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Review

Global Marine Ranching Research: Progress and Trends through Bibliometric Analysis

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Abstract: With the increasing prominence of pollution issues in offshore waters, marine ranching plays a crucial role in restoring marine ecosystems and ensuring the sustainable use of fishery resources. This paper provides a comprehensive bibliometric analysis of global marine ranching research. The study indicates that policy is the primary driver of the industry's development. It also reveals that the low level of interconnectivity between China and other major developing countries, as well as cooperation between governmental and research institutions in the area of marine ranching. In light of these considerations, prospective strategies for the future evolution of marine ranching can be formulated with a view to optimising and enhancing the seedling production system, and to forecasting changes in marine ranching in conjunction with the application of modern computing techniques and the field of remote sensing.

Keywords: Marine ranching; Marine ecosystems; Sustainable fishery resources; Bibliometric analysis; Environmental sustainability

1. Introduction

Marine ranching is a model of the basic marine ecosystem itself [1], which is defined as the adoption of measures such as the construction of artificial reefs [2,3] or value-added

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stocking [4] are taken in a specific area to achieve the restoration of the marine ecosystem [5] and the increased production [6,7] and sustainable use of fishery resources [8]. Marine ranching play an important role in the Earth's marine ecosystem [9]. Not only do they provide habitat for fish and other marine organisms [10], they also contribute to the health of the planet through a range of ecosystem services such as carbon storage [11,12], shoreline protection [13] and water purification [14,15]. Marine ranching are repositories of marine biodiversity and commercially important fisheries production sites [16,17]. Therefore, the conservation and management of marine ranching is an important topic of global research [17-20].

However, marine ranching are under serious threat from human activities and the effects of climate change [21]. Factors such as marine pollution, coastal development, overfishing and rising sea temperatures are accelerating the decline and degradation of marine ranching [21-22]. This situation is seriously affecting the health of marine ecosystems and the planet's biodiversity, and urgent action is needed to effectively protect and restore marine ranching [23-24].

According to the web of science database, the first relevant literature on marine ranching began to appear in 1990, and Figure 1 shows the number of papers in the field related to marine ranching in the web of science. In this regard, marine ranching research has made significant progress over the past few decades, and the importance of marine ranching, their threats, and conservation strategies have been examined in a variety of disciplines [25-26]. However, relatively few studies have comprehensively assessed global trends in marine ranching research, key researchers and institutions, and progress in the field.

In this context, the article will analyse the historical development of marine ranching in various countries and compare them. In addition, bibliometrics will be employed to identify keywords that will reveal the research hotspots of marine ranching in each period.

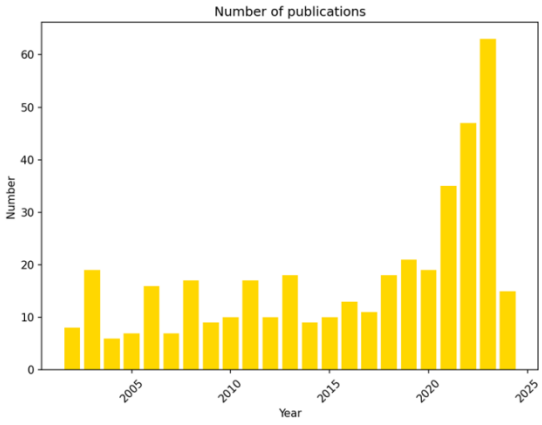

Figure. 1. The number of published results about marine ranching in the Web of Science.

2. History of Marine Ranching

According to the web of science documentation, the emergence of literature on marine ranching dates back as far as 1990. The main role of marine ranching is to increase the number of populations. Its operations consist mainly of biological releases and artificial reef enhancement [28-30].

The development of marine ranching has undergone several phases, which can be broadly categorised into traditional use, scientific exploration and conservation management.

Initial stage: Since mankind began exploiting marine resources, marine ranching have been seen as an important resource for traditional activities such as fishing. However, during this period, there was limited understanding of the complexity and importance of marine ecosystems, and most activities focused on short-term gains [31-32].

The scientific exploration phase: There was a greater understanding of the importance of marine ecosystems and the need for sustainable use of marine resources [22,33]. During the 20th century, researchers from various disciplines, including oceanography, ecology, and biology, conducted studies to comprehend the structure and function of marine ecosystems, including marine ranching. The significance of marine ranching, particularly their role in the carbon cycle and preservation of biodiversity, was increasingly acknowledged during this period [34-36].

The Conservation and Management Stage: As scientific research has increased awareness of the importance of marine ecosystems and ranching, various countries and international organisations have begun to take measures to conserve and manage them [20,37- 39]. These measures include the establishment of Marine Protected Areas (MPAs) [1,40], pollution prevention [41], and ecosystem restoration projects [42]. This phase emphasises the importance of sustainable use of marine resources and the protection of marine ecosystems [43-44].

In recent years, there has been a growing focus on the sustainable use of marine ecosystems, including marine ranching. This involves finding ways to achieve economic and social benefits while also safeguarding marine ecosystems. This encompasses sustainable fisheries management, marine ecosystem-based tourism, and the sustainable development of marine living resources [6,45-47].

2.1 Marine Ranching Development in Different Countries

2.1.1 Japan

Japan is the world's early proponent of concepts related to marine ranching and a leader in the construction of sea ranches. The concept of marine ranching was initially proposed by Japan in 1971 [47]. In 1975, Japan presented the idea at the Okinawa International Ocean Expo with the aim of seeking sustainable use of marine resources and coordinated development for the survival of mankind under human management [48,49]. During the 1980s and 1990s, Japan implemented the 'cultivated fisheries' programme nationwide, which included the construction of the world's first marine ranch, the Kuroshio Ranch [50].

Japan has developed audio signal training technology to train dolphins or other species to take advantage of the habitual characteristics of fish and control their activities through training [51-53]. Audio-signal training-based marine ranching has already achieved some success as a stage in the future refinement of composite marine ranching. With this audio training signal as the main focus, and with the addition of a collection of environmental modification techniques, such as artificial reefs, biological release operations can be

accomplished more effectively [54-57]. The Okayama Prefecture Marine Ranching has expanded the habitat of target fish by improving the environment of the existing fishing grounds, placing artificial reefs, and constructing seaweed beds. Additionally, the use of acoustic baiting equipment has led to a significant increase in target fish. Furthermore, due to improved natural resource management, this sea area has become an exceptional fishing ground and a vital source of Japanese aquatic resources [58,59].

2.1.2 America

The United States is also a leading country in the field of marine ranching. In the mid-19th century, American fishermen used homemade wooden nets as artificial reefs to attract sea and lake fish, even though the concept of artificial reefs did not exist at that time [61]. In 1935, the world's first artificial fish reefs were constructed in Cape May, New Jersey [3]. From 1968 to 1972, the United States passed laws to guarantee the construction of marine ranching using artificial reefs [62-63].

The United States has contributed to the field of marine ranching (mariculture) in a number of ways in the nearly 21st century. These contributions included research and development, technological innovation and the exploration of sustainable farming methods. Universities and research institutes in the United States have conducted many studies in the field of marine ranching. This includes improving aquaculture technology, aquaculture biology and ecosystem impact assessment [64-68]. For example, the University of Alaska led research on salmonid aquaculture, which later had a significant impact on the global salmonid aquaculture industry [69].

The United States has also contributed to innovations in mariculture technology [70-71]. While early mariculture technology began with simple grazing methods [72-73], US researchers have developed more efficient and sustainable farming methods. For example, innovations such as closed-loop aquaculture systems have increased farming efficiency while reducing negative impacts on the marine environment [74-75].

The development and application of sustainable mariculture methods is another important contribution of the United States [76], and methods such as polytrophic aquaculture, which takes advantage of the interactions between different cultured species, have been studied and applied [77-78].

2.1.3 China

In contrast to Japan and some other countries with early development of marine ranching, China's marine ranching process started relatively late [78]. According to scholars at home and abroad, Academician Zeng Chengkui's concept of 'marine agropastoralism' - the transformation of the marine environment through human intervention to create favourable conditions for the growth and development of economic organisms - was the precursor to the idea of marine ranching [79].

