Decreasing and Migration Process of PHC Content in Central Jiaozhou Bay

Dongfang Yang\textsuperscript{1,2,a}, Haixia Li\textsuperscript{1}, Dong Lin\textsuperscript{1}, Yuan Zhang\textsuperscript{1}, Qi Wang\textsuperscript{1}

\textsuperscript{1}Accountancy School, Xijing University, Xi’an 710123, China;
\textsuperscript{2}North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China;
\textsuperscript{a}dfyang_dfyang@126.com

Abstract: Based on the survey data of Jiaozhou Bay in May, August and October 1992, the migration and variation of PHC content of the oil spill in Jiaozhou Bay were studied. It was found that oil spill originally occurred in central Jiaozhou Bay in May, and its PHC content was 0.042mg/L. A series of concentric circles with different gradients formed around there, and there was a descended distribution trend from the center to the periphery along the gradient. The content of PHC decreased from 0.042mg/L at the center to 0.012mg/L in the southwest water, 0.024mg/L in the northwest water, 0.012mg/L in the northern water, 0.020mg/L in the northeast water, 0.014mg/L in the eastern water and 0.010 mg/L in the southeast water. The PHC content in these waters ranged from 0.010mg/L to 0.042mg/L. With horizontal absolute loss velocity model of material content, it was calculated that the horizontal absolute loss velocity of PHC content in the surface waters from the central water to the southwest water in May was 0.36 Yang Dongfang absolute number, to the northwest water 0.25 Yang Dongfang absolute number, to the northeast water 0.31Yang Dongfang absolute number, to the eastern water 0.58 Yang Dongfang absolute number and to the southeast water 0.50 Yang Dongfang absolute number. Therefore, with the central water of Jiaozhou Bay taken as the source of oil spill at sea, there was a descended PHC content distribution trend from the center to the periphery along the gradient, and the horizontal absolute loss velocity of PHC content ranged from 0.25 Yang Dongfang absolute number to 0.58 Yang Dongfang absolute number. With horizontal relative loss velocity model of material content, it was calculated that the horizontal relative loss velocity of PHC content in the surface waters from the central water to the southwest water of Jiaozhou Bay in May was 8.68 Yang Dongfang relative number, to the northwest water 5.95 Yang Dongfang relative number, to the northeast water 12.38 Yang Dongfang relative number, to the eastern water 13.80 Yang Dongfang relative number and to the southeast water 11.90 Yang Dongfang relative number. Therefore, with the central water of Jiaozhou Bay taken as the source of oil spill at sea, there was a descended PHC content distribution trend from the center to the periphery along the gradient, and the horizontal relative loss velocity of PHC content ranged from 5.95 Yang Dongfang relative number to 13.80 Yang Dongfang relative number. The rising PHC content distribution order was: that of the southwest water < that of the northwest water < that of the northern water < that of the eastern water < that of the northeast water < that of the northwest water. The rising horizontal absolute (relative) loss velocity of PHC content order was: that of the northwest water < that of the northeast water < that of the southwest water < that of the southeast water < that of the northern water < that of the eastern water. With horizontal loss velocity model of Yang Dongfang material content, the terminal value and process value of PHC content form the central water toward the six directions can be calculated.
1. Introduction
In Jiaozhou Bay, where there are petroleum storage bases, there are many incoming and outgoing ships, as well as oil spills at sea. Once oil spill occurs at sea, petroleum (PHC) will migrate and decrease toward the periphery from the high content area at the source of oil spill. Thus, the PHC content is transported through the ocean to the whole bay [1-11]. Therefore, by the investigation data in 1992, the terminal value and process value of PHC content can be calculated with the horizontal loss velocity model of Yang Dongfang material content. On this basis, we can carry out a quantitative study the decreasing and migration process of PHC content toward the periphery along the gradient in the waterbody of Jiaozhou Bay, and identify the source and pollution degree of PHC in the waters of Jiaozhou Bay, thus providing scientific theoretical basis for marine environment protection and maintaining ecological sustainable development.

