

# Cause Analysis of Extreme High Temperature Weather in Nanjing in 2022 and Its Impact on Crab Breeding in the Gucheng Lake Waters

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**Abstract.** In 2022, extreme high temperature weather occurred in Nanjing, which had a great adverse impact on aquaculture such as crabs in the waters of Gucheng Lake in Nanjing. This study analyzes the temperature situation in Nanjing in August 2022 through field survey and literature research, and compares it with the weather in the same period in history. Through the analysis of the background of global warming and the study of the atmospheric circulation during the abnormal high temperature weather, the causes of the abnormal high temperature weather in Nanjing are revealed; Study the adverse effects of high temperature weather on water temperature and oxygen content, aquatic organisms, and aquaculture, especially crab aquaculture in Gucheng Lake, and put forward corresponding countermeasures.

**Keywords:** Gucheng Lake; High temperature; Water temperature; Water oxygen content; Aquatic plants; River crab; Aquaculture.

## 1. Introduction

In the context of global warming, extreme weather events are becoming more frequent. In addition, the area of some large water bodies is shrinking due to man-made reasons such as reclamation. As a result, the self-regulation ability to climate change has been weakening. Due to the superposition of these factors, extreme high temperature and other abnormal weather events have great adverse effects on aquatic organisms and aquaculture.

This study uses survey and literature research methods. The paper analyzes the cause of extreme high temperature weather in Nanjing in 2022 and studies its impact on crab farming in the waters of Gucheng Lake, aiming to minimize human damage to the natural environment, and explore the coping strategies for abnormal weather events to minimize adverse effects and losses.

Gucheng Lake is owned by Gaochun District, Nanjing City, Jiangsu Province. It is located between  $31^{\circ}14'-31^{\circ}18'N$ ,  $118^{\circ}53'-118^{\circ}57'E$ . The lake is triangular in shape, which is wide in the north and narrow in the south. Its average water depth is 1.6 meters with maximum water depth of 3.67 meters and storage capacity of 39 million cubic meters. Figure 1 shows the location of Gucheng Lake water system<sup>[1]</sup>.

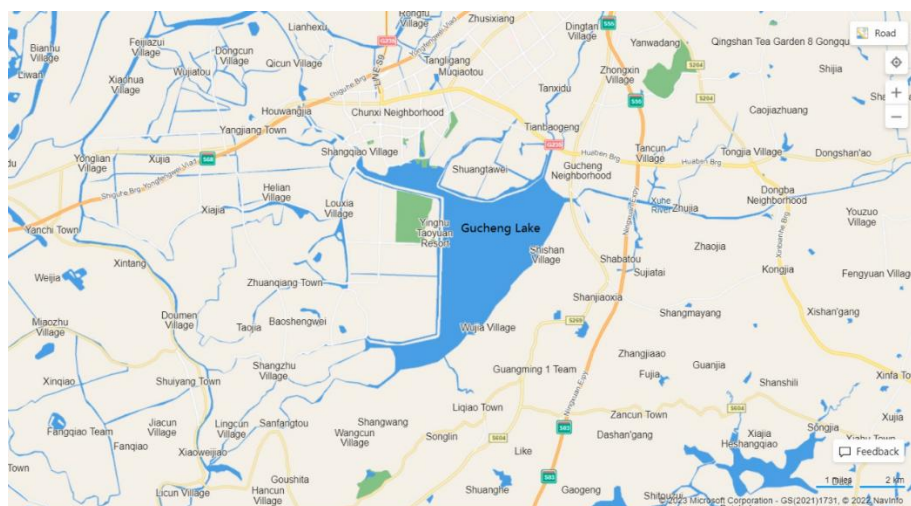


Fig. 1 Location Map of Gucheng Lake Water System

Before 1949, the lake area was 10.4 kilometers long from north to south, 8.2 kilometers wide from east to west with lake area of 76 square kilometers. In about 1990, the lake was 9.5 km long, 4.9 km wide at its maximum, which covered an area of 24.3 km<sup>2</sup>. Reclamation is considered as the main reason for the lake area shrinking. In 1978, Yongsheng polder was built in Gucheng Lake area in Gaochun District, and the area of reclamation was 41400 mu. One time reclamation reduced the lake area by 27.4 square kilometers. With the addition of reclamation of Gucheng Lake in Anhui Province, the area of Gucheng Lake decreased by more than 50% from 1949 to 1990<sup>[1]</sup>.

