Isothermal Water Mass in the Bottom Water at the Bay Mouth of Jiaozhou Bay
Isothermal Water Mass Existence

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Abstract: Based on the survey data of Jiaozhou Bay in May, June, July, August, September and October 1980, the bottom water temperature and its horizontal distribution in Jiaozhou Bay were studied. The results show that the bottom water temperature of Jiaozhou Bay ranged between 10.18℃-25.72℃ in May, June, July, August, September and October, and the bottom seawater temperature reached above 10.00℃. This indicates that the bottom water temperature of Jiaozhou Bay was relatively high in May, June, July, August, September and October, which showed the number, location, scale and temperature change sequence of isothermal water mass in Jiaozhou Bay in May, June, July, August, September and October were determined.

1. Introduction
Oceans become more and more for the temperature regulation of the whole earth. So, it is important to study the changes of water temperature and high temperature waters in coastal waters for the protection of marine environment and the maintenance of ecological sustainable development. [1]

On the basis of investigation data in 1980, the author analyzed the bottom water temperature and the bottom isothermal water mass in Jiaozhou Bay and studied the temperature in the bottom of the waterbody of Jiaozhou Bay, providing a scientific background for a comprehensive analysis of the isothermal zone in the bottom water of Jiaozhou Bay and a theoretical basis for the change of the bottom water temperature.

2. Environment and Methods

2.1 Natural Environment of Jiaozhou Bay
Jiaozhou Bay is a semi-enclosed bay, located between 120°04′~120°23′ E and 35°58′~36°18′N, with an area of 446 km² and an average water depth of 7m. Jiaozhou Bay mouth was between Tuan Island and Xuejia Island, the four rivers of Dagu River, Haibo River, Licun River and Loushan River and Yanghe River around Jiaozhou Bay transported a large amount of matter content into the bay, which showed many changes of matter content in Jiaozhou bay [2,3].

2.2 Materials and Methods
The North China Sea Monitoring Center of the State Oceanic Administration gave the data on water temperature of Jiaozhou Bay in May, June, July, August, September, and October 1980. There were eight stations H34, H35, H36, H37 and H82, providing the water samples in Jiaozhou Bay in May,
June, July, August, September and October (Fig. 1). If there was more than 10m in the water depth, it needed to get samples in both surface layer and bottom layer; if there was less than 10m, it needed to get samples only in the surface layer, which showed the national standard method of sampling included in "The Specification for Marine Monitoring" (1991) [4].

Fig. 1 location of jiaozhou bay survey station

3. Results and Discussions

3.1 Bottom Water Temperature
From May to October, the bottom waterbody temperature of Jiaozhou Bay ranged between 10.18℃-25.72℃, which indicated that the interval length of seawater temperature variation was 13.07℃. In May, the bottom water temperature in Jiaozhou Bay ranged between 10.18℃-12.35℃, and the seawater temperature was very low. In June, the bottom water temperature began to increase, and the water temperature in Jiaozhou Bay ranged between 15.09℃-18.77℃, which indicated that the seawater temperature was relatively low. In July, the bottom water temperature increased significantly, and the range of water temperature in Jiaozhou Bay was 18.67℃-20.49℃, which indicated that the seawater temperature was relatively high. In August, the bottom water temperature increased significantly, and the range of water temperature in Jiaozhou Bay was 24.58℃-25.72℃, which indicated that the seawater temperature reached the highest value. In September, the bottom water temperature decreased significantly, and the range of water temperature in Jiaozhou Bay was 23.79℃-24.43℃, which indicated that the seawater temperature reached the highest value. In October, the seawater temperature in Jiaozhou Bay was 15.53℃-20.04℃, which indicated that the seawater temperature was relatively high. Therefore, in May, June, July, August, September and October, the water temperature of the bottom waterbody of Jiaozhou Bay ranged between 10.18℃-25.72℃, which indicated that the temperature of the bottom of the seawater was relatively high (Table 1) in May, June, July, August, September and October.

| Month    | Temp/℃ |
|----------|---------|
| May      | 10.18-12.35 |
| June     | 15.09-18.77 |
| July     | 18.67-20.49 |
| August   | 24.58-25.72 |
| September| 23.79-24.43 |
| October  | 15.53-20.04 |

3.2 Isothermal Water Mass in the Bottom Layer
In May, June, July, August, September and October, the variation range of the bottom water temperature body of Jiaozhou Bay was 10.18℃-25.72℃. From May to October, the seawater temperature was higher than 10.00℃. Moreover, the interval length of seawater temperature variation was 15.54℃, which showed that the general temperature of the bottom waterbody of Jiaozhou Bay was relatively high in May, June, July, August, September and October.