In the 1980s, China implemented stocking and releasing activities and experiments with artificial reefs to boost fishery production and protect fishery resources [80]. In the early 21st century, China expanded the scale of artificial stocking and releasing [81].

During the research period, many scholars concluded that ocean ranches are primarily breeding sites for increasing aquatic production, formed through the steps of placing artificial reefs and stocking and releasing [82-84] In 2017, the Central Government issued No. A document has been proposed for the first time to develop a modernised ocean ranch to strengthen regional coordinated protection. This marks a new stage in the construction and development of ocean ranches in China. The document puts forward the development of a modern marine ranching, defining it as a fishery model in a specific sea area through artificial reefs and enrichment, among other means [85]. The purpose of this is to increase fishery resources, improve the marine ecological environment, and maintain the sustainable use of fishery resources by breeding, growing, feeding or sheltering marine species in the place of construction or restoration [86-89]. Guangdong, Hainan, Liaoning and other provinces have special economic subsidies for sea ranch projects. China's marine ranching is advancing by leaps and bounds [17,90].

3. Bibliometric Analysis

This paper employs bibliometric methods to analyse the literature on marine ranching, using indicators such as journals, subject categories, countries, and institutions.

The literature was obtained from Web of Science (WOS), a vast scientific citation-indexed database of important literature from nearly a century across disciplines. The study covers important literature in various disciplines. It is a dependable source of literature for scholars as it covers the most influential journals in each field. The platform holds high authority in the academic world.

An advanced search was conducted on the Web of Science website using the search formula: TS = ("marine" OR "sea" OR "ocean") and TS = ("ranching" OR "ranch" OR "pasture"). The selected database was the Web of Science Core Collection, with a time slice covering all available data, and the language was set to English. This initial search retrieved 678 relevant documents, which were then manually screened and de-duplicated using CiteSpace. Ultimately, 405 eligible literature sources were identified.

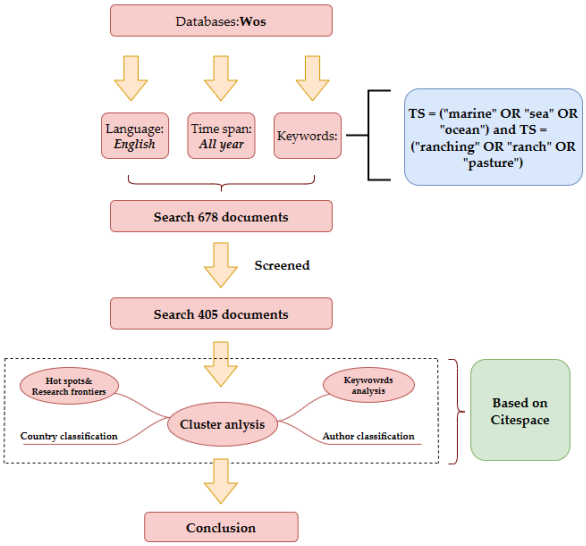

Figure. 2. Schematic diagram of the search process.

3.1 Country Analysis

We carried out a country analysis of the selected 405 marine ranching literatures, which were published in areas covering 52 countries or regions, and we marked them with different colours on a world map and gave a legend to visualise the characteristics of these areas.

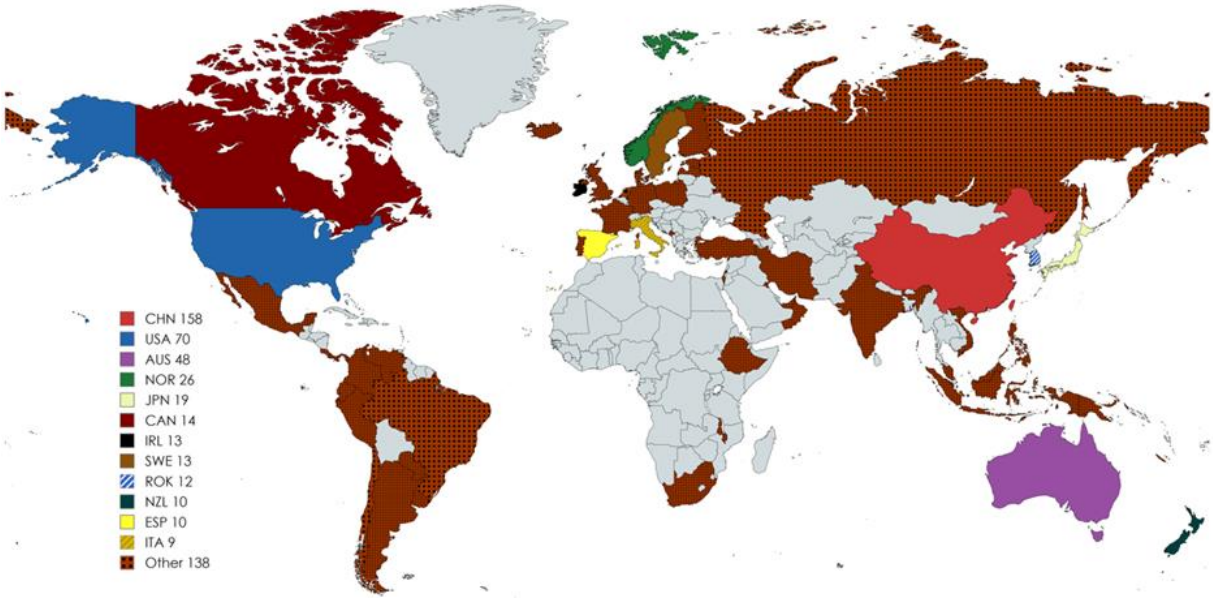

Figure. 3. Distribution of countries and regions with published papers on marine ranching.

As illustrated in Figure 3, the majority of countries that have published on marine ranching are located in coastal areas. Of the 52 samples analysed here, only Paraguay and Ethiopia are inland, representing only 3% of the sample, which is consistent with our general knowledge.

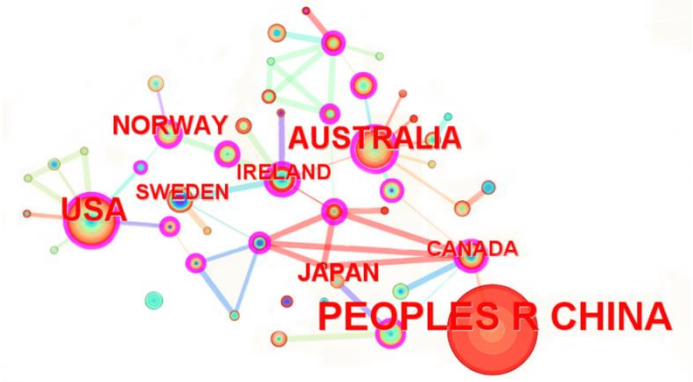

Figure. 4. Relationship map of countries where literature is published based on citespace analysis.

The cluster analysis was performed on all samples using citespace, with the node filtering method chosen to be g-index and k=25. The resulting country relationship graph is presented in Figure 4.

The size of the node in Figure 4 represents the number of papers published by the country in question. The larger the node, the higher the number of papers published. The connecting line between the nodes represent the cooperation relationship between the

countries. The thicker the connecting line, the closer the cooperation. The more the colour of the node is inclined to be red, the more the country has published papers related to marine ranching in the recent past.

Figure 4 illustrates the distribution of publications in the field of marine ranching. China is the largest node, with 158 publications, representing the largest number of papers published in this field. The United States, Australia, Norway and Japan follow in descending order. The nodes of the top countries, including Ireland and Canada, have more lines with the nodes of other countries, indicating that the countries with the highest number of publications have close cooperation with other countries. However, China has only cooperated with Canada, resulting in a centrality of almost zero for China's node.

