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Benthic Environment Effects of Aquaculture Activities in Sansha Bay Based on Different Biological Indices

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Abstract: Sansha Bay is one of the most typical aquaculture bays in the East China Sea. It is of great significance to study the benthic environment effects of aquaculture activities in Sansha Bay. At present, the overall number of studies in this area is relatively small. In order to study the benthic environmental effects of aquaculture activities in Sansha Bay, different scholars have tried to explain the ecological effects of aquaculture activities from different perspectives. The purpose of this paper is to study the benthic environmental effects of aquaculture activities in Sansha Bay based on different biological indices. In the experiment, the Shannon-Wiener diversity index and AMBI biological index calculation formula are used to analyze and investigate the environmental quality. The experimental results show that the results of AMBI and BAMBI in Sanshawan are similar. The average value of AMBI in Sanshawan is 3.41, while that of BAMBI is 3.38. The average value of BAMBI index is lower than that of AMBI index, and both of them are rated as good environmental quality.

1. Introduction

In recent years, marine aquaculture has led to increased levels of nitrates, phosphates and other nutrients in water bodies, resulting in eutrophication of seawater, which in turn leads to more frequent red tide outbreaks. As far as the research content is concerned, these studies are based on the "fruit" produced by aquaculture activities in the water environment, that is, the impact of aquaculture activities on the regional ecosystem is analyzed through the temporal and spatial variation characteristics of environmental factors in aquaculture waters and the succession characteristics of biological community structure [1].

At present, my country's Sanshawan aquaculture is extensive and inefficient. For local aquaculture waters, especially in relatively dense aquaculture areas, long-term accumulation will also damage the water quality of local waters and have a superimposed effect on the benthic environment.Christison The South African government's social progress goals for food security, equity, job creation and economic growth can be achieved through the diversification of fish production in the country's agricultural sector. Little is known about the risks associated with diseases and parasitic infections affecting aquaculture production in South Africa. Significant investments are currently being made to provide OIE disease-free certification to support the aquaculture industry that relies on high-value aquaculture products to enter foreign markets. The expected rapid expansion of the aquaculture industry in South Africa underscores the associated need to prevent the spread of aquatic animal diseases. The main limitation is that the current regulatory framework governing aquaculture activities is not centralized due to the diversity of aquaculture activities in marine, brackish and freshwater areas [2]. Erika conducted her research on a fish farm in Itacuba, Brazil's tropical region. The goal is to quantify the impact of aquaculture on water quality by comparing emissions and impacts, especially in relation to the restrictions of CONAMA Resolution 430 (2011). The emission value, activity value, total phosphorus and total nitrogen value are higher than this value, and other parameters shall be implemented according to the above regulations. Based on these results, we recommend legal treatment of farm effluent before discharge into receiving water bodies, thereby reducing the risk of eutrophication for local residents, protecting food security, and reducing impacts on public health and aquatic biota. Worthy of company stability [3].AMBI index analysis is one of the mainstream methods for evaluating benthic ecological quality in coastal waters.

Based on the domestic and foreign research backgrounds of different biological indices, this paper clarifies the geographical location, hydrological characteristics and related research of Sansha Bay, as well as the research on the benthic environment effect of aquaculture activities on a global scale. During the sampling design experiment, field sampling of macrobenthos was conducted in Sansha Bay, and a total of 12 sample collection stations were set up. In the experiment, the Shannon-Wiener diversity index and the AMBI biological index calculation formula were used to analyze and investigate the environmental quality assessment of Sansha Bay based on the Shannon-Wiener diversity index and the environmental quality assessment of Sansha Bay based on the AMBI index. The experimental results show that the results of AMBI and BAMBI in Sanshawan are similar.

2. Research on Benthic Environment Effects of Aquaculture Activities in Sansha Bay Based on Different Biological Indices

2.1. History of Research

(1) History of Foreign Research

With the increasing attention paid to the health of marine ecosystems, the research on the evaluation method of marine biological index continues to receive attention. The US Environmental Protection Agency has also invested a lot of manpower and material resources in the promotion and improvement of the new benthic index [4-5]. Based on the above background, the research on marine biological index has made great progress in recent years. At present, a series of biological indexes have been launched, especially some biological indexes have been launched in recent years, such as AMBI index, M-AMBI index, ISI index, diversity index, IEI index, benthic quality index (BQI), benthic environment index (BCI) and macrobenthos pollution index (MPI) [6]. The application of these indices has enriched the technical methods for the detection and evaluation of marine water environment quality, and significantly promoted the research progress of marine environmental benthic organism detection.

