine ecosystems and their biological diversity. This trend reflects a heightened recognition of the significance of marine parks in safeguarding species, habitats, and overall ecological well-being, as well as an acknowledgment of the necessity for robust scientific research to inform effective conservation strategies and policy development. Maintaining a continuous dialogue between academics, subject matter experts (SMEs) in marine parks, and professionals in biodiversity conservation is imperative to ensure the practical and coordinated implementation of research findings into conservation strategies. By integrating scientific insights with industry-based approaches, as proposed by Abdul-Latiff, (2022), and involving stakeholders in the collaborative design of Marine Protected Areas (MPAs), as demonstrated by Horta e Costa et al. (2022), conservation endeavors can be more effectively aligned with socioeconomic contexts. Additionally, successful collaboration in conservation, as emphasized by White et al. (2023), underscores the importance of interdisciplinary approaches, long-term commitment, and trust-building among diverse stakeholders. Moreover, incorporating local observations from stakeholders, as advocated by Relano et al. (2022), can enhance the effectiveness of MPAs by addressing gaps in existing databases and fostering inclusive discourse on marine conservation.

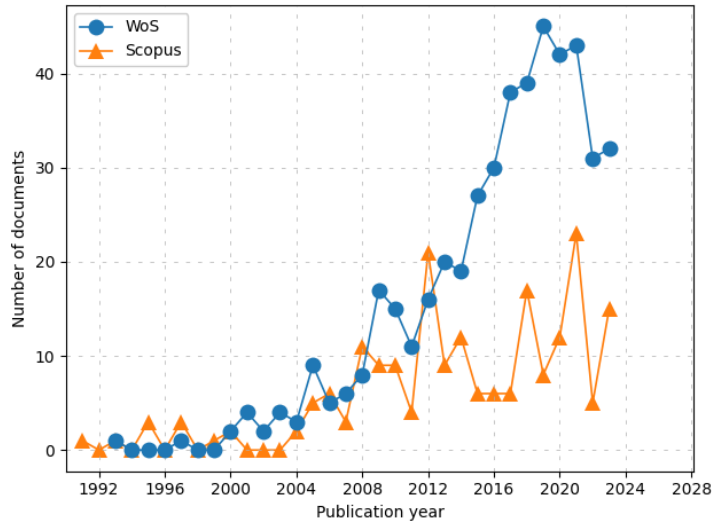


Figure 1: The evolution of publication growth (Source: Author, using ScientoPy 2.1.3).

Figure 2 presents a comprehensive overview of the extensively analyzed document types associated with the conservation of biodiversity in marine parks. The figure demonstrates the distribution of publications before and after 2022. The data indicates that articles are the dominant publication type, constituting most documents. Among these articles, 12% were published between 2022 and 2023. Reviews make up 14% of the total, indicating a substantial number of critical assessments and syntheses of existing research, although a smaller portion of them have been recently published. Notably, there is a lack of proceedings papers, while book chapters represent 7% and conference papers account for 9% of the total publications. This distribution reflects contributions from diverse academic and professional forums. Although present in smaller quantities, early access and data papers show that all their publications occurred between 2022 and 2023. This highlights a recent increase in the availability of preliminary research findings and datasets. Overall, this distribution underscores the central role of peer-reviewed articles in disseminating research, while also emphasizing the importance of reviews, book chapters, and conference papers in providing broader perspectives and facilitating knowledge exchange within the field.

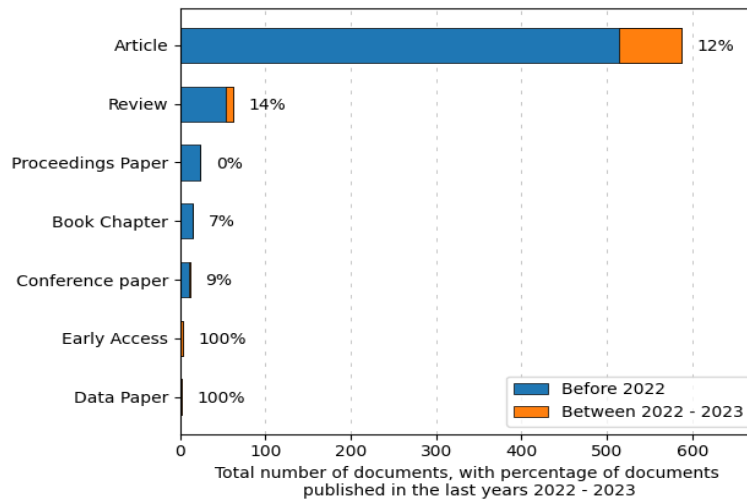


Figure 2: Bar-trend graph of document types (Source: Author, using ScientoPy 2.1.3).