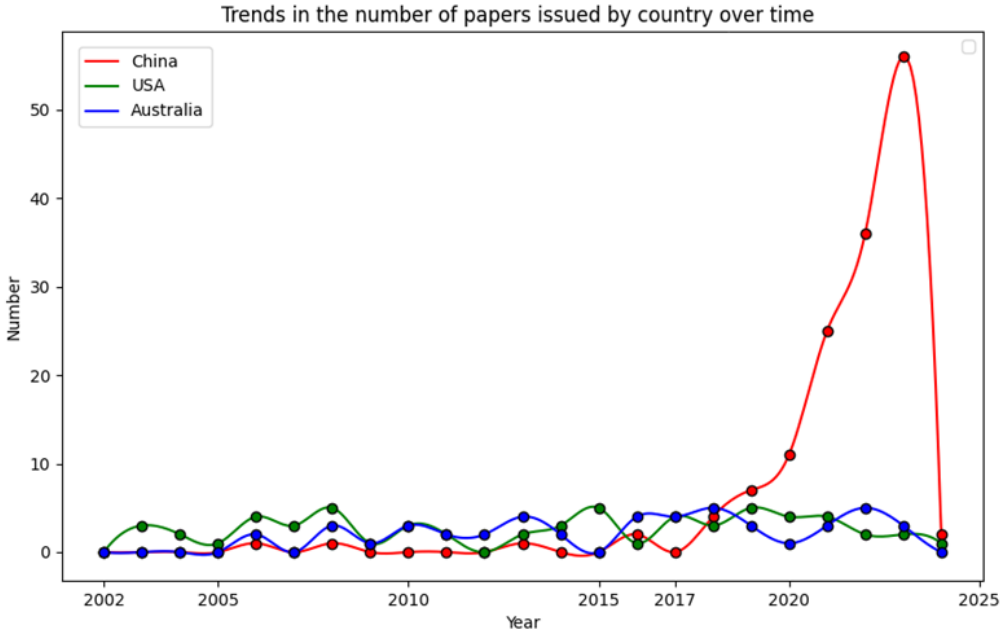

Figure. 5. Trends in the number of papers issued by country over time.

Figure 5 presents a line graph of the number of publications over time for the top three countries in terms of publications: China, the United States and Australia. The graph contains two key time points: 2002 and 2017. The former marks the commencement of this bibliometric analysis, while the latter coincides with the surge in China's publications, which occurred in 2017. In 2017, China's Central Document No. 1 proposed the development of modernised marine ranching, and Chinese provinces subsequently enacted policies and economic subsidies in response to the Central Document No. 1. This led to a surge in the construction of sea ranches. The impact of policy promulgation on the development of the research process is immeasurable.

3.2 Author and Institutional Analysis

This paragraph presents the top six authors in terms of the number of papers published, as shown in Figure 1. Du Yuan-Wei of Ocean University of China has the highest number of papers published, with eight. Wan, Xiaole from Ocean University of China and Taylor, Matthew D from Port Stephens Fisheries Institute were the next most popular authors with seven and six publications, respectively. The total number of articles published by these six researchers is 37, representing a total share of 9.1%. As illustrated in the table, four of the

top six authors' affiliations in terms of the number of publications are in the category of university institutions, reaching a share of 66.7%. Subsequently, a cluster analysis was performed on the 291 institutions included in this study. This analysis revealed that 139 of these institutions were universities, representing a total share of 48%. This finding is consistent with the pattern presented in Table 1, which indicates that universities are a dominant force in the field of marine ranching.

Table 1. Top 6 authors and their institutions by number of publications.

No.	Count	Percentage	Year	Author	Institution
1	8	2.0%	2021	Du, Yuan-wei	Ocean University of China
2	7	1.7%	2021	Wan, Xiaole	Ocean University of China
3	6	1.5%	2013	Taylor, Matthew D	Port Stephens Fisheries Institute
4	6	1.5%	2022	Li, Dashe	Shandong Technology & Business University
5	5	1.2%	2010	Barki, Assaf	Institute of Animal Science
6	5	1.2%	2002	Järvi, T	Stockholm University

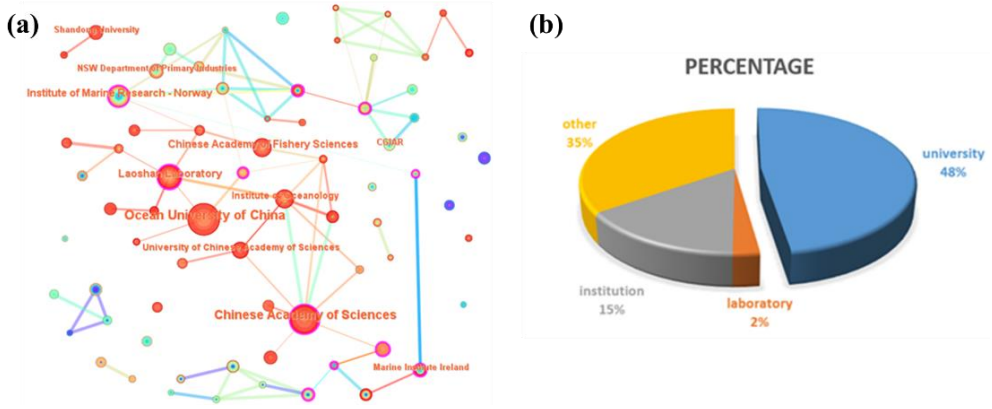

Figure. 6. (a)Clustering diagram of institutions. (b)pie chart for classification of institutions.

In Fig. 6, we have analysed the clustering of the institutions in the 405 papers. The larger nodes in the graph represent the more papers published by the institutions, with Ocean University of China publishing the greatest number of papers (44), followed by the Chinese Academy of Sciences, Laoshan Laboratory, and the Institute of Marine Research - Norway (39, 22, and 19 papers, respectively). The Institute of Marine Research - Norway is the first institution to conduct research on marine ranching, and has been publishing papers since 2002. The top three organisations are all from China, and all published after 2019, which marks the period of greatest growth in marine ranching research in China. The closer the node colour is to red, the closer the time of publication is to the present, and green is vice versa. The red nodes are almost all from Chinese institutions, and there is close cooperation between institutions, with universities, laboratories and research institutes collaborating to advance the field of marine ranching.

3.3 Keywords Analysis

In this paragraph, we will use citespace to analyse and research keywords in marine ranching in an attempt to find hot changes in research in the historical development of marine ranching.

Figure 7 presents an image generated by citespace utilising the keyword mutation feature. This feature is employed to analyse the evolution and transformation of pivotal themes and trends within a specific research domain over time. It is particularly beneficial for monitoring alterations in keywords utilised in academic literature, identifying the future trajectory of a research area. Alterations in keywords enable researchers to swiftly identify pivotal shifts within a particular field, which can inform future research directions.

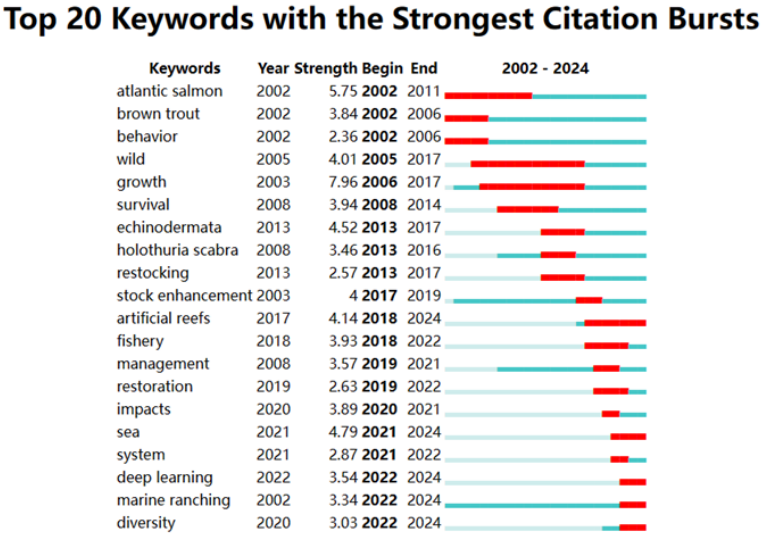

Figure. 7. Keyword mutations in papers related to marine ranching.

In the early 21st century and before, value-added fish, including Atlantic salmon and brown trout, and the study of fish behaviour were the most prominent areas of research in the field of marine ranching. By the 2010s, there was a shift in focus towards the management and ecological restoration of marine ranching, also known as ecological sustainability. By the 2020s, the emergence of keywords such as deep learning in the keyword landscape indicated the emergence of research in marine ranching. For instance, the application of deep learning for water quality studies and analysis of ocean behavioural trajectory studies.

