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The process and mechanisms of the capitalization of marine space in China: a case study of mariculture on Guanglu Island, Changhai County

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The phenomenon of transforming natural marine space into proliferative capital holds global significance in modern modes of production. Under China's socialist market economy, the property rights system and resource allocation methods have created a unique approach to the capitalization of marine space. Drawing on concepts related to the capitalization of space and land, this paper develops the idea of the capitalization of marine space. It is a process where the right to use the sea area is transferred by the rights holders through methods such as transfer, lease, or shares and is ultimately put into production as a means of production to realize the creation of capital value and surplus value. Using the mariculture industry on Guanglu Island in Changhai County as a case, this analysis delves into the process and mechanisms of the capitalization of marine space in China, the world's leading mariculture nation, while considering the material agency of marine space. The research results show that: ① The specific realization process of marine space capitalization in the mariculture industry has gone through three stages: from natural marine space to marine space resources, from marine space resources to marine space assets, and the participation of marine space assets in creating value and surplus value. ② The material agency of marine space determines the feasibility of the capitalization of marine space and is also the decisive subject in shaping the specific practice of capitalization. The survival and profit needs of mariculture fishermen and enterprises drive the realization of the capitalization of marine space. China's central and local governments participate in realizing the capitalization of marine space with the relevant institutional policies and norms aimed at economic development.

KEYWORDS

resources, assets, capital, aquaculture sea, right to use sea area, material agency

1 Introduction

Mariculture, as one of the earliest and most basic ways of using marine space, has a history of more than 3,000 years. Humans initially cultivated certain marine species for purposes such as medicine, rather than as a food supply (McKee, 1967). In the mid-20th century, as wild fishery resources declined, large-scale mariculture emerged. The State of World Fisheries and Aquaculture 2024 report, released by the Food and Agriculture Organization of the United Nations (FAO), shows that global mariculture production reached 130.9 million tons in 2022. Of this total, 52.4 million tons came from marine and coastal aquaculture (Food and Agriculture Organization of the United Nations, 2024). China's mariculture industry did not reach a significant scale until the mid-20th century. In the 1960s, overfishing led to a rapid decline in resources, and to address the shortage of seafood, various marine species, including large yellow croaker and shrimp, were incorporated into the list of cultivated species (McKee, 1967). At present, China has become the world's largest aquaculture country and the only country in the world where farmed aquatic products exceed wild-caught fish (Zhao et al., 2021). China's mariculture area reached 2,214.87 million hectares in 2023. Moreover, the output value of the mariculture industry was about 488.548 billion yuan (Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2024).

One distinctive feature of modern production modes is integrating nature, as different types of resources, into the capital circulation and expansion system. Capital appreciation is realized through the production and sale of related products. Harvey views this as a mode of accumulation with a completely new mechanism, which has spurred a wave of capitalization worldwide (Harvey, 2003). In this process, capital transforms nature, such as land, water, and minerals, into commodities that can be exchanged to address the crisis of over-accumulation (Guan and Li, 2022). According to Lefebvre, this represents a reorganization of spatial resources under the logic of capital, where natural space is viewed as a resource to be exploited for the accumulation and unlimited expansion of capital (Lefebvre, 1991). Marine space is also inevitably included in the global spread of the capital cycle, with the mariculture industry being a typical example.

The capitalization of space is the result and manifestation of the spatialization of capital. It explains how capital invades natural space and how natural space is transformed from an object utilized by capital to some kind of capital capable of producing surplus value by itself. Scholars focus their research on the capitalization of space in modern urban and rural areas, where capital invasion is prominent. They study how the capitalization of space drives the production of diverse urban and rural spaces, examining the processes and mechanisms behind the production of spaces for production (Huang et al., 2015; Yang et al., 2021) and consumption (Zhang and Wang, 2020; Tao et al., 2023; Zheng, 2023). The capitalization of land represents the earliest and typical form of the capitalization of natural space. There is a large body of related studies, with theoretical research focusing on defining and analyzing concepts such as land resources, land assets, and land capital (Zhang and Pang, 2016; Cheng et al., 2022). Empirical research focuses on the specific paths and modes of capitalization (Guo et al., 2016; Xia et al., 2020), the performance and mechanism of capitalization's driving economic development and urban-rural spatial reconfiguration (Chen et al., 2015; Gong et al., 2021; He et al., 2022; Liu et al., 2022) and other aspects. It is crucial to emphasize that the specific social structure and political-economic system constitute the particular background and conditions for the capitalization of space, significantly influencing its modes, paths, and effects. For example, within the context of 'strong government and weak society' in China, the influence of institutions in the capitalization of space is often more direct and potent compared to that of capital and social groups (Wang and Liu, 2011). A typical example is China's 'land for development' model, where local governments promote industrialization and urbanization by monopolizing and controlling land supply within the current land system (Yang and Fan, 2018).