Prominent Publishing Titles

Figure 3 presents a comprehensive breakdown of the publication distribution about biodiversity conservation in marine parks across several renowned journals. It compares the documents published before 2022 with those published between 2022 and 2023. Notably, the journal "Marine Policy" emerges as the leading platform, featuring a significant number of publications, with 16% of its contributions falling within the recent two-year period. This observation highlights the journal's vital role in addressing policy-related aspects of marine biodiversity conservation. It reflects the growing recognition of the significance of policy frameworks in driving effective conservation efforts. Another notable journal is "Frontiers in Marine Science," which stands out with the highest percentage of recent publications (31%). This finding underscores its importance as a pivotal platform for disseminating the latest research developments and innovative studies in marine science and conservation. Additionally, other journals such as "Journal of Environmental Management" and "Diversity and Distributions" exhibit a substantial portion of their publications in recent years, accounting for 25% and 10% respectively. This suggests active engagement in ongoing research trends and emerging issues related to biodiversity conservation. In contrast,

journals like "Environmental Conservation," "Biological Conservation," and "Conservation Biology," despite having a considerable number of overall documents, do not show any recent publications within the specified timeframe. This discrepancy may indicate variations in editorial focus or publication timelines. Overall, the data emphasizes the dynamic nature of research dissemination in the field of marine biodiversity conservation. It reveals that certain journals have gained prominence in publishing timely and relevant research, thereby influencing the direction and focus of future studies.

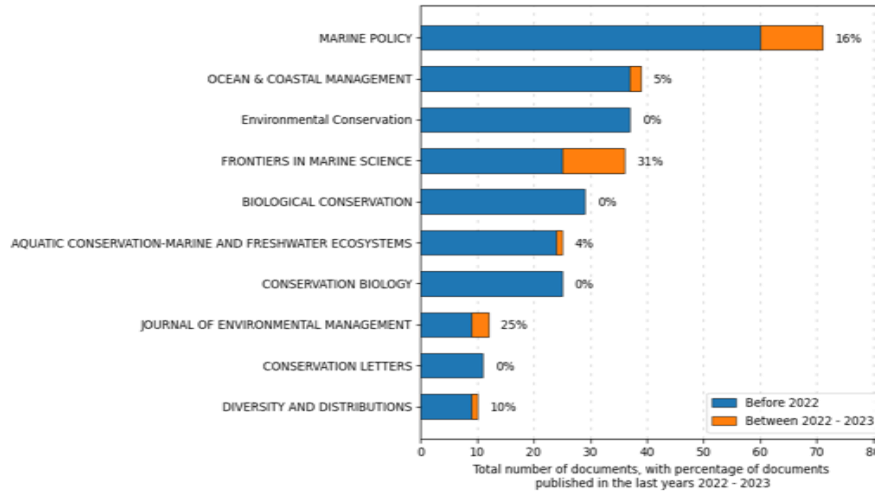


Figure 3: The prolific source titles (Source: Author, using ScientoPy 2.1.3).

Emerging Topics or Themes in Research

This study employs ScientoPy and VOSviewer to assess the authors' keywords and examine the prevailing research trends and notable subjects in the field of marine park biodiversity conservation. Figure 4 displays the top 10 keywords associated with the conservation of biodiversity in marine parks. The selection of words in the list is based on their frequency of occurrence in the papers, represented by the blue bars. Furthermore, the orange shade indicates the proportion of articles published in the past two years (PDLY), specifically in 2022 and 2023.

Figure 4 presents a comprehensive analysis of the frequency of various author keywords related to the conservation of biodiversity in marine parks, highlighting the number of documents published before 2022 compared to those published between 2022 and 2023. The keyword "marine protected areas" stands out with the highest total number of documents, 11% of which were recently published, indicating its ongoing central role in research discussions. Similarly, "marine protected area" also demonstrates significant usage, with 8% of the documents published in the last two years, underscoring the critical importance of these areas in current conservation research.