This paragraph presents the top 10 keywords in terms of keyword frequency, as shown in Table 2 and Figure 8. The keyword "ocean ranch" appears most frequently, with a total of 111 occurrences, and the earliest occurrence. The next two keywords are "growth" and "stock enhancement," with 48 and 42 occurrences, respectively, occurring earlier in 2003.

A review of the frequency of keywords in Table 2 and figure 7. reveals a notable shift in focus over the course of the 21st century. Prior to the 2010s, keywords predominantly pertained to various fish and enrichment. However, after the 2010s, there was a notable shift towards environmental protection-related terms, including artificial reefs and sea.

Table 2. This is sample table caption.

NO.	Count	Year	Keywords

1	111	2002	Marine ranching
2	48	2003	Growth
3	42	2003	Stock enhancement
4	29	2017	Artificial reef
5	27	2002	Atlantic salmon
6	26	2002	Fish
7	19	2005	Aquaculture
8	19	2005	wild
9	14	2002	Behavior
10	14	2021	Sea

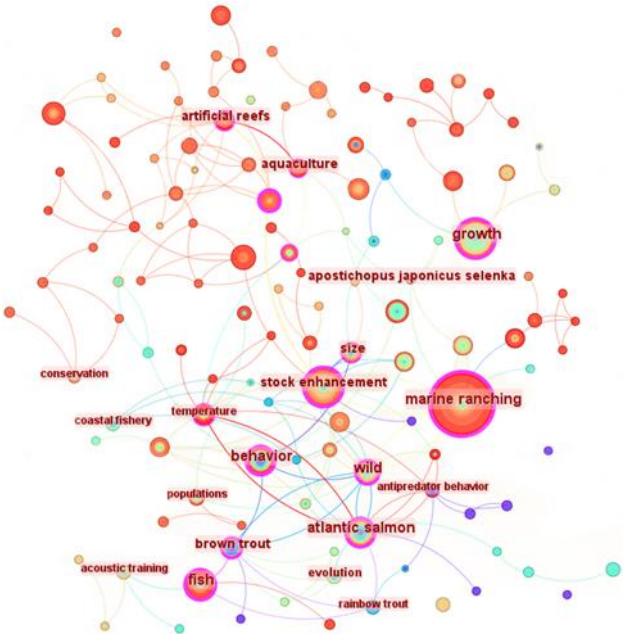

Figure. 8. Keywords network analysis mapping.

The development of marine ranching can be roughly divided into three stages based on the appearance of the keywords, as shown in Figure 9.

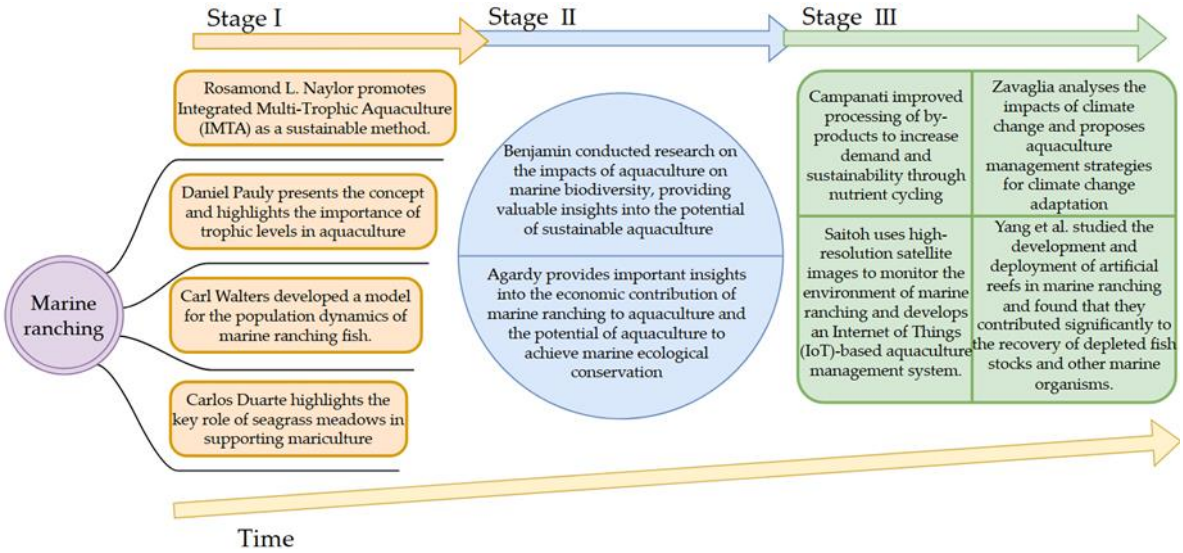

Figure. 9. Marine ranching development process.

3.3.1 Stage I From the Rise of Ideology to the Conceptualisation of Marine Ranching. (Early 20th century -Early 21th century)

During this period, marine ranching was still in its infancy, and the primary objective was to increase production. At that time, there was no concept of marine ranching, but a number of researchers played a pivotal role in the subsequent formation of marine ranching. James Cook made an extremely early record of the marine ecosystem during his voyage to the South Pacific before this period [91-92]. American fishermen employed homemade wooden nets as artificial reefs to attract marine and lake fish.

In the 1970s, Japan used the expressions ‘cultivated fishery’ or ‘sea ranch’ to promote the development of fishery resources enhancement, which attracted a great deal of attention from the fisheries community around the world, and was almost the first conceptualisation of marine ranching fisheries [93].

Carl Walters and Ray Hilborn developed models to understand the dynamics of fish populations in marine ranching, which led to the implementation of more effective fisheries management practices [94]. In the 1990s, Daniel Pauly introduced the concept of trophic levels in aquaculture, emphasising the importance of maintaining the ecological balance of marine ranching [95-96]. In their work, Rosamond L. Naylor et al. emphasised the environmental impacts of fish farming in marine ranching and advocated integrated multi-trophic aquaculture (IMTA) as a sustainable approach [97]. Carlos Duarte's research on seagrass meadows highlights the critical role of seagrass meadows in supporting mariculture by improving water quality and providing habitat for farmed species [98-99]. Stephen Jameson, on the other hand, focuses on coral reef ecosystems in the vicinity of marine ranching, examining their role in supporting sustainable fish farming practices [100-101].

3.3.2 Stage II The Burst of Marine Ranching and the Shift in Research Direction (Early 21th century - 2017)

The foundation of the last period of marine ranching has been the professionalisation and scaling up of the industry. This has resulted in a gradual shift in focus from increasing production to ecological and coordinated development.

Benjamin S. Halpern et al. undertook research into the effects of aquaculture on marine biodiversity. His work provides valuable insights into the impact of aquaculture in marine ranching on biodiversity, as well as the potential for sustainable aquaculture practices that protect biodiversity and ensure the economic value of marine ranching and aquaculture [102-104]. Tundi Agardy's research on marine ecosystem services and marine conservation strategies has revealed the economic value of marine ranching. Agardy's research provides important insights into the economic contribution of marine ranching to aquaculture and the potential for aquaculture to achieve conservation and sustainable use of marine ecosystems [105-107].

3.3.3 Stage Ⅲ Marine Ranching Enters the Chinese Era and the World's Innovative Development Way (2017-Now)

As previously stated, the number of marine ranching papers in China has increased exponentially, becoming the dominant paradigm in the global arena following the release of the No. 1 Central Document in 2017. During this period, a multitude of innovative designs

for marine ranching have emerged, striving to achieve sustainable development.

