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Risk Factors of Mariculture Supply Chain Based on Green Development: A Case Study of Changhai County in China

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Abstract: China is a global leader in aquaculture, and mariculture has become an important part of Chinese agriculture and one of the important growth points of the rural economy. However, environmental changes and industrial restructuring have brought new risks to the aquaculture supply chain. Recently, people have also paid more and more attention to the marine environment because a good marine environment is the foundation of the healthy development of mariculture. This study analyses the risks in the aquaculture supply chain from the perspective of the marine environment, using Changhai County, Liaoning Province, as an example. The study identified marine environmental issues such as over-sized aquaculture, irrational aquaculture structure, resource integration gaps, nuclear wastewater discharge and offshore oil pollution. Recommendations included restructuring aquaculture, professional training, establishing cooperative mechanisms, and improving seafood quality testing and marine environment monitoring. Addressing these challenges is essential to ensure the stable and healthy development of seafood markets and the sustainability of the aquaculture industry.

Keywords: Supply chain risk, Risk factors, Marine environment, Mariculture, Sustainable development

1. Introduction

China is a developed country in the mariculture industry, both in terms of aquaculture area and total output, which are at the forefront of the world. About 40% of the world's aquaculture products come from China, which has become an important part of China's agriculture and one of the important growth points of the rural economy. Due to changes in the environment and industrial restructuring, the mariculture industry's supply chain faces new risks, such as unreasonable breeding structure, excessive breeding scale, lack of resource integration and volatility in the market. Strengthening supply chain risk management is directly tied to the development of mariculture in the future and the stability of the Chinese seafood market.

In recent years, mariculture is continuously developing in China. China is the world's first mariculture country. The area and output of mariculture rank first in the world. Mariculture has become one of the pillars of the marine industry, an important component of Chinese agriculture, and an important point for growth in the rural economy. Mariculture provides high-quality animal protein for Chinese consumers. It plays an important role in improving the agricultural industry structure, stabilizing the employment and income of coastal fishermen in the Chinese seafood market, and

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coping with the depletion of natural fishery resources [1]. In the past 20 years, China's mariculture has shown an accelerated expansion trend. However, the extensive and disorderly expansion of the mariculture industry has also caused problems such as oversupply of some mariculture products, large fluctuations in market prices, and aquaculture diseases, which directly threaten the sustainability of mariculture development [2]. Therefore, the risk analysis of the mariculture supply chain from the perspective of the environment has far-reaching significance in maintaining the stability of the Chinese seafood market and ensuring the healthy development of the fishery economy.

The coastline length of Dalian is 221l kilometers, accounting for 12% of the mainland coastline of China and 75% of Liaoning Province. With a vast territory and abundant seawater resources, Dalian is one of the main cities of mariculture in northern China [3, 4]. Changhai County, Dalian City, Liaoning Province, is an island county surrounded by the sea in the northern part of the Yellow Sea. The output value of mariculture can account for more than 68% of the total output value of agriculture, forestry and fishery in Changhai County. Shellfish has always been the largest and most productive type of mariculture in Changhai County. Under years of development, Changhai County has become the country's largest Marine pasture and shrimp scallop production base. In 2022, shellfish production accounts for 86.9% of the total production of mariculture in the county, and shellfish farming accounts for 74.7% of the county's total area. Changhai County, as a typical area with mariculture, is the main economic source and has an important position in the seafood market. It has more reference value than other areas. Therefore, this paper takes Changhai County in Liaoning Province as an example to analyze the risks of the mariculture supply chain from the perspective of the Marine environment.

2. Status Analysis

2.1. The Breeding Scale is too Large

According to the statistical yearbook released by the Dalian Bureau of Statistics, as shown in Figure 1, the Marine area of Changhai County and the annual mariculture production were obtained.