Since the Industrial Revolution, human activities like the exploitation of natural resources and urban construction have primarily been located on land. The ocean's distinct natural characteristics and unsuitability as a habitat have further contributed to its peripheral status in research. As a result, the study of the capitalization of marine space has been neglected for a long time (Peters, 2010). From the perspective of human-ocean interaction, research on marine space has undergone three stages of evolution. Traditional research has positioned the ocean within the context of modern capitalist development. It has discussed the role of marine space as an essential component of trade routes, strategic space, fishing grounds, and supply chains (Campling and Colás, 2021). Since the 21st century, scholars like Steinberg have studied the role of human societies in constructing marine space. They analyze how people in different eras and geographic regions have shaped marine space's specific meanings and functions. In Micronesia, for example, marine space is considered as important as land. Micronesians view the ocean not only as a part of their lives but also as part of their territory. They incorporate it into their daily lives and social structures through sophisticated navigational techniques and social practices (Steinberg, 2001). Recently, with the development of new materialist thinking, there has been an emphasis on the role of marine space's material agency in human-ocean interactions. This has become an essential feature of studies on the 'oceanic turn.' These studies have particularly criticized the view of considering marine space as a collection of static bodies of water. Instead, they emphasize its dynamic material qualities, such as mobility and three-dimensionality (Steinberg, 2013; He et al., 2024). Researchers use theories like assemblage (Anderson, 2012; Bear, 2013) and actor networks (Lehman, 2013) to reveal how marine space's material agency influences modern societies' material and cultural practices.

These studies provide essential references for analyzing the capitalization of marine space. Aiming at China, which has the largest scale of mariculture in the world, this paper selects an island with mariculture as a pillar industry as a case site. It takes its mariculture industry as the research object. Based on consideration of the material agency of marine space, this paper discusses the realization process and mechanism of the capitalization of marine space in the mariculture industry, in light of China's specific political and economic environment. This paper aims to generate

the following scientific value: ①Integrating an analysis of the agency of material space into the traditional framework of the capitalization of space theory to enhance its theoretical explanatory power. ②Understanding the uniqueness of the Chinese model compared to other countries through an analysis of the processes and mechanisms of the capitalization of China's marine space. ③Providing practical insights for optimizing the model of the capitalization of China's marine space and its spatial planning and management.

2 Materials and methods

2.1 The concept of capitalization of marine space

The concept of capitalization of space can be traced back to Marx's discussion of the right to use natural space (right to use land) in his Capital. According to Marx's theory of land rent, during the early 'enclosure movement,' capitalists separated farmers from land ownership by controlling land space. Farmers then gained the right to use the land by paying rent, turning land space into a tool for capitalists to extract surplus value (Marx, 1867). This process endowed land with the attributes of capital. Subsequent academic definitions of the capitalization of space, particularly the capitalization of land, relate to the three attributes of land: resource, asset, and capital, as well as their transformation. For example, Guo Xu et al. define the capitalization of land in rural areas as the process of establishing standardized systems and measures to pave the way for rural land assets to enter the market and transform into capital to maximize their value (Guo et al., 2015). Gong Lijun believes that the capitalization of land involves transferring rural collective land property rights (either ownership or use rights) to generate income from land appreciation through various forms of property rights transfer, such as ceding, transferring, leasing, and shareholding (Gong et al., 2021).

Based on the previous discussion and the specific practice of China's aquaculture sea use, this paper defines the capitalization of marine space as a process where the right to use sea area is transferred by the rights holders through methods such as transfer, lease, or shares and is ultimately put into production as a means of production to realize the creation of capital value and surplus value Figure 1. In the process, marine space undergoes a series of transformations from natural space to space resources, space assets, and space capital, leading to its value addition. Marine space resources are marine space that can be used to create economic value, emphasizing their economic attributes. Marine space assets are resources attributable to a particular economic entity or entities that can bring about a certain amount of income, emphasizing the property rights attribute. The capitalization of marine space is realized when marine space assets are put on the market at a specific price and utilized in production to obtain profits, emphasizing the value-added property. The capitalization of ocean space is a dynamic and continuous process. Essentially, it is a process based on the (re)definition and transaction of marine spatial rights, where these rights participate in production and generate added value. The corresponding benefits are then (re) distributed according to the specific rights relationships of the relevant stakeholders.

2.2 Case presentations and sources of information

Guanglu Island is located in the northern part of the Yellow Sea, the western part of the outer Changshan Islands, belonging to Changhai County, Dalian City, Liaoning Province. Located at 39 degrees north latitude on the east coast of the Liaodong Peninsula, Guanglu Island benefits from the mix of freshwater from mainland rivers and salty seawater. This results in fertile seawater with low temperatures, abundant nutrient salts, organic matter, and primary bait. These conditions are ideal for the habitat and breeding of shallow sea fish, shrimp, shellfish, sea cucumbers, and other marine organisms. The mariculture industry on Guanglu Island primarily focuses on floating raft mariculture of shellfish and bottom mariculture of sea cucumbers. The island produces a large quantity of shellfish and sea cucumbers, which are notable for their size and quality. This has earned Guanglu Island the reputation of 'the hometown of sea cucumbers and the base of oysters' Figure 2. The island hosts 81 mariculture enterprises and 1,900 individual households, employing over 3,000 people (including more than 1,600 floating population). The mariculture scale spans approximately 24,000 hectares, with an annual collection of sea area usage fees amounting to about 35.92 million yuan. This indicates that Guanglu Island's mariculture industry has a large production scale and high output per unit of sea area, demonstrating evident characteristics of the capitalization of marine space.

