Grading Assessment of Temperature Thresholds and Suitable Temperature Zone Division for Typical Species in Marine Ranching

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Abstract: The construction of Marine Ranching is a safe, efficient, and sustainable way to achieve marine environmental protection and biological resource utilization. In recent years, the construction of Marine Ranching in coastal provinces in China has developed rapidly, but due to the late start, the ability to guarantee ecological security is weak. In this paper, *Pseudosciaena crocea* was selected as typical aquaculture species in Marine Ranching of the East China Sea, by integrating the experimental data from former studies effect of temperature on the Specific Growth Rate of this aquaculture species was evaluated via performing quadratic regression fitting, the results reveal that the optimum temperature ranges for *Pseudosciaena crocea* are 25.3–30.7°C,the preferred range is 18.9–25.3°C, the unsuitable temperature ranges were lower than 18.9°C and higher than 30.7°C. Further, based on the aquaculture specifications, commodity specifications, and aquaculture cycle, the Specific Growth Rate to be achieved by the aquaculture species is determined, and the corresponding temperature threshold and graded evaluation were obtained, finally, the suitable water temperature distribution area of the *Pseudosciaena crocea* was evaluated based on the hydrological data observed in the East China Sea during 2020–2021.

1 INTRODUCTION

Overfishing in the last three decades has led to a dramatic decline in nearshore marine fisheries resources (Li, 2008), coupled with the growth of the world population, the market demand for aquatic products is increasing. Marine Ranching is a controllable and planned harvesting of aquatic biological resources management type fishery production system formed by human intervention in a specific natural sea area, it is a sustainable fishery production method.

Current research on Marine Ranching focuses on the efficiency analysis of artificial reef construction, the concept of Marine Ranching construction, Marine Ranching ecological resources restoration, and other aspects. Although the above studies obtained the optimal temperature range of Pseudosciaena crocea through aquaculture experiments, they were only in the theoretical stage and did not combine relevant data and monitoring systems to guide aquaculture practice. In this paper, through the previous experimental data about temperature on the Specific Growth Rate of the Pseudosciaena crocea, the quadratic regression curve fitting and grading evaluation are carried out, and the temperature threshold affecting the Specific Growth Rate of the Pseudosciaena crocea is clarified, To overcome the disadvantages of Marine Ranching mainly relying on artificial experience in the actual development, and then combined with an automatic monitoring system to realize the warning of pasturing area temperature, reduce the impact of temperature mutation on Marine Ranching and economic losses, and build a modern Marine Ranching ecological security guarantee technology system.

2 DATA AND METHODS

2.1 Data Sources

Data on the effect of temperature on the Specific Growth Rate of *Pseudosciaena crocea* are from previous experiments: Chen Jia et al. (Chen, 2013) concluded through 30 days of aquaculture experiments that the Specific Growth Rate of juvenile *Pseudosciaena crocea* with a weight of about 4 g increased with the increase of temperature in the range of 18.0-32.0 °C, and the optimum temperatures and salinities combination was 24.7 °C + 14.1. The experimental results of Ruan Chengxu et al. (Ruan, 2013) showed that the Specific Growth Rate of juvenile *Pseudosciaena crocea* increased with the increase of temperature at 22-30 °C.

The aquaculture specifications, commodity specifications, and aquaculture cycle of the *Pseudosciaena crocea* from in industry standards, literature: SC / T2049.2-2006 *Pseudosciaena crocea fry fingerlings (*SC/T 2049.2-2006) aquatic industry standards that juvenile *Pseudosciaena crocea* specifications for 3cm, about 0.6g, Huang Weiqing et al. (Huang, 2019) in

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the *Pseudosciaena crocea aquaculture technology* said *Pseudosciaena crocea* commodity specifications for 300g, Liao Hongmei et al (Liao, 2012). in the *Cost-benefit analysis of adult Pseudosciaena crocea* said that the *Pseudosciaena crocea* aquaculture cycle is 1-2 years.