Campanati et al. improved the harvesting and processing of by-products to support the sustainable intensification of aquaculture. This approach can maximise demand and sustainability through nutrient cycling [108]. Zavaglia analysed the impacts of climate change on aquaculture organisms in marine ranching and proposed aquaculture management strategies to adapt to climate change [109]. Saitoh employed high-resolution satellite imagery to monitor environmental changes in marine ranching and to develop an Internet of Things (IoT)-based aquaculture management system [110]. Yang et al. conducted a study on the development and deployment of artificial reefs in marine ranching. Their study demonstrated the positive impact of artificial reefs on local biodiversity and the enhancement of fisheries resources. By providing shelter and breeding grounds, these reefs significantly contribute to the recovery of depleted fish populations and other marine life [111-112]. Xu and Liu reported on a successful genetic improvement programme for a popular Pacific oyster, which resulted in significant improvements in growth rate and disease resistance. This study illustrates the potential of genetic technologies to enhance the productivity and sustainability of marine ranching [113].

4. Conclusions

In this study, we conducted a bibliometric analysis of 405 papers related to marine ranching in the Web of Science database. We employed the professional bibliometric software Citespace to perform econometric analysis of these papers. The analysis included country, author, institution, keyword, and citation analysis. The objective of this study is to analyse the global research trends on marine ranching, identify the key research topics and future research directions, and provide a scientific basis for the conservation and management of marine ranching. This will be achieved through author, institution and keyword analysis.

4.1 Summary and Recommendations for Marine Ranching Construction

The first step in our analysis was to plot the relevant data on a world map for data visualisation. This revealed that 97% of the countries engaged in marine ranching research are located in coastal areas, which is consistent with our expectations. The size of the nodes and the thickness of the lines in the cluster diagram drawn by Citespace indicate the quantity of articles and the degree of cooperation between each country. In the analysis, China, the United States, and Australia is positioned within the top three countries in terms of the quantity of articles, yet according to the cluster diagram, China has only collaborated with Canada. Consequently, its centrality is 0%. China may wish to consider strengthening its marine ranching-related cooperation with other countries. This will undoubtedly facilitate the advancement of marine ranching in China and beyond. Subsequently, the top three countries in terms of the number of articles were analysed. It was found that the number of articles issued by China rose linearly after 2017, which coincided with the publication of the No. 1 document of the Central Government. This document clearly pointed to the development of modern marine ranching. In response, provinces issued

policies and economic subsidies for marine ranching, which triggered a boom in marine ranching construction. The promulgation of the relevant policies has not only set off a boom in marine ranching in China, but other countries that started the process earlier, including the United States and Japan, have also experienced a similar growth in activity. The promulgation of support policies to promote marine ranching has led to a surge in construction activity in these countries [114-116]. In order to sustain this growth, countries must enact policies or provide economic subsidies to stimulate further interest from researchers and construction companies.

Following our cluster analysis of authors and institutions, it was observed that Chinese authors accounted for approximately half of the authors in the top six publications. This finding is consistent with our previous analysis, which indicated that China has the highest number of publications. In the top six authors, four authors were affiliated with university institutions. A subsequent cluster analysis of the institutions that published 405 papers revealed that 139 university institutions accounted for 48% of the total number of institutions. This finding is consistent with the observation that universities play a dominant role in the field of marine ranching. A further cluster analysis was conducted using Citespace to create a graph between institutions. The redder coloured nodes in the graph represent the closer the issuance is to the present, and the red nodes are almost all from China. The close connectivity between the nodes of universities, laboratories and research institutions indicates that there is a high level of cooperation between these institutions, which greatly promotes the development of marine ranching. However, the connectivity with various foreign research institutions is sparse, which suggests that there is room for improvement in the level of cooperation with foreign research institutions. In the institutional analysis, a lack of cooperation between universities, laboratories or research institutions and management institutions is not conducive to the promotion and implementation of research results, which may result in a lag in the timely adjustment of government policies [117-118]. It is therefore recommended that scientific research institutions cooperate more with management institutions to form a virtuous cycle of R&D-policy-practice-incentive for R&D.

Finally, a keyword analysis was conducted on the screened literature in order to identify emerging research trends in marine ranching development. The development of marine ranching was broadly categorised from the time of keyword occurrence, with a keyword mutation map drawn using citespace. We have summarised the development of marine ranching from the formation of the ideology of marine ranching, through to conceptualisation, fish enhancement and ecological sustainability. A number of researchers and scholars have given very innovative studies on the means of enhancement and ecological sustainability, which have greatly contributed to the efficiency and sustainability of marine ranching. A keyword analysis of marine ranching reveals the research hotspots in different periods. After, I will present substantial suggestions for the development and construction of marine ranching based on the results of this research below.

(1) Global Cooperation and Knowledge Sharing: Promote international cooperation and knowledge sharing in marine ranching research, and exchange best practices,

innovative designs, and successful strategies for sustainable development. Learn from the experiences and advances in marine ranching in countries such as China, where marine ranching research is growing exponentially.

(2) Focusing on and promoting ecological sustainability: Shifting the focus of research towards ecological sustainability and coordinated development of marine ranching. Implementation of Integrated Multi-Trophic Aquaculture (IMTA) practices to minimize environmental impacts, encourage nutrient recycling from by-products, support sustainable intensification of aquaculture, and promote sustainable aquaculture.

(3) Integrate gene technology: Emphasize the potential of gene technology to improve productivity and disease resistance in marine ranching. Invest in genetic improvement programs for popular species such as Pacific oysters to increase growth rates and disease resistance.

(4) Adapting to Climate Change: Analyze the impacts of climate change on aquaculture organisms in marine ranching and develop aquaculture management strategies to adapt to changing environmental conditions. Implement sustainable intensification practices to support aquaculture in addressing climate change challenges.

(5) Utilization of Artificial Reefs: Explore the development and deployment of artificial reefs in marine ranching to enhance local biodiversity, provide shelter and nurseries for marine organisms, and promote the recovery of depleted fish stocks.

(6) Invest in monitoring technologies: Utilize high-resolution satellite imagery and Internet of Things (IoT)-based aquaculture management systems to effectively monitor environmental changes in marine ranching. Strengthen monitoring capabilities to track the health and productivity of marine ranching and aquaculture operations.

4.2 Shortcomings of the Article's Research and the Future Outlook of Marine Ranching·

While the article provides valuable insights into the current state of marine ranching research through bibliometric analyses, there are still some shortcomings.

(a) Lack of in-depth analysis: The article only provides a macro-level cluster analysis of the screened articles, but does not provide a more in-depth analysis of specific case studies or successes of marine ranching. The article could have benefited from providing practical examples of best practices and challenges in different regions.

(b) Limited attention to social and economic aspects: Future research should also consider the social and economic impacts of marine ranching, including the impacts on local communities, employment opportunities and economic sustainability.

(c) Interdisciplinary approaches are needed: Marine ranching involve complex interactions between ecological, technological and socio-economic factors. An interdisciplinary approach that involves experts in fields as diverse as marine biology, engineering, economics, and social sciences can provide a more comprehensive understanding of marine ranching.

(d) Integrating stakeholder perspectives: Involving stakeholders such as local communities, fishermen, policy makers and environmental organisations in the research

process can help to ensure that the practice of marine ranching is socially acceptable, environmentally sustainable and economically viable.

The preceding study indicates that the field of marine ranching is experiencing a period of growth and remains a significant area of research interest in the future. Currently, marine ranching has entered an ecologically sustainable stage, with the advancement of science and technology, including gene editing technology to cultivate good seeds [119], artificial intelligence [120]combined with marine ranching to adapt to the impact of rising water temperature and ocean acidification and predict the water quality [121-123]. The integration of remote sensing image and machine learning has enabled to draw high definition image and predict the changes in marine ranching and the implementation of timely adjustments [124-126], as well as the automatic analysis of the nutritional structure of the computer to maximize the efficiency of marine ranching, will become a reality [127-129]. Furthermore, the integration of wind farms in marine ranching and other methods will also become a reality [130-132]. Marine ranching is a complex field, encompassing a multitude of disciplines. By adopting a multi-faceted, multi-disciplinary approach, marine ranching will flourish.