The data in this paper comes from the township records of Guanglu Island, statistical bulletins, government websites, and semi-

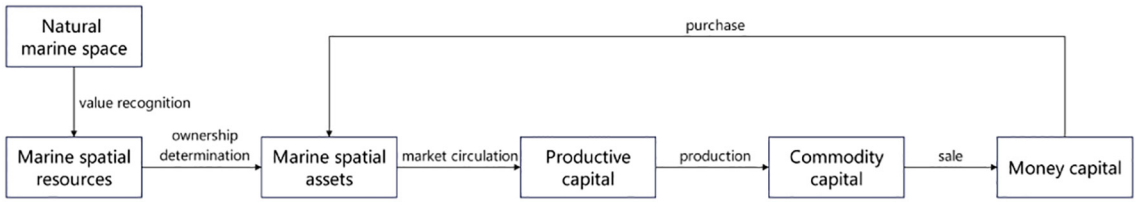

FIGURE 1
The concept of capitalization of marine space (Photo source: Self-made by the authors).

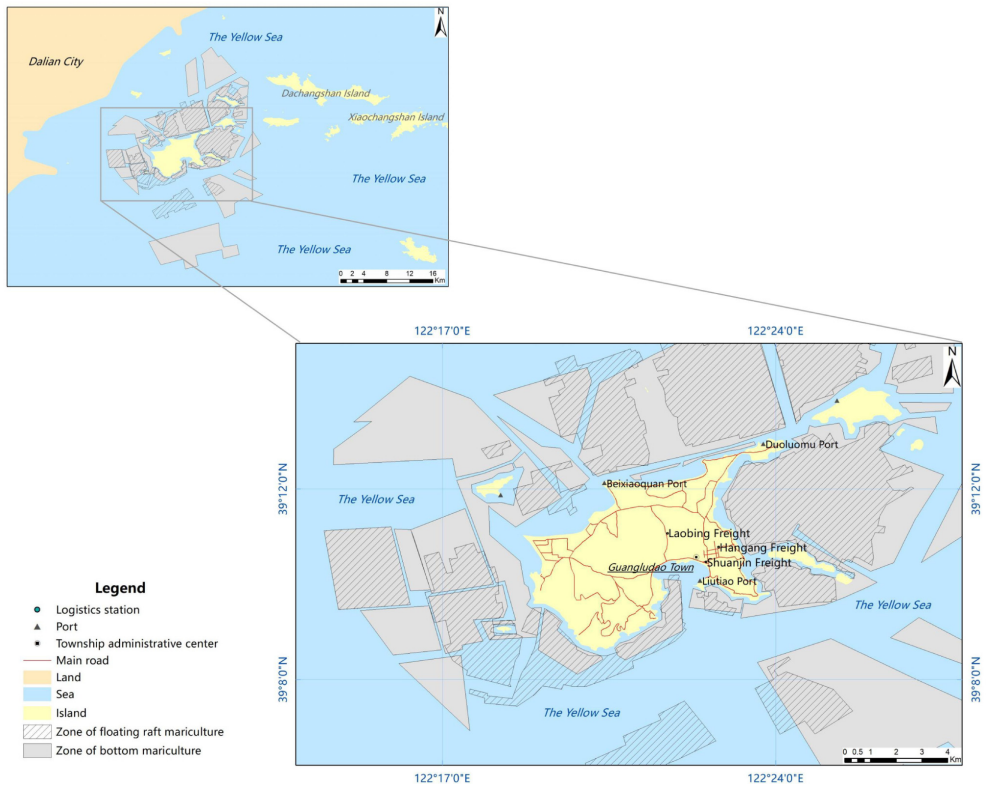

FIGURE 2
General situation of Guanglu Island and distribution of surrounding aquaculture sea (Photo source: Self-made by the authors).

structured interviews. From April to November 2023, the research group went to Guanglu Island for five rounds of field research and selected 33 relevant personnel of the mariculture industry to conduct semi-structured interviews, including 3 government workers, 18 mariculture fishermen and enterprise leaders, 6 logistics practitioners, and 6 other relevant practitioners. The interviews with aquaculture fishermen and enterprise leaders mainly include the acquisition and transfer of the right to use the sea area for aquaculture and the production process of mariculture. The interview content of logistics practitioners mainly includes the entrusting party, mode, and destination of aquaculture seafood transportation. Interviews with other relevant practitioners mainly included the status quo of mariculture in Guanglu Island. The interview time ranged from half an hour to two hours.