The Source of temperature data is the *National Natural Science Foundation of China Experimental Study on the Scientific Investigation of the Yangtze Estuary in 2020 of the shared voyage plan*. The sampling time is 2021 winter (March), summer (July), and autumn (October), covering 29 ° -33 ° N, 121 ° -124 ° E, there are 64 stations and 7 sections in the voyage survey, section A5 is selected as a typical section. The distribution of stations is shown in Fig.1.

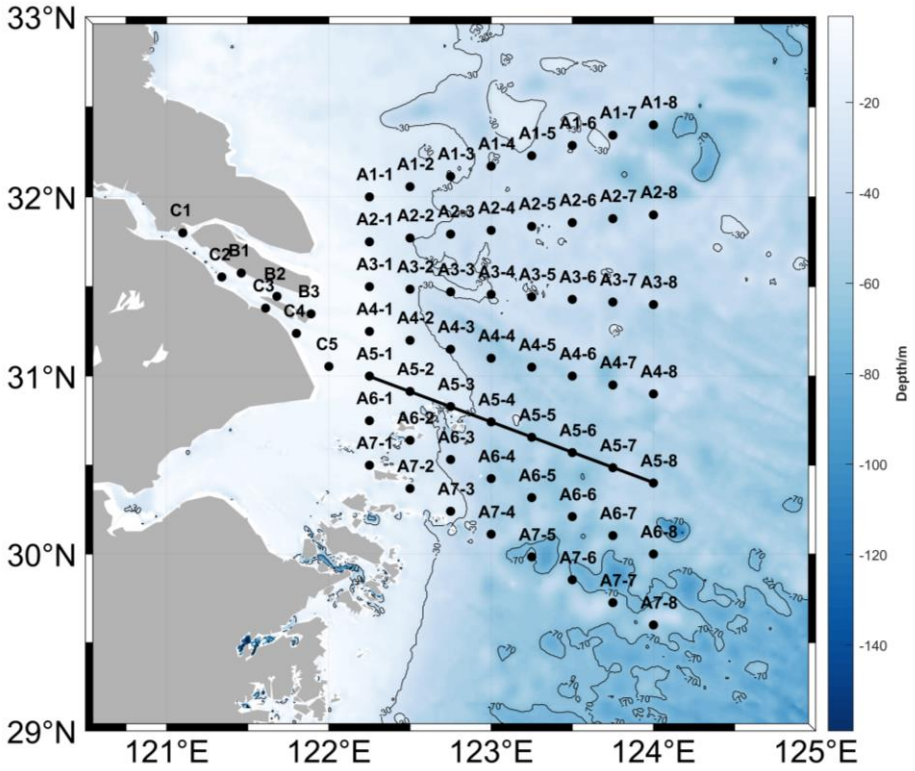

Fig.1 Distribution of sampling stations

2.2 Research Method

In this paper, the Specific Growth Rate (SGR) is used as a criterion to evaluate the effect of temperature on the growth and development of aquaculture species. Specific Growth Rate is the ratio of growth rate to growth days (Lin, 2007). It is a common index to measure the growth status of aquatic species. It can best reflect the weight change of the test body per unit time. The calculation formula is:

$$SGR\left(\%\cdot d^{-1}\right)=\frac{(lnR_b-lnR_a)}{T}\times 100\,\%$$

R_a and R_b are the initial and final weight (g) of the test body, and T is the experimental time (d).

There is no uniform standard for the temperature threshold affecting *Pseudosciaena crocea*. In this paper, the initial weight, final weight, and experimental time of the test body in the Specific Growth Rate calculation formula are corresponding to the aquaculture specifications, commodity specifications, and aquaculture cycle to determine the value of the Specific Growth Rate corresponding to the growth of *Pseudosciaena crocea* to commodity specifications and high-quality commodity specifications (High-quality goods refer to the higher quality of aquaculture organisms in the same aquaculture cycle or commodity specifications in a shorter aquaculture cycle), and then substitute into the fitting result curve to obtain the corresponding temperature interval, and perform grading evaluation, as shown in Fig. 2.