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References:

1. Lee, Sung Il, and Chang Ik Zhang. Evaluation of the effect of marine ranching activities on the Tongyeong marine ecosystem. Ocean Science Journal.2018; 53: 557-582.
2. Kim, Hyun-Young, et al. Hydro-acoustic survey on fish distribution and aggregated fish at artificial reefs in marine ranching area. Journal of the Korean Society of Fisheries and Ocean Technology.2011;47.2: 139-145.
3. YANG, Hongsheng, and Dewen DING. Marine ranching version 3.0: History, status and prospects. Bulletin of Chinese Academy of Sciences.2022;37.6: 832-839. (in Chinese)
4. Shi, Xiao, et al. The mechanism of constructing marine ranching industrial ecosystem based on grounded theory: A case study of Yantai, China. Regional Studies in Marine Science.2023;37.6:103214.
5. Yu, Jinkai, and Linlin Zhang. Evolution of marine ranching policies in China: Review, performance and prospects. Science of the Total Environment 737 (2020): 139782.
6. Qin, Man, and Mingxue Sun. Effects of marine ranching policies on the ecological efficiency of marine ranching—Based on 25 marine ranching in Shandong Province. Marine policy. 2021;134: 104788.
7. Bartley, D. M. Marine ranching: a global perspective. Marine ranching: a global perspective.1999: 79-90.
8. Zhou, Xijie, et al. Marine ranching construction and management in East China Sea: Programs for sustainable fishery and aquaculture. Water 2019;11.6: 1237.

9. Wang, G., X. X. Guan, and Y. H. Shi. Simulation study on the artificial ecosystem of marine ranching at Dalian Zhangzi Island. Applied Ecology and Environmental Research.2021;19.1: 525-548.
10. Liu, Shurong, et al. Characterizing the development of Sea ranching in China. Reviews in Fish Biology and Fisheries.2022;32.3: 783-803.
11. Wang, Wenju, et al. Research on sustainable development of marine ranching based on blue carbon trading. Ocean & Coastal Management. 2024;249: 106988.
12. Feng, Cuicui, et al. The contribution of ocean-based solutions to carbon reduction in China. Science of the Total Environment.202;797: 149168.
13. Wang, Ziwen, et al. Evaluation of the ecological carrying capacity of Wailingding marine ranching in Zhuhai, China by high-resolution remote sensing. Frontiers in Marine Science. 2024;11: 1354407.
14. Tan, Yongming, and Shangyou Lou.Research and development of a large-scale modern recreational fishery marine ranch System☆." Ocean Engineering. 2021;233: 108610.
15. Li, Jiao, et al. Progress on research and construction of marine ranching along the coast of Shandong Province of China. Journal of Shipping and Ocean Engineering.2014;4: 338-347.
16. Whitmarsh, David. Economic analysis of marine ranching. Portsmouth, UK: Centre for the Economics and Management of Aquatic Resources, University of Portsmouth, 2001.
17. Salvanes, A. G. V., et al. Ocean ranching." Marine Policy and Economics. 2001: 226-235.
18. Yu, Jin-Kai, and Yan-Ling Wang. Exploring the goals and objectives of policies for marine ranching management: Performance and prospects for China. Marine Policy.2020;122: 104255.
19. Grant, W. Stewart, et al. Responsible genetic approach to stock restoration, sea ranching and stock enhancement of marine fishes and invertebrates. Reviews in Fish Biology and Fisheries. 2017;27: 615-649.
20. Pickering, Helen. Marine ranching: a legal perspective. Ocean Development & International Law.1999;30.2: 161-190.
21. Zhang, Xuechang, Jingwei Cheng, and Shan Zheng. Can multi-agent cooperation promote the ecological value realization of blue carbon in marine ranching? Heliyon. 2023; 9.8.
22. Mai, Rudi. Design and Construction of Modern Marine Ranching: Technologies, Methods, and Challenges. International Journal of Aquaculture.2023; 13.
23. Xuan, P. E. N. G., et al. Spatial distribution and assessment of nutrients in marine ranching in Zhelin Bay-Nanao Island in summer. South China Fisheries Science. 2014: 10.6: 27-35.
24. Seaman, William. Artificial habitats and the restoration of degraded marine ecosystems and fisheries. Biodiversity in Enclosed Seas and Artificial Marine Habitats: Proceedings of the 39th European Marine Biology Symposium, held in Genoa, Italy, 21–24 July 2004. Springer Netherlands, 2007.
25. Lorenzen, Kai, et al. Developing and integrating enhancement strategies to improve

and restore fisheries. Bulletin of Marine Science.2021;97.4: 475-488.
26. Arthington, Angela H., et al. Fish conservation in freshwater and marine realms: status, threats and management. Aquatic Conservation: Marine and Freshwater Ecosystems. 2016;26.5: 838-857.
27. Du, Yuan-Wei, and Xiao-Xue Li. Critical factor identification of marine ranching ecological security with hierarchical DEMATEL. Marine Policy. 2022;138: 104982.
28. Lorenzen, Kai, et al. Developing and integrating enhancement strategies to improve and restore fisheries. Bulletin of Marine Science. 2021; 97.4: 475-488.
29. Becker, Alistair, et al. Managing the development of artificial reef systems: The need for quantitative goals. Fish and Fisheries.2018;19.4: 740-752.
30. Baine, M., and J. Side. Habitat modification and manipulation as a management tool." Reviews in Fish Biology and Fisheries.2003;13: 187-199.
31. Kitada, Shuichi. Lessons from Japan marine stock enhancement and sea ranching programmes over 100 years. Reviews in Aquaculture.2020;12.3: 1944-1969.
32. Rhyne, Andrew L., Michael F. Tlusty, and Les Kaufman. Is sustainable exploitation of coral reefs possible? A view from the standpoint of the marine aquarium trade. Current Opinion in Environmental Sustainability. 2014;7: 101-107.
33. Okumus, Ibrahim. Coastal aquaculture: sustainable development, resource use and integrated environmental management. Journal of Black Sea/Mediterranean Environment. 2000; 6.2.
34. Zhong, Chongming, et al. A systematic overview, trends and global perspectives on blue carbon: A bibliometric study (2003–2021). Ecological Indicators.2023;148: 110063.
35. Liang, Zhen-lin, et al. Construction concept and technology of the marine ranching mode of the whole life history of fishes." 2020: 1211-1222.
36. Forbes, Hunter, et al. Farms and forests: evaluating the biodiversity benefits of kelp aquaculture." Journal of Applied Phycology.2022;34.6: 3059-3067.
37. Yang, HongSheng, et al. Strategic thinking on the construction of modern marine ranching in China. Journal of Fisheries of China. 2019;43.4: 1255-1262.
38. Walrut, Bernard Phillip. Sea ranching and aspects of the common law: A proposal for a legislative framework. Diss. University of British Columbia, 2002.Lim, Cristina P., Yoshiaki Matsuda, and Yukio Shigemi. Co‐management in marine fisheries: The Japanese experience. Coastal Management.1995;23.3: 195-221.
39. Stoffle, Richard W., et al. Two-MPA model for siting a marine protected area: Bahamian case. Coastal Management. 2010;38.5: 501-517.
40. Qin, Man, Xinru Wang, and Yuanwei Du. Factors affecting marine ranching risk in China and their hierarchical relationships based on DEMATEL, ISM, and BN. Aquaculture.2022;549: 737802.
41. Qin, Man, Caixuan Yue, and Yuanwei Du. Evolution of China's marine ranching policy based on the perspective of policy tools. Marine Policy 117 (2020): 103941.
42. Zhong, Huiping. Exploitation and utilization of marine resources and protection of marine ecology. IOP Conference Series: Earth and Environmental Science. Vol. 369. No. 1. IOP Publishing, 2019;369.1: 012009.

