Variation of Salinity in both Surface and Bottom Layers in Jiaozhou Bay

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Abstract: Based on the investigation data on Jiaozhou Bay in May and October 1979, the vertical distribution and seasonal variation of salinity in the surface and bottom waters from the inner waters to the outer waters of Jiaozhou Bay were studied, and the seasonal distribution, variation range and horizontal distribution trend of the salinity in surface and bottom layers were determined. The results showed that from May to October, in the waters of Jiaozhou Bay mouth, the inner waters of the bay mouth and the outer waters of the bay mouth, the seasonal change of salinity in both surface and bottom layers from low to high was: autumn and spring. In Jiaozhou Bay, from the inner water area to the outer water area, in May and October, the variation ranges of salinity in surface and bottom layers were basically the same. When the salinity content in surface was relatively low, that of the corresponding bottom layer was relatively low; when the salinity content in surface was relatively high, that of the corresponding bottom layer was relatively high. It showed that the salinity was fully transported to every part of the ocean through horizontal current transport and vertical eddy mixing. In Jiaozhou Bay, from the waters inside the bay mouth to the waters of the bay mouth, the horizontal distribution trends of salinity in the surface and bottom were opposite in May and the consistent in October. In May and October, the horizontal distribution trends of salinity in surface and bottom from the bay mouth to the outside of the bay mouth were consistent. Therefore, from May to October, in the inner waters of Jiaozhou Bay mouth, bay mouth waters and the outer waters of bay mouth, the seasonal variation mechanism of salinity in surface and bottom: both high and low salinity were transported by horizontal currents from the outer water area of the bay mouth to the water area of the bay mouth, and then to the inner water area of the bay mouth, which determined the seasonal variation mechanism of salinity in surface and bottom.

1. Introduction

The salinity in the sea water is the marine basic element, which showed the fact that it is important to study the salinity change and high salinity water area in the offshore to protect the marine environment and maintain the ecological sustainable development [1-5]. Based on the data of salinity survey in Jiaozhou Bay in 1979, this thesis studies the vertical distribution and seasonal variation of the salinity in surface and bottom layers of the inner water area of the bay mouth, the water area of the bay mouth and the outer water area of the bay mouth. Then the seasonal distribution, variation range and horizontal distribution trend of salinity in the surface and bottom were defined. And the thesis shows the seasonal variation process and vertical distribution of the salinity in the water area of Jiaozhou Bay, which provides scientific basis for the study of vertical distribution and horizontal movement of salinity in surface and bottom waters.
2. Investigation Waters, Materials and Methods

2.1 Natural Environments of Jiaozhou Bay. Jiaozhou Bay is a typical semi-closed Bay with 120°04′-120°23′E, 35°58′-36°18′N, covering an area of about 446km², with an average water depth of about 7m. There are rivers flowing into the sea in Jiaozhou Bay such as Dagu River, Yang River and Haibo River, Licun River and Loushan River.

2.2 Materials and Methods. The survey data on salinity in Jiaozhou Bay in May and October, 1979, being provided by the North Sea Monitoring Center of the State Oceanic Administration. water samples were taken at stations H34、H35、H36 in Jiaozhou Bay (Figure 1). Meanwhile, the samples were taken in May and October, 1979 respectively. The investigation of the salinity was completed by the national standard method, recorded in the Specification for Marine Monitoring (1991) [6].

Fig.1 Investigation sites in Jiaozhou Bay

3. Results

In Jiaozhou Bay waters, station H36 is located in the inner waters of the bay mouth; and station H35 is in the waters of the bay mouth; and then station H34 is in the outer waters of the bay mouth.

3.1 Surface and bottom waters. In Jiaozhou Bay, from the inner water area to the outer water area, in May, the variation range of salinity in the surface layer of Jiaozhou Bay was 31.47-31.60 ‰, and that of the corresponding bottom layer was 31.49-31.55 ‰. This showed that in Jiaozhou Bay, from the inner water area to the outer water area, the salinity of the whole surface and bottom water was more than 31.47 ‰, and the salinity of the sea water was relatively high. In October, the variation range of salinity in the surface layer of Jiaozhou Bay water was 31.12-31.20 ℃, and that of the corresponding bottom layer was 31.09-31.21 ℃. This showed that in Jiaozhou Bay, from the inner water area to the outer water area, the salinity of the whole surface and bottom water was less than 31.21 ‰, and the salinity of the sea water was relatively low.

Therefore, in May and October, in Jiaozhou Bay, from the inner water area to the outer water area, the range of salinity in surface and bottom layers was 31.09-31.60 ‰, which was larger than 31.00 ‰ in the whole surface and bottom water body. In May, the salinity of sea water was relatively high. In October, the salinity of seawater was relatively low.