"Biodiversity conservation" is another key term with a substantial presence, as 15% of its documents were published between 2022 and 2023. This highlights a growing academic focus on strategies and methods for preserving biodiversity within marine ecosystems. The keyword "conservation" has the highest percentage of recent publications at 24%, reflecting an increased interest in broader conservation practices and their applications. "Marine conservation" and "biodiversity" also feature prominently, with 12% and 22% of their documents being recent, respectively, signifying sustained and expanding research efforts in these areas.

Other noteworthy keywords include "marine reserves," "fisheries," "protected areas," and "systematic conservation planning." While "marine reserves" and "protected areas" exhibit lower recent publication percentages of 3% and 7%, respectively, they remain crucial components of conservation strategies. The term "fisheries," with 13% recent publications, highlights the integration of sustainable fishing practices within conservation frameworks. "Systematic conservation planning," with 10% of its documents published recently, indicates a growing focus on strategic and well-planned conservation efforts. Overall, the distribution and recent trends in these keywords underscore the dynamic and multifaceted nature of research in marine biodiversity conservation, revealing both established areas of focus and emerging topics of interest.

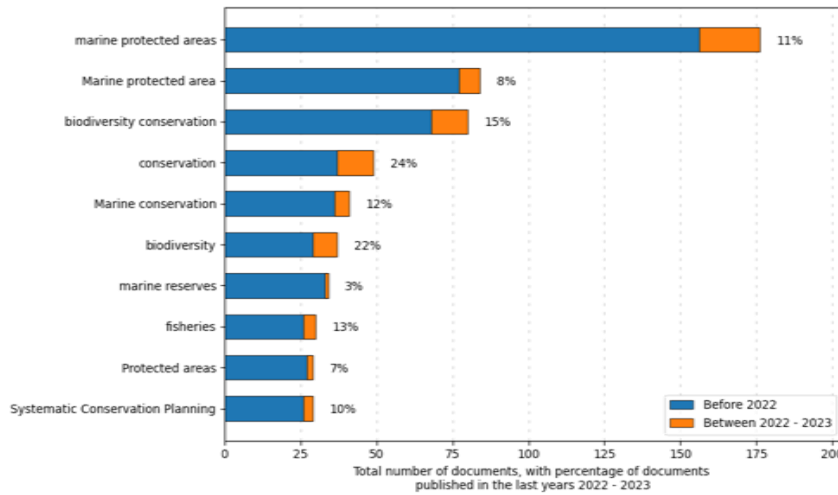


Figure 4: The bar-trend graph of research themes and topics emerging (Source: Author keywords, using SciencioPy 2.1.3).

The VOSviewer platform was used in this study to examine the relationships between keywords in previous studies. Figure 5 illustrates the main keywords that have been studied since 2015, and it is important to explore their connections. The analysis focused on author-selected keywords that appeared at least 5 times. Out of the total of 1448 terms, only 63 met this threshold. Examining the keywords chosen by authors is essential for researchers who want to identify patterns in research and evaluate the progress of research topics. In this study, VOSviewer was used to map the analysis within the context of keyword analysis. Figure 5, generated by VOSviewer, presents a network visualization of author keywords related to the preservation of biodiversity in marine parks.

The size of the nodes represents the frequency of keyword occurrence, while the colors indicate the average year of publication. The keyword "Marine protected areas" stands out as the most prominent keyword, highlighting its central importance in the research field. Other keywords such as "marine protected area," "conservation," and "fisheries" also feature prominently, indicating significant research focus in these areas. Emerging keywords like "climate change," "resource management," and "spatial prioritization" are highlighted in warmer colors (yellow to red), indicating recent and growing interest in these topics. The network reveals strong connections between keywords, demonstrating the interdisciplinary nature of marine biodiversity conservation research. It also highlights interconnected themes such as "ecosystem services," "sustainability," and "marine reserves." This visualization emphasizes the evolving and expanding scope of research, providing insights into critical areas of focus and the integration of contemporary environmental challenges.