43. Rice, Jake C. Achieving coherent policies for conservation and sustainable use of marine ecosystems. Conservation Biology. 2011;25.6: 1065-1068.
44. Burbridge, Hendrick, and Rosenthal. Social and economic policy issues relevant to marine aquaculture. Journal of Applied Ichthyology. 2001;17.4: 194-206.
45. Tan, Yongming, and Shangyou Lou. Research and development of a large-scale modern recreational fishery marine ranch System☆. Ocean Engineering. 2021;233: 108610.
46. Choi, Yong-Bok, Chang-San Boo, and Min-Cheol Kim. Tourism resources and development plan of marine ranch of Chagwido. Journal of Fisheries and Marine Sciences Education. 2012;24.3: 378-386.
47. Nose, Takeshi. Recent advances in aquaculture in Japan. GeoJournal.1985;10: 261-276.
48. Huebner, Stefan. tackling climate change, air pollution, and ecosystem destruction: how US-Japanese Ocean industrialization and the metabolist movement's global legacy shaped environmental thought (circa 1950s–Present). Environmental History. 2020;24: 1.
49. Higa, Yoshimi, Amane Takeuchi, and Shigeru Yanaka. Connecting Local Regions and Cities through Mozuku Seaweed Farming and Coral Reef Restoration: Onna Village, Okinawa. Satoumi Science: Co-Creating Social-Ecological Harmony between Human and the Sea. Singapore: Springer Singapore, 2022. 193-215.
50. Nakahara, Hiroyuki. Japanese Efforts in Marine-Ranching Development. Resources & Environment in Asia's Marine Sector. Routledge, 2018. 199-216.
51. Zion, Boaz, Ilan Karplus, and Assaf Barki. Ranching acoustically conditioned fish using an automatic fishing machine. Aquaculture. 2012;330: 136-141.
52. Fujiya, Masaru, Seiji Sakaguchi, and Osahu Fukuhara. Training of fishes applied to ranching of red sea bream in Japan. Physiological and Behavioral Manipulation of Food Fish as Production and Management Tools. 1980: 200-209.
53. Maniwa, Y. O. S. H. I. N. O. B. U., Y. O. S. H. I. M. I. Hatakeyama, and H. I. S. A. J. U. Motegi. Research on the luring of fish schools by utilizing underwater acoustical equipment. Ocean 73-IEEE International Conference on Engineering in the Ocean Environment. Seattle, WA, USA, 1973, Publisher: New York, USA.1973.
54. Yuan, Huarong, Yanbo Zhou, and Pimao Chen. Research on the Acoustic Conditioning Taming on Fish and Application in Marine Ranching. Water. 2022; 15.1: 71.
55. Zion, Boaz, Ilan Karplus, and Assaf Barki. Ranching acoustically conditioned fish using an automatic fishing machine. Aquaculture. 2012; 330: 136-141.
56. Bullen, C. R., and T. J. Carlson. Non-physical fish barrier systems: their development and potential applications to marine ranching. Reviews in Fish Biology and Fisheries. 2003; 13: 201-212.
57. Björnsson, Björn. Fish aggregating sound technique (FAST): how low-frequency sound could be used in fishing and ranching of cod. ICES Journal of Marine Science. 2018; 75.4: 1258-1268.
58. Tanaka, Takehiro, and Yoshitaka Ota. Reviving the Seto Inland Sea, Japan: applying the principles of Satoumi for marine ranching project in Okayama. Marine Productivity:

Perturbations and Resilience of Socio-ecosystems: Proceedings of the 15th French-Japanese Oceanography Symposium. Springer International Publishing, 2015.
59. Boisnier, E., et al. A habitat association index to distinguish resident species along marine artificial reefs. Community ecology.2009;10: 165-172.
60. Stone, R. B., R. S. Grove, and C. J. Sonu. Artificia] habitat technology in the United States. Today and tomorrow. Proceedings of the JAPAN-US Symposium on Artificial Habitats for Fisheries. June. 1991:11-13.
61. Chen, PiMao, et al. Review on development, definition and classification of marine ranching in domestic and overseas. Journal of Fisheries of China. 2019;43.9: 1851-1869.
62. Berg, Emil R. Private ocean ranching of Pacific salmon and fishery management: a problem of federalism. Envtl. L. 1981;12: 81.
63. Grant, W. Stewart, et al. Responsible genetic approach to stock restoration, sea ranching and stock enhancement of marine fishes and invertebrates. Reviews in Fish Biology and Fisheries. 2017;27: 615-649.
64. Chen, Shuai, et al. Research on Acoustic Domestication Technology in Marine Ranching. International Core Journal of Engineering. 2021;7.1: 493-495.
65. Roodt-Wilding, Rouvay. Abalone ranching: a review on genetic considerations. Aquaculture Research. 2007; 38.12: 1229-1241.
66. PITTS, JOHN L. Marine Ranching. The Use of Aquaculture for Enhancement of the Common Property Fishery in Oregon, Washington, and Alaska. 117.NOAA Technical Report.1991.
67. Friedland, K. D., D. G. Reddin, and J. F. Kocik. Marine survival of North American and European Atlantic salmon: effects of growth and environment. ICES Journal of Marine Science. 1993; 50.4: 481-492.
68. Williams, Abby, Mark Herrmann, and Keith R. Criddle. The effects of Chilean coho salmon and rainbow trout aquaculture on markets for Alaskan sockeye salmon. North American Journal of Fisheries Management. 2009; 29.6: 1777-1796.
69. Olsen, Yngvar. "Resources for fish feed in future mariculture." Aquaculture Environment Interactions. 2011;1: 187-200.
70. Liu, Owen R., et al. Global opportunities for mariculture development to promote human nutrition. PeerJ.2018;6: e4733.
71. Liang, Yinxiu, et al. Historical evolution of mariculture in China during past 40 years and its impacts on eco-environment. Chinese geographical science, 2018;28: 363-373.
72. Kjesbu, Olav Sigurd, Geir Lasse Taranger, and Edward A. Trippel. Gadoid mariculture: development and future challenges: introduction. Ices journal of marine science. 2006;63.2: 187-191.
73. Mosallanezhad, Behzad, Mostafa Hajiaghaei-Keshteli, and Chefi Triki. Shrimp closed-loop supply chain network design. Soft computing.2021;25: 7399-7422.
74. Romano, Nicholas, and Amit Kumar Sinha. Husbandry of aquatic animals in closed aquaculture systems. Aquaculture Health Management. 17-73. Academic Press, 2020.
75. Craig, Robin Kundis. The other side of sustainable aquaculture: mariculture and nonpoint source pollution. Wash. UJL & Pol'y. 2002;9: 163.

76. Chopin, Thierry, et al. Integrating seaweeds into marine aquaculture systems: a key toward sustainability. Journal of phycology. 2001;37.6: 975-986.
77. Switz, Theodore R. Sustainability of Applied Aquaculture in the US. Diss. Evergreen State College, 2007.
78. Du, Yuan-Wei, and Qiong Song. Ecological Security Evaluation for Marine Ranching Based on the PLTS/ANP Method: A Case Study of Rongcheng. Complexity 2022. 2022;1: 1-16.
79. Yang, HongSheng. Construction of marine ranching in China: reviews and prospects. Journal of fisheries of China. 2016;40.7: 1133-1140.
80. Qin, Man, et al. Influencing factors of spatial variation of national marine ranching in China. Ocean & coastal management. 2021;199: 105407.
81. Yang, Junxing, et al. Status of artificial propagation and release of freshwater fishes in China. Zoological Research. 2013; 34.04: 267-280. (in Chinese).
82. Wang, G., X. X. Guan, and Y. H. Shi. Simulation study on the artificial ecosystem of marine ranching at Dalian Zhangzi Island. Applied Ecology and Environmental Research.2021; 19.1: 525-548.
83. Grove, Robert S., Choule J. Sonu, and Makoto Nakamura. Recent Japanese trends in fishing reef design and planning. Bulletin of Marine Science. 1989; 44.2: 984-996.
84. Du, Yuan-Wei, and Wen-Meng Cao. DEPD model for evaluating marine ranching ecological security and its application in Shandong, China. Ocean & Coastal Management.2022;224: 106206.
85. Ministry of Agriculture of the People''s Republic of China, 2017a. SC/T 9111-2017 Classi-fication of Marine Ranching. China Standards Press, Beijing
86. Shao, Kwang-Tsao. Marine biodiversity and fishery sustainability. Asia Pacific Journal of clinical nutrition. 2009;18.4: 527-531.
87. Ali, Ahmad, Raja Bidin Raja Hassan, and Yuttana Theparoonrat. Enhancing management of fishery resources through intensified efforts in habitat conservation and rehabilitation. Secretariat, Southeast Asian Fisheries Development Center, 2011.
88. Pondella, Daniel J., Jeremy T. Claisse, and Chelsea M. Williams. "Theory, practice, and design criteria for utilizing artificial reefs to increase production of marine fishes." Frontiers in Marine Science.2022;9: 983253.
89. Çiçek, Burak Ali. An Opportunity to Introduce Fishermen to Sustainable Development. Artificial Reefs in Fisheries Management.141.CRC Press, 2011.
90. Yu, Huijuan, et al. "Policy network analysis of China's ocean ranching policy: Network structure, actors and interaction." Marine Policy. 2022;140: 105070.
91. Cook, James, and Archibald Grenfell Price. The explorations of Captain James Cook in the Pacific, as told by selections of his own journals, 1768-1779. Courier Corporation, 1971.
92. Cook, James. The Three Voyages of Captain James Cook Round the World.... Vol. 6. Longman, Hurst, Rees, Orme, and Brown, 1821.
93. Zhuo, L. I. U., and Y. A. N. G. Jiming. The status and progress of marine ranching research in Japan. Mod Fish Info. 1995;10.5: 14-18.
94. Hilborn, Ray, and Carl J. Walters, eds. Quantitative fisheries stock assessment: choice,