There are about 62 kinds of fish in the lake area, of which the major commercial fish are carp, crucian carp, black carp, grass carp, silver carp, bighead carp, bream, black bream, xenocyprininae, amur catfish, culter, yellow cheek carp, mandarin fish, etc. There are about 39 species of zooplankton, mainly including *Asplanchna brightwelli*, leaf rotifer, *Diaphanosoma*, *Bosminidae*, *Monospilus*, *Moinidae*, etc. There are about 53 species of phytoplankton, mainly including orchid algae, dinoflagellate algae, golden algae, and *Volvox*. There are about 38 kinds of higher aquatic plants, mainly including *Trapa bispinosa* Roxb, gorgon fruit, lotus, courgette, reed, mat grass, cattail grass, *Arundinella hirta* (Thunb.) Tanaka, and *Myriophyllum spicatum* L. There are about 22 species of aquatic benthic molluscs, mainly including snail, mussel, clam, corbicula, etc.<sup>[1]</sup>.

In 2018, Gaochun District's crab breeding area is 232500 mu with an annual crab output of 17300 tons, an output value of two billion yuan as well as a benefit per mu of 4000 yuan. Crab breeding has driven the number of practitioners to 25000 and the number of practitioners in the whole industry chain to more than 100, 000. The per capita net income of farmers from crabs and related industries in this region is up to 3000 yuan, which also makes the crab industry one of the largest industries to enrich the local citizens<sup>[2]</sup>. Figure 2 shows the picture of Yongsheng Polder Aquaculture Area in the Gucheng Lake Water System.



Fig. 2 Yongsheng Polder Aquaculture Area in the Gucheng Lake Water System

## 2. Literature Review

### 2.1 In the Coming Decades, High Temperature Will Become a New Normal

Meteorologists generally believe that the rhythm and extent of global warming in 2022, as well as the extreme and record-breaking frequency of high temperature are very rare. The study shows that the earth has 15 critical climatic points, which are the key indicators to measure the stability of

the earth's ecological climate. Once these critical points are breached, the earth's climate system will fall into an irreversible state and have unpredictable effects. As one of the critical points, the Greenland ice sheet has been in the state of net ice loss, and the rate of ice loss has increased in recent years [3].

Extreme high temperatures in the northern hemisphere are caused by multiple factors. Global warming is the climate background for the frequent occurrence of high temperature and heat waves in the northern hemisphere, and the continuous anomaly of atmospheric circulation in the middle latitude is the direct reason for the frequent occurrence of high temperature and heat waves in many parts of the world. The thermal dome means that the upper atmospheric thermal high pressure is stagnant for a period of time, and the atmospheric circulation between the high pressure and the nearby low pressure forms a stable  $\Omega$  type. The high pressure is like a cover, which covers the hot air in the heat wave area, but also prevents the cold air from entering, making the temperature in the hot dome higher and higher, thus causing the heat wave and even the super heat wave event [4].

## **2.2 The Main Influencing Factor of Lake Water Temperature is Air Temperature**

At present, there are few publicly published water temperature monitoring data about lakes, rivers, sea water and other surface water in China. In recent years, most researchers attribute the main influence factor of water temperature to air temperature, and take the relationship between water temperature and air temperature as the main research object. For example, some studies have analyzed the stream water temperature, water level and temperature data monitored by the coastal water cycle comprehensive test base in the Zhuhai campus of Sun Yat-sen University from August 2006 to June 2009. It is found that the relationship model between water temperature and air temperature of small-scale streams can be well fitted by linear model and logistic model. The relative temperature of water temperature fluctuation has a phase delay of 2.0 house, and the correlation degree of water temperature-temperature is negatively correlated with the water level value [5]. However, the temperature affects the water temperature of the water body, and the large water body will play a certain role in regulating the climate of the lake area. The size, shape and depth of different water bodies are also different, so the specific situation of the water temperature affected by the temperature is also different. The water temperature of Gucheng Lake system will have its own different characteristics under the influence of temperature.

## **2.3 High Water Temperature will Lead to the Death and Decay of Water Plants, and Deterioration of Water Quality**

When the water temperature is high, it will have adverse effects on aquatic organisms such as water plants in the water. Too high water temperature will lead to the death and decay of aquatic plants in the water, which will seriously affect the quality of the water in which crabs live. When there is continuous high temperature, in order to improve the quality of the water body, the keepers will put drugs into the water body to reduce the impact of decaying substances on the water quality. However, because the crab is weak under the influence of high temperature, it is often unable to bear the side effects of these drugs, which directly leads to the death of the crab [6].