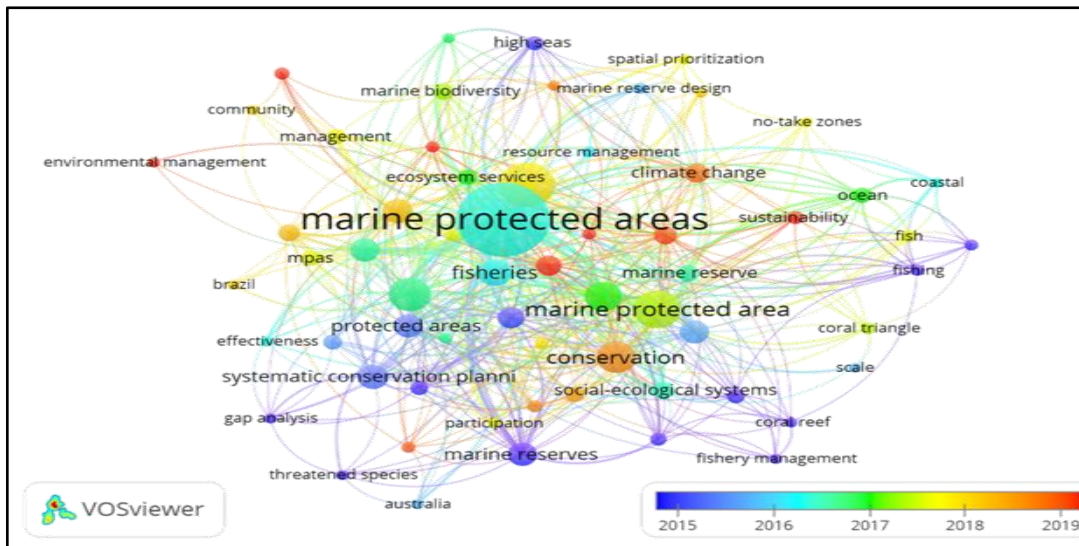


Figure 5: The visualization of overlapping keywords co-used by authors (Source: Author Keywords, using VOSviewer 1.6.19).

The Most Influential Academic Works

Table 2 presents a selection of works that have garnered more than 300 citations which highlights the most influential academic works on the conservation of biodiversity in marine parks, showcasing publications with more than 300 citations. The leading work is the review by Defeo et al. (2009), titled "Threats to sandy beach ecosystems: A review," with an impressive 926 citations, indicating its critical impact on understanding threats to coastal ecosystems. Gray's (1997) article, "Marine biodiversity: Patterns, threats and conservation needs," follows with 570 citations, emphasizing its

foundational role in marine biodiversity research. Maxwell et al. (2020) in their review "Area-based conservation in the twenty-first century" with 436 citations, highlights contemporary conservation strategies. Robert et al. (2017) and Watts et al. (2017) have substantial influence with over 400 citations each, focusing on climate change adaptation through marine reserves and optimal conservation zoning, respectively. McClanahan et al. (2006) compares marine protected areas and alternative reef management approaches, garnering 373 citations. Lastly, Sala et al. (2021) with "Protecting the global ocean for biodiversity, food, and climate" has 320 citations, reflecting its relevance to global conservation efforts. These works collectively underscore the breadth and depth of research driving policy and practical measures in marine biodiversity conservation.

Table 2. List of publications with more than 300 citations

No.	Source	Title	Citation count	Document type
1.	(Defeo et al., 2009)	"Threats to sandy beach ecosystems: A review"	926	Review
2.	(Gray, 1997)	"Marine biodiversity: Patterns, threats and conservation needs"	570	Article
3.	(Maxwellet al., 2020)	"Area-based conservation in the twenty-first century"	436	Review
4.	(Robert et al., 2017)	"Marine reserves can mitigate and promote adaptation to climate change"	407	Article
5.	(Wattset al., 2017)	"Marxan with Zones: Software for optimal conservation based land- and sea-use zoning"	406	Article; Proceedings Paper
6.	(McClanahanet al., 2006)	"A comparison of marine protected areas and alternative approaches to coral-reef management"	373	Article
7.	(Salaet al., 2021)	"Protecting the global ocean for biodiversity, food and climate"	320	Article

Productive Institutions

Figure 6 presents the productivity of different institutions involved in biodiversity conservation in marine parks. It distinguishes between documents published before 2022 and those published between 2022 and 2023. James Cook University in Australia leads with the highest total number of publications, although only 3% of them are recent, indicating a strong historical presence. The University of Queensland, also in Australia, demonstrates considerable recent activity, with 9% of its documents published in the last two years, reflecting ongoing research initiatives. In the United States, Duke University and the University of California, Santa Barbara, have made noteworthy contributions, with the latter showing 10% of recent publications. Canadian institutions like the University of Victoria and the University of British Columbia have also been active in this field, with 5% and 6% of their documents published recently, respectively. The Nature Conservancy and Stanford University in the United States exhibit significant recent activity, with 7% and 14% of their documents published between 2022 and 2023. The University of Tasmania in Australia stands out with an impressive 15% of recent publications, highlighting its growing contribution to the field. In contrast, Pontificia Universidad Católica de Chile has not published any recent documents, which could indicate a focus on earlier research or a potential gap in current contributions. Overall, these findings emphasize the diverse and international nature of research efforts in marine biodiversity conservation, with institutions from multiple countries making significant contributions.