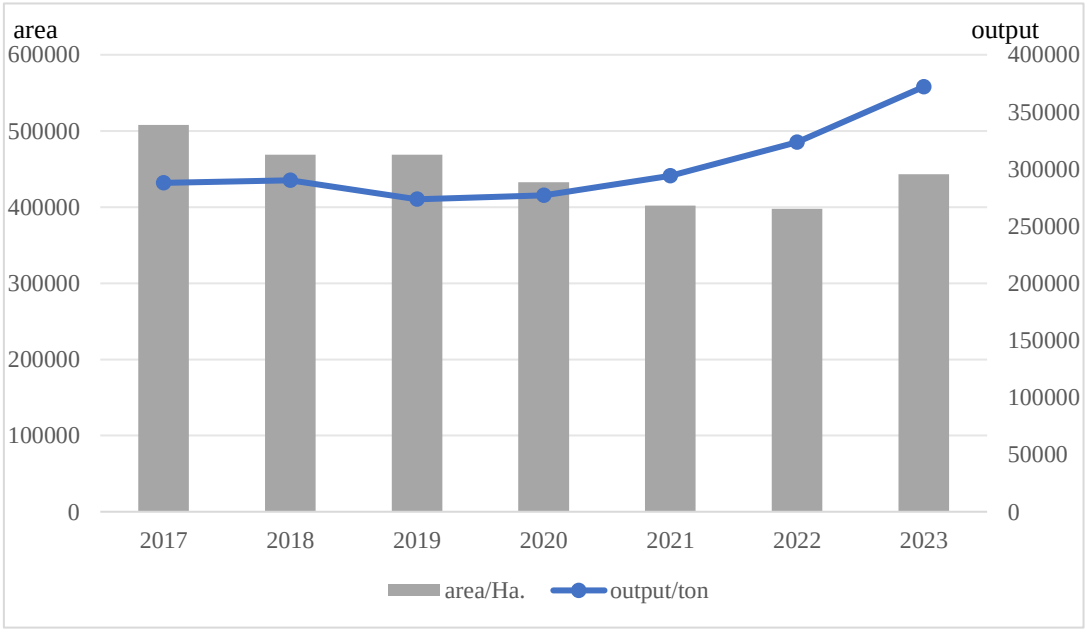

Figure 1: Sea area and output of mariculture in Changhai County.

On June 6, 2019, the General Office of the CPC Central Committee and The General Office of the State Council issued the "Regulations on the Work of the Central Ecological and Environmental

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Protection Supervision", requiring all localities to implement it. Changhai County responded to the "Central Ecological Environmental Protection Supervision Regulations", carried out ecological environmental protection and ecological civilization construction, banned and adjusted floating raft breeding, and reduced redundant and illegal breeding areas. Since 2019, the Changhai County government has re-planned the mariculture area, continuously strengthened the protection, improvement and restoration of Marine resources and the environment, and adopted measures such as gradually recovering the right to use beach waters according to law, returning land to the beach, strictly implementing island ecological remediation and restoration, the Marine ecological red line, the control policy on reclamation and controlling the unrestrained expansion of the mariculture area. The effect was significant. The right of the sea area suitable for mariculture has been confirmed. Expanding the sea area for mariculture may lead to a decline in seafood quality and damage the Marine environment. By comparing the area and output of the mariculture sea area in Changhai County, it can be seen that although the area of the mariculture sea area is declining, the seafood output is increasing yearly. Therefore, it can be inferred that marine farmers increase the breeding density of aquaculture species in the aquaculture sea area. Excessive aquaculture density increases the risk of causing seafood diseases [5].

2.2. The Breeding Structure is Unreasonable

In recent years, due to the decrease in the economic benefits of shrimp scallops, mainly raised in Changhai County, farmers have mostly turned to oysters, which have higher economic effects. According to the report released by the Changhai County government, the sea bottom sowing area of Changhai County in 2022 will reach 4.6 million mu. The bottom sowing area of shrimp and scallops will reach 352.5 mu, and the output will be 79,000 tons. The bottom sowing area of sea cucumber will reach 1.05 million mu, and the output will be 0.58 million tons. The bottom sowing area of Abalone will reach 25,000 mu, and the output will be 0.01 million tons. Floating raft culture area of 330,000 mu, the main breed: oyster of 140,000 mu, the output of 245,000 tons; Chlamys farreri of 80,000 mu, the output of 90,000 tons; Shrimp scallop of 69,000 mu, the output of 60,000 tons; Bay scallop of 20,000 mu, the output of 9,000 tons; Algae cultivation of 11,000 mu, the output of 54,000 tons; Quicarca arca 10,000 mu, production of 5,000 tons. The filter-feeding capacity of oysters is 3-4 times that of scallops, so the plankton food intake and nutrient salt consumption of oysters in the sea area are much higher than that of scallops, which leads to the further decline of the culture condition of shrimp scallops [6, 7]. Because of the high yield of oysters, the density of oysters in the unit sea area after oyster reproduction will cause damage to the native environment of the aquaculture sea area, so the nutrient salt content of the aquaculture sea area will not be enough to continue to carry out multiple rounds of large-scale oyster culture in the mariculture sea area, which is not conducive to the sustainable and healthy development of mariculture.

2.3. Lack of Resource Integration

Changhai County is composed of 18 inhabited islands. Due to geographical factors, many small-scale individual business households are in Changhai County. The mariculture supply chain in Changhai County can be divided into two types: mariculture farmers - consumer market; seafood farmers - circulation enterprises - consumer market. Compared with farmers and consumer markets, circulation enterprises in the supply chain are less affected by the environment. Therefore, from the perspective of environmental protection, the supply chain risk of Changhai mariculture is concentrated in the link between farmers and the consumer market, focusing on supply risk and demand risk.

Because these small self-employed households lack enough seafood for large-scale sales, seafood farmers often earn income by providing seafood to circulation enterprises, selling seafood directly or

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after processing to the market for circulation. Because circulation enterprises directly face the market rather than individual business households, individual business households need help grasping the market trend easily. It increases the risk of bullwhip effect in the seafood supply chain and affects the interests of seafood parties. Considering the extremely short shelf life of seafood and the limited capital scale of self-employed households, seafood farmers cannot bear the risks brought by the bullwhip effect, and the consequences in all links of the seafood supply chain will be more serious. In addition, limited to the management mode of self-employed households, it is easy for farmers to grasp the current seafood market incorrectly, resulting in an unbalanced breeding structure and excess production. They have difficulty coping with external risks and market shocks.

