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Research Progress on Degradation Factors and Restoration Technologies of Seagrass Beds

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Abstract

Seagrass is a kind of higher flowering plant, as one of the main primary producers of shallow sea waters, seagrass can be accumulated in a large area to form seagrass beds, seagrass bed ecosystems have high biomass and productivity, and coral reef ecosystems and mangrove ecosystems are called three typical marine ecosystems, seagrass beds have important ecological functions, in sediment capture, wind breaking, water quality, carbon sequestration and other important roles. However, since the 80s of the 20th century, due to the influence of natural factors and human factors, seagrass beds are in a state of continuous decline, and about 110km^2 of seagrass beds in the world are degraded every year, and nearly 1/3 of the grass beds have disappeared according to current statistics. In this paper, the main restoration technologies of seagrass beds, including habitat method, seed method and transplantation method, are summarized, and the advantages and disadvantages of various methods are compared, in order to provide some reference suggestions for seagrass restoration.

Keywords

Seagrass bed, Ecological function, Vestigial, Repair technology

1. Introduction

Seagrass refers to a general term for a class of higher submerged angiosperms that are fully adapted to marine life, seagrass can differentiate into obvious rhizomes and leaves, and the same process of flowering, fruiting and germination as terrestrial higher plants, and can be reproduced by both sexual and sexual reproduction. In a suitable environment, seagrass beds formed by large-scale accumulation of seagrass, mangroves and coral reefs are collectively called three typical marine ecosystems [1].

Seagrasses have low levels of biodiversity, with 72 species globally recognized as belonging to 13 genera in 6 families. In addition to the Arctic and Antarctic coasts, seagrasses are widely distributed in temperate and tropical continental coastal areas around the world [2]. In different regions, the dominant species of seagrass in each subdivision is different, and in tropical waters, the diversity of seagrasses is abundant, and the most widely distributed seagrass species is Cranberry grass. In the temperate waters of the Northern Hemisphere, the genus Eelgrass predominates, and the dominant seagrass species is Zostera marina L [3]. There are 22 species of seagrass in 4 families, 10 genera and 22 species in China, mainly distributed in 9 provinces and regions, which can be divided into southern regions and northern regions according to regional divisions. The southern region mainly includes Fujian, Guangdong Zhanjiang, Guangxi Beihai, eastern Hainan, Hong Kong and Taiwan, and in northern China, seagrass is mainly distributed in Shandong, Hebei, Liaoning and other places [4].

2. Ecological function of seagrass beds

As an important member of the marine ecosystem, the dense formation of seagrass beds has a very important ecological function in the marine ecosystem [5]. Seagrass beds provide important shelter and habitat for marine life, attracting large numbers of marine life to live and reproduce in them. Seagrass bed ecosystem provides important food resources for marine organisms, including fish, shellfish, shrimp, crustaceans, crabs and other invertebrates, which rely on seagrass beds as the basis

for their life and reproduction, greatly enriching the diversity of organisms in seagrass beds; Seagrasses hold sediments in place, and their root systems and underground stems penetrate sediment on the seafloor, fixing sediment on the seafloor and preventing the loss of seafloor soil. In addition, seagrass can also alleviate marine erosion through its leaves and stems, reduce the impact of waves, maintain the stability of seafloor sediments, help maintain the stability of coastal ecosystems and maintain the integrity of coastlines, Bos et al. proved through seagrass transplantation experiments that the settlement rate of suspended particulate matter after seagrass transplantation accelerates, and the argillaceous components in the substrate increase [6]; Seagrass beds also help purify water quality, and seagrass absorbs carbon dioxide through photosynthesis, increasing dissolved oxygen in the water and curbing ocean acidification. The aboveground and underground parts of seagrass control the nutrient content in the water by absorbing nutrients in the water, such as nitrogen and phosphorus, and reduce eutrophication in the water body. Seagrass can also reduce pollutants in water and increase transparency by absorbing harmful substances such as heavy metals and organic chemicals; Seagrass has the function of reducing carbon emissions. Seagrass grows by absorbing large amounts of carbon dioxide, converting it into organic matter and storing it in the body, which deposits on the seafloor after seagrass dies, forming organic carbon sinks, helping to reduce carbon emissions in the ocean. According to the study, although the seagrass bed is relatively small in the global distribution area, the seagrass bed can absorb and store as much carbon dioxide per year as much as 1-2 times that of all land plants in the world, among which the annual productivity of the red whiskered root shrimp algae is 696g/m2, the annual productivity of the eel bed is 564g/m2, and the clumpy eel grass is 432g/m2, so seagrass is one of the important carbon sinks [7].

