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Review

A Review on Marine Economics and Management: How to Exploit the Ocean Well

Shuhong Wang [1], Weiyao Li [1] and Lu Xing [2,*]

[1] Institute of Marine Economics & Management, Shandong University of Finance and Economics, Jinan 250014, China
[2] School of Economics, Ocean University of China, Qingdao 266100, China
* Correspondence: xinglu0320@foxmail.com

Abstract: With the objective of establishing methods for high-quality marine development and effective marine management, this review focuses on four dimensions of marine development: marine economy, marine resources, marine ecology, and marine accounting. The focus of marine economy research is the marine industry, with the marine circular economy being the latest research frontier. Marine resources are the foundation of the marine economy. To use different types of marine resources more efficiently, it is necessary to apply the property right system of natural resources to marine fields. The healthy development of the marine economy is guaranteed by marine ecology. How to scientifically measure marine ecological loss and evaluate the marine ecological environment carrying capacity and marine ecological security is key to the sustainable development of the marine economy. The development of the marine economy is based on successful marine accounting. The lack of marine data globally has made marine accounting controversial. The study aims to review the development history and latest research frontiers for various marine-related fields and identify existing problems in the processes of marine economic development and marine management, with a view to finding a breakthrough for transforming and upgrading marine development, improving the marine economic governance system, and strengthening the modernization of marine governance capacity, so as to better develop and utilize the oceans.

Keywords: marine economy; marine resources; marine ecology; marine statistical accounting

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1. Introduction

Along with scientific and technological developments and the increasing scope of human activities, the importance of marine resources, the marine environment, marine space, and strategies regarding marine management have been gradually realized by countries worldwide. Due to their ecological and economic value, marine resources have always been, and remain, a dynamic force for human survival and development, and the value the ocean generates continues to increase [1]. Marine research includes a combination of economic, social, and ecological elements. When exploiting and utilizing marine resources, people must not only consider economic objectives but also evaluate how that exploitation and utilization influences the local natural environment. Moreover, influences on society, the economy, and the environment after resource exploitation should also be preliminarily evaluated. The dynamic nature of marine exploitation has allowed previously unusable marine materials or marine environmental factors to become utilizable. However, although ocean development has continuously increased in breadth and depth, it still faces many problems. Inefficient marine development models, unreasonable marine resource-management systems, the threatened security of marine ecology, and insufficiently comprehensive ocean statistics all have a negative effect on high-quality marine development.

The ocean is the cradle of human life and provides abundant material resources for human beings. As an important source of modern economic commodities and social

activities, it is not only the focus of sustainable ecological development but also of economic and societal development. If the study of the ocean is not improved upon with better statistics, models, systems, and security measures, societal and economic development of the ocean will face further problems [2]. Therefore, the best way to utilize the ocean has become a key issue in current research. This study will review the literature related to the ocean and carry out a systematic review and summary of the economy, resources, ecology, and statistical accounting of marine resources. Based on the latest research frontiers for various marine-related fields, we may find appropriate methods and ideas to solve the problems facing marine economic development and marine management from different perspectives, and thus provide a direction for future sustainable development and effective management of the ocean.

2. Marine Economy

Recently, China has paid increasing attention to green and sustainable development of the marine economy. As an important extension of land economy, the marine economy has become another growth point for China's new era of economic development.

Each sector of the marine industry can serve as an important impetus to drive the marine economy [3], including marine tourism [4]. The marine renewable energy industry [5] is conducive to optimizing the developmental structure and improving the developmental level of the marine economy. Efficiency in the marine industry is crucial for improving the marine economy. Many scholars have found that factors affecting efficiency in the marine industry include industrial agglomeration and environmental regulation, and they have advocated for strengthening interregional cooperation in coastal areas to promote marine industry agglomeration, alleviate environmental regulation constraints, promote environmental protection and marine industry efficiency, and develop the marine economy. However, Wang et al. [6] believe that productivity can be improved in the marine industry by strengthening financial support, which will enhance the efficiency of the marine industry, thereby also improving the marine economy.

Furthermore, a reasonable marine industrial infrastructure is also crucial to the development of the marine economy. Zhu et al. [7] proposed building a diversified industrial system to enhance economic risk resistance and promote marine economic development. Zhang et al. [8] also noted that optimization of the marine industrial infrastructure is a favorable foundation for the coordinated, stable, and rapid development of the marine economy. Wang and Wang [9] evaluated the contribution of China's marine industry through input–output analysis to determine the inter-industry correlation, production induction, sector supply shortage, and employment induction effects, and explored the evolution of the marine industry infrastructure and improvement of the marine economy.

The development of the marine circular economy is very important for the marine economy overall, as this development is the only way to ensure the transformation of the marine economy development model. The development of the marine circular economy has multiple perspectives. From the development model perspective, Pardilhó et al. [10] used the extraction and utilization of marine macroalgae waste as an important model for the development of the marine circular economy. Zapelloni et al. [11] analyzed the marine equipment manufacturing sector by using fiber-reinforced polymers from a circular economy perspective to identify sustainable solutions at the manufacturing process stage. Lehmusto and Santasalo–Aarnio [12] have discussed energy utilization in the marine circular economy, analyzed the cost of lithium battery transformation through mathematical model development, and considered its feasibility as a key point of marine industry circular economy development. Fadeeva and Berkel [13] posit that a custom marine plastic-pollution policy that integrates the circular economy and life cycle perspectives is crucial for the recovery of fishery productivity and the development of the marine circular economy.

From the development measurement perspective, Ding et al. [14] have considered the two-way connection between economic production and environmental treatment subsystems in the marine circular economy system, which can be used to evaluate marine

circular economic performance. Guo and Li [15] previously discussed marine circular economy theory, defects in China's current marine circular economic fiscal and tax policies, how to promote marine circular economic development, and the feasibility of fiscal policy construction. Zapelloni et al. [11] examined sustainable production solutions for marine equipment and stressed the importance of a circular economy.