In May, the bottom water temperature of Jiaozhou Bay ranged between 10.18℃-12.35℃. The seawater temperature in Jiaozhou Bay was very low. In Jiaozhou Bay, there were three waters whose temperature ranged slightly, namely the waters inside the bay mouth, the waters at the bay mouth and the waters outside the bay mouth. At stations H36 and H37 in the waters inside the bay mouth, the
water temperature ranged slightly between 12.25℃-12.35℃, which indicated that the interval length of the seawater temperature variation was 0.10℃. At H35 station in the waters at the bay mouth, the water temperature ranged relatively slightly between 11.63℃-11.63℃, which indicated that the interval length of seawater temperature variation was 0.00℃. At stations H34 and H82 in the waters outside the bay mouth, the water temperature ranged slightly between 10.18℃-10.26℃, which indicated that the interval length of the seawater temperature variation was 0.06℃. Thus, three waters formed in the bottom water in May due to the change of seawater temperature, including the waters inside the bay mouth, the waters at the bay mouth and the waters outside the bay mouth. The temperature difference in each waters was relatively small, while the temperature difference among the three waters was relatively large (Fig. 2).

Fig.2 Isothermal water mass in the bottom water of Jiaozhou Bay in May 1980 (℃)

In June, the bottom water temperature of Jiaozhou Bay ranged between 15.09℃-18.77℃. The seawater temperature in Jiaozhou Bay was relatively low. In Jiaozhou Bay, there were three waters whose bottom water temperature ranged slightly, namely the waters at the bay mouth and in the western waters inside the bay mouth, the eastern waters inside the bay mouth and the waters outside the bay mouth. At stations H36 and H35 in the waters at the bay mouth and the western waters inside the bay mouth, the water temperature ranged slightly from 17.38℃ to 17.44℃, which indicated that the interval length of the seawater temperature variation was 0.06℃. At station H37 in the eastern waters inside the bay mouth, the water temperature ranged relatively slightly between 18.77℃-18.77℃, which indicated that the interval length of seawater temperature variation was 0.00℃. At stations H34 and H82 in the water outside the bay mouth, the water temperature ranged slightly from 15.09℃ to 15.32℃, which indicated that the interval length of the seawater temperature variation was 0.23℃. Thus, three waters formed in the bottom water in June due to the change of seawater temperature, including the waters at the bay mouth and in the western waters inside the bay mouth, the eastern waters inside the bay mouth, and the waters outside the bay mouth. The temperature difference in each water was relatively small, while the temperature difference among the three waters was relatively large (Fig. 3).

Fig.3 Temperature in the bottom water of Jiaozhou Bay in June 1980 (℃)

In July, the bottom water temperature of Jiaozhou Bay ranged between 18.67℃-20.49℃. The seawater temperature in Jiaozhou Bay was relatively high. In Jiaozhou Bay, there were three waters whose bottom water temperature ranged slightly, namely the waters inside the bay mouth, the water at the bay mouth and in the northern waters outside the bay mouth, and the southern waters outside the
bay mouth. At stations H36 and H37 in the waters inside the bay mouth, the water temperature ranged slightly from 20.20℃ to 20.49℃, which indicated that the interval length of the seawater temperature variation was 0.29℃. At stations H35 and H34 in the waters at the bay mouth and the northern waters outside the bay mouth, the water temperature ranged relatively slightly between 19.68℃-19.78℃, which indicated that the interval length of seawater temperature variation was 0.10℃. At station H82 in the southern waters outside the bay mouth, the water temperature ranged slightly from 18.67℃ to 18.67℃, which indicated that the interval length of the seawater temperature variation was 0.00℃. Thus, three waters formed in the bottom water in July due to the change of seawater temperature, including the waters inside the bay mouth, the waters at the bay mouth and in the northern waters outside the bay mouth, and the southern waters outside the bay mouth. The temperature difference in each water was relatively small, while the temperature difference among the three waters was relatively large (Fig. 4).