2. Materials and Methods Used in the Investigation of the Waters

2.1 Natural Environment of Jiaozhou Bay
Located in the southern part of Shandong Peninsula, between 120°04′-120°23′ E and 35°58′-36°18′N, Jiaozhou Bay is a typical semi-enclosed bay with an area of 446 km² and an average water depth of 7m. With the line between Tuan Island and Xuejia Island as the boundary, Jiaozhou Bay is adjacent with the Yellow Sea. There are more than a dozen seagoing rivers in Jiaozhou Bay, among which Dagu River and Yanghe River is of larger runoff amount, Haibo River, Licun River and Loushan River in Qingdao City belong to seasonal stream and show hydrological characteristics varying with seasonal changes [12,13].

2.2 Materials and Methods
The data of PHC in the waterbody of Jiaozhou Bay in May, August and October 1992 used in this study were provided by the North China Sea Monitoring Center, the State Oceanic Administration. Water samples were taken from thirteen stations set in Jiaozhou Bay in May, August and October respectively and were marked as H52, H53, H54, H55, H56, H57, H58, H59, H60, H61, H2104, H2105 and H2106 (Fig. 1). When the water depth is more than 10m, it is supposed to take samples from surface layer and bottom layer; when it is less than 10m, it is supposed to take from the surface layer only. This is the national standard method of sampling included in the national document “The Specification for Marine Monitoring” (1991)) [14].

3. Results

3.1 Source
In May, PHC content at Station 55 in the central water of Jiaozhou Bay reached a relatively high level of 0.042mg/L and thus formed a high PHC content area. There were a series of concentric circles with different gradients forming around there and a descended distribution trend from the center to the periphery along the gradient. The content of PHC decreased from 0.042mg/L at the center to 0.012mg/L in the southwest water, 0.024mg/L in the northwest water, 0.012mg/L in the northern water, 0.020mg/L in the northeast water, 0.014mg/L in the eastern water and 0.010mg/L in the southeast water (Fig. 2).
In May, a high PHC content area formed in the center of the waterbody of Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042 mg/L. The decline of PHC content during the transportation led to a descended PHC content distribution trend along the gradient. The content of PHC decreased to 0.012 mg/L in the southwest water, 0.024 mg/L in the northwest water, 0.012 mg/L in the northern water, 0.020 mg/L in the northeast water, 0.014 mg/L in the eastern water and 0.010 mg/L in the southeast water. Then, at the same time, whether the horizontal loss of flows with the same PHC content but toward different directions during was consistent in the process of migration at sea.

3.2 Distance from the Central Station to Surrounding Stations
In May, with Station 55 at the center, there were Station 54 in southwest Jiaozhou bay, Station 56 in northwest Jiaozhou Bay, Station 57 in northern Jiaozhou Bay, Station 2106 in northeast Jiaozhou Bay, Station 61 in eastern Jiaozhou Bay and Station 60 in southeast Jiaozhou Bay (Fig. 3). The PHC content at each station was shown in Table 1.
Fig. 3 The lines connecting the station in central Jiaozhou Bay and each station in the periphery.

| Station | Longitude  | Latitude  | PHC content (mg/L) |
|---------|------------|-----------|--------------------|
| 55      | 120.2566°  | 36.1166°  | 0.042              |
| 54      | 120.1866°  | 36.0933°  | 0.012              |
| 56      | 120.1966°  | 36.1366°  | 0.024              |
| 57      | 120.2666°  | 36.1666°  | 0.012              |
| 2016    | 120.3166°  | 36.1333°  | 0.020              |
| 61      | 120.3000°  | 36.1083°  | 0.014              |
| 60      | 120.2833°  | 36.0666°  | 0.010              |

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station 54 in southwest Jiaozhou Bay is as follows: To assume that the distance from Point 55 to Point 54 is \( L_1 \) and consider that \( 1'=1858 m \), \( L_1 \) is obtained.