3. Innovation in Marine Science and Technology and Marine Economy

Many scholars have studied marine scientific and technological innovation at the regional and industrial levels [16,17]. For example, at the regional level, Zhong et al. [18] found significant differences in marine scientific and technological innovation in China's coastal areas from 2006 to 2016. Chavez Estrada et al. [19] and Alvarez et al. [20], respectively, studied the scientific and technological innovation of fishing boats in Chile and Spain, and further explored the rapid development of marine scientific and technological innovation caused by collective rights management and specialization. Xu et al. [21] examined the effect of science and technology finance on the scientific and technological innovation of the marine industry from the industry perspective, combining the development of and financing for scientific and technological development in the marine industry. Zhang and Wang [22] analyzed overall and partial marine scientific and technological innovation in China's coastal areas from 2006 to 2016 and found that marine industrial agglomeration and environmental regulation play a positive role in the development of marine scientific and technological innovation.

As an important driving force of the sustainable development of the marine economy, research related to marine innovation has focused on the relationship between technological innovation and the marine economy. Lawrence [23] noted that scientific and technological progress must be used to promote solutions to energy problems and explained the dialectical unity between the sustainable development of the marine economy and scientific and technological progress. Shao et al. [24] examined the short- and long-term relationship between marine economic growth technological innovation in China from 2006 to 2016 and found that they promote each other in the long term. Ren and Ji [25] studied the influence of scientific and technological innovation on the marine economy global trade finance program (GTFP) under environmental regulations in order to provide a theoretical basis for transforming and upgrading the marine economy under environmental regulations. Wang et al. [26] analyzed the interactive relationships between marine scientific and technological innovations, marine finance, and marine higher education. Wang and colleagues did this from a system-coupling perspective, and they constructed a composite system involving innovation, finance and higher education. Their system provides a decision-making reference for sustainable marine economic development. Liu et al. [27] measured scientific and technological innovation in China's coastal areas from 2006 to 2016 and found a non-linear relationship between scientific and technological innovation and high-quality marine economic development.

4. Marine Resources

4.1. Marine Resource Utilization

Marine resource development can effectively guarantee the survival and sustainable development of human society in the 21st century. The United States was among the first countries to realize the importance of marine resources and change its position regarding the ocean. The 21st Century Ocean Blueprint published in 2004 proposed, for the first time, the principle of the sustainable utilization of marine resources at the national strategic level, and established the policy goal of preserving the marine environment and protecting the integrity of the coastal environment. The National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes, issued in 2010, was the third national ocean policy in the United States and concerns ecosystem-based management as the basic principle of marine ecological environment conservation and the sustainable use of marine resources. In terms of marine ecological environment conservation, it puts forward requirements for protecting,

maintaining, and restoring the ecological health and biodiversity of the ocean, coastal areas, and the Great Lakes region. Meanwhile, Australia also attaches great importance to the use and protection of marine resources. the Australian coast and its offshore waters can be roughly divided into four types of functional areas: ports, marine tourist areas, sea area wildlife refuges, and marine nature reserves. In these areas, artificial reclamation, reclamation, pollution, and abuse are forbidden in order to protect the marine-specific natural environment, biological resources, and biodiversity for the use of marine resources in marine fishery resource exploitation and the use of marine space resources, ocean energy resources, etc.

4.1.1. Marine Fishery Resource Utilization

Australia has established a full quota-management system for its fishing industry and legislated the electronic monitoring of fishing at sea. In examining the history of commercial fishing in southeast Australia, Santos et al. [28] noted that with technological progress and the emergence of new resources, fishing activities have moved offshore and into deeper waters. That previous study found that in southeast Australia, the relatively short history of fishing and the small size of the fishing industry played important roles in limiting the extent to which fishing affected local populations and helped the local environment to recover when fishing restrictions were put in place. The authors presented the management history of complex multi-species trawling fisheries in southeast Australia over the past three decades. They illustrated the hazards of overfishing and noted that fisheries in southeast Australia have returned to positive profitability and made broad improvements in environmental performance, particularly in managing the effects of fishing on protected species and benthic habitats.

4.1.2. Marine Space Resource Utilization

Unlike in Australia, the efficient use of marine resources in other developed countries includes the use of not only marine species, fisheries, and seawater but also marine resources in architectural spaces. Some scholars used buildings in the shallow sea area of Kyushu prefecture, Japan as examples of buildings that should be investigated with regard to functionality, structure, setting, location conditions, offshore construction processes, and post-construction challenges. These scholars noted that, functionally, the structures of these buildings can make full use of regional marine resources and environments. Structurally, these buildings' architects consider the harsh environmental conditions of the coastal areas and provide architectural space at the beginning of construction. Therefore, marine architectural planning should combine use, function, and infrastructure with marine conditions. Ummerhofer et al. [29] analyzed marine resource characteristics in the Indian Ocean, which is conducive to the effective and rational exploitation and utilization of marine resources and the sustainable development of human society. As a result of social progress, the demand for the efficient use of marine space in the form of marine architecture is already high. Some scholars have noted that in Canada, due to the intensification of marine environmental activities and competition, access to marine resources and the utilization of marine space are important issues of concern in many coastal areas. From a policy perspective, such scholars have argued that the use of coastal areas should be a priority in all policy decision-making processes related to Canada's oceans and that the "access" system should be implemented to realize the effective use of marine space resources.

4.1.3. Marine Energy Resource Utilization

Marine energy generally refers to renewable natural energy contained in the ocean, mainly including tidal energy, wave energy, ocean current energy (tidal current energy), seawater temperature-difference energy, and seawater salt-difference energy. In a broader sense, marine energy also includes wind energy over the ocean, solar energy on the ocean surface, and marine biomass energy [30]. Extracting wave energy from the ocean is a promising solution for renewable energy production because of the high energy intensity

of waves compared to other renewable energy sources [31]. China has rich ocean energy resources at an internationally advanced level for marine energy accumulation ability. However, the marine energy industry is still in its infancy, and China's proposed peak carbon and carbon-neutral strategy to achieve green energy and power transformation also provides a crucial opportunity for the development of marine energy resource use [32].