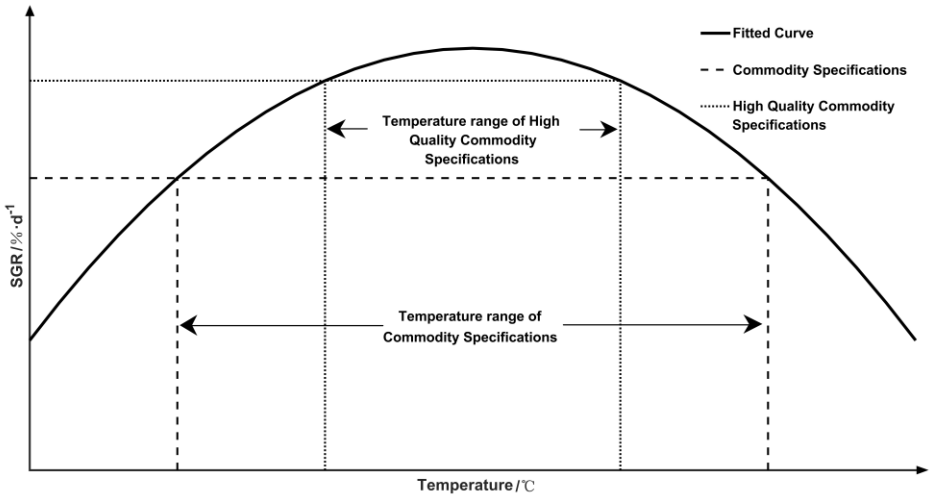

Fig.2 Schematic diagram of temperature threshold classification evaluation

3 RESULT

3.1 Effect of Temperature on Specific Growth Rate of Pseudosciaena crocea

The experimental data of Chen Jia et al. (Chen, 2013) and Ruan Chengxu et al. (Ruan, 2013) were fitted to obtain the Quadratic Regression Curve:

$$SGR = -0.0069x^2 + 0.3872x - 3.6620 \ (R^2 = 0.5820, P < 0.05)$$

According to Huang Weiqing et al. (Huang, 2019), Liao Hongmei et al. (Liao, 2012), Research results and SC / T2049.2-2006 *Pseudosciaena* crocea *fry fingerlings (*SC/T 2049.2-2006) aquatic industry standard: The initial specifications of *Pseudosciaena crocea* are 3cm, about 0.6g, and the commodity size is 300g. The aquaculture cycle is 18 months, and the aquaculture cycle of high-quality commodity specification *Pseudosciaena crocea* is 12 months. Substituting the aquaculture specifications, commodity specifications, high-quality commodity specifications, and aquaculture cycle into the calculation formula of Specific Growth Rate, the SGR of *Pseudosciaena crocea* was 1.2 %·d^{-1} when it reached the commercial specification, and 1.73%·d^{-1} when it reached the high-quality commercial specification. The corresponding temperature ranges were greater than 18.9 °C and 25.3-30.7 °C, respectively.

