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The Impact of Marine Conservation on the Sustainable Development of Fisheries

Lei Zhang

School of Chemistry and Chemical Engineering, Guangzhou University, Guangzhou, China

18027313234@163.com

Abstract. The ocean covers more than 70% of the Earth's surface and is an important part of the global life support system. However, in recent years, due to factors such as overfishing, marine pollution, and climate change, the marine ecosystem has been under unprecedented pressure, and there is a serious trend of in fishery resources. This study focuses on the impact of marine conservation on the sustainable development of fisheries, exploring synergistic effects with green chemical technology. By analyzing the relationship between marine ecosystem services and fishery resources, it reveals the negative impacts of overfishing and pollution on fisheries and ecosystems, emphasizing the necessity of conservation measures. The study indicates that green chemical technology significantly reduces pollution from fishery activities to the marine environment through some means such as developing friendly fishing nets, degradable materials, and efficient wastewater treatment systems, providing technical support for the recovery of fishery resources and so on.

Keywords: Green chemistry, Marine environmental protection, Marine fisheries technological progress, Sustainable development

1. Introduction

The ocean, which covers over 70% of Earth's surface, serves as a cornerstone of the global life support system, regulating climate, oxygen production, and nutrient cycling. The ocean not only provides abundant natural resources but also has a crucial impact on the global climate, ecosystem services, and economic activities. Fisheries, as an important way of utilizing marine resources, are of great significance to human food supply, economic income, and cultural traditions. .

Ma highlights a significant concern in the realm of marine fisheries. The deteriorating marine environment has emerged as a substantial hurdle preventing the marine fishery system from attaining a high degree of coordinated symbiosis. This degradation disrupts the delicate balance within the ecosystem, affecting fish populations, their habitats, and ultimately, the overall productivity of the fishery [1]. Jin further elaborates on the imperative actions required to revitalize the marine economy. There is an urgent need to expedite the circulation of resources within the marine economic circle. This includes accelerating research in fishery technology to improve efficiency and sustainability. Additionally, actively promoting the development of carbon sink fishery can contribute to environmental conservation while enhancing economic viability. Moreover, enhancing the specialization of aquatic product processing can add value to the industry [2]. Patrick Reis-Santos presents an innovative perspective. The application of hard tissue chemistry offers multiple opportunities. It can be used to combat seafood fraud, ensuring consumers receive authentic products. Quantifying past food webs provides insights into historical ecological dynamics. Coordinating aspects such as growth, movement, heat, metabolism, and life history allows for a deeper understanding of how fishing and global change impact fish health and fishery productivity [3].

Overall, these studies together paint a comprehensive picture of the challenges and opportunities in the field of marine fisheries. This study focuses on the impact of marine conservation on the sustainable development of fisheries, exploring synergistic effects with green chemical technology by literature review. In this context, it is of great theoretical and practical significance to explore the impact of marine protection on the sustainable development of fisheries. By analyzing the use of green chemistry in marine protection, the important role of scientific and technological innovation in solving marine environmental problems is demonstrated, providing new ideas and methods for the sustainable development of.

2. The Relationship between Marine Conservation and Fishery Resources

2.1. Marine Ecosystem Services and Fishery Resources

The ocean plays a crucial and multifaceted role in maintaining the balance of our planet. It contributes approximately 50% of the world's oxygen through the process of photosynthesis carried out by marine plants like phytoplankton. Moreover, it acts as a significant carbon sink, absorbing around 30% of the carbon dioxide emitted by humans [4]. This helps mitigate the effects of climate change.

Ecosystems within the ocean, such as vibrant coral reefs and extensive seagrass beds, are of great importance. They serve as vital habitats for countless marine species, providing shelter, breeding grounds, and food sources. Additionally, they offer coastal protection by reducing the impact of waves and storms. Indirectly, these ecosystems support the reproduction of fishery resources, ensuring a stable supply of fish for human consumption.

To ensure the long-term viability of fisheries, the Global Agreement has introduced an ecosystem approach to sustainable fisheries governance. This approach demands that countries do not merely focus on the target fish stock. Instead, they must consider the entire ecological context, including the target species and its habitat [5]. By doing so, countries can comprehensively assess and effectively mitigate the impact of fishing activities on the marine ecosystem as a whole, safeguarding the health and productivity of the oceans for future generations.

2.2. The Impact of Fishing on Marine Ecosystems

Ghost fishing, the pervasive phenomenon of abandoned, lost, or discarded fishing gear (ALDFG) continuing to trap and entangle marine life, poses a multifaceted threat to global marine ecosystems and coastal economies. Derelict nets, lines, and traps drift across ocean currents, acting as "silent killers" that indiscriminately capture fish, turtles, seabirds, and marine mammals. An estimated 640,000 tons of ALDFG enter oceans annually, contributing to 10% of global plastic pollution. These ghost traps not only cause direct mortality through suffocation or starvation but also disrupt critical habitats, such as coral reefs damaged by entangled gear [6].