\[
L_1^2 = [(120.2566-120.1866) \times 60 \times 1858]^2 + [(36.1166-36.0933) \times 60 \times 1858]^2
\]

\[ L_1 = 0.0737 \times 60 \times 1858 = 8224.54 (m) \]

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station 56 in northwest Jiaozhou Bay is as follows: To assume that the distance from Point 55 to Point 56 is \( L_2 \) and consider that \( 1'=1858 m \), \( L_2 \) is obtained.

\[
L_2^2 = [(120.2566-120.1966) \times 60 \times 1858]^2 + [(36.1166-36.1366) \times 60 \times 1858]^2
\]

\[ L_2 = 0.0632 \times 60 \times 1858 = 7050.61 (m) \]

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station 57 in northern Jiaozhou Bay is as follows: To assume that the distance from Point 55 to Point 57 is \( L_3 \) and consider that \( 1'=1858 m \), \( L_3 \) is obtained.

\[
L_3^2 = [(120.2566-120.2666) \times 60 \times 1858]^2 + [(36.1166-36.1666) \times 60 \times 1858]^2
\]

\[ L_3 = 0.0509 \times 60 \times 1858 = 5684.38 (m) \]

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station 2106 in northeast Jiaozhou Bay is as follows: To assume that the distance from Point 55 to Point 2106 is \( L_4 \) and consider that \( 1'=1858 m \), \( L_4 \) is obtained.

\[
L_4^2 = [(120.2566-120.3166) \times 60 \times 1858]^2 + [(36.1166-36.1333) \times 60 \times 1858]^2
\]

\[ L_4 = 0.0622 \times 60 \times 1858 = 6943.05 (m) \]

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station 61 in eastern Jiaozhou Bay is as follows: To assume that the distance from Point 55 to Point 61 is \( L_5 \) and consider that \( 1'=1858 m \), \( L_5 \) is obtained.

\[
L_5^2 = [(120.2566-120.3000) \times 60 \times 1858]^2 + [(36.1166-36.1083) \times 60 \times 1858]^2
\]

\[ L_5 = 0.0432 \times 60 \times 1858 = 4819.35 (m) \]

The calculation process of the distance between the Station 55 in central Jiaozhou Bay and Station
To assume that the distance from Point 55 to Point 60 is \( L_6 \) and consider that 1′=1858 m, \( L_6 \) is obtained.

\[
L_6 = \sqrt{(120.2566 - 120.2833)^2 + (36.1166 - 36.0666)^2} \times 60 \times 1858 = 0.0565 \times 60 \times 1858 = 6306.26 \text{ (m)}
\]

### 3.3 Horizontal Loss Velocity Model of Yang Dongfang Material Content

The authors put forward “the horizontal loss velocity model of Yang Dongfang material content”, which consists of the horizontal absolute loss velocity model of material content and the horizontal relative loss velocity model of material content.

The horizontal absolute loss velocity model of material content: to assume that the surface material content in the waterbody of Jiaozhou Bay decreases from value a at Point A to value b at Point B, the distance between Point A and Point B is \( L \), and the horizontal absolute loss velocity of material content is \( V_\text{asp} \). Then, the horizontal absolute loss velocity model of material content is obtained:

\[
V_\text{asp} = \frac{a - b}{L}
\]

Then, to assume that the horizontal relative loss velocity of material content is \( V_\text{rsp} \), the horizontal relative loss velocity model of material content is obtained:

\[
V_\text{rsp} = \frac{(a - b)/a}{L} = \frac{a - b}{aL}
\]

From the Point of spatial scale, this model reveals the loss amount of material content in per unit distance in horizontal migration. Horizontal absolute loss velocity of material content indicates the absolute loss amount in per unit distance, while horizontal relative loss velocity of material content indicates the relative loss amount in per unit distance.

