The Variation of Water Temperature at Bottom in Bay Mouth of Jiaozhou Bay

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Abstract: According to investigation data of Jiaozhou Bay in May, August and October of 1979, the variation and horizontal distribution of water temperature at bottom in Jiaozhou Bay were studied. The results showed that in May, August and October, the variation was 10.90-23.97 ℃. From May to October, the water temperature was more than 10.90 ℃, and the variation range reached 13.07 ℃, showing that the water temperature at bottom was high. The variation range was 10.90-11.80 ℃ in May, 22.50-23.97 ℃ in August and 17.62-18.39 ℃ in October. In inside waters and bay mouth, the variation range was 0.00 ℃ in May, 0.01 ℃ in August and 0.00 ℃ in October. And in outside waters, bay mouth and inside waters, it was 0.90 ℃ in May, 1.02 ℃ in August and 0.77 ℃ in October. The water temperature reached 11.80 ℃ in May and 23.97 ℃ in August in inside waters, and 18.39 ℃ in October in outside waters, forming the high-temperature respectively. In May, August and October, at bottom, the water temperature in bay mouth was consistent with the high temperature in inside waters or outside waters.

1. Introduction
Ocean plays an important role in regulating the climate [1]. The temperature variation of coastal area in Qingdao is consistent with the world, however, the mean surface temperature increased stably and dramatically, three times more than the world [2]. The air and water temperature have a strong influence on plants, animals, microorganism and human body [3-10]. Thus, the study on the variation of nearshore water temperature and high-temperature waters can provide reference for protecting marine environment and maintaining the sustainable development of ecology.

This paper, based on the investigation data of 1979, analyzes the variation, horizontal distribution and source variation of water temperature at bottom in Jiaozhou Bay, and studies the variation, source variation process and source amount, to provide scientific background for comprehensively analyzing the source and high-temperature area of water temperature, and theoretical reference for the variation of water temperature at bottom and its influence on the environment.
2. Investigation Waters, Materials and Methods

2.1 Natural environment of Jiaozhou Bay
Jiaozhou Bay, located in southern Shandong Peninsula, is a typical semi-closed bay. The geographical location is 120°04′-120°23′E, 35°58′-36°18′N. Bounded by the line connecting Tuandao Cape and Xuejiadao Island, it connects with Yellow Sea, covering an area of about 446 km², with the average depth of about 7 m. There are dozens of rivers reaching the ocean in Jiaozhou Bay, among of which, the rivers with a larger volume of runoff and sand content include Dagu River, Yang River, Haibo River in Qingdao, Licun River, Loushan River and so on. These rivers are seasonal streams, and hydrological characteristics vary seasonally [11, 12].

2.2 Materials and methods
The materials about water temperature in Jiaozhou Bay waters in May, August and October of 1979 was provided by North China Sea Environment Monitoring Center, State Oceanic Administration. In May and October, 3 sites were established for sampling in Jiaozhou Bay: H34, H35 and H36, whereas, in August, 4 sites were established, including H34, H35, H36 and H37, shown in Figure 1. Samplings were performed for three times in May, August and October in 1979, respectively. According to the depth of water, sampling and survey were conducted (surface and bottom layers were sampled when the depth of water is more than 10m, but just surface layer when less than 10m). The survey on water temperature of Jiaozhou Bay waters was in accordance with national standard method, which was included in The Specification for Marine Monitoring (1991) [13].

![Fig.1 Investigation sites in Jiaozhou Bay](image)

3. Results

3.1 The variation of water temperature at bottom
In May, August and October, the variation was 10.90-23.97 ℃, and the variation range reached 13.07℃. The variation range was 10.90-11.80 ℃, low in May, 22.50-23.97 ℃, high in August but 17.62-18.39 ℃ in October, which was still high after decreasing dramatically. The variation range of, more than, indicated that in terms of water temperature variation, it was relatively high in the entire Jiaozhou Bay, shown in Table 1.

| Time       | May      | August   | October  |
|------------|----------|----------|----------|
| Water temperature/ ℃ | 10.90-11.80 | 22.50-23.97 | 17.62-18.39 |
3.2 The horizontal distribution at bottom
In May, in site H36 at inside waters and H35 at bay mouth, water temperature reached high as 11.80 °C, forming the high-temperature area centered by inside waters and a series of parallel lines from inside waters to outside waters. The water temperature decreases from 11.80 °C in the center to 10.90 °C in outside waters in southern bay along with the gradients, shown in Figure 2.

In August, in site H36 and H37 at inside waters, from inside waters to bay mouth, water temperature reached high as 23.52-23.97 °C, forming the high-temperature area centered by inside waters and a series of parallel lines from inside waters to outside waters. The water temperature decreases from 23.52-23.97 °C in the center to 22.50 °C in outside waters in southern bay along with the gradients, shown in Figure 3.