## **2.4 High Water Temperature Slows Down the Growth Rate of River Crab and Increases the Disease**

For aquatic organisms in temperate climate areas, their survival temperature is  $0^{\circ}\text{C}$  -  $40^{\circ}\text{C}$ , and their growth temperature is  $10^{\circ}\text{C}$  -  $30^{\circ}\text{C}$ . A large number of studies have proved that the optimum growth temperature of river crab is  $22^{\circ}\text{C}$  -  $30^{\circ}\text{C}$ . Once the temperature of the environment where the crab lives is higher than  $30^{\circ}\text{C}$ , it will affect the growth rate of the crab. When the temperature of the water body is higher than  $33^{\circ}\text{C}$ , the growth and feeding of the crab basically shows a stagnant state. This is mainly because the temperature of the water body has exceeded the physiological endurance limit of the river crab. Living in the environment with high water temperature for a long time will

weaken the constitution of the river crab, and eventually lead to a large number of outbreaks of disease in the river crab, increasing the death rate of the river crab [6].

### 3. Analysis of Extreme High Temperature Weather in Nanjing in 2022 and Its Causes

#### 3.1 Extreme High Temperature Weather

In August 2022, the average temperature in Nanjing is 30.2°C (Lishui District) ~31.6°C (Gaochun District). Compared with the same period of the year, the average temperature in each region is from 2.3 to 3.2°C higher than that in the same period of the year, which is the highest in August since 1961. There was a wide range, strong intensity and long duration of high temperature weather in Nanjing from August 1 to 16 and from August 18 to 23. High temperature weather above 37°C occurred in most areas of the city for thirteen consecutive days, especially from August 3 to 15. From 9th to 15th, Nanjing (Jiangning District) experienced high temperature above 39°C for seven consecutive days[7]. Figure 3 shows the daily temperature change trend of Nanjing in August 2022.

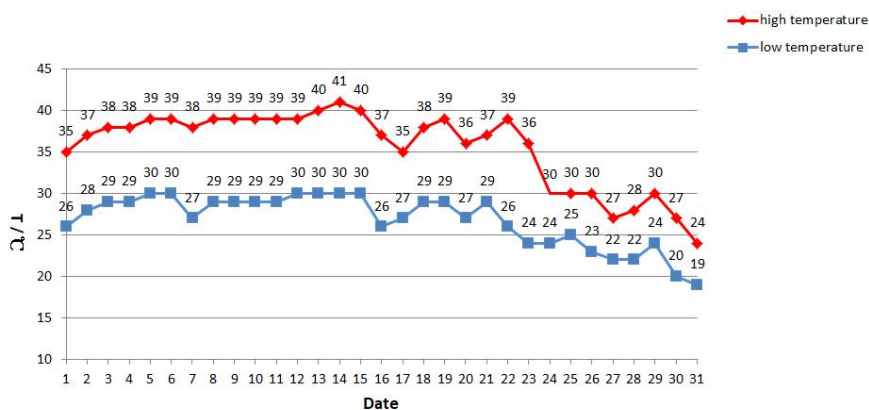


Fig. 3 Daily temperature in Nanjing in August 2022

#### 3.2 Global Warming

As for the cause of this extreme high temperature weather, first of all, the general background is global warming. Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels. The earth as a whole is being hotter and hotter. Since the 21st century, extreme high temperature weather events have occurred more and more frequently in the Northern Hemisphere. As for the reason of global warming, it can be resorted to the short wave radiation of the sun that can penetrate into the ground through the atmosphere, while the long wave radiation emitted after the ground warms up is absorbed by carbon dioxide and other substances in the atmosphere, which can lead to temperature increasing of the surface and lower atmosphere. Figure 4 shows the greenhouse effect traps thermal energy in the atmosphere.

