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Policy, Practice, and Prospects of China's Marine Carbon Sink Trading: Postprint

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Abstract

Ocean carbon sink trading constitutes an intrinsic requirement and effective mechanism for advancing strategies such as marine ecological civilization construction and maritime power development. This article analyzes and compares the policies and practices of ocean carbon sink trading in China, and provides prospects for its future development. The results indicate that under the framework of carbon market construction and the “dual carbon 1+N” policy, the top-level institutional framework for ocean carbon sink trading in China has begun to take shape, specifically manifested in: the promulgation and implementation of multiple ocean carbon sink standards at the national level; at the local level, certain regions have issued and implemented accounting guidelines or methodologies for typical ocean carbon sink trading, with operational policies being gradually constructed; and individual regions have launched exploratory practices in ocean carbon sink trading, involving trading subjects such as mangroves, bivalve shellfish, macroalgae, and salt marshes, as well as trading methods including direct purchase, insurance participation, pledge loans, and auctions. China's policy norms and exploratory trading in ocean carbon sink have accumulated valuable experience for more standardized ocean carbon sink trading in the future. However, factors such as imperfect trading processes, non-standardized review and reporting, lack of supervised platforms, and generally low prices have diminished the role that ocean carbon sink should play in optimizing carbon resource allocation and facilitating the transformation and upgrading of the blue economy. To this end, the article proposes recommendations for advancing the future development of ocean carbon sink trading: integrating ocean carbon sink into the trading system centered on China Certified Emission Reduction (CCER), accelerating the development of standards and methodologies to improve operational policies, improving trading processes, perfecting methodologies, diversifying entities, and conducting targeted practices.

Full Text

Trading Policy, Practice and Prospect on Marine Carbon Sequestration in China

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Abstract

Marine carbon sequestration trading is an inherent requirement and effective mechanism for advancing marine ecological civilization and maritime power strategies. This paper analyzes and compares China's marine carbon sequestration trading policies and practices, and provides future prospects. The results indicate that under the carbon market construction and the "Dual Carbon 1+N" policy framework, China's top-level system for marine carbon sequestration trading has begun to take shape. At the national level, multiple marine carbon sequestration standards have been introduced and implemented. At the local level, some regions have issued and implemented accounting guidelines or methodologies for typical marine carbon sequestration transactions, with operational policies being gradually constructed. Individual regions have conducted exploratory practices in marine carbon sequestration trading, involving transaction targets such as mangroves, bivalves, macroalgae, and salt marshes, as well as transaction methods including direct purchase, insurance participation, pledged loans, and auctions. China's policy standardization and exploratory trading of marine carbon sequestration have accumulated valuable experience for more standardized marine carbon sequestration trading in the future. However, factors such as incomplete transaction processes, non-standard verification and reporting, lack of supervisory platforms, and generally low prices have diminished the role that marine carbon sequestration should play in optimizing carbon resource allocation and transforming the blue economy. Therefore, this paper proposes recommendations for advancing future marine carbon sequestration trading development: integrating marine carbon sequestration into the China Certified Emission Reduction (CCER)-centered trading system, accelerating the development of standards and methodologies to improve operational policies, improving transaction processes and methodologies, diversifying participants, and conducting targeted practices.

Keywords: marine carbon sequestration trading, marine carbon sequestration policy, carbon trading policy, blue carbon trading, marine ecological restoration

The Potential of Marine Carbon Sequestration

The development of marine carbon sequestration potential is an inevitable choice and effective pathway for humanity to address climate change and for economies to achieve carbon peak and carbon neutrality (hereinafter referred to as “Dual Carbon”) goals. In terms of carbon pool volume, the ocean is the world’ s largest carbon sink, with carbon storage of approximately 39 trillion tons—20 times that of terrestrial carbon pools and 50 times that of atmospheric carbon pools. Marine ecosystems sequester 55% of global carbon, with oceans absorbing about 30% of CO₂ emitted into the atmosphere by human activities annually. In terms of efficiency, biological carbon sequestration per unit area of ocean is 10 times that of forests and 290 times that of grasslands [1,2]. Regarding resource endowment, approximately 70% of Earth’ s surface is ocean, and China possesses about 3 million square kilometers of claimed jurisdictional sea area and 18,000 kilometers of continental coastline, indicating abundant marine carbon sequestration resources and tremendous potential. In terms of carbon sequestration technology, with the development of the Microbial Carbon Pump (MCP) theory, in addition to traditional marine ecosystem restoration (such as mangrove, seagrass bed, and salt marsh restoration and protection) for enhanced carbon sequestration, land-sea coordination, marine negative emissions, and ocean alkalization have also been formally incorporated into the marine carbon sequestration framework system. Internationally, the United States, Indonesia, Kenya, Madagascar, and Senegal have all planned to advance or have already implemented marine carbon sequestration trading projects.