4.2. Natural Resource Property Rights System

As a type of natural resource, the management of marine resources is based on and referenced by the system of natural resource property rights. Natural resource property rights determine the allocation efficiency of economic resources and provide an important basic system for strengthening ecological protection and promoting the construction of ecological civilization. Consummate with the system of natural resources in the rights system is the premise of natural resources property rights system reform. Therefore, the study of specific rights within the natural property rights system results in many different viewpoints. The right to resources can be defined as a person's legal right to the rational utilization of natural resources, including natural resource rights and artificial resource rights. Reform of the paid use system of natural resources owned by society as a whole is a key part of the reform of the property rights system for natural resources. Some scholars have proposed that natural resource rents, renewable energy, and urbanization reduce ecological footprints, indicating that they have a positive contribution to environmental quality. Institutional reform will guarantee the transformation of the natural resource property rights system and will accelerate the implementation of the system accordingly.

Some studies have posited that the implementation and transformation of the natural resource property rights system needs to break through conventional administrative means, actively innovate the administrative supervision system, and overcome the "last kilometer" of transformation from institutional system construction to governance efficiency. This is particularly important. Pamela Jagger et al. [33] proposed that the reform of the natural resource property rights system must adhere to the principle that nothing prohibited by law can be done. All manner of civil subjects can equally enjoy all types of civil rights related to natural resources according to law, and these rights should be strictly protected to ensure that any infringement is remedied. Only in this way can the civil rights of natural resources, including marine resources, be added to the "protection lock" and "safety gate" of the rule of law. Studies have also emphasized that legal systems should be used to facilitate the implementation of the system of natural resource property rights; however, China has mainly adopted conventional administrative means, such as supervision, inspection, notification, and accountability. The use of environmental taxes is also an effective implementation method, and one that is likely to be applied to matters related to the marine environment, as well as to those of other areas and countries [34]. Thomas Sikor et al. [35] also proposed that the policy system of natural resource property rights must transform its objectives and legislatively confirm abstract environmental policies by virtue of the standardization and stability of laws to ensure the effective implementation of the system.

4.3. Marine Resources Management System

Regarding marine resource management systems, the United States has taken the global lead. Singleton [36] conducted research on fishery resource management in the Pacific Northwest and posited that when establishing a community-based or jointly-managed natural resource management system, the participation of national government departments could effectively improve the probability that the system will be successfully established. Although the current relationship between the state and the community is relatively tense, the natural resource management model is extensive. However, the establishment of a common natural resource management system should not completely overturn the existing management model and then re-establish a new model, but should gradually improve the existing model, a process in which social trust plays an important role. Borja et al. [37]

and Fulton et al. [38] have posited that the United States is a country that typically combines centralized and decentralized management systems. The administration of maritime affairs in the United States is distributed among federal agencies, whereas maritime law enforcement is centralized by one agency. In the United States, state governments are responsible for marine resources within a three-mile territorial sea offshore area, whereas the federal government is responsible for marine resources from 3–200 nautical miles offshore. Laws and programs enacted by the federal government are functionally carried out by federal executive agencies. Sutton–Grier et al. [39] studied three acts protecting coastal zones and marine habitats—the Clean Water Act, the Coastal Zone Management Act, and the Oil Pollution Act—from the perspective of coastal blue carbon resources. They found that the federal government has already integrated some ecosystem functions and services into existing resource regulation and pollution reduction practices. If carbon resource regulation is integrated into the existing regulatory system as an additional ecosystem service, no legislative obstacles exist from a legal perspective. This only depends on advanced science that can more accurately measure the movement and emission rates of blue carbon between different environments and marine habitats.

In France, the Marine Fishery and Aquaculture Management Bureau, the Marine Oil, Gas and Other Mineral Resources Management Bureau, and the Marine Renewable Energy Management Bureau are under the French Ministry of Oceans. The coastal regions, provinces, and cities have also established corresponding marine resource management agencies, thereby forming a typical centralized management system of marine resources. The United Kingdom is a country that typically implements a decentralized marine management system. The Ministry of Maritime, Air and Environmental Group is responsible for the coordination of government ministries of foreign-related maritime policy and law. The Ministry of Communications is responsible for maritime traffic safety management and marine environmental protection and survival. The Department for Environment, Food and Rural Affairs is responsible for 200 nm fishing area management and fishery resource protection. The Department of Energy is responsible for managing oil and gas resource development. The Land Commission regulates seabed and beach placer mining, and the Coal Board regulates seabed coal development, among other things.

5. Marine Ecological Environment

5.1. Marine Ecological Environment Protection

5.1.1. Marine Ecological Loss Assessment and Compensation

The scientific definition of "marine ecological damage" is the premise of damage assessment and damage relief. However, no universally recognized definition of "marine ecological damage" is available at present, although many scholars and relevant legal systems of European and North and South American countries have elaborated on the concept of "ecological damage" or "environmental damage". For example, Lahnstein [40] posits that ecological damage refers to "physical damage to nature; that is, damage to soil, water, air, climate, landscape, animals and plants living in it and their interactions". E. S. Scheblyakov et al. [41] has defined the concept of environmental damage as "the change, deterioration, or destruction of any part or whole of environmental resources, resulting in adverse effects on human beings and nature". In 2000, the European Union's White Paper on Environmental Responsibility defined environmental damage as "including damage to biodiversity and damage in the form of polluted sites". In 2004, the EU Environmental Responsibility Directive on the Prevention and Remedy of Environmental Damage (2004/35/CE) [42] clearly included "damage of Natural Resource Service" into the scope of what is considered "damage".

Ecological damage assessment is an entire process, from the physical condition of ecological damage to the expression of monetary value. By confirming the ecological damage caused by human activities or pollution events, economic measurements of the damage are conducted, and the ecological damage is expressed with monetary indicators. Two problems are involved in determining the physical amount of ecological damage.

The first is how to select a variable index that represents ecological damage (i.e., damage factor). The second is how to determine the amount of ecological damage. Cendrero [43] and de Mulder et al. [44] found that damage factors caused by reclamation mainly focus on fishery resources, mammals such as seals, habitat resources such as mangroves and coral reefs, wetland water quality, and coastal tourism resources such as beaches. Studies have also been conducted on marine ecological damage caused by toxic leaks and land-based pollution. For example, McConnell et al. [45] have all analyzed land-based pollution and other emergencies and evaluated the damage they cause to fisheries and beaches.