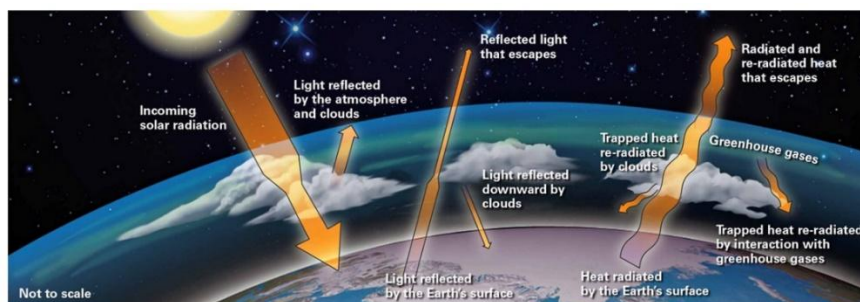




Fig. 4 The greenhouse effect traps thermal energy in the atmosphere

Source: from the text book earth portrait of a planet

Due to the burning of coal and oil in human production and living activities, a large amount of carbon dioxide comes into the atmosphere, and the reduction of forest area results in less carbon dioxide absorption. These conditions result in higher and higher carbon dioxide contents in the atmosphere as the greenhouse effect leads to global warming. Figure 5 shows remaining forests today are much smaller than forests of 8,000 years ago.

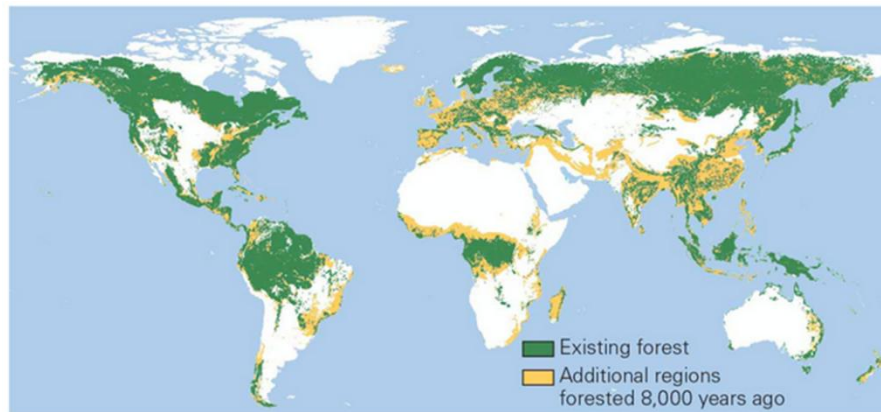


Fig. 5 Remaining forests today are much smaller than forests of 8000 years ago

Source: from the text book earth portrait of a planet

Figure 6 shows the global average surface temperature change between 1990 and 2019. Note that continents and arctic regions are warming the most. And research shows the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

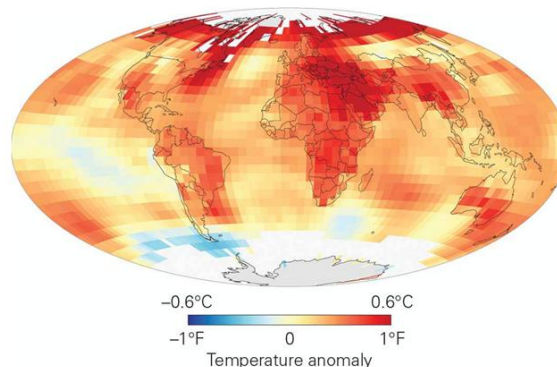


Fig. 6 Global temperature change between 1990 and 2019.

Source: from the text book earth portrait of a planet

### 3.3 Cause Analysis of High Temperature Weather

Nanjing, Jiangsu Province, China is located on the mainland of the Northern Hemisphere, and it is more affected by the greenhouse effect.

The above general background of global warming has resulted in a remarkable increase in the frequency of abnormal high temperature weather. In fact, global warming has not only warmed the atmosphere, but also warmed the oceans. Due to this situation, the oceans are far more volatile than before. Global warming is not uniform, there will be Arctic amplification effect, which means the abnormal temperature increase near the Arctic Circle is due to this reason. Global warming has a greater impact on climate sensitive areas and ecologically fragile areas, such as the Qinghai Tibet Plateau where snow is melting rapidly. The direct causes of this abnormal high temperature weather are mainly composed of several aspects. First, near the Arctic Circle, especially Hokkaido, Chukchi

Peninsula, the east coast of Canada and Northern Europe, the warming rate of seawater and coastal land is much faster than expected. Figure 7 shows global sea surface temperatures from August 7, 2022 to August 7, 2022.

