The Rising and Decreasing Heat of Waters

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Abstract: According to the investigation data of Jiaozhou Bay in May, August and October of 1979, the vertical distribution and seasonal variation of water temperature at surface and bottom in inside and outside waters were studied, and the seasonal distribution, variation range and horizontal distribution trend were determined. The results showed that, in inside waters, bay mouth and outside waters, from May to August and to October, the seasonal variation was spring, autumn and spring, respectively, from high to low. It indicated that the water temperature was transported to everywhere in the ocean after the current transport in horizontal and vortex motion mixing in vertical direction. In terms of variation range, it was basically the same at surface and bottom in May, August and October. When it was low at surface, it was low at corresponding bottom; otherwise, it was opposite. From inside waters to bay mouth, the horizontal distribution of water temperature at surface was inconsistent with that at bottom in May, contrary in August and consistent in October. From bay mouth to outside waters, it was contrary in May, consistent in August and inconsistent in October. The horizontal distribution trend of water temperature disclosed that the source of high water temperature was the rising and decreasing heat.

1. Introduction
Ocean plays an important role in climate regulation [1-10]. 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]. The study on nearshore water temperature variation and high-temperature waters is conductive to protecting ocean environment and maintaining the sustainable development of ecology. According to the water temperature of Jiaozhou Bay in 1979, in this paper, the vertical distribution and seasonal variation of water temperature at surface and bottom layers from inside waters to outside waters were studied, and the seasonal variation and vertical sediment were displayed, providing scientific reference for the study on vertical sediment and horizontal transport of water temperature at surface and bottom.

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 446km², with the average depth of about 7m. There are dozens of rivers reaching the ocean in Jiaozhou Bay, among of which,

[Continuation of text]
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, August and October, 3 sites were established for sampling in Jiaozhou Bay: H34, H35 and H36, 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

3. Results
Site H36 was set in inside waters, H35 in bay mouth and H34 in outside waters.

3.1 The surface and bottom waters
In May, the variation range of water temperature was 12.00-12.10°C at surface, and 10.90-11.80°C at corresponding bottom layer, less than 12.10°C, showing that the water temperature was low. In August, it was 24.02-27.21°C at surface and 22.50-23.52°C at bottom, more than 22.50°C, showing that the water temperature was high. In October, it was 18.25-18.39°C at surface and 17.62-18.39°C at bottom, more than 17.62°C, showing that the water temperature was high.

Hence, in May, August and October, the variation range was 10.90-27.21°C, more than 10.00 °C, so the water temperature was high.

3.2 The seasonal distribution at surface layer
At surface layer, the water temperature at surface was 12.00-12.10°C in May, 24.02-27.21°C in August and 18.25-18.39°C in October, thus the variation range was 12.00-27.21°C. From low to high, the variation was May, October and August, respectively, and the seasonal variation was spring, autumn and summer.
3.3 The seasonal distribution at bottom layer
At bottom layer, the water temperature at surface was 10.90-11.80°C in May, 22.50-23.52°C in August and 17.62-18.39°C in October, thus the variation range was 10.90-23.52°C. From low to high, the variation was May, October and August, respectively, and the seasonal variation was spring, autumn and summer.

3.4 The variation range at surface and bottom layers
In May, when the water temperature was as low as 12.00-12.10°C at surface, it was low at corresponding bottom layer as 10.90-11.80°C. In August, it was as high as 24.02-27.21°C at surface and 22.50-23.52°C at bottom. In October, it was 18.25-18.39°C at surface and 17.62-18.39°C at bottom. The variation of 12.00-27.21°C at surface was more than 10.90-23.52°C at bottom, however, the variation amount was basically same. In a word, when it was high at surface, it would also be high at corresponding bottom, showing that the water temperature at surface and bottom was consistent.

3.5 The horizontal distribution trend at surface and bottom
From inside waters to bay mouth, in site H36 and H35, at surface, the water temperature decreased from 12.10°C to 12.00 °C along with the gradients, and at bottom, it remained as 11.80 °C. In August, it increased from 27.12°C to 27.21°C along with the gradients, and at bottom, it decreased from 23.52 °C to 23.51°C. In October, it increased from 18.25°C to 18.39°C at surface and from 17.62°C to 18.39 °C at bottom along with the gradients. In short, the water temperatures at surface and bottom were inconsistent in May, contrary in August and consistent in October.

From bay mouth to outside waters, in site H35 and H34, in May, it increased from 12.00°C to 12.10 °C at surface but decreased from 11.80°C to 10.90°C at bottom. In August, it decreased from 27.21°C to 24.02°C at surface and from 23.51°C to 22.50°C at bottom. In October, it increased from 18.38°C to 18.39°C at surface but remained as 18.39°C at bottom. In short, the water temperatures at surface and bottom were contrary in May, consistent in August and inconsistent in October.

4. Discussion
4.1 The vertical variation process
Due to the effect of vertical waters, the water temperature varied greatly through the waters. The heat exchange caused by the vortex motion mixing in vertical direction played an important role in distributing the heat of waters at surface and bottom in vertical surface. The direction of heat transport was decided by the vertical distribution of temperature. When the water temperature at upper surface was higher than that at lower surface, the heat was transported downward. Otherwise, it was transported upward. The exchange of heat between upper and lower surfaces inevitably caused the new distribution of water temperature in vertical direction and variation of temperature at each layer [1]. Thus, the vertical variation of water temperature could be determined after obtaining the variation of water temperature at surface and bottom.