In August, the bottom water temperature of Jiaozhou Bay ranged between 24.58℃-25.72℃. The seawater temperature in Jiaozhou Bay was extremely high. In Jiaozhou Bay, there were two waters where the bottom water temperature ranged slightly, namely the waters inside the bay mouth and at the bay mouth and the waters outside the bay mouth. At stations H37, H36 and H35 in the waters inside the bay mouth and at the bay mouth, the water temperature ranged slightly from 25.20℃ to 25.72℃, which indicated that the interval length of seawater temperature variation was 0.52℃. At stations H34 and H82 in the waters outside the bay mouth, the water temperature ranged relatively slightly between 24.58℃-24.80℃, which indicated that the interval length of seawater temperature variation was 0.22℃. Thus, two waters formed in the bottom water in August due to the change of seawater temperature, including the waters inside the bay mouth and at the bay mouth, and the waters outside the bay mouth. The temperature difference in each water was relatively small, while the temperature difference between the two waters was relatively large (Fig. 5).

In September, the bottom water temperature of Jiaozhou Bay ranged between 23.79℃ -24.43℃. The seawater temperature in Jiaozhou Bay was extremely high. In Jiaozhou Bay, there were two waters where the bottom water temperature ranged slightly, namely the waters inside the bay mouth-at the bay mouth-in the southern waters outside the bay mouth, and the northern water outside the bay mouth. At stations H37, H36, H35 and H82 in the waters inside the bay mouth-at the bay mouth-in the southern waters outside the bay mouth, the water temperature ranged slightly from 23.79℃ to 23.91℃,
which indicated that the interval length of the seawater temperature variation was 0.12℃. At station H34 in the northern waters outside the bay mouth, the water temperature ranged relatively slightly between 24.43℃-24.43℃, which indicated that the interval length of seawater temperature variation was 0.00℃. Thus, two waters formed in the bottom water in September due to the change of seawater temperature, including the water inside the bay mouth-at the bay mouth-in the southern waters outside the bay mouth and the northern water outside the bay mouth. The temperature difference in each waters was relatively small, while the temperature difference between the two waters was relatively large (Fig. 6).

![Fig.6 Temperature in the bottom water of Jiaozhou Bay in September 1980 (℃)](image)

In October, the bottom water temperature of Jiaozhou Bay ranged between 15.53℃-20.04℃. The seawater temperature in Jiaozhou Bay was relatively low. In Jiaozhou Bay, there were three waters whose bottom water temperature ranged slightly, namely the water at the bay mouth and in the western waters inside the bay mouth, the eastern waters inside the bay mouth and the waters outside the bay mouth. At stations H36 and H35 in the waters at the bay mouth and western waters inside the bay mouth, the water temperature ranged slightly from 16.33℃ to 16.74℃, which indicated that the interval length of the seawater temperature variation was 0.31℃. At station H37 in the eastern waters inside the bay mouth, the water temperature ranged relatively slightly between 15.53℃ to 15.53℃, which indicated that the interval length of seawater temperature variation was 0.00℃. At stations H34 and H82 in the waters outside the bay mouth, the water temperature ranged slightly from 20.00℃ to 20.04℃, which indicated that the interval length of the seawater temperature variation was 0.04℃. Thus, three waters formed in the bottom water in October due to the change of seawater temperature, including the water at the bay mouth and in the western waters inside the bay mouth, the eastern waters inside the bay mouth and the waters outside the bay mouth. The temperature difference in each water was relatively small, while the temperature difference among the three waters was relatively large (Fig. 7).

![Fig.7 Temperature in the bottom water of Jiaozhou Bay in October 1980 (℃)](image)

4. Conclusion

In May, June, July, August, September and October, the temperature in the bottom water body of Jiaozhou Bay ranged between 10.18℃-25.72℃, which indicated that the temperature of the bottom of the seawater reached above 10.00℃, which showed that the temperature in the bottom water body of Jiaozhou Bay was relatively high in May, June, July, August, September and October.

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References
[1] Dongfang Yang, author. Silicon Dynamics of Earth Ecosystem [M]. Beijing: China Ocean Press, 2013, 1-372.
[2] Dongfang Yang, Y CHEN, Z H GAO, et al. Silicon Limitation on primary production and its destiny in Jiaozhou Bay, China IV transect offshore the coast with estuaries [J]. Chin. J. Oceanol. Limnol. 2005, 23(1): 72-90.
[3] Dongfang Yang, Fan Wang, Zhenhui Gao, et al. Ecological Phenomena of Phytoplankton in Jiaozhou Bay [J]. Marine Science, 2004, 28 (6): 71-74.
[4] State Oceanic Administration. The Specification for Marine Monitoring [Z]. Beijing: China Ocean Press, 1991