### 3.4 Simplification of Units

Horizontal absolute loss velocity and horizontal relative loss velocity of oil are complex units and need to be simplified. So the author defines \( x \times 10^{-5} \text{ (mg/L)/m} \) as Yang Dongfang Number, which can also be used in English and marked as \( \text{ydf} \).

For horizontal absolute loss velocity value of PHC content, it is referred as \( V_\text{asp} \) and can be obtained through the equation \( V_\text{asp} = 30.84 \times 10^{-5} \text{ (mg/L)/m} \). It can be called 30.84 Yang Dongfang absolute number or 30.84 \( \text{ydfa} \).

For horizontal relative loss velocity value of PHC content, it is referred as \( V_\text{rsp} \) and can be obtained through the equation \( V_\text{rsp} = 7.78 \times 10^{-5} \text{ (mg/L)/m} \). It can be called 7.78 Yang Dongfang relative number or 7.78 \( \text{ydfr} \).

Therefore, in any waterbody, horizontal loss amount of any material content can be measured with Yang Dongfang absolute number(\( \text{ydfa} \)) and Yang Dongfang relative number(\( \text{ydfr} \)).

### 3.5 Horizontal Loss Velocity between Central Jiaozhou Bay and Southwest Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in the central water body of Jiaozhou Bay, which indicated that the source of PHC was the oil spill transportation at sea and the PHC content was 0.042 mg/L. The PHC content in the surface waters from Point 55 to Point 54 in the southwest water was 0.012 mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, the PHC content in the surface waters decreased from 0.042 mg/L at Point 55 to 0.012 mg/L at Point 54. \( V_\text{asp} = (0.042-0.012)/8224.54 = 0.36 \times 10^{-3} \text{ (mg/L)/m} \). \( V_\text{asp} = 8.68 \times 10^{-5} \text{ (mg/L)/m} \). Then, in May, the source of PHC in the water body of Jiaozhou Bay was oil spill transportation at sea. In the southwest water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 54 was 0.436 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the surface from Point 55 and Point 54 was 8.68 Yang Dongfang relative number.
3.6 Horizontal Loss Velocity from Central Jiaozhou Bay to Northwest Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in central Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042 mg/L. The PHC content in the surface from Point 55 to Point 61 in the northwest water was 0.024 mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, the PHC content in the surface decreased from 0.042 mg/L at Point 55 to 0.024 mg/L at Point 56. $V_{asp} = (0.042-0.024)/7050.61 = 0.25 \times 10^{-5} (\text{mg/L})/m = 0.25 \text{ydffa}$. $V_{rsp} = 5.95 \times 10^{-5} (\text{mg/L})/m = 5.95 \text{ydffa}$.

Then, in May, the source of PHC was oil spill transportation at sea. In the northwest water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 56 was 0.25 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the surface from Point 55 and Point 61 was 0.58 Yang Dongfang relative number.

3.7 Horizontal Loss Velocity from Central Jiaozhou Bay to Northern Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in central Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042 mg/L. The PHC content in the surface from Point 55 to Point 57 in the northern water was 0.012 mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, PHC content in the surface decreased from 0.042 mg/L at Point 55 to 0.012 mg/L at Point 57. $V_{asp} = (0.042-0.012)/5684.38 = 0.52 \times 10^{-5} (\text{mg/L})/m = 0.52 \text{ydffa}$. $V_{rsp} = 12.38 \times 10^{-5} (\text{mg/L})/m = 12.38 \text{ydffa}$.

Then, in May, the source of PHC was oil spill transportation at sea. In the northeast water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 57 was 0.52 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the surface from Point 55 and Point 57 was 12.38 Yang Dongfang relative number.

3.8 Horizontal Loss Velocity from Central Jiaozhou Bay to Northeast Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in central Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042 mg/L. The PHC content in the surface from Point 55 to Point 2106 in the northeast water was 0.020 mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, PHC content in the surface decreased from 0.042 mg/L at Point 55 to 0.020 mg/L at Point 2106. $V_{asp} = (0.042-0.020)/6943.05 = 0.31 \times 10^{-5} (\text{mg/L})/m = 0.31 \text{ydffa}$. $V_{rsp} = 7.38 \times 10^{-5} (\text{mg/L})/m = 7.38 \text{ydffa}$.