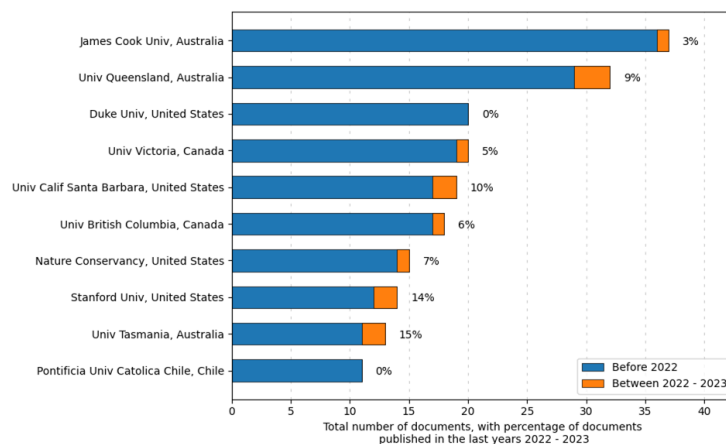


Figure 6: The ten leading institutions in terms of productivity (Source: Authors, using ScientoPy 2.1.3)

DISCUSSION

Given the limited existing research on evaluating biodiversity conservation in marine parks using scientometric methods, conducting a comprehensive analysis of current studies using analytical techniques would be a valuable addition to the field. This study aims to investigate the current state of research on biodiversity conservation in marine parks worldwide and provide essential insights into academic collaboration. To achieve this, we will visualize the relationships between significant studies and researchers in the field by examining the most frequently cited papers.

Scientometric investigations, which employ analytical methods, are crucial for gaining a comprehensive understanding of specific areas of study. Scientists can analyze patterns in scientific research related to a particular subject or discipline. This involves evaluating the growth of published literature, identifying prevalent topics, scrutinizing the sources of these works, and categorizing different types of papers. Furthermore, these investigations can provide valuable guidance to fellow researchers by identifying research organizations and individuals who have demonstrated expertise in their research endeavors. The use of biodiversity components in conservation is vital for improving marine park environments and disseminating relevant information about environmental awareness and related issues, which are currently widespread. These phenomena can be identified by analyzing the dominant research subjects and themes in this study. Consequently, researchers can assess the current state of the subject to identify potential contributions and novel approaches for future research.

The study's findings shed light on the concentration of biodiversity conservation in marine parks. These findings offer valuable insights into publishing patterns and trends within this specific sector. Figure 1 demonstrates a consistent rise in publications on this subject, which began in the early 2000s. The significant surge in publications since 2018 can primarily be attributed to heightened ecological concerns, particularly during the COVID-19 pandemic. This crisis highlighted the interconnectedness of human and environmental well-being, resulting in greater research activity and funding in this field.

The COVID-19 pandemic has had a significant impact on the adoption of biodiversity conservation in marine parks. One of the primary factors contributing to this is the reduction of human activities and the resulting decrease in anthropogenic stress on ecosystems. This reduction in human interference has led to positive effects on biodiversity, as evidenced by studies showing an increase in live coral cover, fish diversity, and abundance in marine environments during lockdown measures (Popkova et al., 2022). In addition to these short-term effects, the pandemic has also highlighted the importance of maintaining environmental benefits and conserving biodiversity through sustainable practices and reduced resource consumption. Improved air and water quality are among the environmental benefits that have been emphasized during this time (Somchuea et al., 2022). To ensure long-term biodiversity conservation, it is crucial to involve local communities and experts in conservation efforts, particularly in developing countries. This integration is seen as a vital strategy to build resilience and address challenges, especially in the face of global crises like the COVID-19 pandemic (Razanatsoa et al., 2021).