3 The process of the capitalization of marine space

3.1 Conversion of natural marine space into marine space resources

The transformation of natural marine space into natural resources requires two prerequisites. First, humanity must recognize that marine space can be utilized as a means of production to engage in economic activities and create value. In the context of mariculture, this means that the marine space can be utilized for fish farming to generate profits. Second, there needs to be recognition of the scarcity of marine space, meaning that marine space is limited relative to the human need to obtain its value (Wei and Wei, 2013). These two points have led to the human motivation to appropriate marine space and benefit from its utilization.

Guanglu Island's marine area has significant comparative advantages, with its expansive size and high-quality water bodies making it highly suitable for mariculture sites. In the 1950s, aiming to diversify the marine fishing industry, Guanglu Island Commune, under the unified direction of the Changhai County Government, decided to embark on the development of the mariculture industry. From this starting point, mariculture gradually developed into the mainstay industry of Guanglu Island. This shift in perception and action marked a significant change from the past, where naturally grown fish in marine space were only harvested as a resource. It signified the recognition of marine space itself as a valuable resource capable of supporting marine fisheries production, thus transforming from natural marine space into marine space resources.

Utilizing marine space as a resource for mariculture also necessitates the development of supporting infrastructure and the training of mariculture labor for its production and reproduction. In practice, the government of Guangludao Town invested in the construction of Liutiao Port and Duoluomu Port, while the Dalian Port Group invested in the construction of Beixiaoquan Port. The town government is also responsible for constructing and maintaining the island's main roads and side roads. Additionally, enterprises and individual residents have invested in constructing cold storage

facilities and cargo terminals, such as Shuanjin Freight and Hangang Freight. These facilities link Guanglu Island's fishery production activities to a more expansive geographical space, facilitating the capitalization of marine space and improving its efficiency.

In disseminating and updating mariculture knowledge, besides traditional communication among fishermen households and individuals, the Guangludao Town government partners with local fisheries authorities, county fisheries, and marine bureaus, and other relevant units. They invite experts and scholars to give lectures and utilize downtime in offshore mariculture for training sessions on mariculture techniques. Additionally, the town government established a mariculture association to foster mutual assistance among fishermen, facilitate the exchange and learning of mariculture techniques, and organize representatives of mariculture fishermen and the association's leaders to participate in external visits and learning opportunities. At the same time, the government of Guangludao Town has assisted the Fisheries Mutual Insurance Association of the Ministry of Agriculture of the People's Republic of China in promoting fisheries insurance and encouraging mariculture fishermen to take out insurance. The enhancement of fishermen's skills and labor security continues to support mariculture fishery production, thereby accelerating the capitalization of marine space.

3.2 Transformation of marine space resources into marine space assets

At the core of transforming marine space resources into marine space assets lies the determination of ownership attribution. This means that ownership of marine space resources is an asset attributed to the subject. By virtue of their ownership, these subjects also possess the right to use marine space. The separability of the ownership from the right to use facilitates the circulation of the right to use and its combination with other means of production to bring out its use value. This process promotes the capitalization of marine space. Property owners may opt to transfer the right of use, thereby realizing the exchange value of marine space through the outflow of its utility value. The right to use sea area is an intangible marine space asset each property owner holds in the circulation process. The circulation of the right to use can occur in one transaction or be subdivided multiple times before reaching mariculture fishery producers, where it is transformed into a means of production. The forms of circulation mainly include transfer, leasing, and equity investment.

The state owns the aquaculture sea of Guanglu Island. The Changhai County Marine and Fisheries Bureau (CMFB) manages the ownership and right to use the sea area on behalf of the state, per relevant provisions of the "Law of the People's Republic of China on the Management of Sea Area Use." Relying on the right to use sea areas as an indispensable production condition for mariculture production, Guanglu Island's aquaculture sea has become an asset for the CMFB to obtain a fixed income. The CMFB has established a three-dimensional layered rights framework for aquaculture sea based on different mariculture methods. This includes setting up the right to use sea area for floating raft mariculture, utilizing the water surface and part of the water body space, as well as the right to use sea area for bottom mariculture, utilizing the seabed and the adjacent water body space. Due to the difference in the mode of use and value-added potential, the acquisition method and the price of sea area usage fees differ between the two types.

The right to use sea areas for floating raft mariculture was acquired in two ways. The first method is the continuation of use by the original operator after the nationalization of the ownership of sea areas, which represents a continuation and alteration in the allocation of marine space under the planned economic system. After the dissolution of the Guanglu Production Team in 1983 and the reform of the property rights system of villages and major mariculture companies in 1996, all the rafts originally owned by these collective economic organizations, along with the sea areas, cultured products, and semi-finished products, were either priced for sale or contracted out, and transferred to individual ownership. All sea areas were nationalized after implementing the "Law of the People's Republic of China on the Management of Sea Area Use" in 2003. So, for the parts of the sea areas owned initially by individuals that comply with the marine function zoning, the right to use them remains with the original owners after approval by the CMFB, provided they continue to pay the annual sea area usage fee to the Bureau. The second type of the right to use sea area for floating raft mariculture is distinctly characterized by marketization. Local fishermen obtain this right by applying to the CMFB and paying an annual fee of RMB 80 per 0.067 hectares (the price varies according to specific conditions each year, sometimes even allowing for reductions or exemptions) for using sea area.