With the deepening of research, the AMBI index has gradually shown its limitations. If the number of species is small, the AMBI index may be inaccurate [7]. Therefore, the AMBI biological index, the Shannon-Will diversity index and the species abundance are combined to perfect the M-AMBI evaluation index, broaden the application scope of the AMBI index, and verify it in different types of waters. When M-AMBI was first proposed, some experts have raised different opinions, and concluded that the M-AMBI index is not sufficiently convincing for the evaluation results of newly added benthic data. Within the % confidence interval, the prediction results of M-AMBI are characterized to be trustworthy [8].

(2) History of Domestic Research

The domestic marine biological index research was carried out relatively late. In the 1950s, the investigation of marine environmental conditions and resource conditions was gradually established, and the research results were mostly based on qualitative descriptions [9]. Relying on the introduction of the Shannon-Wiener diversity index, the quantitative index result analysis of biological community evaluation can be achieved. This method has been classical and widely used for the characteristics of macrobenthos community structure in China. However, there are also limitations. Long-term sampling surveys are needed to determine whether the fluctuations in diversity values are caused by the number of species or the evenness of individuals. In a certain pollution situation, it cannot accurately reflect the pollution situation. It is worth mentioning that some domestic scholars have also launched biological indexes. The Macrobenthos Pollution Index (MPI) was established based on the ABC curve comparison, which is a biological index for autonomous benthic-based pollution evaluation. Since then, foreign biological index evaluation systems, such as AMBI, M-AMBI and B-IBI index, have been widely introduced in China, which effectively supplemented the research process of benthic fauna in my country. The use of biological indices based on macrobenthic communities to evaluate water environment is gradually filling in the research, such as the use of AMBI index to evaluate the applicable characteristics of benthic community health in the intertidal zone of the Bohai Sea. The AMBI and M-AMBI indices were used to evaluate the environmental ecological quality of the Shenzhen Bay intertidal zone, and various biological indices and fouling biological communities were used to evaluate the water quality. Summarizing the analysis of the improvement and application of biological index in China, due to the late start, data shortage and many other factors, it lags behind foreign countries [10]. At present, the Shannon-Wiener diversity index evaluation is the usual method for analyzing the environmental effects of marine benthic communities in my country. my country has introduced new indices, such as AMBI, M-AMBI, feeding uniformity index, etc., but there are also major problems in the process of utilization.

2.2. Overview of Sansha Bay

(1) Geographical location and hydrological characteristics of Sansha Bay

Located on the northeastern coast of Fujian Province (southwest of the East China Sea), Sansha Bay is a typical semi-closed bay (mouth diameter less than 3 km), with a total area of about 570 km^2 and a water area of 262 km^2 [11]. Surrounded by mountains, Sansha Bay provides an advantageous marine environment for human activities. The maximum depth of the bay is about 90m. In this bay, the current velocity is stronger, with the highest subsurface velocity, followed by the surface and bottom. The maximum velocity of ebb tide is higher than that of high tide (1.90 m/s and 1.40 m/s), and this difference ensures greater water depth and lower silt in the bay. In addition, the tidal water level of the bay varies greatly, the difference between low tides reaches 5.38m, and the whole bay water exchange cycle is about 18 days.

(2) Related Research

So far, a certain number of studies have been conducted on the ecological and environmental effects of aquaculture activities in Sansha Bay, mainly including the following aspects:

The effects of aquaculture activities on the physical and chemical factors of water bodies and sediments in the water body of Sansha Bay have been studied, and there are many reports on the changes of physical and chemical factors of water bodies caused by aquaculture in the water body of Sansha Bay [12]. The quality evaluation of the surface sediments in the sea area of Yantian Port in Sansha Bay shows that due to the poor hydrodynamic conditions and long-term aquaculture activities in Yantian Port, the nitrogen and phosphorus pollution in the sediments is serious, and the endogenous load is high. The investigation of the distribution of diatoms in the surface sediments of Sansha Bay shows that it is mainly affected by the depth of tidal current and salinity. Compared with phytoplankton, benthic animals are more used for environmental indicators or pollution prediction because of their poor mobility, easy collection, direct exposure to sediment pollutants, and sensitivity to pollutants [13]. The response of benthic ecological environment to aquaculture has been studied to some extent in my country, but the research on the sea area of Sansha Bay is slightly insufficient. The research on the polychaete community structure in the cage aquaculture waters of Sansha Bay shows that the main environmental factors affecting the distribution pattern of polychaetes include water body, water depth and dissolved oxygen, and the cage aquaculture activities have had a certain impact on the composition of the polychaete community [14].

2.3. Research on Benthic Environment Effects of Aquaculture Activities on a Global Scale

According to statistics, my country has become the first country in the world whose output of marine aquaculture exceeds that of marine fishing. The improvement of marine aquaculture in China has three characteristics:

(1) The marine aquaculture industry has a large scale and rapid improvement [15];

(2) The industry has obvious advantages and has become an important pillar of the improvement of the marine economy [16];

(3) The serious environmental pollution of marine aquaculture restricts its sustainable improvement [17].

While the utilization of marine resources brings huge economic benefits, the discharge of human domestic waste, the large-scale reclamation of the ocean, and the extensive and inefficient farming methods are constantly challenging the carrying capacity and self-purification capacity of the marine environment. Cage culture is one of the most typical production methods in marine aquaculture in my country [18]. Feeding production methods such as cage aquaculture can cause significant ecological and environmental effects in the waters where they are located, and the sedimentation of aquaculture-derived organic matter is the fundamental cause of such effects. AOM includes residual bait, excreta of cultured organisms, and a small amount of dead organisms, etc. Currently, the world's knowledge of the impact and mechanism of such substances on biological communities is relatively limited [19].

3. Investigation and Research on Benthic Environment Effects of Aquaculture Activities in Sansha Bay Based on Different Biological Indices

3.1. Sampling Design

Field sampling of macrobenthos was conducted in Sansha Bay. A total of 12 sample collection stations (Station 10) were set up, covering the main aquaculture waters in Sansha Bay, covering medium water types, including 3 large yellow croaker cages. Breeding stations, 4 abalone breeding stations and 3 seaweed breeding stations, and 2 non-breeding area control stations were set at the same time. The environmental factor data of different stations in Sanshawan aquaculture activities are shown in Table 1 below:

Table 1. The environmental factors of sampling stations in cruise in Sansha Bay

Breeding type	Haliotis gigantea	Sargassum	Pseudosciaena crocea	Control group
Erect position	10	8	9	4
Longitude	38.2	10.3	7.21	39.1
Latitude	26.1	26.8	26.4	26.3
Degree of depth	19.4	8.5	30.1	29.8
Temperature	28.1	29.4	29.8	29.2
Salinity	35.4	32.1	34.2	34.7

3.2. Calculation of Biological Index

(1) Shannon-Wiener diversity index

In the formula, S is the number of species, which is the ratio of the number of the i species to the total number, and $H^{'}$ represents the degree of disturbance of the benthic community and the level of environmental quality. The index has been widely used in the environmental quality evaluation of various ecosystems in my country. The Shannon-Wiener diversity index is calculated as:

$$H^{'} = -\sum_{i=1}^{S} p_i \cdot lOG_2 P_i \qquad (1)$$

(2) AMBI biological index

The AMBI index by Boija et al. is based on the marine biological index BI. It is proposed for the first time that the biological coefficient BC can be obtained by multiplying the respective coefficients by the proportion of each ecological group in the macrobenthic community, and then adding them together. The calculation formula is:

$$BC = (0.00 \times \%GI + 1.50 \times \%GII + 3.00 \times \%GIII + 4.50 \times \%GIV)/100 \qquad (2)$$

4. Analysis and Research on Benthic Environment Effects of Aquaculture Activities in Sansha Bay Based on Different Biological Indices

4.1. Environmental Quality Assessment of Sansha Bay Based on Shannon-Wiener Diversity Index

The Shannon-Wiener diversity index calculation result is between 2.09 and 3.13, which shows that in moderate disturbance and moderate pollution, large yellow croaker cages and seaweed cultivation stations each account for 50%; Large yellow croaker cage culture stations accounted for 55%, seaweed culture and control stations each accounted for 45%; showing no disturbance and high ecological quality, among which large yellow croaker cage culture stations accounted for 78% and seaweed culture stations accounted for 22% . The calculation results of Shannon-Wiener diversity index are shown in Table 2 and Figure 1:

Table 2. Shannon-Wiener indices of each sampling stations in Sansha Bay

Breeding type	Erect position	Index
Haliotis gigantea	10	2.31
Sargassum	8	3.01
Pseudosciaena crocea	9	2.09
Control group	4	3.13

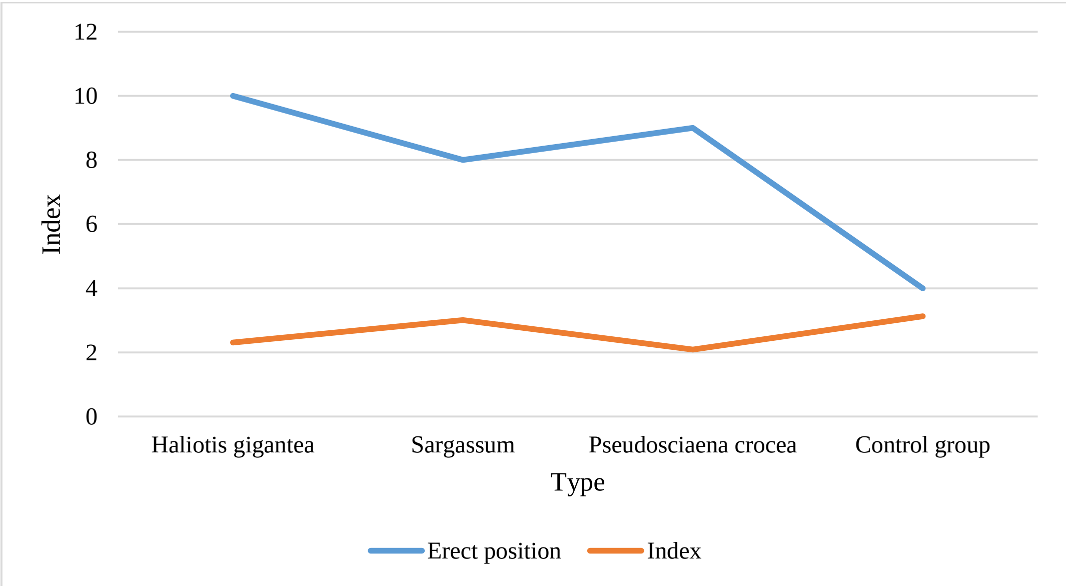

Figure 1. Comparison diagram of different biological indexes in Sansha Bay

The results showed that the environmental results of abalone culture were evaluated as good; the diversity index of large yellow croaker cage culture was in high or good state, and the results were generally good; extreme disturbance and poor ecological quality were characterized in seaweed culture; the evaluation results of the control group were mostly in good state . According to the analysis of the mean value of the diversity index of different aquaculture types, each station was in a mild disturbance and a good state.

4.2. Environmental Quality Assessment of Sansha Bay Based on AMBI Index

The AMBI index evaluation index is based on the proportion of the five ecological groups, and is also based on the index setting of the ecological community health level. The benthic environment quality is divided into: 0.00≤high≤2, 2≤good≤4, 4≤medium ≤5, 5≤bad≤6, 6≤bad≤7. The calculation result of AMBI index evaluation index is between 0-5.12, and the calculation result of BAMBI index evaluation index is between 0-6.9, as shown in Table 3 and Figure 2:

Table 3. Sandanna environmental environment based on AMBI index

Breeding type	AMBI	BAMBI
Haliotis gigantea	0.14	0.21
Sargassum	1.42	3.12
Pseudosciaena crocea	4.23	5.24
Control group	5.12	6.90