In Figure 2, it is evident that journal articles constitute the predominant form of documentation generated within this sector. This observation implies that the conservation of biodiversity in marine parks relies heavily on original research endeavors and scholarly dialogues. The substantial number of papers serves to demonstrate the noteworthy emphasis and discourse surrounding this subject matter in educational and conference settings. According to Garousi and Fernandes (2017), as cited by Abdullah (2023), journal publications tend to receive an average of 12.6 citations, whereas conference papers garner an average of 3.6 citations. This discovery lends support to the commonly held belief that scholarly journal publications wield a greater overall impact in comparison to conference papers. Journal articles offer a multitude of advantages as sources of research findings. They afford recognition and prestige to the authors and their work (Vadhera et al., 2022). Furthermore, journal articles undergo a comprehensive evaluation process to ensure the research's high caliber (Gustafsson, 2022).

Figure 3 demonstrates the importance of respected scholarly publications and conference proceedings in effectively sharing research on marine park biodiversity conservation. Well-known sources like "Marine Policy" and "Frontiers in Marine Science" are particularly notable for their high number of recent publications. The significant impact factor and publication volume of these sources highlight the growing significance and relevance of research on biodiversity conservation in marine parks, attracting attention from researchers and practitioners alike. This is partly because articles published in prestigious and influential journals tend to receive more citations. Therefore, it is advisable for researchers to submit their scientifically rigorous work to these journals in order to enhance the impact and visibility of their studies (Achugbue & Tella, 2023; Bahadoran et al., 2020). The use of policy tools in national research assessment systems, academic promotion processes, and competitive funding schemes can also influence the quantity of published articles. Policy tools such as interest registries can help identify and resolve conflicts of interest that may affect publication practices (Kianersi et al., 2023). It is important to recognize that the increase in the number of publications has not led to a decline in publishing quality, as assessed by scientometric indicators.

Figure 4 presents an overview of the main research areas and emerging concerns related to understanding biodiversity conservation in marine parks. The term "marine protected areas" is used to emphasize the importance of conserving marine biodiversity and ecosystems. The widespread use of this term in current studies on biodiversity conservation in marine parks shows that scholars and experts recognize the need to establish designated zones for the preservation and sustainable management of marine ecosystems. The literature explores various challenges faced by MPAs, including inefficiencies in governance, conflicts with local communities, and the need for increased stakeholder involvement (Abdullah, 2021; Abdullah et al., 2022). Despite the documented positive impacts of MPAs on habitats and species diversity, concerns remain about the effectiveness of ongoing conservation efforts, particularly in light of ongoing biodiversity loss (Arneth et al., 2023). To address these challenges, there has been a shift towards

more equitable approaches in MPAs, focusing on balancing biodiversity conservation with the well-being of coastal communities through diverse fisheries regulations and community involvement (Church et al., 2023). The call for increased global targets for protected areas reflects the recognition by experts of the importance of designated zones for the preservation and sustainable management of marine ecosystems (Andradi-Brown et al., 2023).

Furthermore, the analysis of keyword co-occurrence using VOSviewer (Figure 5) elucidates the connections between different research topics and concepts. The increasing significance of terms such as "marine protected area," "conservation," and "fisheries" underscores the shifting research focus and the importance of biodiversity conservation in promoting environmental awareness and education. The frequent usage of the term "marine protected area" in scholarly discussions indicates the acknowledgment of these areas' pivotal role in preserving marine biodiversity and ensuring the sustainable utilization of ocean resources (Ban et al., 2019; Picone et al., 2021; Turnbull et al., 2021). Scholarly discussions concerning MPAs emphasize their critical role in safeguarding marine biodiversity and advancing the sustainable utilization of ocean resources (Favoretto et al., 2023; Jones et al., 2023; Salazar-Sepúlveda et al., 2023). Research demonstrates that well-designed MPAs not only benefit marine ecosystems but also replenish nearby fisheries without causing economic losses to the fishing industry (Ziegler et al., 2023). Additionally, studies indicate that MPAs can enhance the long-term resilience of nearshore fish communities by mitigating the impacts of marine heatwaves and aiding in the recovery of taxonomic diversity after warming events (Marzo et al., 2023). Moreover, the social acceptability of MPAs, particularly among local communities and small-scale fishing communities, is crucial for their success, underscoring the importance of stakeholder engagement and support to enhance MPA effectiveness and conservation outcomes. Overall, the substantial scientific literature on ocean literacy and MPA research highlights the recognition of MPAs as indispensable tools for marine conservation and sustainable resource management.