Since bottom mariculture sea areas in Changhai County are primarily used for cultivating valuable marine species, which yield significant economic benefits, the government has mandated that the right to use this kind of sea area can only be acquired by enterprises through competitive bidding at the CMFB. Most of the right to use sea areas for bottom mariculture sea in Guanglu Island is transferred to local fishermen after winning the bidding by Guanglu Fishery Industry and Commerce Corporation. The company is a collective economic organization established in the 1980s when the government separated from the community and abolished the commune system to establish a township. It is currently managed and operated by the Guangludao town government. While they differ in name and function, they share management and operational resources, fostering an economic interdependence. After winning the bid organized by the CMFB, Guanglu Fishery Industry and Commercial Corporation annually pay sea area usage fees per mu based on their bidding price, thus obtaining the right to use sea areas for bottom mariculture. However, Guanglu Fishery Industry and Commercial Corporation does not produce mariculture. Instead, they divide the acquired bottom mariculture sea into different sections based on latitude and longitude coordinates. They subsequently transfer the right to use these sea areas to the island's fishermen at different prices, depending on the seawater fertility of each area. The right to use sea areas for a small portion of Guanglu Island's bottom mariculture sea was awarded to other private aquaculture enterprises that participated in the bidding process and won the bid.

Based on the separation of ownership and use rights and relying on the transfer policy of the CMFB, the aquaculture sea undergoes a

series of processes to eventually reach mariculture enterprises and fishermen. This removes obstacles to the marine space being utilized in mariculture as a means of production, thereby creating value.

3.3 Participation value and surplus value creation of marine space assets

Integrating marine space into the mariculture production process as a means of production is the final step in its capitalization. This step is the one that realizes value and surplus value creation, and thus the purpose of capitalization. In the case of aquaculture, in addition to the acquired marine space, monetary capital also needs to purchase other means of production and thus be converted into productive capital. Through mariculture, productive capital is converted into commodity capital in the form of farmed seafood. After the sale, the commodity capital is converted back into money capital, realizing capital appreciation and recycling and preparing for the next round of capital recycling.

During the purchase stage, aquaculture capital purchases means of production and labor in monetary terms, transforming money capital into productive capital. The means of production purchased by floating raft mariculture fishermen include marine space (the right to use sea area), shellfish fry, fishing boats, hanging cages, etc. Figure 3. Shellfish seedlings are purchased from southern provinces such as Fujian and Shandong and transported back to the island by boat. Seedlings from the southern seas must acclimate to lower sea temperatures in Shandong waters before being transported back to the island. Other means of production, such as fishing boats and hanging cages, are purchased at fishery stores on the island or through the Internet. Floating raft mariculture fishermen and temporary laborers hired during busy fishing seasons for seeding, transplanting, and harvesting, constitute the labor force. The means of production purchased by bottom mariculture fishermen and enterprises include marine space (the right to use sea area), sea cucumber seedlings, and fishing vessels. There are two sources of sea cucumber seedlings: during the sea cucumber breeding season, fishermen and enterprises hire divers to pick up adult sea cucumbers from their waters, where they are bred into juvenile seedlings in cages; alternatively, to pick up juvenile seedlings in public waters directly. Other means of production, such as fishing boats, are also purchased at the island's fishery stores or through the Internet. The labor force required for production in bottom mariculture consists of fishermen, company employees, and temporary workers hired during the production process.

In the production stage, mariculture enterprises or fishermen put relevant means of production and labor into the production process, facilitating the transformation of productive capital into marketable fishery commodities. Shellfish seedlings, according to their species and growth habits, are placed at different depths of the sea in temporary hanging cages. Once the seedlings have naturally grown to a certain extent, they are moved to different cages for further growth. This process of transferring and subdividing continues until they reach a suitable size for harvesting Figure 4. Sea cucumber fry is sown on the seabed reefs. Once they have grown to a specific size naturally, they are harvested by divers. During the growth process of the fry, the three-dimensional marine space not only provides them with an environment that includes water temperature, water quality, and light but also supplies food necessary for their growth. In addition, to ensure the normal growth of fry, producers usually need to check for any signs of illness, deformities, or deaths caused by environmental impacts such as red tides. Producers should also inspect the wear and tear of production tools, such as the condition of float buoyancy and cage corrosion, to address any severe damage by repairing or replacing them promptly. During the production process, the value of the depletion of marine space and other labor resources, and the value created by related laborers such as mariculture fishermen, hired laborers, and divers, are continuously incorporated into shellfish and sea cucumber seedlings, which are the object of labor. This process transforms their physical forms into farmed seafood ready for sale.

FIGURE 3
Means of production: fishing boats (Photo source: Shoot by the authors).