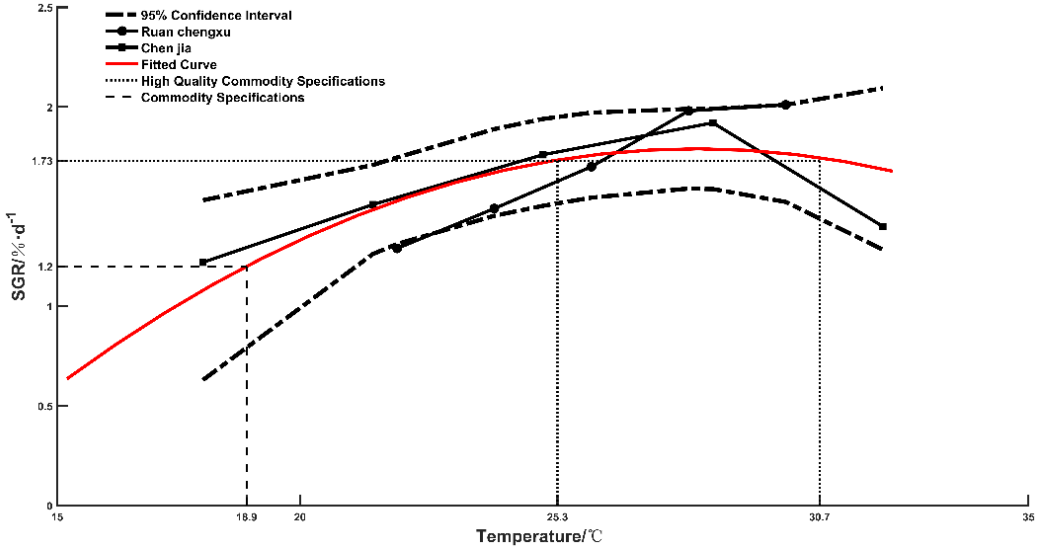

Fig.3 The influence curve of temperature on the Specific Growth Rate of Pseudosciaena crocea and graded evaluation thresholds

3.2 Temperature Threshold Grading Evaluation

If the Specific Growth Rate of *Pseudosciaena crocea* during the aquaculture cycle can support its quality to a high-quality commercial specification and beyond, then the temperature threshold corresponding to this SGR is defined as the appropriate range, if the SGR only supports the *Pseudosciaena crocea* to reach the commodity specifications and is lower than the high-quality commodity specifications, the temperature threshold corresponding to the SGR is defined as the more suitable range, if the SGR does not support *Pseudosciaena crocea* to commercial specification then the corresponding temperature threshold is defined as the unsuitable range.

The suitable range, more suitable range and unsuitable range are defined as Risk-Free (Blue), Low Risk (Green) and General Risk (Yellow) respectively. The graded assessment of temperature thresholds for *Pseudosciaena crocea* is summarised in the table below:

Table.1 Temperature evaluation threshold of Pseudosciaena crocea

Species	Temperature Evaluation Threshold (℃)		
	Risk-Free	Low Risk	General Risk
Pseudosciaena crocea	25.3–30.7	18.9–25.3 25.3–30.7	<18.9 >30.7

3.3 Distribution of Suitable Temperature Zone of Pseudosciaena crocea in the East China Sea

China prevails over the North Monsoon in winter, the convective mixing of seawater is strong, the vertical mixing of seawater is sufficient, and the vertical temperature difference is small, except for a warm water tongue extending northward due to the Taiwan Warm Current in the southern part of the study area (the temperature at the tongue axis reaches 17 °C), the temperature in the remaining sea areas is about 11-13 °C, which is lower than the critical value of the general risk temperature of *Pseudosciaena crocea* . According to the fixed-point observation data of the national Marine Ranching- Shandong Pole Island, the average temperature in this area from October 20, 2020 to June 20, 2021 is 15.1 °C, and the minimum temperature is 9.1 °C, from December 2,2020 to May 20,2021, the sea surface temperature always lower than 18.9 °C, and the duration accounts for about 70 %. Therefore, the temperature environment in the East China Sea in winter is not suitable for the growth and development of Pseudosciaena crocea.