The results depicted in Figures 4 and 5 are substantiated by the notable prevalence of terms pertaining to marine protected areas, conservation, and fisheries. These findings exemplify the dynamic emphasis of academic investigations and underscore the significance of biodiversity conservation in enhancing situational awareness and education within marine parks. An analysis of keyword co-occurrence yields valuable insights into the interconnectedness of diverse research topics and concepts, thereby ultimately enhancing our understanding of the level of integration and interdisciplinarity in the realm of marine conservation research.

Table 2 presents a compilation of scholarly articles ranked by their number of citations. These articles provide valuable insights into the current state of biodiversity conservation in marine parks. The publication "Threats to sandy beach ecosystems: A review" by Defeo et al. (2009) has received the highest number of citations, indicating its significant impact in the field. Articles with a substantial number of citations demonstrate widespread recognition and utilization within the academic community. As a result, these important publications serve as valuable resources for scholars seeking to understand the current state of biodiversity conservation in marine park discussions and contribute to shaping research direction and advancing the existing knowledge base.

Figure 6 provides an analysis of successful institutions, highlighting the notable contributions made by different establishments in various countries. Australian institutions such as James Cook University and the University of Queensland have consistently shown their dedication to researching biodiversity conservation in marine parks, as evidenced by the publication of over 30 articles. This consistent output serves as a testament to their unwavering commitment and outstanding performance in these areas.

The analysis identifies several gaps in the existing literature, particularly in under-researched areas and methodological limitations. There is a need for more comprehensive and standardized reporting to enhance the understanding of global research efforts. Future research should focus on integrating social, economic, and ecological aspects to develop holistic conservation strategies. Emphasizing stakeholder involvement, robust enforcement, and adaptive management will be crucial in addressing the challenges of marine biodiversity conservation effectively.

In summary, this scientometric analysis highlights significant trends, productive sources, dominant themes, and influential works in the field of biodiversity conservation in marine parks. By identifying research gaps and suggesting future directions, this study provides valuable insights for advancing conservation efforts and promoting sustainable management of marine ecosystems.

CONCLUSION

This scientometric analysis of biodiversity conservation in marine parks reveals several key findings and trends, providing valuable insights into the field. The increasing volume of research publications since the early 2000s, with a notable surge from 2018 to 2020, underscores the growing academic interest and recognition of the importance of marine biodiversity conservation. This trend reflects heightened ecological concerns, especially during the COVID-19 pandemic, which highlighted the interconnectedness of human and environmental well-being.

The dominance of journal articles in the publication types indicates that original research and scholarly discussions are the primary methods for disseminating knowledge in this field. Respected journals like "Marine Policy" and "Frontiers in Marine Science" have emerged as pivotal platforms for publishing cutting-edge research, emphasizing the significance of policy frameworks and innovative studies in marine conservation.

Keyword analysis reveals the prominence of terms such as "marine protected areas," "biodiversity conservation," and "fisheries," indicating a dynamic and evolving research focus. The co-occurrence of these keywords highlights the interdisciplinary nature of marine conservation research, integrating ecological, social, and economic dimensions. The frequent use of terms related to marine protected areas (MPAs) underscores their central role in preserving marine biodiversity and promoting sustainable resource management.

Influential academic works, such as Defeo et al.'s (2009) review on threats to sandy beach ecosystems and Gray's (1997) article on marine biodiversity patterns, have significantly shaped the field. These highly cited publications serve as foundational resources for scholars and policymakers, guiding future research directions and conservation strategies.

Productive institutions, particularly from Australia and the United States, have made notable contributions to the field, with James Cook University and the University of Queensland leading in publication output. The diverse and international nature of research efforts highlights the global importance of marine biodiversity conservation.

This analysis identifies gaps in the existing literature, particularly in under-researched areas and methodological limitations. Future research should focus on integrating social, economic, and ecological aspects to develop holistic conservation strategies. Emphasizing stakeholder involvement, robust enforcement, and adaptive management will be crucial in addressing the challenges of marine biodiversity conservation effectively.

In summary, this scientometric analysis elucidates key trends, prolific sources, prevailing themes, and seminal works within the domain of biodiversity conservation in marine parks. By pinpointing research gaps and proposing future directions, this study offers crucial insights for advancing conservation efforts and fostering sustainable management of marine ecosystems.

Ethical considerations

Not applicable.

Conflict of Interest

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