FIGURE 4
Empty the cage and separate the seedlings of oysters (Photo source: Shoot by the authors).

In the selling stage, mariculture enterprises and fishermen transform from commodity capital to money capital by selling farmed seafood. There are two types of sales channels for shellfish on Guanglu Island. The first involves intermediaries purchasing shellfish on the island and then transporting them to processing plants and markets outside the island through its logistics station Figure 5. In this sales channel, enterprises, fishermen, and traders typically maintain long-term cooperation and stable relationships with the off-island market, establishing it as the primary distribution channel for shellfish. The second type consists of itinerant mobile external merchants who, after agreeing on price and quantity with mariculture enterprises and fishermen, organize the transportation of products to the off-island market or proceed with further processing. Most farmed sea cucumbers on the island are purchased by the Xiaoqin Sea Cucumber Company in Dalian, and the mariculture enterprises sell the rest. At the point of sale, farmed seafood is converted into money, realizing the creation of value and surplus value, thus setting the stage for the next round of the capital cycle Figure 6. It is noteworthy that due to differences in the tenure of the right to use sea area among various mariculture producers, as well as variations in the timing of stocking and harvesting of different species of mariculture seedlings, multiple asynchronous cycles of capital circulation in mariculture have formed. These cycles constitute the overall capital circulation of the mariculture industry on Guanglu Island.

4 Subjective roles and mechanisms in the capitalization of marine space

4.1 The material agency of marine space determines the possibilities of its own capitalization and the specific ways of realizing it

The capitalization of marine space is not merely a human-dominated process of transforming marine environments; instead, it is a dynamic process where marine space serves as a crucial 'agency' element (Blum, 2010). As a participant in the capitalization process, marine space not only largely determines the possibility of its capitalization but also plays a decisive role in shaping the specific ways this process is realized.

FIGURE 5
Logistics station to transport farmed seafood (Photo source: Shoot by the authors).

Firstly, the precondition for the capitalization of marine space through mariculture is that marine space can be used for aquaculture and continue to generate economic benefits. This depends on the suitability of the dynamic and stable environment formed by the variety of substances in the marine space to the aquaculture species. The marine area around Guanglu Island has optimal physical and chemical properties such as water temperature, water quality, and salinity. These conditions provide suitable and high-quality environments for mariculture species like oysters, Japanese scallops, and sea cucumbers. Additionally, they contribute to forming a marine ecosystem with regulatory functions. These natural attributes ensure marine space can be utilized for mariculture, sustaining continuous economic value.

Secondly, marine space's three-dimensional structure and heterogeneous composition determine the specific implementation of its capitalization in Guanglu Island's mariculture industry. This includes aspects such as establishing and pricing the right to use sea area and the methods of mariculture. The three-dimensional marine space can be divided into four spatial layers: surface, water column, seabed, and subsoil. In the same sea area, the difference in water temperature, water flow, pressure, and other environmental conditions in different spatial layers determines the difference between cultured varieties and their economic benefits. The CMFB has thus established rights to use sea areas in three-dimensional layers, stipulating that the right to use sea areas in different layers has different prices. The non-homogeneous nature of marine space, being a mixture, dictates significant variability in seawater fertility (the abundance of nutrients necessary for fish growth) across different sea areas. More fertile sea areas yield higher output, with resulting excess profits transformed into sea area usage fees, producing what is termed as 'differential land rent I' (Marx, 1867). In practice, the CMFB sets the initial auction price for the right to use sea areas in bottom mariculture, and the Guanglu Fishery Industry and Commercial Corporation determines the contractual price for these rights. Both use seawater fertility as a critical reference index.

Finally, marine space is categorized from the mainland into near-shore and far-shore based on proximity to the coast. The varying sea conditions in these areas determine specific mariculture methods and input costs. In the near-shore area, where wind and waves are minimal, basic floating net boxes or rafts are typically used for mariculture. In offshore areas farther from the coast, where wind and waves are more robust and waters are more profound, large-scale mariculture equipment such as gravity-based net cages, framework net cages, mariculture platforms, and mariculture vessels are primarily used. These rely on mechanized, automated, and intelligent equipment technologies to adapt to offshore environments' high waves and strong currents. Mariculture zones around Guanglu Island primarily concentrate in near-shore areas with calm sea conditions. This leads to hanging cage floating raft mariculture and natural spatial bottom mariculture as the main farming methods.