Compensation for ecological damage is based on the previous environmental utility level of individual members of the public who suffer losses, and standard compensation is the monetary amount that can ensure the integrity of environmental welfare on an individual level. Based on the above definition, several scholars have used environmental resource value assessment methods to conduct monetary assessments of resource or ecological damage in emergencies, such as oil spills and dangerous chemical leaks, and take this as the basis for measuring damages.

5.1.2. Coastal Zone Ecological Environment Management and Protection

Several scholars have studied ecological environment management modes of coastal zones. For example, Hassanali [46] proposed the use of more sustainable, fair, and feasible means to manage the current ecological environment of Trinidad and Tobago's coastal region. Yu et al. [47] analyzed the main driving factors of reclamation in the Beibu Gulf of Guangxi and interpreted these factors to facilitate decision making for ecological and environmental management in the gulf's coastal zone. Smith and Rodriguez–Labajos [48] analyzed an existing indicator system in coastal areas and compared this system with the needs of coastal stakeholders in developing countries, on the basis of which they proposed an indicator system that could be part of a systematic eco-environmental management framework for coastal zones.

Sea-level rise is also important to coastal ecological environment management. To ensure effective coastal ecological environment management, developed countries have specifically conducted monitoring studies on the impact of sea-level rise to identify changes in various natural systems, such as seawater intrusion, storm surge intensification, coastal erosion, and lowland inundation [49–54], which have, respectively, caused the expansion of seawater intrusion, inundation range, population migration, possible economic loss, and coastal wetland area loss in coastal zones, to reflect different types of impact and degrees of harm [55–59]. Although a comprehensive monitoring and management system for coastal ecological environment damage caused by sea-level rise has not yet been created, the development trend is gradually shifting toward comprehensive quantitative and fine management, with increased consideration provided to applying research results in coastal environment planning, design, and management.

5.2. Storm Surge Disaster Risk and Loss Assessment

The marine economy has increasingly become a new growth point for national economic development. In China, reliance on marine resources to achieve sustainable economic development against the current global marine background is an inevitable trend [60]. However, the role of this reliance in storm surge disasters should not be ignored when developing the marine economy. To reduce the possibility of storm surge disasters related to economic development and decrease losses from storm surge disasters, it is crucial to maintain a reasonable level of economic development. Although the current level of economic development along China's coastal area is improving, it is still at a lower stage, which is not conducive to alleviating the degree of storm surge disaster losses. This urges China to actively seek methods to guide economic development and effectively consider the economic and ecological social benefits of coastal areas.

Storm surge disaster loss assessment is a systematic project involving a very wide range of methods, in which risk assessment is an important research focus. Storm surge

disaster risk-assessment methods have been widely studied in European and North and South American countries and applied when conducting empirical research in various different cities. This research provides the scientific basis for formulating reasonable disaster-prevention plans and has achieved good results. The United States was the first country worldwide to conduct a national storm surge disaster risk assessment. In the early 1990s, the National Oceanic and Atmospheric Administration, in combination with the Federal Emergency Management Agency (FEMA) and state governments nationwide, conducted storm surge disaster risk-assessment work that shifted the focus of storm surge disaster prevention and mitigation in the storm surge disaster risk assessment and regionalization, providing auxiliary decisional support for government disaster prevention and mitigation departments.

In research on models and quantitative methods of disaster loss assessment, studies from the United States started earlier and achieved more results; however, a few are specifically for storm surge disaster loss assessment. The SLOSH model was first used to estimate storm surge loss in the United States in 1992. Water depth and ground digital elevation data were input into the model through a geographic information system (GIS) to determine the storm surge disaster risk area and estimate storm surge losses. The seven-step common methodology (CM) vulnerability assessment method proposed by the International Panel on Climate Change in 1997 established an assessment index system that considered five factors: social, economic, ecosystem, cultural, and historical heritage loss. Okuyama [61] added the time series concept to the static input–output model and constructed a dynamic input–output model to evaluate indirect economic losses caused by natural disasters. FEMA and the National Academy of Building Sciences developed the multi-disaster loss assessment model HAZUS-MH in 2003, which mainly examines three disaster types: earthquakes, hurricanes, and floods. In 2003, The United Nations Economic and Social Council for Latin America and the Caribbean proposed a set of methods to assess the socioeconomic impact of natural disasters, integrating loss assessments with long-term national (regional) socioeconomic development plans.

Furthermore, Narayan [62] used a computable general equilibrium model to assess tropical cyclone disaster losses and study their impact on a short-term macroeconomy. In addition, some scholars analyzed the input–output model, computable general equilibrium model, social accounting matrix, and disaster loss evaluation models (e.g., mathematical programming), and constructed a disaster-affected computable general equilibrium model to evaluate the indirect economic losses to associated sectors and associated areas resulting from the interruption of the water system in Portland, USA, caused by an earthquake disaster like the one that happened on February 28, 2001. Hallegatte [63] proposed a modeling framework based on an input–output table to examine the consequences of natural disaster losses during the reconstruction stage. Erdik and Else [64] established a new earthquake rapid-response system function to estimate the loss time of the city after an earthquake. Finally, Hayashi [65] noted that it is impossible to quickly assess economic losses after any natural disaster without post-disaster reconstruction plans and financial budgets.