3. Analysis of the status and causes of seagrass bed degradation

3.1 Status of seagrass bed degradation

In the past few decades, the important role of seagrass in the ocean has not been paid enough attention, and under the multiple effects of natural factors and human activities of global change, the health of seagrass has declined sharply, directly leading to a decrease in seagrass productivity, causing a sharp decrease in seagrass bed coverage worldwide, and many areas have experienced serious degradation of seagrass beds, resulting in a decline in biodiversity within ecosystems. From 1980 to 2006, seagrass beds disappeared at a rate of 110 km2/year, which is already 2-15 times the rate of loss of tropical rainforests [8]. Short et al. [9] estimate that 90,000 km2 of seagrass beds worldwide have disappeared, and according to the World Seagrass Atlas published in 2003, the global seagrass bed area has decreased by 26,000 km2 in the past decade, to 15% of the total [10]. About 140,000 m2 of eel grass beds disappeared at the mouth of the Mondego River in Portugal, leaving only 200 m2 by 1997 [11]; Due to human disturbance and other reasons, the area of seagrass beds in Australia decreased by 450 km2 [12]; The area of eel seagrass beds off the coast of South Korea has also been declining, and it is in danger of disappearing completely. China's seagrass beds were once very abundant, but now they have also declined on a large scale. For example, the total area of seagrass beds near Hepu, Guangxi, decreased year by year, from 2.67 km2 to 0.001 km2 from 1994 to 2001, and was on the verge of extinction. Eel grass beds in Shandong's coastal waters have now been degraded by more than 80 percent, and some seagrass fields have even disappeared. After preliminary investigation in 2015~2016, the eel grass in the shallow sea area along the coast of Rizhao and Rushan has disappeared; In the waters near Yantai, the area of eel grass seagrass beds was reduced from 13 km2 to less than 0.05 km2. According to the 2009 large-scale survey report of offshore seagrass resources, eel grass has disappeared in the remaining waters of Qingdao offshore except Qingdao Bay and Huiquan Bay, and the presence of shrimp algae has been found in Fushan Bay and Shilao [13].

3.2 Natural factors

There is often an interaction between human activities and changes in natural factors on seagrass, with large CO2 emissions leading to global warming, and rising temperatures affecting the abundance and growth of seagrass. Seagrass species are gradually declining off the southeast and southwest coasts of Australia due to global warming. Massive CO2 emissions also cause changes in seawater pH and carbonate systems, leading to ocean acidification, which indirectly affects seagrass growth by changing the cover and species composition of attached organisms. In addition, with global climate change, the probability of drought and flood increases, and the situation caused by such extreme rainfall causes significant changes in light intensity and salinity in the short term, which has a significant impact on coastal seagrass habitats. Other natural disasters such as diseases, typhoons, earthquakes, etc. often destroy seagrass beds. The feeding of seagrass seeds and leaves by some herbivorous marine organisms can also adversely affect the recovery of seagrass beds.

3.3 Human factor

Since the Industrial Revolution, human activities have caused great damage to the natural environment. The decline of sea-

grass beds worldwide, although influenced by natural factors, is mainly due to human disturbance. With the development of industry, a large number of factories discharge industrial wastewater and sewage into the ocean, causing water pollution. Water pollution will lead to eutrophication of the water body, so that there are too many nutrients in the seawater, thereby stimulating the proliferation of algae and phytoplankton, making the water turbid, insufficient light, and limiting the growth of seagrass. In addition, the import of harmful substances such as organic pollutants and heavy metals can also adversely affect seagrass growth. The impact of marine projects such as land reclamation on seagrass cannot be ignored, and large-scale marine engineering will change the flow mode and quality of seawater, thereby negatively affecting the seagrass bed ecosystem. For example, factors such as increased water velocity and massive amounts can lead to the destruction of seagrass beds. Human fishing practices are also a cause of seagrass bed degradation. Trawling can cause physical damage to the seabed, and overfishing can lead to changes in the number and structure of biological populations in marine ecosystems, which can disrupt the structure and ecosystem balance of seagrass beds, thereby depriving seagrass beds of their living conditions, and eventually leading to the degradation and disappearance of seagrass beds. Natural factors usually occur in small and uncontrollable cases, but human activities impose interference conditions, so it is important to reduce the intensity and frequency of human interference to protect seagrass beds from destruction.

4. Seagrass bed restoration techniques

Although seagrass has a wide distribution, large area and abundant number, for a long time, the seagrass bed ecosystem has not received enough attention and has been greatly affected by human activities, resulting in serious degradation. In recent years, the ecological restoration of seagrass beds has attracted extensive attention from scholars at home and abroad, and has become a worldwide research hotspot. The restoration of seagrass fields has attracted more and more attention, and researchers from all over the world are exploring effective seagrass bed restoration techniques and achieving some results. Various projects are currently being carried out to restore damaged seagrass beds, mainly including habitat restoration, transplantation restoration and seed.