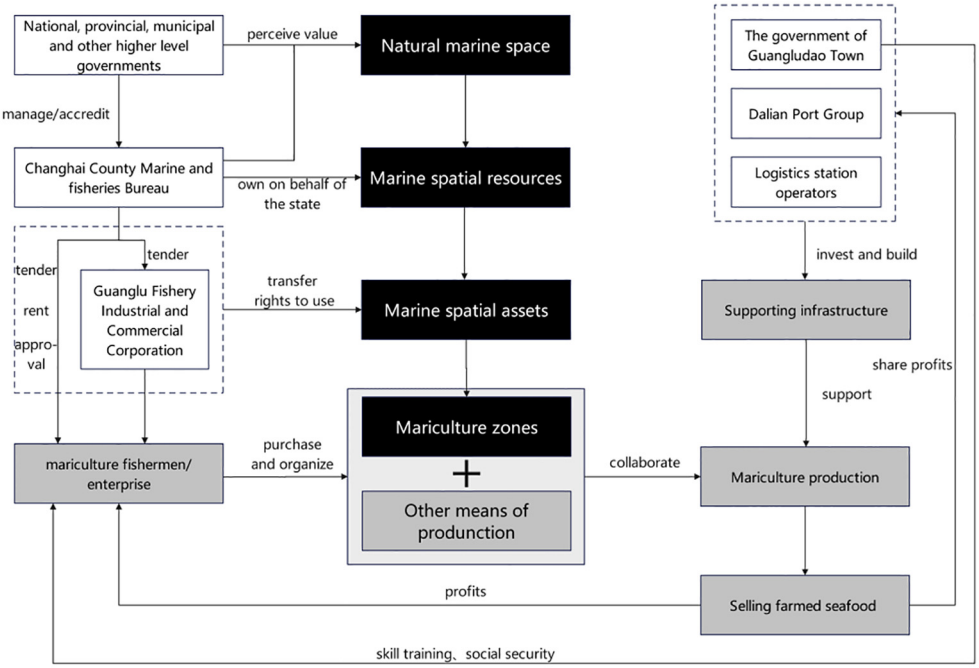

FIGURE 6
The process of capitalizing the marine space of Guanglu Island (Photo source: Self-made by the authors).

4.2 Driven by survival and profit, aquaculture fishermen and enterprises promote the realization of the capitalization of marine space

The survival and profitability requirements of mariculture fishermen and enterprises drive the capitalization of marine space in Guanglu Island's mariculture industry. The pursuit of economic profit by local fishermen and enterprises has gradually shifted the focus from traditional fishing to mariculture as the primary industry on Guanglu Island, resulting in higher economic benefits. This shift is a continual search by capital for new value-added spaces, moving away from the singular commoditization of natural materials to the capitalization of natural space by incorporating it into the profit-seeking system of capital. For artisanal fishermen, the occupational choices crucial for their survival are inseparable from the kinship and social relations within which they are embedded. The traditional mariculture industry on Guanglu Island operates primarily as a family-based business unit. This setup facilitates the transfer of tangible and intangible resources such as the right to use sea area, mariculture production means, knowledge, and skills from fathers to sons through kinship ties. As a result, the mariculture industry has become a preferred employment choice for the island's residents.

For capital-oriented mariculture companies, the pursuit of profit is the primary motivation driving their involvement in mariculture production. Relying on the spatial resource endowment in the sea area, productive infrastructure, and labor resources, the enterprise carries out large-scale mariculture fishery production to capitalize on marine space and generate profits. Moreover, the scale effect resulting from enterprises pursuing profits has spurred innovations in mariculture techniques and management models, contributing to developing a comprehensive economic ecosystem and significantly enhancing the capitalization of marine space.

4.3 Driven by development, the government builds a framework, provides services for the capitalization of ocean space, and participates in profit-sharing

Today, economic development has become a core priority for China's central and local governments, with marine space serving as a crucial means to achieve this goal. Regimes and policies related to marine space establish the principles and guidelines for its specific utilization, serving as tangible expressions of the state's development intentions. Specifically, the sea area management system, anchored by laws such as the 'Law of the People's Republic of China on the Management of Sea Areas' and policies like the 'Opinions on Compensatory Use of Sea Areas and Uninhabited Sea Islands,' enables extensive government participation in the process of the capitalization of marine space. The relevant laws stipulate that China operates a public ownership system of sea areas, where individuals or entities may acquire the right to use sea areas through application, tender, or auction with compensation from the competent ocean administration department of the government at or above the county level. The use of sea areas must adhere to ocean and sea functional areas planning. Therefore, the CMFB is the actual monopolist of the

primary supply market of the aquaculture sea area on Guanglu Island. As the contracting party in the initial transaction of the right to use the sea area, it has absolute control over the ownership, circulation, and use of the right to use the sea area. In practice, the CMFB publicizes the supply and demand of the right to use sea area and ownership information. It also establishes pricing standards for these rights by relevant national and Dalian municipal regulations and oversees their trading and usage. The central and local governments ensure that the capitalization of marine space aligns with national and local development strategies by establishing frameworks and overseeing the concrete implementation process.

In addition, promoting local economic development is a core element of local government assessment and an essential source of government finance. Mariculture on Guanglu Island is the region's traditional pillar industry and the core industry that the town government prioritizes in promoting local economic development. To this end, the town government has consistently supported the capitalization of marine space through fixed capital investments in improving the production environment and infrastructure and labor reproduction investments in upgrading workforce quality and ensuring labor welfare. On the other hand, it also participates in the distribution of the value created by mariculture through the market-based allocation of the right to use sea area, thereby securing a certain amount of fiscal revenue.