In October, in site H34 at outside waters and H35 at bay mouth, water temperature reached high as 18.39 °C, forming the high-temperature area centered by outside waters and a series of parallel lines from outside waters to inside waters. The water temperature decreases from 18.39 °C in the center to 17.62 °C in inside waters in southern bay along with the gradients, shown in Figure 4.
4. Discussion

4.1 The regional variation of water temperature at bottom
In May, August and October, the variation was 10.90-23.97 °C, more than 10.90°C, and the variation range reached 13.07°C, indicating that the water temperature at bottom in the entire Jiaozhou Bay was high.

The variation range was 10.90-11.80 °C, low in May, 22.50-23.97 °C, high in August and 17.62-18.39°C, also high in October. The variation was 11.80-11.80 °C in site H36 and H35 in May, 23.51-23.52 °C in site H36 and H35 in August, and 18.39-18.39 °C in site H34 and H35 in October. The variation range was 0.00°C, 0.01°C and 0.00°C, respectively. The difference in water temperature between outside waters and bay mouth, and inside waters was 0.90°C in May and 1.02°C in August. And the difference between inside waters and bay mouth, and outside waters was 0.77°C in October.

4.2 The source of water temperature at bottom
The rising water temperature was caused by short-wave radiation from the sun and sky and heat of sea water from long-wave radiation from the air, which was provided all the time. Besides, the heat was also brought by aerial conduction and sea current.

In May, from northeastern and northern nearshore waters, the surface water temperature reached 15.30-16.50°C, forming the high-temperature area centered by northern nearshore waters. It decreased from this waters to inside waters, bay mouth and outside waters along with the gradients, forming a series of parallel lines from inside waters to outside waters. It decreased from inside waters to outside waters in southern bay along with the gradients. From May, the water temperature began to increase from inside waters to bay mouth and to outside waters.

In August, from eastern and northern nearshore waters, the surface water temperature reached 28.09-28.70 °C, forming the high-temperature area centered by eastern and northern nearshore waters. It decreased from this waters to inside waters, bay mouth and outside waters along with the gradients, and began to increase in bottom waters, forming a series of parallel lines from inside waters to outside waters. It decreased from inside waters to outside waters in southern bay along with the gradients. From August, the water temperature began to increase from inside waters to bay mouth and to outside waters.

In October, in site H34 from eastern nearshore waters, the surface water temperature reached high as 18.39°C, forming the high-temperature area centered by eastern nearshore waters. It decreased from
outside waters to bay mouth and inside waters along with the gradients, and began to decrease in bottom waters, forming a series of parallel lines from outside waters to inside waters. It decreased from outside waters to inside waters along with the gradients. From October, the water temperature began to increase from inside waters to bay mouth and to outside waters.

4.3 The water temperature at bottom in bay mouth
The variation was 11.80-11.80°C in site H36 and H35 in May, 23.51-23.52°C in site H36 and H35 in August, and 18.39-18.39°C in site H34 and H35 in October. The variation range was 0.00°C, 0.01°C and 0.00°C, respectively. In May and August, the water temperature of inside waters was more than that in outside waters, and the water temperature of bay mouth was consistent with inside waters. In October, the water temperature of outside waters was more than that in inside waters, and the water temperature of bay mouth was consistent with outside waters.

In May, August and October, at bottom waters, the water temperature of bay mouth was consistent with inside or outside waters with higher water temperature. Hence, the water temperature of bay mouth was consistent with the high temperature in inside or outside waters. In other words, the higher water temperature in inside and outside waters decided that of bay mouth.

5. Conclusion
In May, August and October, the variation was 10.90-23.97°C, more than 10.90°C, and the variation range reached 13.07°C, indicating that the water temperature at bottom in the entire Jiaozhou Bay was high.

The variation range was 10.90-11.80°C, low in May, 22.50-23.97°C, high in August and 17.62-18.39°C, also high in October. The variation was 11.80-11.80°C in site H36 and H35 in May, 23.51-23.52°C in site H36 and H35 in August, and 18.39-18.39°C in site H34 and H35 in October. The variation range was 0.00°C, 0.01°C and 0.00°C, respectively. The difference in water temperature between outside waters and bay mouth, and inside waters was 0.90°C in May and 1.02°C in August. And the difference between inside waters and bay mouth, and outside waters was 0.77°C in October.

The water temperature reached 11.80°C in May, 23.97°C in August in inside waters, and 18.39°C in October in outside waters, forming the high-temperature area in inside waters in May and August and outside waters in October, respectively.

Hence, the water temperature of bay mouth was consistent with the high temperature in inside or outside waters. In other words, the higher water temperature in inside and outside waters decided that of bay mouth.

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