5.3. Storm Surge Disaster Monitoring and Early Warning and Emergency Management

At present, relatively mature methods, such as satellites and marine and ground observation stations, have been used worldwide, to monitor and forecast typhoon storm surge formation, movement, type, and characteristics. China, the United States, the United Kingdom, Japan, and other developed countries have established storm surge disaster-prediction systems; however, research on storm surge disaster monitoring and early warning management is relatively sparse [66,67]. Regarding emergency management of storm surge disaster losses, the initial studies mostly focused on technical aspects such as GIS software specifications, spatial data acquisition technology, disaster models and their spatial distribution, and visualization results. Since then, scholars have gradually increased their research on natural disaster early warning management [68–70], and the application of GIS technology

in storm surge disaster loss emergency response management has also attracted increasing attention. The success of storm surge disaster loss emergency management is affected by many factors, with the effectiveness of emergency management institutions being key to improving storm surge disaster loss emergency management efficiency. Sufficient resources and resource integration are crucial for emergency management to successfully deal with storm surge disaster losses. Furthermore, an emergency management auxiliary decision support system is important for the emergency management of storm surge disaster losses. The emergency management system of China and developed countries such as the United States, the United Kingdom and Japan has been relatively perfected. In the United States, FEMA developed a disaster assessment and simulation software system named HazUS-MH, forming a disaster emergency management mechanism based on risk management and the five-layer emergency management organization system of "federal, state, county, city, and community". In addition, FEMA has applied GIS technology to predict the hazards of natural disasters. Furthermore, the Japanese government has also invested significant human and material resources to conduct technical research on disaster prevention and mitigation of storm surges, mainly including the country's immediate response system and disaster prevention and rescue system.

6. Marine Ecosystem

6.1. Marine Eco-Economic System

The marine eco-economic system is a complex dynamic system, which includes three subsystems: marine economy, marine ecology, and marine society. From an impact mechanism perspective, Costanza [71] has argued that human beings are blindly driven by economic interests, which has seriously damaged the ocean and led to coastal disasters that cause sizeable economic, societal, and ecological losses. He has also posited that a common vision of sustainable utilization of the ocean should be developed. Beaumont et al. [72] proposed that materials and services to improve marine biodiversity could play a fundamental role in the effective utilization of marine ecosystems. From a development measurement perspective, Bolam et al. [73] and Vassallo et al. [74] have comprehensively evaluated marine economic development from aspects of the marine environment, marine organisms, and the marine ecosystem, in combination with the concept of sustainable development, and summarized the basis and methods for marine ecological evaluation.

In addition, Martinez et al. [75] showed the necessity of vigorously promoting the assessment of the marine ecological economy to realize the most valuable sustainable development in coastal areas. Jin et al. [76] scientifically evaluated marine fishery management by using the ecological and economic integration framework. Based on the economic data of coastal cities and marine ecological data, a general equilibrium model of the marine economy and the marine food chain model were combined to construct sub-models of economic and ecological systems, respectively. Armstrong [77] constructed an eco-economic model based on protected marine areas and explained how the marine economic system affects the marine ecosystem. Pioch et al. [78] proposed criteria for ecological, social, and economic benefits when studying issues in the field of marine economy.

6.2. Evaluating the Marine Ecological Environment Carrying Capacity

According to Bishop [79], environmental carrying capacity refers to the intensity of human activities that a region can permanently sustain under the conditions of an acceptable standard of living. The author stated that environmental carrying capacity refers to the ability of the natural environment or social environment system to bear human development activities without significant environmental degradation. Most studies on ecological carrying capacity are based on population ecology. Furthermore, carrying capacity can refer to "economic carrying capacity" or "ecological carrying capacity". Ecological carrying capacity refers to the equilibrium point reached between the population and the environment in the absence of hunting and other disturbances. The absence of hunting or hunting at a normal level has little impact on the population, and ecological carrying

capacity is only determined by limited habitat resources, and ecosystem carrying capacity is the maximum population that a specific ecosystem can support in a specific time.

According to the different ideas regarding how ecological carrying capacity should be measured, its evaluation methods can be divided into three categories. The first category includes comprehensive evaluation methods based on various index systems, including a comprehensive evaluation index system, an ecological footprint model, a state space method, and a supply-and-demand balance method. The second category is the product cycle comprehensive evaluation method, including the cure theory method and life cycle method. Finally, the third category comprises comprehensive evaluation methods that combine different disciplines and methods, including the natural vegetation net primary productivity evaluation method, the system dynamics method, and the "3S technology" comprehensive analysis method.

By combining the characteristics of the marine economy, scholars have inherited and innovated the methods used to evaluate ecological carrying capacity. For example, Adrianto et al. [80] used Tidung Island in Jakarta as a case study to evaluate tourism activities from the perspective of the impact on the island's socioecological system through the coupling model of social and ecological carrying capacity, and then calculated the optimal carrying capacity to provide references for marine tourism management. Sun et al. [81] proposed a marine ecological carrying capacity framework and used the AHP–entropy-based TOPSIS method to evaluate marine ecological carrying capacity in Shandong Province from multiple perspectives. Du et al. [82] combined an energy system analysis of marine ranching and the accounting rules of the energy ecological footprint model to analyze the sources of uncertainty in the evaluation of marine ranching resources and environmental carrying capacity, and, based on the Dempster–Shafer evidence theory, reduced the uncertainty of the original model by introducing expert experience and an Emergy ecological footprint approach that considers uncertainty. Tang et al. [83] proposed the concept of spatial scenarios, which are highly unified in socioeconomic attributes, land cover, ecological function, and externalities, and can replace land use/land cover in the traditional three-dimensional ecological footprint model in order to establish a new coastal ecological carrying capacity assessment framework.

6.3. Marine Ecological Security

As the ocean's strategic position becomes increasingly prominent, its ecological security also becomes increasingly important [84]. Although ecological security problems are mostly caused by humans' improper use of resources and the environment, scholars increasingly believe that marine resources and environmental quality is deeply correlated with human society's economic development level and environmental policy response [85]. Although marine resource development and utilization are necessary to realize "sea power", the rapid development of regional marine economies at the expense of marine resources and the environment of consumption, so dominated by the economic development of the marine economy development mode must eventually lead to the exposure of marine resource depletion and environmental problems.