China’ s total carbon emissions are approximately 10.4 billion tons, with a potential carbon sink demand for offsetting of about 400 million tons, while the amount of carbon sinks issued domestically is nearly exhausted. Therefore, China has a strong demand for marine carbon sequestration trading with high efficiency and great potential. Against the backdrop of China’ s “Dual Carbon” goals, marine ecological civilization construction, and maritime power strategy, trading policies and practices remain in the initial exploration stage as an effective means to realize marine carbon sequestration value and restore and protect marine ecosystems, urgently requiring strengthened research [3,4]. This paper summarizes and analyzes relevant policies and exploratory practices of China’ s marine carbon sequestration trading, and proposes strategic recommendations based on practical needs and existing challenges to provide references for building a feasible trading mechanism for capitalizing marine carbon sequestration and coordinating the advancement of “pollution reduction, carbon reduction, green expansion, and growth” and “Dual Carbon” goals.

1. Current Status of China’ s Marine Carbon Sequestration Trading Policies

China’ s marine carbon sequestration trading policies can be broadly divided into two categories: (1) **Institutional policies**, which focus on the overall lay-

out of the national carbon trading market (hereinafter referred to as the “carbon market”) and provide directional or principal policies that create institutional possibilities for marine carbon sequestration trading, primarily reflected in carbon market systems and national top-level policies related to marine carbon sequestration; and (2) **Operational policies**, which focus on practical implementation and provide operational guidelines for marine carbon sequestration trading, primarily reflected in marine carbon sequestration trading procedures, assessment standards, and methodologies.

1.1 Institutional Policies for Marine Carbon Sequestration Trading

China’s marine carbon sequestration trading can be examined from two dimensions. First, the **market space dimension**: the carbon market is divided into national and regional categories, evolving from regional pilot programs to the current coexistence of national and local carbon markets. Second, the **trading target dimension**: China’s carbon market is divided into two types—the mandatory Carbon Emission Allowance (CEA) trading market and the voluntary China Certified Emission Reduction (CCER) trading market [5], which has mainly experienced a development process where the carbon emission rights market took the lead, followed by coexistence of both, and then a single carbon emission rights market.

Currently, China lacks a national-level CCER trading system for marine carbon sequestration. Theoretically and institutionally, marine carbon sequestration belongs to the CCER trading market. However, due to issues such as non-standard early-stage trading and limited contribution to policy goals, this market was closed in 2017, halting incremental business related to CCER trading. Because of insufficient basic research on marine carbon sequestration and incomplete assessment standards and methodologies, marine carbon sequestration had not yet been incorporated into the CCER market in early practices [3,4]. Nevertheless, as the national carbon market construction advances, China’s CCER trading market is being improved based on previous experiences and is about to restart.

Institutional policies for integrating marine carbon sequestration into carbon offset mechanisms are continuously improving. Carbon offset mechanisms are a set of standards formulated by an organization, primarily used for monitoring, regulating, and reviewing the registration of voluntary emission reduction projects and the trading of voluntary emission reductions. Although marine carbon sequestration has not yet been incorporated into the carbon market or CCER market, relevant national policies have already established it as an important component of China’s climate change response and carbon offset efforts. Specifically, in 2012, the State Council issued the *National Marine Economic Development “Twelfth Five-Year” Plan*, which first explicitly proposed the concept of marine carbon sequestration in China [6] and gradually launched ecological restoration actions with marine carbon sequestration effects domestically. In 2015, the CPC Central Committee and the State Council is-

sued multiple documents including the *Opinions of the CPC Central Committee and the State Council on Accelerating Ecological Civilization Construction* and the *Overall Plan for Ecological Civilization System Reform*, which explicitly proposed increasing marine carbon sequestration as an effective means to control greenhouse gas (GHG) emissions, exploring marine carbon sequestration pilots, and intensifying marine ecological restoration with carbon sequestration effects.