The ecological ripple effects are profound. Overfishing-induced depletion of apex predators like sharks—a key consequence of ghost fishing—disrupts trophic cascades, leading to unchecked population growth of prey species and subsequent collapse of foundational food webs. For example, studies in the Northwest Atlantic revealed that declining shark populations due to ghost gear entanglement correlated with a 97% reduction in ray species, destabilizing coastal ecosystems [7]. Furthermore, economic losses compound as fisheries suffer from depleted stocks, tourism industries face degraded coastal aesthetics, and governments incur costly cleanup operations. In the Chesapeake Bay, annual removal of derelict crab pots costs $3.2 million while reducing commercial harvests by 20% [8].

3. The Application of Green Chemistry in Marine Conservation

3.1. Basic Concepts of Green Chemistry

The concept of green chemistry emerged in response to the environmental and health crises triggered by traditional chemical practices. As shown in Figure 1, the field of Green Chemistry is grounded in the Twelve Principles first articulated by the U.S. Environmental Protection Agency in 1998. These principles emphasize the importance of minimizing waste, maximizing atom efficiency, and designing safer chemicals. However, as global challenges intensified, the scope of green chemistry expanded beyond technical criteria to encompass social and environmental justice.

Recently, the inclusion of lifecycle assessments and social costs has become imperative. For instance, while a product may exhibit eco-friendly properties, its production process might rely on energy-intensive technologies or exploit labor in regions with lax regulations. Green chemistry now demands a holistic evaluation, considering factors like carbon emissions, water pollution, occupational hazards, and resource equity. This shift reflects a deeper understanding that sustainability requires addressing systemic inequalities alongside technological innovation [9].

Figure 1. Sustainability as a multidimensional concept [9]

3.2. Application of Green Chemistry —Case Study

3.2.1. Case of Marine Conservation and Sustainable Development of Fisheries

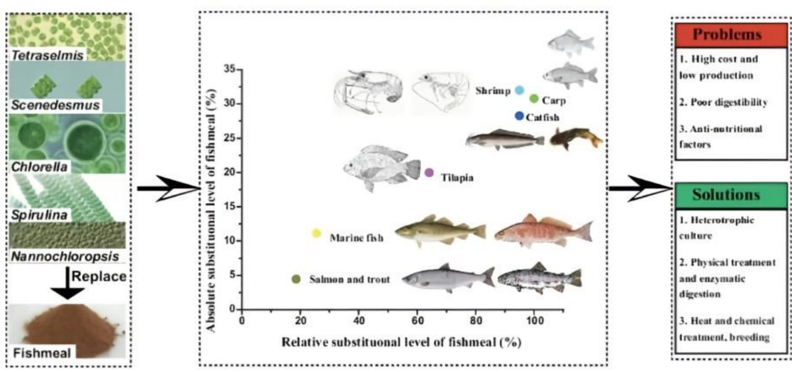

Figure 2. Graphical explication [10]

Gao et al. showed that appropriate replacement of fishmeal with microalgae benefits the growth performance of fish, but excessive replacement results in decreased growth and feed utilization. As a result, the research on the maximum replacement level of microalgae for fish, and the main problems and possible solutions for the replacement of fishmeal with microalgae are proposed. The maximum replacement level is influenced by the species of microalgae, feeding habits of fish, quality of fishmeal and microalgae meal, and the addition level of fishmeal in the control group. Microalgae can usually 100%, 95%, 95%, 64.1%, 25.6%, and 186% of the protein in fishmeal in carp, shrimp, fish, tilapia, marine fish, and salmon and herring, respectively. As shown in Figure 2, the main obstacles to microalgae replacing fishmeal include low yield and high production cost, poor digestibility, and antinutritional factors [10]. Traditional fish meal mainly comes from marine lower food chain fish (such as anchovies, sardines, etc.), and overfishing these fish has led to the imbalance of marine ecosystems and the decline of biodiversity. Microalgae, as an alternative, can significantly reduce the reliance on wild fish, thereby protecting the stability of marine ecosystems.

3.2.2. Green Chemical Technology in Marine Ecological Restoration

Green chemical technology emerges as a powerful tool in restoring damaged marine ecosystems through a series of ecological remediation measures. Seagrass planting and shellfish aquaculture, as bioremediation strategies, play a pivotal role in rejuvenating the biodiversity of nearshore regions. Seagrass beds act as nurseries for numerous marine species, while shellfish filter pollutants, enhancing water quality [11]. Moreover, this technology is instrumental in developing eco-friendly fishing gear and aquaculture facilities. By using biodegradable materials or designing gear with reduced by - catch, it significantly lessens the harm inflicted on marine life.