3.2 Seasonal Distribution of the Surface Layer. In Jiaozhou Bay, from the inner water area to the outer water area of the bay mouth, salinity in the surface layer was between 31.47-31.60 ‰ in May and 31.12-31.20 ‰ in October. The results showed that in May and October, the variation range of salinity in surface layer was 31.12-31.60 ‰, and the order of salinity from low to high was October and May. Therefore, the seasonal variation of salinity from low to high was autumn and spring.
3.3 Seasonal Distribution in the Bottom Layer. In Jiaozhou Bay, from the inner water area to the outer water area of the bay mouth, the salinity content of bottom layer was between 31.49-31.55‰ in May and 31.09-31.21‰ in October. This showed that in May and October, the range of salinity in the bottom layer was 31.09-31.55 ‰, a relatively wide level. The order of salinity in bottom layer from low to high was October and May. Therefore, the seasonal variation order of salinity in the bottom layer from low to high was autumn and spring.

3.4 Variation Range of Salinity in Both Surface and Bottom Layers. From the inner water area to the outer water area of Jiaozhou Bay, when the salinity of the surface layer was between 31.47-31.60‰, that of the corresponding bottom layer was between 31.49-31.55‰. In October, when the salinity in surface was between 31.12-31.20‰, that of the bottom was between 31.09-31.21‰. Moreover, the variation range of salinity in the surface layer was 31.12-31.60 % with a length of 0.48 ‰, which was wider than that in the bottom layer, that was between 31.09~31.55‰, with a length of 0.46 ‰. But lengths of change ranges were very close, and the change amount was basically the same. Therefore, when the salinity in surface was relatively high, that of the corresponding bottom layer was relatively high; when the salinity in surface was relatively low, that of the corresponding bottom layer was relatively low. This showed that the salinity of the surface and bottom was the same.

3.5 Horizontal Distribution Trends of surface and bottom layers. In Jiaozhou Bay, the salinity in waters inside the bay mouth and the waters of bay mouth was studied.

In May, from station 36 in the inner water area of the bay mouth to station 35 in the water area of bay mouth, the salinity in the surface layer increased from 31.47 ‰ to 31.58 ‰. In the bottom layer, the salinity decreased from 31.55 ‰ to 31.49 ‰ along the gradients. This showed that the horizontal distribution trends of salinity in the surface and bottom were opposite.

In October, from station 36 in the inner water area of the bay mouth to station 35 in the water area of bay mouth, in the surface layer, the salinity decreased along the gradients from 31.20 ‰ to 31.18 ‰. In the bottom layer, the salinity decreased from 31.21 ‰ to 31.20 ‰ along the gradients. This showed that the horizontal distribution trends of salinity in the surface and bottom were consistent.

In Jiaozhou Bay, from the inner water area of the bay mouth to the water area of the bay mouth, in May, the horizontal distribution trend of salinity in the surface was opposite to that of the bottom; in October, the horizontal distribution trend of salinity in the surface was consistent with that of the bottom.

In Jiaozhou Bay, the salinity in waters outside the bay mouth and the waters of bay mouth was studied.

In May, from station 35 at the water of bay mouth to station 34 at the water outside of the bay mouth, the salinity in the surface layer increased from 31.58 ‰ to 31.60 ‰. In the bottom layer, the salinity increased from 31.49 ‰ to 31.53 ‰. This showed that the horizontal distribution trend of salinity in the surface and bottom was consistent.

In October, from station 35 at the water area of bay mouth to station 34 of water area outside of the bay mouth. In the surface layer, the salinity decreased along the gradients, from 31.18 ‰ to 31.12 ‰. In the bottom layer, the salinity decreased from 31.20 ‰ to 31.09 ‰. This showed that the horizontal distribution trends of salinity in the surface and bottom were consistent.

In Jiaozhou Bay, the horizontal distribution of salinity in the surface was consistent with that of bottom in May and October.

4. Discussion

4.1 Vertical Change Process. Under the effect of vertical water body, the salinity changed greatly. The eddy mixing in the vertical direction of salinity had a great effect on the uniformity, which made the salinity in surface and bottom layers redistribute vertically. The direction of salinity transport was determined by the vertical distribution of currents. The upward and downward movement of currents will inevitably cause the salinity to redistribute vertically and change the salinity of each layer [1]. Therefore, the vertical variation process of salinity can be determined by knowing the variation of salinity in the surface and bottom water.

4.2 Seasonal variation process of salinity in the inner water area of the bay mouth. In the surface of the inner waters of Jiaozhou Bay mouth, the salinity reached a high value of 31.47 ‰ in May. Then it began to decline. By October, the salinity reached a relatively low value of 31.20 ‰. Therefore, the seasonal
variation order of salinity from low to high was autumn and spring.

In the bottom of the inner waters of Jiaozhou Bay mouth, the salinity reached a relatively high value of 31.55‰ in May. Then it began to decline. By October, the salinity reached a relatively low value of 31.21‰. Therefore, the seasonal variation order of salinity from low to high was autumn and spring.

Therefore, from May to October, in the water body inside the Jiaozhou Bay mouth, the seasonal change order of salinity in the surface and bottom layers from low to high were autumn and spring.

4.3 Seasonal variation process of salinity in waters of the bay mouth. In the surface water of Jiaozhou Bay mouth, the salinity reached a high value of 31.58‰ in May. Then it began to decline. By October, the salinity reached a relatively low value of 31.18‰. Therefore, the seasonal variation order of salinity from low to high was autumn and spring.