In 2016, marine carbon sequestration was formally incorporated into the *People's Republic of China First Biennial Update Report on Climate Change* (Chapter 5) and submitted to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) in 2017 [7,8], marking marine carbon sequestration as an important component of China's carbon offset efforts. Marine carbon sequestration trading has become an institutional policy for achieving the top-level design of the "Dual Carbon" goals. In 2020, China explicitly proposed the "Dual Carbon" goals, and the gradually improved "1+N" policy system has made systematic arrangements for marine carbon sequestration trading. The "1" refers to the national-level *Opinions of the CPC Central Committee and the State Council on Completely, Accurately, and Comprehensively Implementing the New Development Concept to Achieve Carbon Peak and Carbon Neutrality* and the *Action Plan for Carbon Peak Before 2030*, which provide systematic planning and overall deployment for the "Dual Carbon" work. These documents explicitly propose overall advancement of marine ecosystem protection and restoration, including: enhancing the carbon sequestration capacity of mangroves, seagrass beds, and salt marshes; improving carbon sequestration statistical monitoring capabilities for oceans and other ecosystems; incorporating carbon sequestration trading into the national carbon trading market; and vigorously promoting low-carbon agricultural models such as offshore wind power + marine ranching. On this basis, "N" policies for relevant departments or regions have also been issued, such as the *14th Five-Year Plan for Marine Ecological Environment Protection* jointly issued by the Ministry of Ecology and Environment, the National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Transport, the Ministry of Agriculture and Rural Affairs, and the China Coast Guard; the *Implementation Plan for Consolidating and Enhancing Ecosystem Carbon Sink Capacity* jointly issued by the Ministry of Natural Resources, the National Development and Reform Commission, the Ministry of Finance, and the National Forestry and Grassland Administration; and the *Shandong Province Carbon Peak Implementation Plan* issued by the Shandong Provincial People's Government. These policies further emphasize the importance of strengthening marine carbon sequestration monitoring, consolidating marine ecosystem carbon sequestration capacity, improving ecosystem carbon sequestration-related laws and policies, and promoting the realization of ecological product value, signifying that marine carbon sequestration trading has become a specific measure for China to implement the "Dual Carbon" goals and providing institutional support for incorporating marine carbon sequestration into the carbon market in the future, while also facilitating the advancement of monitoring guidelines, methodology development, and implementation [9,10].

1.2 Operational Policies for Marine Carbon Sequestration Trading

Considering the carbon offset mechanism attributes of marine carbon sequestration trading, this section analyzes operational policies from two aspects: the corresponding national-level CCER trading market and the local-level carbon inclusive market.

1.2.1 National-Level CCER Operational Policies The existing CCER trading market, especially the forestry carbon sink trading market which is highly similar to marine carbon sequestration, provides certain reference for marine carbon sequestration trading mechanism research and design, with the most fundamental aspect being project development and trading procedures [5]. Taking the forestry carbon sink CCER trading market as an example, it can be mainly divided into three stages: project filing, emission reduction filing, and listing trading (Figure 1 [Figure 1: see original paper]).

(1) Project Filing Stage. This stage requires project selection and design based on appropriate marine carbon sequestration methodologies, and submission of materials including Project Design Documents (PDD), environmental assessment approvals, and project validation reports issued by third parties to relevant authorities. The focus is on demonstrating the monitoring, reporting, and verification capabilities of carbon sequestration projects, as well as their additionality and barrier factors. After passing compliance review and filing by relevant authorities, the project can be officially called a “Marine Carbon Sequestration CCER” project and receive national publicity.

(2) Emission Reduction Filing Stage. The focus is on completing quantitative work such as monitoring, reporting, and verification (MRV) during the implementation of marine carbon sequestration CCER projects, and submitting a series of materials primarily based on MRV [11]. After review by relevant authorities, the marine carbon sequestration volume and CCER are issued.

(3) Listing Trading Stage. The issued marine carbon sequestration CCER is listed for trading and used for carbon allowance offsetting based on the principle of equivalence. In each stage of the carbon sequestration project development and trading process (Figure 1), key aspects such as project additionality demonstration, baseline scenario setting, compliance review, carbon sequestration monitoring, reporting, and verification are crucial. The project methodology [10] is the most important operational basis and the operational guideline for achieving optimal allocation of carbon resources through carbon sequestration trading.

Currently, national-level operational policies for marine carbon sequestration have not been fully developed. However, to advance the restart process of the CCER trading market, the Ministry of Ecology and Environment officially issued the *Letter on Publicly Soliciting Methodology Suggestions for Greenhouse Gas Voluntary Emission Reduction Projects* in March 2023, which explicitly proposes establishing and improving the methodology system for greenhouse gas voluntary emission reduction projects, providing a major opportunity for the

development and introduction of marine carbon sequestration project methodologies. Meanwhile, some marine carbon sequestration operational policies have been released and implemented at the national level (Table 1), which, although not covering core methodological content such as baseline scenarios and carbon sequestration additionality and not fully considering the most important principles of artificial intervention in tradable carbon sequestration and carbon offsetting, still provide a certain basis for future marine carbon sequestration project methodology research.