4.1 Habitat restoration

Fragmentation or loss of habitats, affected by natural or anthropogenic disturbances, is an important cause of seagrass bed decline. Habitat restoration refers to the method of making seagrasses self-repair through sexual and asexual reproduction by protecting, improving or simulating habitats. This method relies on the natural reproduction of seagrass, relying on natural resilience, and does not require a lot of human and material investment, but simple natural recovery is a relatively slow process, which takes a long time and has slow results. Scientists have explored the feasibility of restoring seagrass beds through habitat improvement, and studies have shown that natural recovery of damaged seagrass beds is very slow, with the growth rate of Paraphyllum polyphyllum in the Spanish coast being only 23 cm/year, and the growth rate of Tailai Tailai in the Caribbean Sea being 22.3 cm/year, in fact, the rate of natural recovery is far less than the rate of seagrass decline.

4.2 Transplant repair method

Transplant restoration is a method of using the asexual reproduction of seagrass to collect seagrass seedlings or mature plants, or even whole seagrass turf, from natural seagrass beds, and transplant them into the sea area to be repaired so that it can survive and reproduce. The transplantation method is a relatively feasible recovery method, and the operation method is relatively simple. The whole transplantation process is divided into two steps: the collection of transplanted seagrass (the collection of transplanted seagrass) and planting, and the difference between different transplantation methods lies in the collection of transplanted units and the planting methods. The methods of seagrass plant transplantation include (1) turf method: the flat seagrass turf is directly tiled in the transplanted sea, and the planting is relatively simple. Phillips et al. conducted a transplant experiment with Halodule Endl and Thalassia in Tampa Bay, Florida, and found that the survival rate of both after transplantation was very low. This method does not bury the seagrass turf in the substrate, when the waves are large and the impact is strong, the whole seagrass turf is easily washed by seawater. (2) Grass block method: PVC pipe or shovel is used to completely transplant the rhizome leaves and substrate nutrients of transplanted seagrass to the sea area to be repaired, which preserves the living environment of transplanted seagrass, reduces the interference of the outside world on seagrass during the transplantation process, and the transplantation survival rate is relatively high. Paling et al. transplanted Posidoniaceae in western Australia and found an average survival rate of 57%. On the basis of the experiment, Paling et al. used a machine for transplanting seagrass, which could use the grass block method to transplant and repair seagrass on a large scale, improve the transplantation efficiency, and push seagrass transplantation to mechanization. However, this method will cause some damage to the original seagrass ground, the use of large machines leads to a large cost of investment, and transplanting seagrass into a new environment requires manual diving operations, which consumes a lot of human resources. (3) Rhizome method: The rhi-

zome method transplanting seagrass is similar to the grass block method, and the biggest difference is that the rhizome method does not contain substrate during the transplantation process. The problem with this method is how effectively the transplanted seagrass is fixed in the substrate, so several other methods derived from the rhizome method include the staple method, the shell method, the frame method, the horizontal rhizome method, and the single branch method. These methods have been widely used in eel transplantation experiments. Among them, the survival rate of eel grass transplanted by shell method reached 81.3%, but the seagrass transplanted by this method was more stable than that in the sandy bottom sea area.

The feasibility of the transplantation method is high, the technical development is relatively mature, and the survival rate of seagrass after transplantation is relatively high, but the disadvantage is that due to the sudden change of habitat environment, it is difficult for seagrass transplanted to the restoration sea area to adapt to the new living environment and grow and survive healthily in the short term, in addition, the cost of various transplantation methods is generally high, requiring a lot of manpower, material and financial resources, and causing certain damage to the original seagrass bed.

4.3 Seed method

The use of seed methods to restore and rebuild seagrass beds is a tool worth replicating. This method propagates seagrass by seed, avoiding damage to existing seagrass beds while being less affected by space constraints. At the same time, the use of seed method to restore seagrass beds can improve genetic diversity, especially suitable for places where adult plants are missing, and the seeds are small in size and easy to transport, as long as enough seeds are collected, large-scale sowing can be carried out conveniently and quickly without destroying the seagrass bed.

However, there are also many problems and difficulties in the practical application of the seed method. (1) Seed collection: The use of seed method to restore the seagrass bed requires the collection of a large number of seeds, and the collection of seeds on the reproductive branches of seagrass through machines will cause damage to the original seagrass bed habitat, so a large number of manual collection of seeds is required. In addition, seeds fall off soon after maturity, and the time between seed maturity and shedding is short, making seed collection more difficult.

5. Prospect

At present, effective conservation measures need to be taken, including the census of seagrass species resources and seagrass field distribution, strengthening the dynamic monitoring of seagrass fields, accelerating the establishment of seagrass nature reserves, strengthening seagrass bed restoration and seagrass germplasm resources conservation research. These measures require governments, businesses, researchers and ordinary people to work together to protect and restore seagrass beds and maintain the stability and health of marine ecosystems.

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