In the bottom water of Jiaozhou Bay mouth, the salinity reached a high value of 31.49‰ in May. Then it began to decline. By October, the salinity reached a lower value of 31.20‰. Therefore, the seasonal variation order of salinity from low to high was autumn and spring.

Therefore, from May to October, in the water body of Jiaozhou Bay mouth, the seasonal change order of salinity in the surface and bottom layers from low to high was autumn and spring.

4.4 Seasonal variation process of salinity in the outer waters of the bay mouth. In the surface waters outside the Jiaozhou Bay, the salinity reached a relatively high value of 31.60‰ in May. Then it began to decline. By October, the salinity reached a relatively low value of 31.12‰. Therefore, the seasonal variation order of salinity from low to high was autumn and spring.

In the bottom of the water outside the mouth of Jiaozhou Bay, the salinity reached a relatively high value of 31.53‰ in May. Then it began to decline. By October, the salinity reached a relatively low value of 31.09‰. Therefore, the seasonal variation order of salinity from low to high was autumn and spring.

Therefore, from May to October, in the water body of Jiaozhou Bay mouth, the seasonal change order of salinity in surface and bottom layers from low to high was autumn and spring.

4.5 The mechanism of seasonal change. In May, the highest salinity was between 31.58-31.60‰ in the water area of the bay mouth and the water area outside the bay. The surface currents with high salinity in the open sea brought the high salinity to Jiaozhou Bay, which made the salinity in the water area of the bay mouth and the water area outside the bay reach the highest value. It showed that the surface currents carried the high salinity from the outer water area of the bay mouth to the water area of the bay mouth, and then to the inner water area of the bay mouth.

In October, the lowest salinity was between 31.12-31.18‰ in the water area of the bay mouth and the water area outside the bay. The surface currents of low salinity in the open sea brought the low salinity to Jiaozhou Bay, which made the salinity in the water area of the bay mouth and the water area outside the bay reach the lowest value. It showed that the surface currents carried the low salinity from the outer water area of the bay mouth to the water area of the bay mouth, and then to the inner water area of the bay mouth.

Both high and low salinity were transported by horizontal currents from the outer water area of the bay mouth to the water area of the bay mouth, and then to the inner water area of the bay mouth. Therefore, from May to October, in the inner waters of Jiaozhou Bay mouth, waters of bay mouth and the outer waters of bay mouth, the seasonal variation order of salinity from low to high was autumn and spring. At the same time, the salinity was transported from the surface layer to the bottom layer through vertical eddy mixing. The seasonal change order of salinity in bottom layer from low to high was autumn and spring. It showed that the salinity was fully transported to every party of the ocean through horizontal current transport and vertical eddy mixing.

5. Conclusion

In May and October, in Jiaozhou Bay, from the inner water area to the outer water area, the range of salinity in surface and bottom layers was 31.09-31.60‰. And in the whole surface and bottom water body, the salinity was more than 31.00‰. In May, the salinity of sea water was relatively high. In October, the salinity of seawater was relatively low. Therefore, the order of salinity in the surface layer from low to high
was October and May. Thus, the seasonal variation order of the salinity in the surface layer from low to high was autumn and spring.

In Jiaozhou Bay, from the inner water area to the outer water area, in May and October, the variation ranges of salinity in the surface and bottom layer were basically the same. When the salinity in the surface was relatively low, that of the corresponding bottom layer was relatively low; when the salinity in the surface was relatively high, that of the corresponding bottom layer was relatively high. This showed that the salinity of the surface and bottom water was consistent by mixing.

From May to October, in the inner waters of Jiaozhou Bay mouth, bay mouth waters and the outer waters of bay mouth, the seasonal variation order of salinity from low to high was autumn and spring. At the same time, the salinity was transported from the surface layer to the bottom layer through vertical eddy mixing. The seasonal change order of salinity in the bottom from low to high was autumn and spring. It showed that the salinity was fully transported to every part of the ocean through horizontal current transport and vertical eddy mixing. Therefore, from May to October, in the inner waters of Jiaozhou Bay mouth, bay mouth waters and the outer waters of bay mouth, the seasonal variation mechanism of salinity in surface and bottom was as below, both high and low salinity were transported by horizontal currents from the outer water area of the bay mouth to the water area of the bay mouth, and then to the inner water area of the bay mouth, which determined the seasonal variation mechanism of salinity in surface and bottom.

In Jiaozhou Bay, from the inner water area of the bay mouth to the water area of the bay mouth, in May, the horizontal distribution trend of salinity in the surface was opposite to that of the bottom; in October, the horizontal distribution trend of the salinity in the surface was consistent with that of the bottom.

In Jiaozhou Bay, from the water area of the bay mouth to the water area outside the bay mouth, the horizontal distribution of salinity in surface was consistent with that of bottom in May and October.

The horizontal distribution trend of salinity in surface and bottom layers revealed that only in May, the horizontal distribution trends of salinity in surface and bottom layers were opposite in the water body from the inside of the bay mouth to the bay mouth, while in other waters, the horizontal distribution trends of salinity in surface and bottom layers were the same at any time.

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