1.2.2 Local-Level Carbon Inclusive Market Operational Policies Currently, local-level carbon markets include allowance markets and carbon inclusive markets. This study only discusses carbon inclusive markets directly related to marine carbon sequestration trading. The carbon inclusive markets in provinces such as Fujian, Beijing, and Guangdong are the most representative [5] and are the regions most likely to be the first to incorporate marine carbon sequestration into carbon offset mechanisms. Consistent with the national level, local carbon inclusive markets have not yet incorporated marine carbon sequestration into carbon offset mechanism trading scopes.

Many regions have conducted beneficial explorations in methodologies, which are the main operational basis for marine carbon sequestration trading (Table 2). Guangdong, Hainan, Hebei, and other regions have developed and released regional carbon sequestration methodologies for mangroves or bivalves, while Shenzhen has developed accounting guidelines for typical marine ecosystem carbon sequestration within its region. Fujian, Guangdong, Shanghai, Shandong, Hainan, and other coastal provinces and cities have conducted baseline surveys of marine ecosystem carbon sequestration and attempted to construct carbon sequestration accounting systems including marine carbon sequestration baseline, monitoring, storage assessment, potential assessment, protection and restoration, and effectiveness evaluation of increased sequestration. These will provide a foundation for future marine carbon sequestration trading project development (such as project boundary and baseline scenario setting, carbon monitoring plans, carbon pool selection, additionality demonstration, and acquisition of missing parameters).

2. Analysis of Marine Carbon Sequestration Trading Practices

Against the backdrop of the “Dual Carbon” goals and the initially formed marine carbon sequestration trading policies, regions such as Fujian’s Lianjiang County have actively explored and promoted marine carbon sequestration trading practices (Table 3). Trading targets have focused on marine carbon sequestration systems with mature carbon sequestration measurement or methodologies, specifically including mangroves, seagrass beds, wetlands, and macroalgae and bivalve aquaculture. Buyers are primarily enterprises such as banks and material companies, as well as non-governmental organizations (NGOs), with

transaction prices mainly determined through offline negotiations. These trading practices have pioneering significance for project development and process exploration of marine carbon sequestration trading mechanisms. However, carbon offset mechanisms referencing the CCER trading market and local-level carbon inclusive markets require completion of two stages—project filing and emission reduction filing—before trading can occur [3]. Existing marine carbon sequestration trading practices still face numerous challenges, mainly concentrated in four aspects.

(1) Absence of Project Filing. Project filing is the primary step in carbon sequestration development and trading. However, based on disclosed information from existing marine carbon sequestration trading, none of the conducted transactions have included this critical step. This is likely to result in unclear project boundaries, erroneous baseline scenario settings, and issues with monitoring feasibility, especially regarding carbon leakage and negative ecological environmental impacts, which are insufficiently assessed and may lead to deviations. Ultimately, projects may fail to meet the core trading condition of additionality (i.e., some projects may not meet net carbon sequestration standards when considering carbon pool rationality, project activity carbon emissions, and soil disturbance). Except for the Zhanjiang mangrove carbon sequestration, which was validated and verified by the China Quality Certification Center (CQC) with CCER qualifications, other existing carbon sequestration transactions do not have compliance validation from relevant authorities. They only have review reports issued by research institutions as third parties, which are not truly based on monitoring and verification reports, and these research institutions do not possess corresponding qualifications.

(2) Non-Standard Methodologies and MRV. First, there is a significant gap between the reference standards and methodologies for carbon sequestration accounting. From existing marine carbon sequestration trading practices, except for the Zhanjiang mangrove trading where carbon sequestration accounting complied with methodological standards, other transactions' carbon sequestration volumes were based on industry-standard accounting by research institutions or self-monitoring and reporting, mostly using carbon removal amounts as carbon sequestration results without considering baseline scenarios, carbon leakage, and the carbon deposition effects of biological carbon pumps and microbial carbon pumps. Therefore, the scientific validity and rationality of such carbon sequestration accounting reference standards need improvement. Second, third-party validation and verification units lack qualifications. Currently, there are 12 institutions across six batches with CCER project validation and verification qualifications, but not all are qualified for all ecosystem types. For instance, only six institutions have forestry carbon sequestration validation qualifications: China Quality Certification Center (CQC), Guangzhou CEPREI Certification Center, China Environmental United (Beijing) Certification Center Co. Ltd., Beijing Chuangzao Carbon Investment Technology Co. Ltd., Chinese Academy of Agricultural Sciences, and Chinese Academy of Forestry's Institute of Forestry Science and Technology Information. There are no clear regulations on marine