Then, in May, the source of PHC was oil spill transportation at sea. In the southeast water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 2106 was 0.31 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the surface from Point 55 and Point 2106 was 7.38 Yang Dongfang relative number.

3.9 Horizontal Loss Velocity from Central Jiaozhou Bay to Northern Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in central Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042 mg/L. The PHC content in the surface from Point 55 to Point 61 in the northern water was 0.014 mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, PHC content in the surface decreased from 0.042 mg/L at Point 55 to 0.014 mg/L at Point 61. $V_{asp} = (0.042-0.014)/4891.93 = 0.58 \times 10^{-5} (\text{mg/L})/m = 0.58 \text{ydffa}$. $V_{rsp} = 13.80 \times 10^{-5} (\text{mg/L})/m = 13.80 \text{ydffa}$.

Then, in May, the source of PHC was oil spill transportation at sea. In the eastern water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 61 was 0.58 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the
surface from Point 55 and Point 61 was 13.80 Yang Dongfang relative number.

3.10 Horizontal Loss Velocity from Central Jiaozhou Bay to Southeast Jiaozhou Bay

In May, a high PHC content area formed at Point 55 in central Jiaozhou Bay, which indicated that the source of PHC was oil spill transportation at sea and the PHC content was 0.042mg/L. The PHC content in the surface from Point 55 to Point 60 in the southeast water was 0.010mg/L.

According to the horizontal loss velocity model of Yang Dongfang material content, the horizontal absolute loss velocity and horizontal relative loss velocity of PHC content were calculated.

In May, PHC content in the surface decreased from 0.042mg/L at Point 55 to 0.010mg/L at Point 60. \( V_{\text{abs}} = \frac{(0.042 - 0.010)}{6306.26} = 0.50 \times 10^{-2} \text{(mg/L)/m} = 0.50 \text{ydfr} \). \( V_{\text{rel}} = 11.90 \times 10^{-2} \text{(mg/L)/m} = 11.90 \text{ydfr} \).

Then, in May, the source of PHC was oil spill transportation at sea. In the southeast water, the horizontal absolute loss velocity of PHC content in the surface from Point 55 and Point 60 was 0.50 Yang Dongfang absolute number, and the horizontal relative loss velocity of PHC content in the surface from Point 55 and Point 60 was 11.90 Yang Dongfang relative number.

4. Discussion

4.1 Horizontal Content Variation of the Same Source

In May, PHC content at Station 55 in central Jiaozhou Bay reached a high level of 0.042mg/L, and a high PHC content area formed around the central water with a series of concentric circles with different gradients. There was a descended PHC content distribution trend from the center toward the periphery along the gradient. The content of PHC decreased from 0.042mg/L at the center to 0.012mg/L in the southwest water, 0.024mg/L in the northwest water, 0.012mg/L in the northern water, 0.020mg/L in the northeast water, 0.014mg/L in the eastern water and 0.010mg/L in the southeast water (Fig. 2).

Some results in Table 2 were calculated with horizontal absolute loss velocity model of material content. In May, the horizontal absolute loss velocity of PHC content in the surface from the central water to the southwest water of Jiaozhou Bay was 0.36 Yang Dongfang absolute number, to the northwest water 0.25 Yang Dongfang absolute number, to the northern water 0.52 Yang Dongfang absolute number, to the northeast water 0.31 Yang Dongfang absolute number, to the eastern water 0.58 Yang Dongfang absolute number and to the southeast water 0.50 Yang Dongfang absolute number. Therefore, with Station 55 in central Jiaozhou Bay as the source of oil spill at sea, there was a descended PHC content distribution trend from the center to the periphery with the horizontal absolute loss velocity of 0.25-0.58 Yang Dongfang absolute number.