2.4. Marine Environmental Problem

As early as 2021, seafood caught off the coast of Fukushima, Japan had been detected with radiation levels exceeding the limit, and some Marine fish have been detected with radioactive elements 180 times the limit [8].

On August 24, 2023, Japan began the nuclear wastewater discharge plan, and the nuclear wastewater discharged by it will flow into the Chinese Sea area with the ocean current, which will affect the Marine resources in the sea area. According to the macro simulation results of Liu Yi et al., the nuclear sewage discharged by Japan will reach the coastal waters of China about 240 days after being discharged, and the Chinese mariculture industry will undoubtedly face huge quality and safety problems [9]. Radioactive substances contained in nuclear sewage are easily absorbed by Marine organisms after entering the ocean, which will affect the ecological environment for a long time and cause unpredictable impacts on Marine living resources. Marine environmental problems have aroused consumers' doubts about the quality and safety of seafood and caused turbulence in the seafood market. From August to November 2023, the price of seawater products in China declined.

In addition to the problem of nuclear sewage, offshore oil pollution is also one of the main problems that damage the Marine ecological environment and affect the stability of the supply chain of Marine aquaculture. After the occurrence of oil pollution, its harmful substances will lead to the structural imbalance of the offshore ecosystem, the degradation of ecological functions, and the decline of the value of ecological services. Harmful substances will also be transferred and enriched along the Marine food chain, which seriously impacts Marine ecology and fishery production [10, 11].

3. Suggestions

3.1. Adjust the Breeding Structure and Do a Good Job of Breeding Planning

The competent fisheries department adjusts the aquaculture area, combines the carrying capacity of the mariculture sea area, plans the mariculture area on sustainable development, strengthens the management of the mariculture area, and timely recovers the area that cannot be cultured. Analyze the ecological niche relationship of aquaculture species, put forward scientific and reasonable suggestions for mariculture density to make full and reasonable use of the resources in the mariculture sea area, maintain the diversification and high quality of aquaculture species and avoid the economic loss caused by the excessive mariculture of seafood. Through policy advocacy, the competent fisheries department should protect mariculture sea areas while expanding economic benefits, preventing damage to mariculture sea areas while developing the mariculture industry and maintaining green and healthy economic development.

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3.2. Conduct Professional Training in Mariculture

Since a large number of farmers with low scientific and cultural quality are engaged in the seafood aquaculture industry in Changhai County, it will be better for the relevant government to invite experts in mariculture and market economists to train farmers aiming for cultivating technical talents to enhance the quality of products and reducing technical risks. The relevant government should enhance farmers' ability to control the market trend and cultivate market talents to reduce market risks, improve the professional knowledge and culture level of practitioners, improve the level of production science and technology, promote the overall stable and good development of the mariculture economy and reduce the risks induced by farmers without professional knowledge.

3.3. Establish a Cooperation Mechanism to Integrate Small Enterprises and Farmer

Encourage the establishment of integrated institutions among mariculturists, such as cooperatives. By integrating the dispersed capital and resources of individual business households, the government can strengthen the guiding ability of mariculture resources, and the mariculture industry's ability to respond to the market can be improved. Centralizing the characteristics of small enterprises and farmers and guiding integrated institutions to share information can reduce losses in the face of external risks. Maintain the industry's credibility through integrated institutions and introduce capital under the guidance of policies to accelerate the modernization of the industry.

3.4. Improve Seafood Quality Testing and Strengthen Marine Environmental Monitoring

To protect the safety and rights of consumers, strict, safe and open seafood safety and quality management regulations should be established in the seafood supply chain from breeding, processing, transportation, circulation to sales, and public credibility should be maintained through reasonable testing mechanisms. Accelerate the construction of blockchain-based seafood supply chain management and build trust in seafood by all supply chain parties to maintain the seafood market's normal operation. Strengthen environmental monitoring of coastal waters and respond to changes in the Marine environment promptly to respond to impacts caused by the Marine environment in the first place.

4. Conclusion

Marine environmental issues are of common concern to all countries in the world and are also a major issue concerning the whole world. For Marine environmental protection, countries should strengthen cooperation, jointly cope with the challenge of Marine pollution, and seek feasible solutions to the problem of nuclear-contaminated water. Strengthening the Marine ecological safety barrier, strengthening the construction of Marine ecological civilization, and realizing the sustainable development of the Marine industry are the most basic and effective measures to maintain the stability of the supply chain of Marine aquaculture. The Marine environment is closely related to the mariculture supply chain, and the in-depth study of these issues will help solve the risk problem of the seafood supply chain and contribute to the healthy development of the industry. Therefore, these problems deserve further study in the future.

In summary, through in-depth analyses of the risk factors in the aquaculture supply chain, this study not only identifies a series of key problems but also proposes corresponding solutions. There is a need to adjust the scale and structure of aquaculture, enhance resource integration, improve seafood quality testing and marine environment monitoring, and strengthen professional training. These initiatives will help improve the resilience and adaptability of the aquaculture industry, push the

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industry in a greener and more sustainable direction, and ensure the stability and healthy development of the seafood market.

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