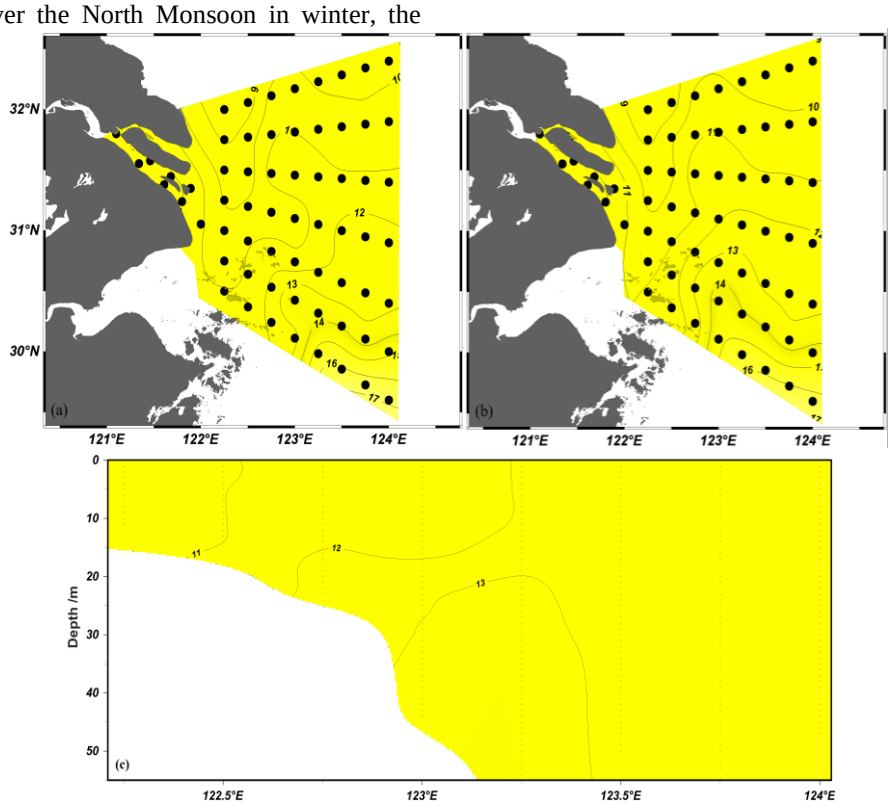

Fig.4 Surface(a), bottom (b) and section A5(c) Suitable temperature zone division of East China Sea in winter

In summer, the sea surface temperature in the East China Sea is the highest in the whole year, with an average sea surface temperature of about 26.2 °C and an average seabed temperature of about 22.3 °C. It can be seen from Figs.8a and 8b that the temperature in the study area has a complex structure in both horizontal and vertical directions. In the sea area near the Yangtze River estuary and Hangzhou Bay, the isotherms are dense and the water temperature gradient is large under the influence of coastal currents, the Yangtze River diluted water, upwelling and other factors. The characteristics of warm water tongue under the influence of the Taiwan Warm Current are not obvious, and the overall sea temperature decreases from both sides to the middle, and there is an isolated cold water masses near the estuary, whose central water temperature is about 4-5 °C lower than the surrounding sea. Fig. 8c shows that there is a bottom-up cold water tongue near the coast of Section A5 in the study area, with significant stratification of the seawater in areas outside the upwelling control zone.

In summer, except for a small part of the southern part of the bottom layer in the East China Sea, the temperature is lower than the suitable growth range for Pseudosciaena crocea, and other sea areas are suitable for *Pseudosciaena crocea* growth. The risk-free area is distributed in the surface layer of the Changjiang Estuary and the eastern sea area, and 0-25 m in the range of 123 ° -124 ° E of Section A5. The low-risk sea areas are mainly in the central sea

area of the surface layer and the outer sea area of the bottom layer, and the area ratio is higher than that of the non-risk area.