dynamics and uncertainty. Springer Science & Business Media, 2013.
95. Pauly, Daniel, et al. Fishing down marine food webs. Science. 1998; 279.5352: 860-863.
96. Pauly, Daniel, et al. Diet composition and trophic levels of marine mammals. ICES journal of Marine Science. 1998;55.3: 467-481.
97. Klinger, Dane, and Rosamond Naylor. "Searching for solutions in aquaculture: charting a sustainable course." Annual Review of Environment and Resources.2012;37: 247-276.
98. Duarte, Carlos M., et al. Can seaweed farming play a role in climate change mitigation and adaptation?. Frontiers in Marine Science.2017;4: 100.
99. Duarte, Carlos M., Annette Bruhn, and Dorte Krause-Jensen. A seaweed aquaculture imperative to meet global sustainability targets. Nature Sustainability. 2022;5.3: 185-193.
100. Jameson, Stephen C., et al. Charting a course toward diagnostic monitoring: a continuing review of coral reef attributes and a research strategy for creating coral reef indexes of biotic integrity. Bulletin of Marine Science. 2001;69.2: 701-744.
101. Jameson, Stephen C., et al. Development of biological criteria for coral reef ecosystem assessment. Atoll Research Bulletin 1998.
102. Froehlich, Halley E., Rebecca R. Gentry, and Benjamin S. Halpern. "Conservation aquaculture: Shifting the narrative and paradigm of aquaculture's role in resource management." Biological conservation. 2017;217: 162-168.
103. De Silva, Sena S. Aquaculture: a newly emergent food production sector—and perspectives of its impacts on biodiversity and conservation. Biodiversity and conservation. 2012;21: 3187-3220.
104. Diana, James S. Aquaculture production and biodiversity conservation." Bioscience. 2009;59.1: 27-38.
105. Agardy, M. Tundi. Accommodating ecotourism in multiple use planning of coastal and marine protected areas. Ocean & Coastal Management. 1993; 20.3: 219-239.
106. Sale, Peter F., et al. Transforming management of tropical coastal seas to cope with challenges of the 21st century. Marine Pollution Bulletin. 2014;85.1: 8-23.
107. Agardy, Tundi, et al. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas." Aquatic conservation: marine and freshwater ecosystems.2003;13.4: 353-367.
108. Campanati, Camilla, et al. Sustainable intensification of aquaculture through nutrient recycling and circular economies: more fish, less waste, blue growth. Reviews in Fisheries Science & Aquaculture. 2022;30.4: 143-169.
109. Gomez-Zavaglia, Andrea, Juan Carlos Mejuto, and Jesus Simal-Gandara. "Mitigation of emerging implications of climate change on food production systems." Food Research International. 2020;134: 109256.
110. Prapti, Dipika Roy, et al. Internet of Things (IoT)-based aquaculture: An overview of IoT application on water quality monitoring. Reviews in Aquaculture. 2022;14.2: 979-992.
111. Yang, Xinyuan, et al. Effects of artificial reefs on the meiofaunal community and

benthic environment-A case study in Bohai Sea, China. Marine pollution bulletin. 2019;140: 179-187.

112. Song, Minpeng, et al. Evaluation of artificial reef habitats as reconstruction or enhancement tools of benthic fish communities in northern Yellow Sea. Marine Pollution Bulletin. 2022;182: 113968.
113. Meng, Lingxin, et al. Hybridization improved stress resistance in the Pacific oyster: Evidence from physiological and immune responses. Aquaculture. 2021;545: 737227.
114. Sakiyama, Teruji. Policies in pollution, aquaculture and coastal management in Japan." Marine Policy.1979;3.1: 20-39.
115. Lester, Sarah E., et al. Offshore aquaculture in the United States: Untapped potential in need of smart policy.Proceedings of the National Academy of Sciences. 2018; 115.28: 7162-7165.
116. Ruff, Elizabeth O., Heidi K. Alleway, and Chris L. Gillies. The role of policy in supporting alternative marine farming methods: A case study of seafloor ranching in Australia. Ocean & Coastal Management. 2023;240: 106643.
117. Van Dierdonck, Roland, and Koen Debackere. Academic entrepreneurship at Belgian universities. R&D Management. 1988;18.4: 341-353.
118. Ramos-Vielba, Irene, Mabel Sánchez-Barrioluengo, and Richard Woolley. Scientific research groups' cooperation with firms and government agencies: motivations and barriers. The Journal of Technology Transfer .2016;41: 558-585.
119. Kofler, Natalie, et al. Editing nature: Local roots of global governance. Science 2018; 362.6414: 527-529.
120. Zhang, Yi, Dapeng Zhang, and Haoyu Jiang. "A review of artificial intelligence-based optimization applications in traditional active maritime collision avoidance." Sustainability 15.18 (2023): 13384.
121. Elkiran, Gozen, Vahid Nourani, and S. I. Abba. Multi-step ahead modelling of river water quality parameters using ensemble artificial intelligence-based approach. Journal of Hydrology. 2019; 577: 123962.
122. Lowe, Matthew, Ruwen Qin, and Xinwei Mao. A review on machine learning, artificial intelligence, and smart technology in water treatment and monitoring. Water. 2022;14.9: 1384.
123. Scucchia, Federica, et al. Artificial intelligence as a tool to study the 3D skeletal architecture in newly settled coral recruits: insights into the effects of ocean acidification on coral biomineralization. Journal of Marine Science and Engineering.2022;10.3: 391.
124. Chen, Yanlin, et al. Comparative study of marine ranching recognition in multi-temporal high-resolution remote sensing images based on DeepLab-v3+ and U-Net. Remote Sensing. 2022; 14.22: 5654.
125. Saitoh, Sei-Ichi, et al. Some operational uses of satellite remote sensing and marine GIS for sustainable fisheries and aquaculture. ICES Journal of Marine Science.2011; 68.4: 687-695.
126. McCarthy, Matthew J., et al. Satellite remote sensing for coastal management: A review of successful applications. Environmental management .2017;60: 323-339.

127. Zhang, Yuru, et al. Precision nutritional regulation and aquaculture. Aquaculture reports. 2020;18: 100496.
128. Zhou, Chao, et al. Near infrared computer vision and neuro-fuzzy model-based feeding decision system for fish in aquaculture. Computers and electronics in agriculture. 2018;146: 114-124.
129. Zhang, Yi, Dapeng Zhang, and Haoyu Jiang. "Review of challenges and opportunities in turbulence modeling: A comparative analysis of data-driven machine learning approaches." Journal of Marine Science and Engineering 11.7 (2023): 1440.
130. Wever, Lara, Gesche Krause, and Bela H. Buck. Lessons from stakeholder dialogues on marine aquaculture in offshore wind farms: Perceived potentials, constraints and research gaps. Marine Policy.2015;51: 251-259.
131. Hongsheng, Y. A. N. G., et al. Industrial convergence of marine ranching and offshore wind power: Concept and prospect. Bulletin of Chinese Academy of Sciences. 2019;34.6: 700-707.
132. Kou, Lei, et al. Review on monitoring, operation and maintenance of smart offshore wind farms. Sensors.2022;22.8: 2822.