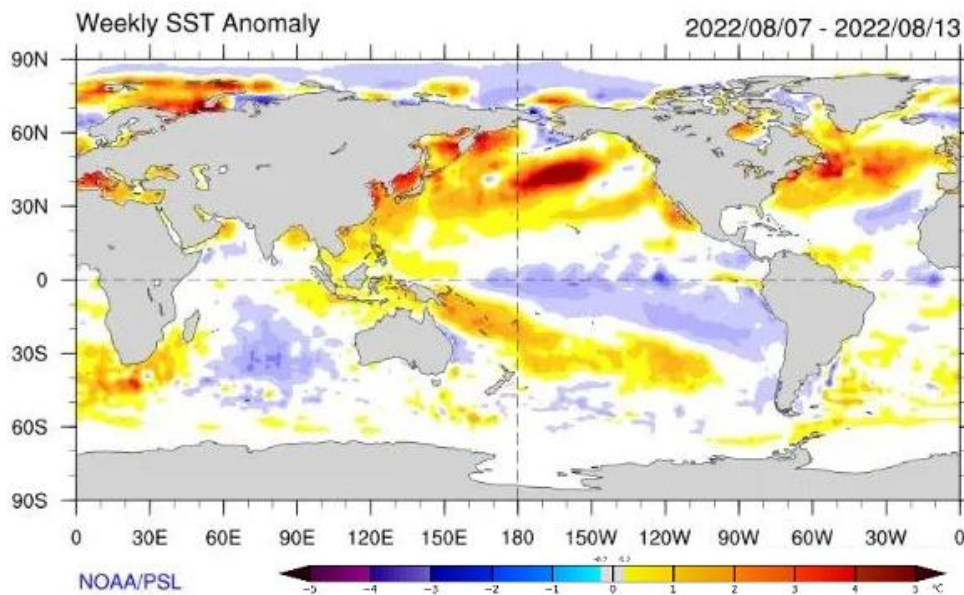


Fig. 7 Global sea surface temperatures 2022/08/07 – 2022/08/13 .

Source: <https://www.ospo.noaa.gov/Products/ocean/cb/sst5km/>

The rapid warming has widened the temperature gap near the Arctic Circle. The westerly jet stream twisted and bifurcated and a strong double jet stream appeared from May. At ordinary times, the broad westerly jet flows smoothly cross the temperate zone, separating the extreme heat from the cold; However, the westerly jet after the bifurcation lost its barrier function, which led the subtropical cool hot air flow along the longitude to the temperate zone, cold temperate zone and even the Arctic region, as a result of the abnormal atmospheric circulation at mid latitude. Over the subtropical region of the Northern Hemisphere, the western Pacific subtropical high, the Atlantic high and the Iranian high are all periodically enhanced. The upper atmospheric thermal high has been stagnant for a period of time, and the atmospheric circulation between the high and the nearby low pressure forms a stable  $\Omega$ -type. The high pressure is like a hood, which not only covers the hot air in the area where the heat wave occurs, but also prevents the cold air from entering, which makes the hot air stay near the ground without dispersing, and then a high temperature heat wave event occurs. According to this influence, the abnormal high temperature weather in Nanjing was caused.

## 4. Effects of Extreme High Temperature Weather on Aquatic Organisms and Crab Breeding

### 4.1 Influence of High Temperature Weather on Water Temperature and Oxygen Content

High temperature weather will affect the water temperature, oxygen contents and the growth of aquatic plants, which have a significant impact on the survival and growth of crabs.

Affected by the temperature, water temperature change lags behind the temperature change. Its change is less than the temperature change rate with relatively stable changes, as the water temperature change in large water bodies is relatively small. The average water depth of Gucheng Lake is only 1.6 meters, and the lake area has been greatly reduced through reclamation in history. What's more, the extreme high temperature weather in Nanjing is characterized by high temperature and long duration as a result of more water temperature rise. During this extremely hot weather,

some athletes happened to be here to participate in the training and competition of the Sailing Competition of the 20th Games of Jiangsu Province. At that time, some athletes jumped into the water to feel the water temperature. According to the feedback of those athletes, the basic feeling was that the water above the ankle is hot, while only the soil near the bottom of the lake was slightly lower.