carbon sequestration validation qualifications (Table 4). Third, they do not comply with local-level carbon inclusive market policies. According to policies from regions that have implemented carbon inclusive markets, marine carbon sequestration has not yet been formally incorporated into trading targets and is inconsistent with locally published methodologies or accounting guidelines, nor does it meet the registration, recording, and filing procedures required by local carbon inclusive markets.

(3) Non-Standard Trading Platforms and Failure of Carbon Offset Mechanisms. Most existing marine carbon sequestration trading is conducted offline, such as in Zhanjiang mangroves, Weihai seagrass beds, and Ningbo coastal zones. Individual online trading delivery platforms (such as for kelp, shellfish, and wetlands) do not have CCER trading qualifications. There are significant differences in trading needs between parties: suppliers have relatively inelastic trading demands, while buyers have more elastic demands, giving buyers significantly stronger bargaining power in price negotiations [11,12], meaning the existing marine carbon sequestration market is a “buyer’ s market.”

(4) Underdeveloped Price Mechanisms in Carbon Markets. Existing marine carbon sequestration trading prices are about 20 yuan/ton, with kelp carbon sequestration trading prices as low as 8 yuan/ton, significantly lower than the average trading price of the national carbon emission allowance (CEA) market from July 16, 2021, to March 17, 2023 (45 yuan/ton). The fundamental reason is that existing projects are not genuine carbon sequestration trading. From the supply side, existing marine carbon sequestration does not meet additionality requirements; from the demand side, since they are not national key emission-controlled enterprises, existing projects cannot offset carbon allowances in the system. Therefore, the supply and demand of marine carbon sequestration are not matched under genuine carbon offset mechanisms, but rather represent informal carbon inclusive trading.

3. Conclusions and Recommendations

3.1 Research Conclusions

Marine carbon sequestration resources are abundant with tremendous potential [9,14,15]. Theoretically, marine carbon sequestration trading is feasible and effective for offsetting carbon emissions, optimizing resource allocation, and enhancing social welfare. Marine carbon sequestration trading is essentially the value realization process of carbon sequestration as an ecological product, specifically achieving optimal allocation of carbon rights among different entities through carbon offset mechanisms, guiding dispersed carbon emission individuals to balance economy and ecology, and eliminating the positive externalities of main ecological agents’ behaviors, thereby ensuring that collectives (nations or specific regions and industries) follow a coordinated growth path of “pollution reduction, carbon reduction, green expansion, and growth” to ultimately achieve the “Dual Carbon” goals.

Currently, marine carbon sequestration trading has important practical significance and strong demand, with the trading system gradually being constructed. Many regions and entities have carried out marine ecological restoration and protection actions in sea areas with obvious carbon sequestration benefits, conducting beneficial explorations in standardized accounting and measurement methods and trading practices. Compared with the international community, China's marine carbon sequestration trading started later, but its exploratory practice process has developed rapidly with more diverse trading targets. In addition to traditional typical marine carbon sequestration systems such as mangroves, seagrass beds, and salt marshes that are the focus of the international community represented by the IPCC [12], it also involves fishery (macroalgae and shellfish aquaculture) carbon sequestration. These have accumulated policy and practical foundations for future standardized marine carbon sequestration trading. Future marine carbon sequestration trading will become an important tool for China's marine economic transformation and upgrading and efficient implementation of the "Dual Carbon" goals.

3.2 Policy Recommendations

Based on China's carbon market trading experience and addressing the existing policy and practical dilemmas of marine carbon sequestration trading, this paper recommends that future efforts should promote marine ecological restoration and protection, systematic carbon sequestration enhancement, and negative emissions, and advance the marine carbon sequestration trading process from the following three aspects.

(1) Improve Institutional Policies for Marine Carbon Sequestration Trading. Current marine carbon sequestration trading does not involve key enterprises, and the marine carbon sequestration market mechanism has not played its role in optimizing carbon resource allocation, mainly because under current policies, marine carbon sequestration cannot offset carbon allowances of market entities, and market entities lack purchasing motivation. Therefore, against the backdrop of the imminent reopening of the CCER market, proposed policy documents should incorporate marine carbon sequestration into the CCER system, establishing a national-level carbon offset market mechanism for marine carbon sequestration to expand demand for marine carbon sequestration trading and moderately increase transaction prices.