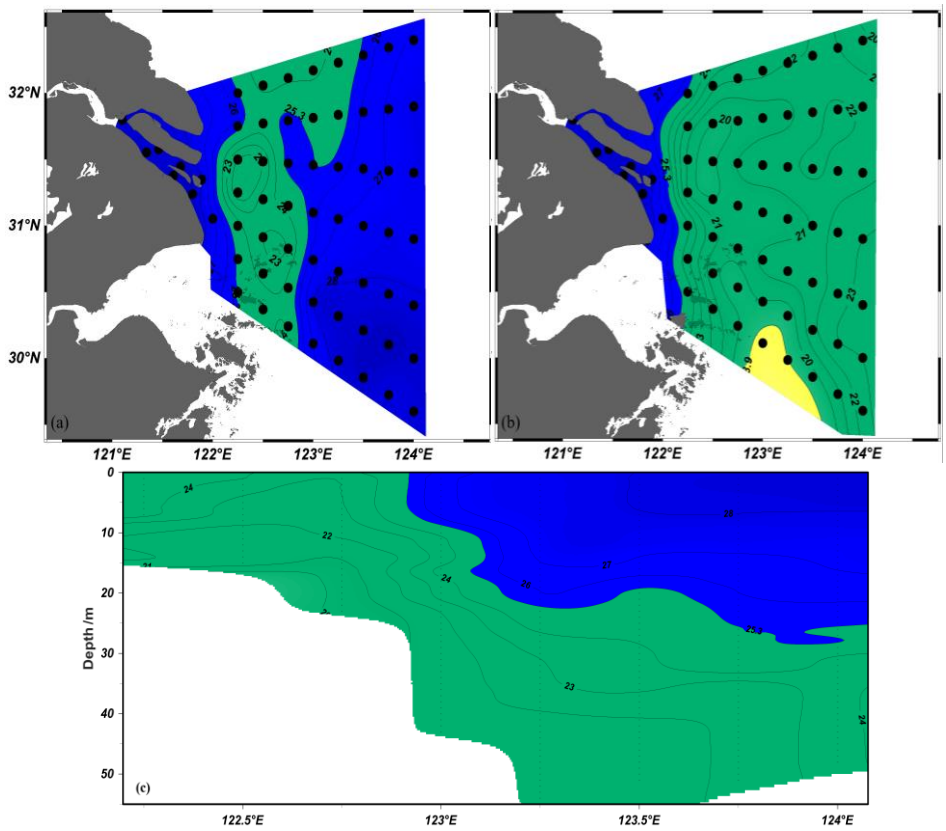

Fig. 5 Surface (a), bottom (b) and section A5(c) Suitable temperature zone division of East China Sea in summer

The water temperature in the East China Sea is higher in autumn, but it is lower than that in summer, between 23-27 °C, and the temperature variation in the eastern sea area is smaller than that in the estuary. The temperature difference between the north and south sea areas is about 4 °C. There is a small cold water masses at the estuary that extends eastward, it can be seen from Fig. 9c that the mixing of surface and bottom seawater is sufficient in autumn, and the vertical temperature difference is small. The Low-Risk area of Pseudosciaena crocea was smaller than that in summer, distributed in the middle east and south of the East China Sea, section A5 is in the suitable temperature range of Pseudosciaena crocea.