The major sources of oxygen in water are atmospheric oxygen and photosynthesis of aquatic plants. The oxygen in the air is first dissolved in the surface layer of the water body, and then the oxygen in the surface layer is transported to the water body through the convection mixing between the upper and lower layers of the water body. Oxygen in the air and dissolution occurs when it comes into contact with the surface of the water body, and there are two major meteorological factors that can affect this process. One is atmospheric pressure. If there is high atmospheric pressure, high partial pressure of oxygen in the air as well as high dissolution rate, the oxygen contents of the surface layer of the water body will increase. Conversely, if the atmospheric pressure is low, the oxygen content also decreases. The other is the surface water temperature. The amount of dissolved oxygen on the surface of the water is inversely proportional to the temperature of the water, that is, when the water temperature is high, the amount of dissolved oxygen is low. When the water temperature is low, the amount of dissolved oxygen is high. The surface water temperature is directly affected by the temperature. For example, at an atmospheric pressure, the dissolved oxygen saturation at 0 °C is 14.62mg/L, and the dissolved oxygen saturation at 20 °C is 9.17mg/L. This prolonged period of high temperature has led to a significant reduction in the amount of dissolved oxygen on the surface of the water [8].

#### **4.2 Influence of High Temperature Weather on Aquatic Plants**

Hot weather leads to an increase in water temperature, which has a great impact on aquatic plants. For example, this will cause *Elodea nuttallii* to die and float in large numbers, and the vitality of black algae and *Vallisneria* will also be weakened, and yellow roots and black roots will increase. The higher the temperature, the lower the solubility of oxygen, and long-term high temperature can easily lead to hypoxia in the water. Continuous hot weather will make the residual bait and metabolites in the water body unable to effectively decompose, and the death and decay of aquatic plants will seriously weaken the water purification ability of aquatic plants, which will result in the continuous deterioration of pond water quality and breed cyanobacteria[9]. A large number of algae colonies are concentrated on the water surface, further hindering gas exchange and normal photosynthesis in the water body, which will lead to a decrease in the amount of dissolved oxygen in the water, consume oxygen in the water, and also deteriorate the water quality. In addition, algal toxins produced after the death of cyanobacteria will directly affect the molting growth of river crabs.

#### **4.3 Influence of High Temperature Weather on Crab Breeding**

For aquatic organisms in temperate climate regions, their survival temperature is 0-40 °C, and their growth temperature is 10-30 °C. As a benthonic animal, crabs like cool places, so they also like places with rich water and grass. Because of this characteristic, crabs fear high temperatures. The optimal growth temperature of river crabs is 22-30°C. Once the environmental temperature of river crabs is higher than 30 °C, their food intake decreases, which will have a great impact on the growth rate of river crabs. When the temperature of water body is higher than 33°C, the growth and feeding of river crabs are basically at a standstill.

In addition, the reduction of oxygen content in water caused by high water temperature and the death of aquatic plants have a great adverse impact on the survival and growth of crabs.

Through the field survey and questionnaire survey of crab farmers in the waters of Gucheng Lake in Nanjing, it was found that the growth of crabs was slower than in previous years, and a certain number of crabs died.

## 5. Conclusions

Taking Gucheng Lake in Nanjing as a case study, this paper studies the impact of abnormal high temperature weather on crab aquaculture. The main conclusions are as follows.

High temperature weather will lead to high water temperature, reduced oxygen content in water, death and decay of aquatic plants as well as reduced water quality, which will have a serious adverse impact on the growth and survival of river crabs. Compared with previous years, the time for crabs to come into the market in the Gucheng Lake area of Gaochun District, Nanjing will be delayed in 2022, as the production will also be reduced.

In order to cope with the impact of high temperature weather on crab farming in the waters of Gucheng Lake, first of all, we need to strengthen the protection of the lake area to prevent the lake area from shrinking, because it can reduce the water temperature, oxygen in the water body and the self-regulation capacity of aquatic grass growth. Secondly, we should timely clean up the floating aquatic plants that are broken and dead by crabs, so as to prevent the aquatic plants from rotting and damaging the water quality. In addition, if conditions permit, we also need to take advantage of aerators and other equipment to increase the oxygen content of water bodies. In the end, we should pay special attention to increasing the variety of aquatic plants because the abnormal high temperature weather is more and more frequent. When high temperature leads to the death of *Elodea nuttallii* and other heat-resistant aquatic plants, there are other types of aquatic plants that can continue to survive, so as to better maintain the water temperature and oxygen contents.

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