Therefore, with the continuous development and increasing utilization of the human marine economy, the concept of ecological security has been introduced into the marine field in an increasingly wide manner [86]. Marine ecological security refers to the state of equilibrium in which the marine ecosystem can maintain its structure and function undamaged or less damaged and provide balanced and stable natural resources for the sustainable development of human ecology, economy, and society within a certain spatiotemporal range. Unlike the narrow meaning of "marine ecological health", marine ecological security incorporates more extensive content, which primarily includes three aspects: the security of the symbiotic relationship between marine ecology and the marine economy, marine ecological security, and marine economic security. All three constitute a causal order: the first is the security motivation of the latter two aspects and the second aspect provides the guaranteed security of ecological services for the third aspect.

Well-known ecologists, Ma et al. [32], first proposed their theory of a "socioeconomic–natural" composite ecosystem in 1984 [87]. This theory has provided a foundation for the development of the concept and related model of the coordinated development of the ecological economy and society. As a competitive symbiotic complex of social, economic, and ecological subsystems, the marine ecological security system not only involves unilateral ecological content but also a comprehensive ecological and economic system with complex coupling relationships [88]. However, there are still relatively few specialized works on marine ecological security, with most studies mainly exploring the concept definition, evaluation, and analysis of marine ecological security. Du and Gao [89] defined marine ecological security from the perspective of the ocean itself as the ability of the marine ecosystem to recover from a certain degree of threat and maintain a healthy state. Du and Sun [84] comprehensively considered the relationship between economic development and the ocean and posited that marine ecological security is a comprehensive balance between environmental protection, resource protection, and the sustainable development of economic activities.

The marine ecosystem is complex and dynamic but is also controllable [90]. Therefore, some scholars evaluated the current status of marine ecological security based on their own research to pave the way for further optimization. For example, Gao et al. [91] conducted a dynamic evaluation on the ecological security of Pingtan Island. Du and Gao [89] constructed an evaluation index system for the safety of marine ecological pastures and identified the best path for the ecological management of marine pastures. Meanwhile, some scholars have also made methodological and theoretical innovations. Considering the complex relationships among factors affecting marine ecological conditions, Wang [85] studied the evaluation of marine ecological security based on a neural network algorithm. Focusing on issues related to marine ecological security caused by the degradation of marine ecosystem services and functions, Huang et al. [92] constructed an evaluation index system for marine ecological services and standardized the evaluation criteria and weight determination method. Bogadóttir [93] evaluated and discussed the negative impact of economic growth on the ocean and the relationship between current ocean development strategies and long-term sustainability and human well-being.

Marine ecological security has an irreplaceable role in social, economic, and natural systems. Therefore, it is necessary to reasonably monitor and evaluate the protection effect of marine ecological security and effectively solve the contradiction between economic development and ecological protection [94]. However, although many achievements of marine ecological security assessment have developed from a simple description of concepts and definitions to a point at which an accurate quantitative assessment is performed (but most of all belong to the ecological theory of the lack of evaluation), the warning effect is small, and the existing research results cannot be directly used to solve the problems of the marine ecosystem. Therefore, it is necessary to conduct more in-depth research according to the marine ecosystem's characteristics themselves [91].

7. Marine Accounting System

7.1. Statistical Accounting System of Marine Economy in China

China's relatively complete statistical system was established in 1952 but did not include marine economic statistics at that time. In 1990, the State Oceanic Administration promulgated the National Marine Statistical Index System and Index Interpretation, which covers eight categories of marine industries, including marine transportation, coastal tourism, marine fisheries, marine minerals, marine energy, seawater utilization, the marine salt industry, and marine drugs. In 1993, the scope of the marine industry statistics in China's Marine Statistics Yearbook was adjusted again to include seven categories: marine fisheries, the marine salt industry, ports and shipping, coastal international tourism, offshore oil and gas, marine science and technology and education, and marine services. In 1994, the "marine shipbuilding" industry was further added to the "China Marine Statistics Annual Report," and "marine transportation" was replaced by "ports and marine

transportation". In 1995, the "Notice on Marine Statistics in Coastal Areas" was issued, marking the official start of marine economic statistics in coastal provinces and cities. This was the first marine economic statistical accounting system formulated by the State Oceanic Administration, which established the general framework of China's marine economic accounting for the future, expanded the industrial scope of marine economic statistical accounting, and provided a foundation for the subsequent improvement of marine statistical accounting.

In 1999, to further improve the marine economic statistics and accounting system, the National Bureau of Statistics implemented the System of Comprehensive Statements of Marine Statistics, incorporating marine economic statistics and accounting into the national statistical accounting system, clearly defining coastal areas and coastal provinces (municipalities and autonomous regions), and clarifying the scope of marine economic statistics. Furthermore, according to the "Classification and Code of National Economy Industries", the "Classification and Code of Marine Economy Statistics" was issued, which adjusted the principles and methods of classification of marine economy statistics, classified the marine economy statistics plan according to the order of the first, second, and third industries, increased the marine industry to 12 categories, and expanded the scope of accounting of marine economy industries. At the same time, the marine industry has made minor adjustments. These adjustments have clarified industry classifications, adapted to the needs of marine industry development, improved various types of marine economy industries, and refined classifications under each industry. In 2006, the State Oceanic Administration released the marine industry's classification and those of related industries. Through splitting and merging, the marine economic activities are divided into three levels: large class, medium class, and small class. These classes solve the problem of statistical range overlap, expand the scope of marine economic statistics calculation, and achieve hierarchical statistical accounting for marine economic regions.

To fully reflect the overall development of the marine economy and its contribution to the national economy in the China National Economic Accounting System (2002) overall framework, basic principles and calculation methods are based on the coastal marine economic accounting systems in developed countries. In 2005, China issued the Marine Economic Accounting System Implementation Plan, which first created marine economic subject accounting and basic accounting, extended the calculation of the marine economic accounting system framework, and provided accounting content such as marine economic GDP accounting, the input and output of accounting, and fixed capital accounting, while at the same time building the ocean GDP accounting methods and models. It also called for nationwide accounting of gross marine product. In 2006, the National Bureau of Statistics approved the Gross Marine Product Accounting System, which was subsequently implemented nationwide in 2007. To adapt to economic development and changes, improve the statistical system and classification, and accurately reflect the final results of marine economic activities in a certain period, several revised versions of the Gross Marine Product Accounting System were released in 2008, 2011, 2013, 2016, and 2019. The latest revision of the Gross Marine Product Accounting System in 2019 is mainly applied to the calculation of the gross marine product and marine industrial infrastructure of coastal provinces and cities. The scope of industry calculation is determined according to the Classification of Marine and Related Industries, and the specific accounting results are published through the Statistical Bulletin of China's Marine Economy [60].