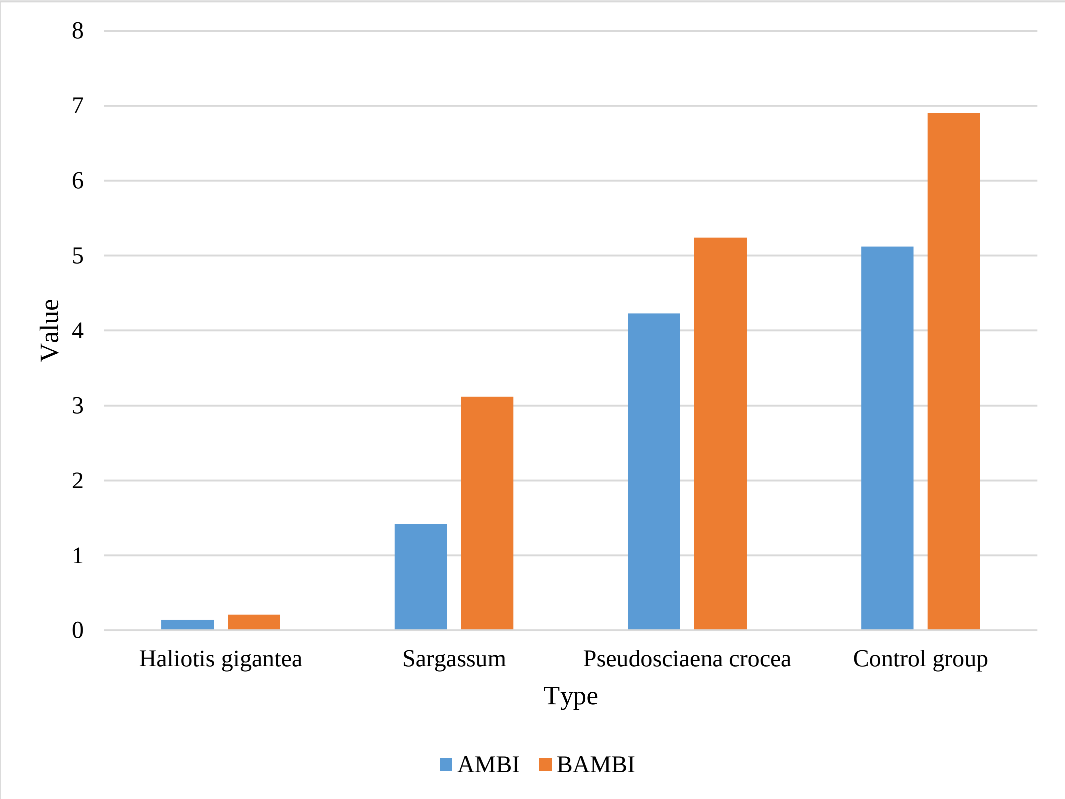

Figure 2. Habitat quality comparison diagram of Sansha Bay

Abalone farming is in good and medium environmental quality; AMBI index in large yellow croaker cage culture shows relatively stable results, in good condition and medium environmental quality; seaweed farming shows high or good ecological status, AMBI index environmental sensitivity is reduced, indicating that it is not affected by Disturbed and in a state of high ecological quality; the control group was mostly in a good state. According to the average value of large yellow croaker, seaweed, abalone culture and control stations, it shows that each station is in a state of mild disturbance and good ecological quality. Abalone farming is the most polluted, followed by large yellow croaker cage culture, and seaweed farming is polluted. lowest. The results of AMBI and BAMBI in Sanshawan were compared and the results were similar. The average value of AMBI in Sanshawan is 3.41, while that of BAMBI is 3.38. The average value of BAMBI index is lower than that of AMBI index, and both of them are rated as good environmental quality.

5. Conclusion

In order to investigate the environmental effects of aquaculture activities in Sansha Bay, the quantitative evaluation of the ecological environment quality and the health of macrobenthos community in the typical Sansha Bay aquaculture sea area in my country was carried out, and the applicability of each biological index was discussed accordingly. Make reasonable suggestions for index selection. Due to the limited level of the author, this paper will inevitably have omissions in the process of data collection, and there will be errors in the process of data processing. Therefore, my research in this field is still a preliminary analysis conclusion, which needs to be confirmed in future work. For the purposes of this study, it is difficult to improve new biological indices due to insufficient standardization, sampling methods and continuity of the data. However, this study provides suggestions for the selection of indices for the evaluation of the ecological environment quality of Sansha Bay, a typical breeding bay, but there are still obvious deficiencies in the selection of indicators, the setting of reference states, and the specific relationship between various biological indices and environmental factors.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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