Some results in Table 2 were calculated with the horizontal relative loss velocity model of material content. In May, the horizontal relative loss velocity of PHC content in the surface from the central water to the southwest water of Jiaozhou Bay was 8.68 Yang Dongfang relative number, to the northwest water 5.95 Yang Dongfang relative number, to the northern water 12.38 Yang Dongfang relative number, to the northeastern water 7.38 Yang Dongfang relative number, to the eastern water 13.80 Yang Dongfang relative number and to the southeast water 11.90 Yang Dongfang relative number. Therefore, with Station 55 in central Jiaozhou Bay as the source of oil spill at sea, there was a descended PHC content distribution trend toward the periphery with the horizontal relative loss velocity of 5.95-13.80 Yang Dongfang relative number.

| Time                  | May         | May         | May         | May         | May         | May          |
|-----------------------|-------------|-------------|-------------|-------------|-------------|--------------|
| The waters from 55    | to 54       | to 56       | to 57       | to 2106     | to 61       | to 60        |
| Variation range       | 0.012-0.04  | 0.024-0.04  | 0.012-0.04  | 0.020-0.04  | 0.014-0.04  | 0.010-0.04  |
| horizontal absolute   | 0.36        | 0.25        | 0.52        | 0.31        | 0.58        | 0.50         |
| loss velocity of PHC  | content     | content     | content     | content     | content     | content      |

Table 2 PHC content velocity values of the central water in Jiaozhou Bay
4.2 Characteristics of Calculation Values of the Same Source
Under the condition of same time, same starting point and different endpoints, the absolute loss amount in per unit distance was different. In May, the PHC content of the central water of Jiaozhou Bay was 0.042mg/L, and there was a descended distribution trend toward the periphery along the gradient. The PHC content decreased from 0.042mg/L at the center to 0.012mg/L in the southwest water, 0.024mg/L in the northwest water, 0.012mg/L in the northern water, 0.020mg/L in the northeast water, 0.014mg/L in the eastern water and 0.010mg/L in the southeast water.

Therefore, the rising PHC content distribution order was: that of the southeast water < that of the southwest water < that of the northern water < that of the eastern water < that of the northeast water < that of the northwest water. With horizontal absolute loss velocity model of material content, it was calculated that the order of horizontal absolute loss velocity of PHC content was: that of the northwest water < that of the northeast water < that of the southwest water < that of the southeast water < that of the northern water < that of the eastern water. With horizontal relative loss velocity model of material content, it was calculated that the order of horizontal relative loss velocity of PHC content was: that of the northwest water < that of the northeast water < that of the southwest water < that of the southeast water < that of the northern water < that of the eastern water.

The order of horizontal absolute loss velocity of PHC content was consistent with that of horizontal relative loss velocity of PHC content but different from that of PHC content distribution order, in which PHC content decreasing from the center toward the periphery along the gradient.

Terminal value indicates the PHC content in the water from the point of oil spill at sea to another certain point. Process value indicates horizontal absolute (relative) loss velocity of PHC content from the point of oil spill at sea to another certain point. This reveals that both terminal value and process value present the migration process of PHC content in water body. Therefore, terminal value and process value of PHC content in the water from the point in central Jiaozhou Bay to another certain point in each of the six directions can be calculated.

4.3 Quantitative Migration Process
A series of concentric circles with different gradients formed around the center of the eastern bay, the source of offshore oil spill with a PHC level of 0.056mg/L. Then, the PHC content ranged between 0.024mg/L to 0.056mg/L along the gradient among the central bay, the northwest bay and the northeast bay and the southeast bay. Through the horizontal loss velocity model of Yang Dongfang material content, it was calculated that the horizontal absolute loss velocity of PHC content ranged between 0.29\( \text{ydfr} \)-0.45\( \text{ydfr} \), and the horizontal relative loss velocity of PHC content ranged between 5.17\( \text{ydfr} \)-8.03\( \text{ydfr} \). After the migration of certain distance, the final value and process value of PHC content from the same source were same. That is, the PHC content from the same source was consistent with its horizontal absolute (relative) loss velocity. Therefore, with horizontal loss velocity model of Yang Dongfang material content, the decreasing and migration process of PHC content toward the periphery along the gradient can be calculated and quantified.