(2) Establish and Improve Operational Policies for Marine Carbon Sequestration Trading. By summarizing relevant policies and trading processes from the early CEA trading market and CCER trading market, drawing lessons from green carbon trading mechanisms, and strengthening basic research on marine carbon sequestration trading mechanisms—including ecosystem research (mangroves, seagrass beds, salt marshes and other coastal blue carbon, and macroalgae and bivalve aquaculture carbon sequestration) and technical means research (ecological restoration and protection for increased sequestration, land-sea coordination for negative emissions or economic activity emission reduction,

marine microbial carbon sequestration, etc.)—we should accelerate the formulation and introduction of relevant assessment standards and methodologies for marine carbon sequestration, and promote the construction of marine carbon sequestration MRV systems (including technical specifications, key procedures, and third-party institution qualifications).

(3) Encourage Higher-Quality Exploratory Trading Practices. Before the formal carbon offset system is introduced, “civilian” exploratory marine carbon sequestration trading practices have multiple significance in promoting consensus, accumulating experience, and demonstrating innovation. Specifically, four aspects of exploratory practices can be emphasized: (1) **Process:** Attempt more rigorous trading procedures referencing CCER; (2) **Value Realization Methods:** Explore multiple approaches such as financial insurance and pledged credit, ecological disaster loss compensation, and large-event carbon offsetting (such as conference organizers purchasing marine carbon sequestration); (3) **Stakeholders:** Incentivize and attract potential customers such as socially responsible enterprises, NGOs, and financial institutions, encouraging diverse owners, platforms, and third-party institutions to participate in marine carbon sequestration trading practices; and (4) **Trading Targets:** Based on mangrove and shellfish/algae carbon sequestration, explore carbon sequestration project development and trading for more abundant resources such as salt marshes, *Tamarix* planting and rejuvenation, and *Spartina alterniflora* prevention and control in typical ecological restoration and protection efforts.

References

1. Macreadie P I, Robertson A I, Spinks B, et al. Operationalizing marketable blue carbon. *One Earth*, 2022, 5(5): 485-492.
2. Zhao P, Jiang S, Shi J B. Blue carbon in the special report on the ocean and cryosphere in a changing climate and its impacts. *Marine Sciences*, 2022, 45(2): 137-143. (in Chinese)
3. Yang Y, Chen L, Xue L. Top design and strategy selection of blue carbon market construction in China. *China Population, Resources and Environment*, 2021, 31(9): 92-103. (in Chinese)
4. Zhao Y, Qiao Y, Zhang L W. Development mechanism and trading mode of marine carbon sink. *Bulletin of Chinese Academy of Sciences*, 2021, 36(3): 288-295. (in Chinese)
5. [Reference content appears to be cut off in the original]
6. [Reference content appears to be cut off in the original]
7. [Reference content appears to be cut off in the original]
8. [Reference content appears to be cut off in the original]
9. Jiao N Z, Liu J H, Shi T, et al. Implement negative ocean emissions and implement carbon neutrality strategy. *Scientia Sinica Terrae*, 2021, 51(4): 632-643. (in Chinese)
10. Li X, Liu Z F, Zhao M J, et al. Carbon peak and carbon neutralization

- goals and realization paths of the aquaculture and fishing industry in China. *Journal of Agricultural Science and Technology*, 2022, 24(11): 13-26. (in Chinese)
11. Forest Greening Management Division of National Forestry Administration. *Guideline for Carbon Sink Measurement and Monitoring of Afforestation Projects*. Beijing: Forestry Press of China, 2014. (in Chinese)
 12. IPCC. *Climate Change 2014: Synthesis Report*. Geneva: IPCC, 2014.
 13. Costanza R, d' Arge R, De Groot R, et al. The value of the world' s ecosystem services and natural capital. *Nature*, 1997, 387: 253-260.
 14. Zhang J H, Liu J H, Zhang Y Y, et al. Strategic approach for mariculture to practice “ocean negative carbon emission”. *Bulletin of Chinese Academy of Sciences*, 2021, 36(3): 252-258. (in Chinese)
 15. Tang Q S, Liu H. Strategy for carbon sink and its amplification in marine fisheries. *Strategic Study of CAE*, 2016, 18(3): 68-73. (in Chinese)

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