5 Results

In the context of economic globalization led by neoliberalism, the capitalization of marine space has become a global phenomenon, and it shows variability in the social structures and political and economic systems of different countries. The maritime management systems of most Western countries are decentralization systems and emphasize the role of market mechanisms in resource allocation (Zhang and Chen, 2022). Under this marine management system, the capitalization of marine space shows the characteristics of high marketization. In contrast, in China, the ownership of sea areas is vested in the state, and the government holds exclusive monopolistic rights over the acquisition, and transfer of the rights to use sea areas. This system allows the government to play an important role in the capitalization of China's marine space. This paper focuses on this unique model of the capitalization of marine space, discusses its specific realization path in the mariculture industry, and deeply analyzes the role of various subjects in this process. The main conclusions are as follows:

Firstly, the capitalization of marine space involves a series of processes that transform natural space into marine resources, assets, and production inputs used as means of production. (1) When the waters of Guanglu Island began to be recognized as a resource for marine fishery production, the natural marine space was transformed into marine space resources. (2) The right to use sea areas as an indispensable production factor in the mariculture industry has been transferred from the CMFB to mariculture producers through one or multiple transactions. The sea areas become marine space assets for each property rights holder during circulation. (3) The mariculture fishery producers of Guanglu Island ultimately employ the right to use sea areas and other means of production in the production process to generate value and surplus value, thus achieving the capitalization of marine space.

Secondly, the capitalization of marine space results from the joint actions of multiple subjects such as marine space, mariculture fishermen and enterprises, and government agencies at different levels. (1) The physical and chemical properties of the water temperature, three-dimensional, and fluidity of the Guanglu Island sea area are the prerequisites for mariculture and also determine the concrete realization of the capitalization of marine space in the mariculture industry. Incorporating the material agency of marine space into the analysis framework of the capitalization of marine space not only enhances the explanatory power of this theory but also is an attempt to break through the duality between humans and nature. (2) The fishermen and enterprises of Guanglu Island carry out mariculture production under the demand of survival and profit, which is the main driving force for realizing the capitalization of marine space. (3) China's central and local governments regard marine space as a crucial carrier for achieving economic development goals. They not only ensure the smooth capitalization of marine space through institutional policies and concrete practices but also share the benefits generated by the process.

6 Discussion

The government is the single supplier in China's primary trading market for the right to use sea area, providing these rights to individuals or units through applications and competitive bidding. The auction of the right to use sea area is characterized by transparent results but opaque procedures. The government retains discretion over bidder qualifications and access conditions, holding centralized authority as a transaction participant and a regulatory overseer. Although auctions are held for the right to use sea areas, the government may seek rent at various stages, such as during the construction of trading platforms and the transfer of property rights. The Changhai County government's restriction on the qualifications of bidders for the right to use sea areas for bottom mariculture, allowing bids only from companies, suggests potential rent-seeking behavior by the county government. Hence, establishing a robust intermediary organization to assess the transfer price of the right to use sea area and disclose transaction information can share governmental functions and mitigate the risk of government rent-seeking. This also signifies an important step toward the maturity of the market economy.

Leasing the right to use sea area is the most common method of transferring aquaculture sea areas. In this arrangement, driven by market interests or government guidance, the owner of the right to use sea areas leases the area to a lessee, who pays rent to the lessor. This model is currently the predominant approach for the capitalization of marine space in China, favored for its operational simplicity and stable income for the lessor. However, with the development of the capitalization of marine space, although lessors can derive some income from leasing the right to use sea area, this income is relatively limited and has gradually failed to meet their expectations

of using marine space as a capital element for capital appreciation. Therefore, the introduction of social capital and the string of financial and securities industries have become new explorations for the capitalization of marine space. This may include the implementation of mariculture area securitization, the issuance of mariculture area income as a security, introducing social idle and scattered capital to invest in aquaculture sea areas, establishing a financing system such as aquaculture marine banks to reduce the financing costs and risks of mariculture fishermen. These changes will undoubtedly alter how the capitalization of marine space will take place in the future.

Traditional economic growth theories usually regard resource and ecological environment factors as exogenous variables and focus on the pursuit of maximizing economic welfare. However, this growth model is often accompanied by resource consumption and environmental costs and fails to fully consider the constraints and sustainability of natural capital. In the mariculture industry of Guanglu Island, local fishermen, due to a lack of experience and driven by interests, blindly increase the density of aquaculture, which leads to the decline of seawater fertility and ecological environment problems such as seawater eutrophication. The key to solving this contradiction is to promote the green development of the mariculture industry to achieve the coordination of ecological environment protection and sustainable industrial growth. To this end, it is necessary to adopt the concept of green development, encourage the application of green aquaculture technology, and strengthen the Marine environment monitoring and early warning mechanism to ensure timely response to ecological problems.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TL: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. YW: Conceptualization, Data curation, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. SZ: Data curation, Investigation, Visualization, Writing – review & editing. PX: Data curation, Investigation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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