7.2. Value Accounting of Marine Resource Assets

Marine resource assets accounting includes both physical quantity and value quantity accounting, which is the premise of value quantity accounting and can systematically show the actual ownership and consumption of marine resources in China and the flow of marine resource assets during the accounting period. The ultimate goal of marine resource assets physical volume accounting is value volume accounting, which requires asset valuation

and adopts different valuation methods according to various development and utilization modes and resource attributes.

The asset-based management of marine resources must comprehensively consider national management requirements and accounting technical support, clarify the status and role of marine resources in the reform of natural resources and the ecological environment management system, and technologically connect environmental economic accounting with marine economic accounting [95]. Wang et al. [95] planned and designed an accounting table of expected service flows of marine ecosystems based on SEEA experimental ecosystem accounting and discussed the pricing of marine ecosystem services and the selection of asset discount rates. They also noted the possibility of using the NPV method to calculate marine ecosystem assets and create marine ecosystem asset accounts. Wang et al. [95] analyzed marine ecosystem services and their accounting and introduced the concept of the "fourth industry" on the basis of the current marine economic accounting framework, which is conducive to a more scientific assessment of the benefits, products, and services obtained from the ocean.

Although countries have made significant progress in expanding the scope of and improving the framework for marine accounting, only a few scholars have incorporated social and cultural factors into marine statistical accounting and ocean governance [96,97]. Thus, social and cultural values have not received due attention. Marine economic management decisions are also affected by incomplete information [98,99]. In this context, Perkiss et al. [100] suggests that critical accounting be incorporated into the marine statistical accounting framework to contribute to addressing issues in the ocean governance process, such as sustainability, subsidies, and illegal fishing.

7.3. Statistical Accounting Methods for the Marine Economy

The traditional statistical accounting of the marine economy ignores the prices or costs of the marine environment, which may not provide a scientific and accurate basis for the macrocontrol of marine undertakings and the formulation of marine policies. To accurately reflect the ecological and environmental costs paid during the development of the marine economy, as well as promote high-quality marine economic development, many scholars are committed to incorporating environmental prices or costs into statistical accounting for the marine economy and discussing how to build a green marine economy accounting system.

7.3.1. Stripping Coefficient Method

The stripping coefficient method can undoubtably be applied to the calculation of the total value of the marine economy, and its scientific nature has been widely recognized internationally. The main idea of this method is to select indicators reflecting marine and related industries from national income accounts and calculate the output value of marine-related industries by using the stripping coefficient. Many countries use this method to calculate the value of their marine economy. For example, Australia has mainly used the satellite accounts of the marine industry, industrial survey method, and general equilibrium model stripping method in marine economy evaluation research. In 1998, Canada issued a report entitled the "Contribution of Canadian Marine Industry to National Economy", which proposed calculating the stripping coefficient by the proportion of stripping and calculating the total output value of the marine industry by the stripping coefficient.

In October 2002, China used the stripping coefficient for the first time to conduct marine economic statistics in a national survey of maritime employment. However, it is still a significant problem to determine the stripping coefficient of all the sea-related industries at present, and the proposed methods have their own limitations. The marine fishery service, marine oil and gas industry, marine passenger transportation, marine cargo transportation, marine technology service industry, marine fishery wholesale, and marine aquatic product retail industries are suitable for the stripping method to calculate the added value of the industry. How to construct the ocean coefficient stripping method in a manner

that is suitable for different industries is a key step in marine economic statistics. Therefore, the actual situation of different marine industries should be fully considered in the process of marine industry stripping, so as to construct an accurate and effective ocean industry stripping coefficient.

7.3.2. Input–Output Table

In the early discussion on the contribution of the marine economy to GNP, the input–output table of the national economy was generally used to measure the contributions; however, no input–output table of the marine economy was compiled [101]. However, as the interrelationship between marine and coastal economies became clear, countries began to refine the marine industry sector data and improve the feasibility of compiling input–output tables of the marine economy. García-de-la-Fuente et al. [102] were the first to apply the input–output model to quantify and compare the economic contributions of marine recreational and commercial fishing to regional economies in Europe. Carvalho and Inacio de Moraes [103] quantified Brazil's coastal and marine economy in 2015 by estimating and establishing the national input–output matrix of the marine sector, which was the first time that Brazil's coastal economy and marine economy were presented using the input–output model. Suris-Regueiro et al. [104] also proposed an input–output approach to comprehensively estimate the economic impact of production in the activity sectors affected by ocean planning, including the total economic impact of direct, indirect, and induced impacts.

Although much research has been conducted on input–output theory at home and abroad, some problems remain in relation to theory and application. Due to the different national conditions of various countries, it is difficult to unify the definition and classification standards of marine economic sectors, the division scope of output and input indicators is still vague, and the statistical caliber is not uniform. However, input–output is generally calculated by value quantity, which lacks the basis of physical measurement and the standard of the value quantity calculation method. At the same time, no one has proposed and solved detailed problems such as the time delay and discontinuity when compiling the input–output table or how to compile the input–output extension table for years with unpublished data. Only by clarifying the classification system of the marine sector and specific input–output accounting methods, as well as the continuity of structure and producer prices, can specific and feasible solutions be made.