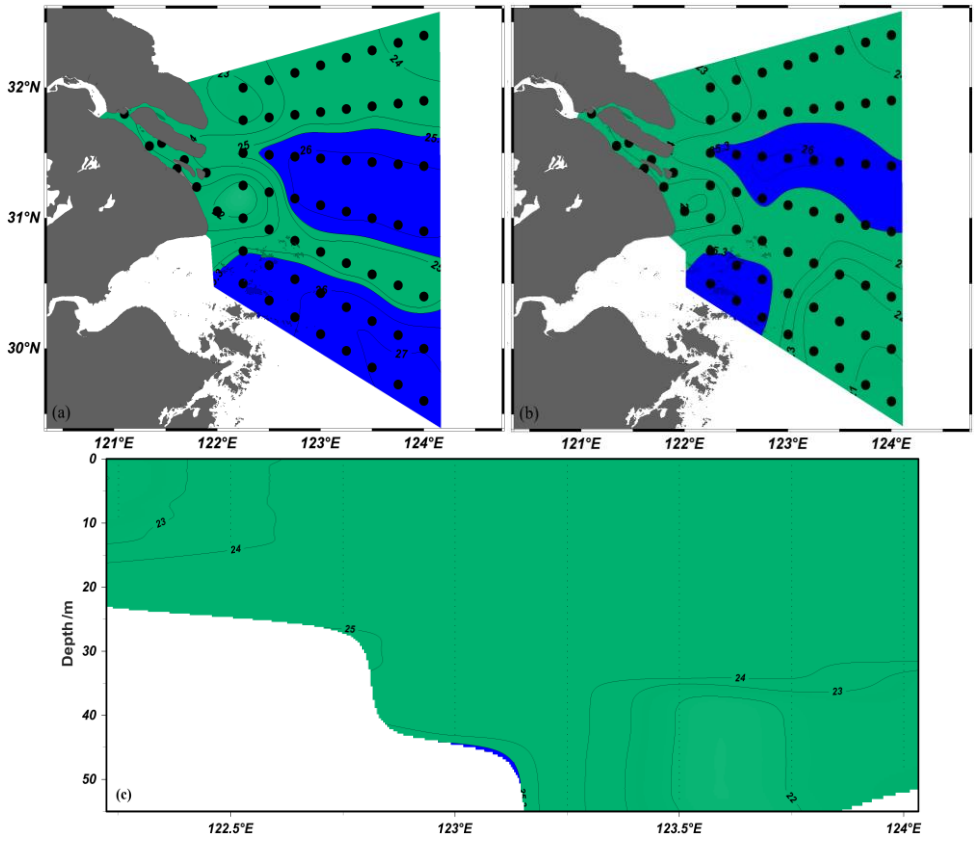

Fig.6 Surface (a), bottom (b) and section A5(c) Suitable temperature zone division of East China Sea in autumn

4 CONCLUSION

The results of this paper show that: The *Pseudosciaena crocea* can be aquacultured in a healthy temperature range of 18.9-30.7℃, based on the correlation analysis between the evaluation threshold of *Pseudosciaena crocea* temperature classification and the measured temperature field in the East China Sea in 2021, the suitable temperature distribution area of *Pseudosciaena crocea* in the East China Sea in different seasons was divided. The results showed that the East China Sea in 2021 was in the risk-free and low-risk temperature range, except that the overall seawater temperature in winter was too cold for *Pseudosciaena crocea* to grow and develop, there was no significant change or extreme value in summer and autumn.

5 DISCUSS

Temperature is one of the most important environmental factors affecting the survival of aquatic organisms in Marine Ranching (Brett, 2015). The effect of temperature on aquaculture species is manifested in the physiological inadaptability of aquatic organisms caused by temperature change, excessive temperature may cause microorganisms in the seawater to proliferate and consume oxygen, forming a hypoxic zone and leading to the hypoxic death of aquatic organisms.

In recent years, the abnormal phenomena of global climate change are increasing, such as frequent extreme high and low-temperature weather; increased eutrophication degree of coastal waters; and increasing area of the anoxic zone, which has caused significant economic losses to the marine aquaculture industry: Sustained low temperatures occurred in Zhoushan City, Zhejiang Province from December 2010 to February 2011, causing losses of about CNY 20 million for swimming crabs in Putuo District and about CNY 10 million for fish in a net cage. Therefore, it is of great significance to timely carry out temperature threshold analysis and suitable temperature zone division for the growth and survival of temperature-sensitive organisms in Marine Ranching.

The purpose of temperature threshold assessment is to explore the critical value of the impact of temperature on aquaculture species in complex ecosystems such as oceans and to provide a benchmark for monitoring and early warning. The most critical step is to convert the theoretical threshold into a threshold that can be used for actual management services. The grading evaluation of the temperature threshold in this study is a new attempt based on three factors: aquaculture specifications, commodity specifications, and aquaculture cycle, which is more in line with the actual aquaculture, it can be adjusted according to different aquaculture needs in actual aquaculture and has stronger flexibility and operability, which can provide basic data support for the online environmental monitoring and early warning and forecasting expert decision-making system of Marine Ranching.

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AUTHORS' INTRODUCTION

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