5. Conclusion
It was found that oil spill originally occurred in central Jiaozhou Bay in May, and its PHC content was 0.042mg/L. A series of concentric circles with different gradients formed around there, and there was a descended distribution trend from the center to the periphery along the gradient. The content of PHC decreased from 0.042mg/L at the center to 0.012mg/L in the southwest water, 0.024mg/L in the northwest water, 0.012mg/L in the northern water, 0.020mg/L in the northeast water, 0.014mg/L in the

| horizontal relative loss velocity of PHC content | 8.68 | 5.95 | 12.38 | 7.38 | 13.80 | 11.90 |
|---|---|---|---|---|---|---|
| the characteristics values | same time, same source, different distances |
eastern water and 0.010 mg/L in the southeast water. The PHC content in these waters ranged from 0.010 mg/L to 0.042 mg/L.

With horizontal absolute loss velocity model of material content, it was calculated that the horizontal absolute loss velocity of PHC content in the surface waters from the central water to the southwest water in May was 0.36 Yang Dongfang absolute number, to the northwest water 0.25 Yang Dongfang absolute number, to the northern water 0.52 Yang Dongfang absolute number, to the northeast water 0.31 Yang Dongfang absolute number, to the eastern water 0.58 Yang Dongfang absolute number and to the southeast water 0.50 Yang Dongfang absolute number. Therefore, with the central water of Jiaozhou Bay taken as the source of oil spill at sea, there was a descended PHC content distribution trend from the center to the periphery along the gradient, and the horizontal absolute loss velocity of PHC content ranged from 0.25 Yang Dongfang absolute number to 0.58 Yang Dongfang absolute number.

With horizontal relative loss velocity model of material content, it was calculated that the horizontal relative loss velocity of PHC content in the surface waters from the central water to the southwest water of Jiaozhou Bay in May was 8.68 Yang Dongfang relative number, to the northwest water 5.95 Yang Dongfang relative number, to the northern water 12.38 Yang Dongfang relative number, to the northeast water 7.38 Yang Dongfang relative number, to the eastern water 13.80 Yang Dongfang relative number and to the southeast water 11.90 Yang Dongfang relative number. Therefore, with the central water of Jiaozhou Bay taken as the source of oil spill at sea, there was a descended PHC content distribution trend from the center to the periphery along the gradient, and the horizontal relative loss velocity of PHC content ranged from 5.95 Yang Dongfang relative number to 13.80 Yang Dongfang relative number.

In May, with the source of the oil spill at sea in Jiaozhou Bay as the center, there was a rising PHC content distribution trend toward the periphery and the order is as follows: that of the southeast water < that of the southwest water < that of the northern water < that of the eastern water < that of the northeast water < that of the northwest water. With horizontal absolute loss velocity model of material content, it was calculated that the order of horizontal absolute loss velocity of PHC content was: that of the northwest water < that of the northeast water < that of the southwest water < that of the southeast water < that of the northern water < that of the eastern water. With horizontal relative loss velocity model of material content, it was calculated that the order of horizontal relative loss velocity of PHC content was: that of the northwest water < that of the northeast water < that of the southwest water < that of the southeast water < that of the northern water < that of the eastern water. The order of horizontal absolute loss velocity of PHC content was consistent with that of horizontal relative loss velocity of PHC content but different from that of PHC content distribution order, in which PHC content decreasing from the center toward the periphery along the gradient.