7.3.3. Marine Resources Balance Sheet

The compilation of the marine resources balance sheet plays an important role in promoting the statistical accounting of the marine economy. Although neither an authoritative theoretical framework nor a compilation method has been established at home or abroad, governments and scholars in Western countries have conducted many beneficial explorations into the accounting of natural resources and the environmental economy. Havranek et al. [105] showed that developed Western countries such as the United Kingdom and the United States have strengthened the definition and protection of marine resource property rights in the form of legislation. On this basis, marine resource asset accounting has been added to the work of natural resource asset accounting and is regarded as an important part of it. Obst et al. [106] studied the relationship between marine resource consumption and marine economic growth and further proposed that marine resources should be regarded as an important part of the national asset accounting system, positing that the changes in marine resource assets should be included in the assessment indicator system for marine ecological environment development. However, there are various types and structures for the compilation of the balance sheet of marine resources, including embedded statements, independent statements, and consolidated statements. Based on the accounting method of assets and liabilities of marine resources, the compilation of physical statement of assets and liabilities of marine resources can adopt the compiling procedure of classification before synthesis, the statistical principle of stock before flow, and the account-

ing method of physical assets and liabilities before value. In terms of an accounting system, the Integrated Environmental and Economic Accounting System (SEEA2012) and National Economic Accounting System (SNA2008), as the most internationally recognized natural resources accounting and national balance sheet compilation systems, have important reference significance for marine resource balance sheets. However, compared with other natural resources, the survey, monitoring and statistical accounting of marine resources are more difficult because the significant characteristics of marine resources, such as seasonality, fluidity, latent nature, complexity, and the monetary measurement conditions of natural resources and environment are not mature. Thus, the concrete implementation of the preparation of a balance sheet for marine resources is considerably difficult. It is also difficult for countries to have a unified standard in terms of the category, classification, and methods of accounting items. Therefore, disputes exist in the balance sheet compilation for marine resources in terms of the definition of property rights, technical methods, and elements of value accounting, which need to be resolved.

8. Discussion and Conclusions

8.1. Discussion

The paper contributes to the study of ocean economics and management by reviewing the development history and the latest research frontiers for various marine-related fields and pointing out problems in the process of ocean development. However, the paper also has weaknesses.

First, although the review covers four dimensions—marine economy, marine resources, marine ecology and marine accounting—the scope of the study is still not comprehensive and needs to be further expanded. Most of the ocean-related literature in this paper has studied ocean development from the perspective of economics or environmental economics. In fact, other marine fields not mentioned in the paper, such as marine engineering, marine construction, marine equipment, and marine law, are also the focus of a variety of research. They are closely related to marine economics and management and are important for the better utilization of the ocean. Therefore, interdisciplinary reviews and the integration of marine research are factors that deserve further study.

Secondly, different countries have different national conditions. The stage of marine development also differs. The overview is a discussion of the current state of marine economics and management in various countries, which tends to make the conclusions lack national applicability. It is necessary to make an appropriate distinction between studies according to countries. Only in this way can the review be of practical significance and provide directional guidance and feasible policy recommendations for the development of marine economy and effective marine management in different countries. Subsequent research should continue to advance this aspect if possible.

Finally, the paper is based on a review of the literature and is somewhat subjective. The presentation of statistical data is essential if the article is to be more convincing. This content might include the number of papers on marine resources that have been published in the last five years, the frequency of marine ecology as keywords in papers, and a comparison of the number of papers in different ocean dimensions. To better define the focus of marine economy, marine resources, marine ecology, and marine accounting, and provide a breakthrough for the transformation and upgrade of marine development, the statistical data of relevant marine literature should be further collected.

8.2. Conclusions

To improve the marine economic governance system and strengthen the modernization of marine governance capacity, this study reviews the literature related to the ocean from different perspectives and provides a systematic summary of marine economy, marine resources, marine ecology, and marine accounting to clarify the focus and shortcomings of existing research.

First, with the increasing attention of the government to the ocean, the marine economy is gradually becoming an important part of scholarly research. Marine industry is the focus of the marine economy. Most studies focus on the marine industry from the perspective of industry efficiency and industry structure. The literature related to the marine industry is relatively well developed. The marine circular economy is a research frontier that has been discussed mainly from a development model and development measurement perspective. However, until now, technology to realize the marine circular economy has been rarely mentioned and needs to be further studied. As an important driving force of the marine economy, marine innovation has been highly emphasized by the government, who have tried to clarify the relationship between marine innovation and the marine economy, with the aim of promoting the high-quality development of the marine economy.

Second, marine resources are the foundation of the marine economy. Marine resources contain resources of marine fisheries, marine spaces, and marine energy, etc. Western countries recognized the importance of marine resources earlier and this is reflected through their national policies. The enactment of national laws, the improvement in the natural resource property rights system and the establishment of marine resource management system are all successful experiences that marine countries can learn from developed countries, such as the U.S., Australia, and Canada. However, for most countries, the transformation and implementation management system of marine resource property rights is not perfect and still has a number of controversial issues.

Third, the healthy development of the marine economy is guaranteed by marine ecology. Research on marine ecology mainly focuses on two aspects. One is marine ecological loss. Concept definition, assessment methods, compensation criteria, and monitoring for marine ecological loss have all been thoroughly studied. As the main source of marine ecological loss, ocean disasters, especially storm surge disasters, are the most important research areas. Another area of importance is the marine ecosystem. Relevant studies take the marine ecological environment carrying capacity and marine ecological security as the research objects. Scholars have continuously innovated the methods used to evaluate the marine ecological environment carrying capacity. Multi-aspect evaluation, the uncertainty model, and spatial scene have been proposed as the latest research. Although great progress has been made in the study of marine ecological security, most achievements of marine ecological security assessment are realized post-evaluation, meaning that these security assessments cannot play a role in early warning efforts or effectively solve the problems of marine ecological overload and marine pollution.

Fourth, developed marine economy is based on successful marine accounting. Marine research needs accurate marine data to support it. The Chinese statistical accounting system has been gradually improved, but the accounting of marine resource assets is still in the exploratory stage, and requires in-depth research in theory, connotation definition, resource asset accounting methods, and other aspects. The environmental economic accounting system (SEEA) is the most common and basic method by which to discuss the marine economic accounting system. The scope of marine accounting is expanded and the framework for marine accounting is improved through this approach. However, there are still two problems for existing research. Intangible assets, such as society and culture, are not widely integrated into the marine accounting framework. Meanwhile, it is difficult for scholars to study the compilation of the marine resources balance sheet due to the characteristics of marine resources and disputes caused by the technical methods or elements of value accounting.

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