4.2 The seasonal variation in inside waters
At surface layer of inside waters, the water temperature increased from 12.10°C in May to 27.12°C in August, and began to decrease to 18.25°C in October, so the seasonal variation, from low to high, was spring, autumn and summer, respectively.

At bottom layer of inside waters, the water temperature increased from 11.80 °C in May to 23.52°C in August, and began to decrease to 17.62°C in October, so the seasonal variation from low to high, was spring, autumn and summer, respectively.

In short, at surface and bottom layers of inside waters, the seasonal variation, from low to high, was spring, autumn and summer, respectively.
4.3 The seasonal variation in bay mouth
At surface layer of bay mouth, the water temperature increased from 12.00℃ in May to 27.21℃ in August, and began to decrease to 18.38℃ in October, so the seasonal variation, from low to high, was spring, autumn and summer, respectively.

At bottom layer of bay mouth, the water temperature increased from 11.80℃ in May to 23.51℃ in August, and began to decrease to 18.39℃ in October, so the seasonal variation from low to high, was spring, autumn and summer, respectively.

In short, at surface and bottom layers of bay mouth, the seasonal variation, from low to high, was spring, autumn and summer, respectively.

4.4 The seasonal variation in outside waters
At surface layer of outside waters, the water temperature increased from 12.10℃ in May to 24.02℃ in August, and began to decrease to 18.39℃ in October, so the seasonal variation, from low to high, was spring, autumn and summer, respectively.

At bottom layer of outside waters, the water temperature increased from 10.90℃ in May to 22.50℃ in August, and began to decrease to 18.39℃ in October, so the seasonal variation from low to high, was spring, autumn and summer, respectively.

In short, at surface and bottom layers of outside waters, the seasonal variation, from low to high, was spring, autumn and summer, respectively.

4.5 The mechanism of seasonal variation
In May, in northeastern and northern nearshore waters, the water temperature reached 15.30-16.50℃, forming the high-temperature area in northern nearshore waters, which was transported from inside waters to bay mouth, further to outside waters.

In August, in eastern and northern nearshore waters, it reached 28.09-28.70℃, forming the high-temperature area in eastern and northern nearshore waters, which was transported from inside waters to bay mouth, further to outside waters.

In October, in eastern nearshore waters, it reached 18.39℃, forming the high-temperature area in eastern nearshore waters, which was transported from outside waters to bay mouth, further to inside waters.

It was transported horizontally by ocean current in either way. At the same time, it was also transported from surface to bottom through vortex motion mixing in vertical direction.

From May to August and October, in three areas, at surface and bottom, the seasonal variation, from low to high, was spring, autumn and summer, respectively. It showed that the water temperature could be transported to all corners of the ocean owing to ocean current in horizontal direction and the vortex motion mixing in vertical direction.

4.6 The influence from internal waters and external factors
In terms of variation range, it was basically the same at surface and bottom in May, August and October. When it was low at surface, it was low at corresponding bottom; otherwise, it was opposite. It indicated that the water temperature could be rapidly mixed from surface to bottom layers, resulting the consistent variation amount of water temperature at surface and bottom. If the variation at surface was larger than that at bottom, it showed that the water temperature was more influenced by atmosphere than sea floor.

4.7 The transport of water temperature
The source of high water temperature at different time was different waters, specifically, northeastern and northern nearshore waters in May, eastern and northern nearshore waters in August and eastern nearshore waters in October.

The variations at surface and bottom layers of inside waters and bay mouth were inconsistent in May, which indicated that the water temperature at surface began to rise, however, it at bottom
remained. The variations at surface and bottom layers of bay mouth and outside waters were contrary, which indicated that the water temperature at surface began to rise, whereas, it at bottom was not influenced yet.

The variations at surface and bottom layers of inside waters and bay mouth were contrary in August, which showed that the water temperature at surface began to decrease, however, it at bottom began to rise. The variations at surface and bottom layers of bay mouth and outside waters were consistent, which indicated that the water temperature at surface and bottom began to rise.

The variations at surface and bottom layers of inside waters and bay mouth were consistent in October, which indicated that the water temperature at surface and bottom began to decrease. The variations at surface and bottom layers of bay mouth and outside waters were inconsistent, which indicated that the water temperature at surface began to decrease, whereas, it at bottom remained.

The horizontal distribution of water temperature at surface and bottom disclosed the rising and decreasing water temperature according to the source of high water temperature. In any waters and at any time, different sources of high temperature decided the varied horizontal distribution of water temperature at surface and bottom.

5. Conclusion
The source of high water temperature at different time was different waters, specifically, northeastern and northern nearshore waters in May, eastern and northern nearshore waters in August and eastern nearshore waters in October.

The water temperature was transported horizontally by ocean current in either way. At the same time, it was also transported from surface to bottom through vortex motion mixing in vertical direction.

From May to August and October, in three areas, at surface and bottom, the seasonal variation, from low to high, was spring, autumn and summer, respectively. It showed that the water temperature could be transported to all corners of the ocean owing to ocean current in horizontal direction and the vortex motion mixing in vertical direction.

In terms of variation range, it was basically the same at surface and bottom in May, August and October. When it was low at surface, it was low at corresponding bottom; otherwise, it was opposite.

From inside waters to bay mouth, the water temperatures at surface and bottom were inconsistent in May, contrary in August and consistent in October. From bay mouth to outside waters, the water temperatures at surface and bottom were contrary in May, consistent in August and inconsistent in October.

The horizontal distribution of water temperature at surface and bottom disclosed the rising and decreasing water temperature according to the source of high water temperature. In any waters and at any time, different sources of high temperature decided the varied horizontal distribution of water temperature at surface and bottom.

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