Therefore, terminal value and process value of PHC content in the water from the point in central Jiaozhou Bay to another certain point respectively in southwest Jiaozhou Bay, northwest Jiaozhou Bay, northern Jiaozhou Bay, northeast Jiaozhou Bay, eastern Jiaozhou Bay and southeast Jiaozhou Bay can be calculated. With horizontal loss velocity model of Yang Dongfang material content, terminal value and process value of PHC content can be calculated. With horizontal loss velocity model of Yang Dongfang material content, the decreasing and migration process of PHC content toward the periphery along the gradient can be calculated and quantified.

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References
[1] Dongfang Yang, Youchi Zhang, Jie Zou, et al. Contents and distribution of petroleum hydrocarbons (PHC) in Jiaozhou Bay waters [J]. Open Journal of Marine Science, 2011, 2(3): 108-112.
[2] Dongfang Yang, Peiyan Sun, Chen Chen, Hongyan Bai, Qing Zhou. Pollution Source and
Distribution of PHC in the Jiaozhou Bay Waters [J]. Coastal Engineering, 2013, 32(1): 60-72.

[3] Dongfang Yang, Peiyan Sun, Lian Ju, Chunhui Wang, Yunlong Liu. Distribution and changing of petroleum hydrocarbon in Jiaozhou Bay waters [J]. Applied Mechanics and Materials Vols.644-650. 2104, 5312-5315.

[4] Dongfang Yang, Youfu Wu, Huozhong He, Sixi Zhu, Fengyou Wang. Vertical distribution of Petroleum Hydrocarbon in Jiaozhou Bay [J]. Proceedings of the 2105 international symposium on computers and informatics. 2105, 2647-2654.

[5] Dongfang Yang, Fengyou Wang, Sixi Zhu, Xiaoli Zhao, Jialian Luo. Distribution and homogeneity of petroleum hydrocarbon in Jiaozhou Bay [J]. Proceedings of the 2105 international symposium on computers and informatics. 2105, 2661-2666.

[6] Dongfang Yang, Peiyan Sun, Lian Ju, Qingyun Yu, Jing Cao. Input features of Petroleum Hydrocarbon in Jiaozhou Bay [J]. Proceedings of the 2105 international symposium on computers and informatics. 2105, 2675-2680.

[7] Dongfang Yang, Sixi Zhu, Fengyou Wang, Xiaoli Zhao, Yunjie Wu. Distribution and Low-Value Feature of Petroleum Hydrocarbon in Jiaozhou Bay [J]. 4th International Conference on Energy and Environmental Protection. 2105, 3784-3788.

[8] Dongfang Yang, Fengyou Wang, Sixi Zhu, Mingzhong Long, Xiuqin Yang. River was the only source of PHC in Jiaozhou Bay in 1984 [J]. Advances in Engineering Research. 2105, 431-434.

[9] Dongfang Yang, Fengyou Wang, Sixi Zhu, Xiuqin Yang, Mingzhong Long. Effects of PHC on water quality of Jiaozhou Bay: IAnnual variaiton of PHC content [J]. Meterological and Environmental Research, 2105, 6(11-12): 31-34.

[10] Dongfang Yang, Sixi Zhu, Fengyou Wang, Ming Wang, Xiuqin Yang. Change laws of PHC contents in bottom waters in the bay mouth of Jiaozhou Bay [J]. Advances in Engineering Research. 2106, Part E: 1351-1355.

[11] Dongfang Yang, Fengyou Wang, Sixi Zhu, Mingzhong Long, Xiuqin Yang. Effects of PHC on water quality of Jiaozhou Bay: IIChanging process of pollution sources [J]. Meterological and Environmental Research, 2106, 7(1): 44-47.

[12] D F 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.

[13] Dongfang Yang, Fan Wang, Zhenhui Gao, et al. Ecological Phenomena of Phytoplankton in Jiaozhou Bay [J]. Marine Science, 2004, 28 (6): 71-74.

[14] State Oceanic Administration. The Specification for Marine Monitoring [Z]. Beijing: China Ocean Press, 1991.