Green chemical technology adheres to the principle of source-control of pollution. Through optimizing industrial production processes, it minimizes the utilization of harmful substances. For instance, substituting traditional solvents with green counterparts and employing efficient catalysts in industrial operations can curtail the release of toxic wastewater [12]. This not only alleviates the pressure on the marine environment but also paves the way for sustainable coexistence between human activities and the delicate marine ecosystems.

4. Strategies for Sustainable Development of Fisheries

4.1. Fishery Management Policies and Regulations

When fisheries managers are unable to monitor who is fishing and where fishing activities are taking place, the scope of their management interventions becomes severely constrained. This lack of visibility in fishing operations is widely regarded as a primary contributor to illegal, unreported, and unregulated (IUU) fishing, as well as overfishing. These issues not only deplete fish stocks but also pose a significant obstacle to managers striving for sustainable fisheries and consumers seeking responsibly sourced seafood.

Enhanced transparency regarding the location of fishing activities is emerging as a potentially effective strategy to enhance global fisheries management. By providing real-time data on fishing vessels' whereabouts, authorities can better enforce regulations, prevent illegal practices, and promote sustainable resource exploitation.

However, despite the promise of increased transparency, the specific mechanisms through which it can be effectively achieved remain inadequately explored. There is a pressing need to carefully examine technological solutions, regulatory frameworks, and stakeholder engagement strategies. Additionally, the costs associated with implementing transparency measures, such as investing in monitoring technologies and data management systems, must be weighed against the expected benefits. These costs and benefits can vary significantly depending on the unique context of each fishery, including its geographical location, the types of fish species targeted, and the scale of operations. Future research should focus on identifying these context-specific factors and filling these critical information gaps to inform more effective fisheries management strategies [13].

4.2. Technological Innovation Sustainable Development of Fisheries

Fishery technology innovation has significantly improved production efficiency through intelligent equipment and precise management. For example, smart feeding systems can automatically adjust the amount and timing of feeding based on the needs of the cultured organisms, reducing feed waste and lowering farming costs [14]. In addition, the application of the Internet of Things and big data technologies enables fishery practitioners to monitor water quality, meteorological and other environmental parameters in real-time. This capability helps optimize the breeding environment, and increase production and economic benefits.

Smart fishing gear uses sensors and communication equipment to monitor data such as the direction and number of fish schools in real-time, helping to formulate reasonable harvesting plans and prevent overfishing. At the same time, the setting of a closed fishing season. In addition, the application of the Internet of Things and big data technologies enables fishery practitioners to monitor water quality and catch quotas. When combined with remote monitoring technology, these tools can effectively prevent illegal fishing activities and the sustainable use of fishery resources [15].

4.3. International Cooperation and Information Sharing

International fisheries organizations manage fisheries resources through multilateral cooperation mechanisms, coordinating national policies, and formulating rules for sustainable use. For example, the China-Russia Mixed Committee on Fisheries Cooperation has deepened cooperation in areas such as fishery resources conservation, marine fishing and scientific and technological cooperation through regular meetings and the signing of agreements, becoming a model for neighboring countries' fisheries cooperation [16].

Information sharing is the foundation of fisheries resources management. By sharing data on fishery resources (such as fish population size, catch volume, etc.), international organizations and countries can more accurately assess the resource situation and formulate scientific management measures. For example, the International Council for the Exploration of the sea has provided reliable resource assessment reports for member countries through a data-sharing mechanism. However, in international cooperation, countries have different interests and demands, which may limit the cooperation [17].

5. Conclusion

This paper explores the impact of marine conservation on the sustainable development of fisheries and analyzes the application of green chemical technology in marine protection. The study shows that marine ecosystem services are crucial to fishery resources, and overfishing and pollution have negative effects on fisheries and ecosystems. Green chemical technology reduces pollution and restores damaged ecosystems, providing technical support for the recovery of fishery resources. In conclusion, marine conservation and the application of green chemical technology are essential for the sustainable development of fisheries.

There are some current shortcomings and improvement directions. More detailed analysis of specific cases can be added to provide practical operational suggestions. More quantitative analysis methods, such as model prediction and data analysis, can be introduced to enhance the scientificity and accuracy of the research. More recent research can be cited to reflect the latest advancements in marine protection and green chemical technology.

Looking ahead, further research is needed on the application of green chemical technology in marine protection, such as new environmentally friendly materials and pollution control techniques. It is essential to explore more effective fishery management policies and international cooperation mechanisms to achieve the sustainable use of fishery resources. Additionally, studying how to restore damaged marine ecosystems through ecological restoration measures will help improve biodiversity. The development and application of smart technologies, such as the Internet of Things and big data, are also crucial for optimizing fishery production and resource management.

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