2019

Report on Marine Environmental Status and Trends of the Yellow Sea

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Contents

1. Status and Trends of Seawater Quality of the Yellow Sea

1.1 Status of Seawater Quality

1.1.1 Basic Situation

In 2018, the sea areas of the Yellow Sea with water quality below Seawater Quality Standard Grade I[1] in spring, summer, and autumn were 110 880, 109 790, and 138 130 km^2 respectively. The sea areas with water quality which worse than Seawater Quality Standard Grade IV were 45 140, 33 270, and 41 510 km^2 respectively. These areas were mainly located at the coastal areas of Northern Yellow Sea and Jiangsu coast. The elements exceeding the standard were mainly dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP).

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[1] Based on "Sea Water Quality Standard (GB3097-1997)." In accordance with the function and protection objectives of the water body, sea water is classified into four categories:
Category I: Fisheries, marine protected areas, rare and endangered marine organism protected areas.
Category II: Aquaculture, bathing beach, recreational areas where coastal and marine waters come into direct contact with humans, water body in industrial areas where water is used for human consumption.
Category III: General industry, coastal scenic area.
Category IV: Harbors, ports, areas for marine development.

Fig.1 Distribution diagram of water quality status of the Yellow Sea in 2018

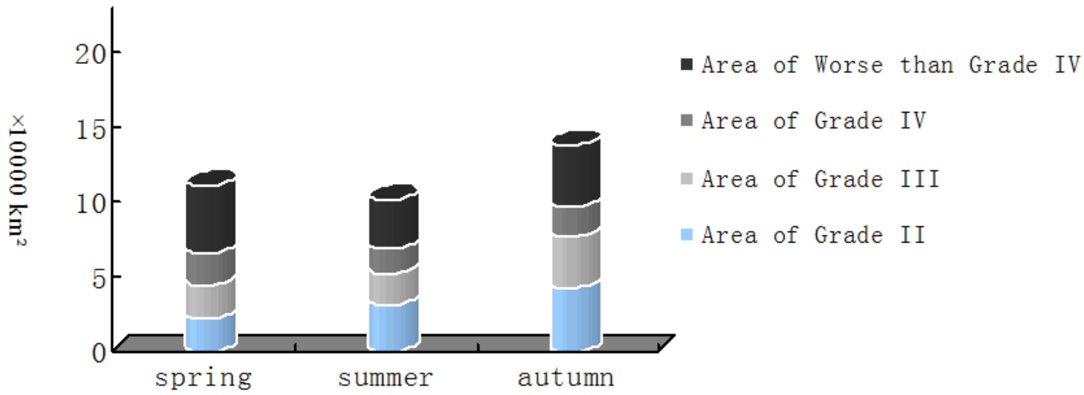


Fig.2 The sea areas with water quality below Seawater Quality Standard Grade I of the Yellow Sea in 2018

1.1.2 Content Distribution of DIN

In 2018, the sea areas of the Yellow Sea with DIN content more than 0.2 mg/L in spring, summer, and autumn were 102810, 95440, and 119150 km^2, respectively. The sea areas with DIN content exceeded 0.5 mg/L were 42650, 32430, and 40630 km^2, respectively. These areas were mainly located at the coastal areas of Northern Yellow Sea and Jiangsu Coast.

DIN was sampled from surface layer and bottom layer in the Yellow Sea. Surface layer refers to 0.1-1 m below sea level, and the sample from surface layer is named as DIN(S) in this report. Bottom layer refers to 2 m water layer from the bottom for estuary and harbor, while the distance can be increased as appropriate in the deep sea or big waves. The sample from bottom layer is named as DIN(B).

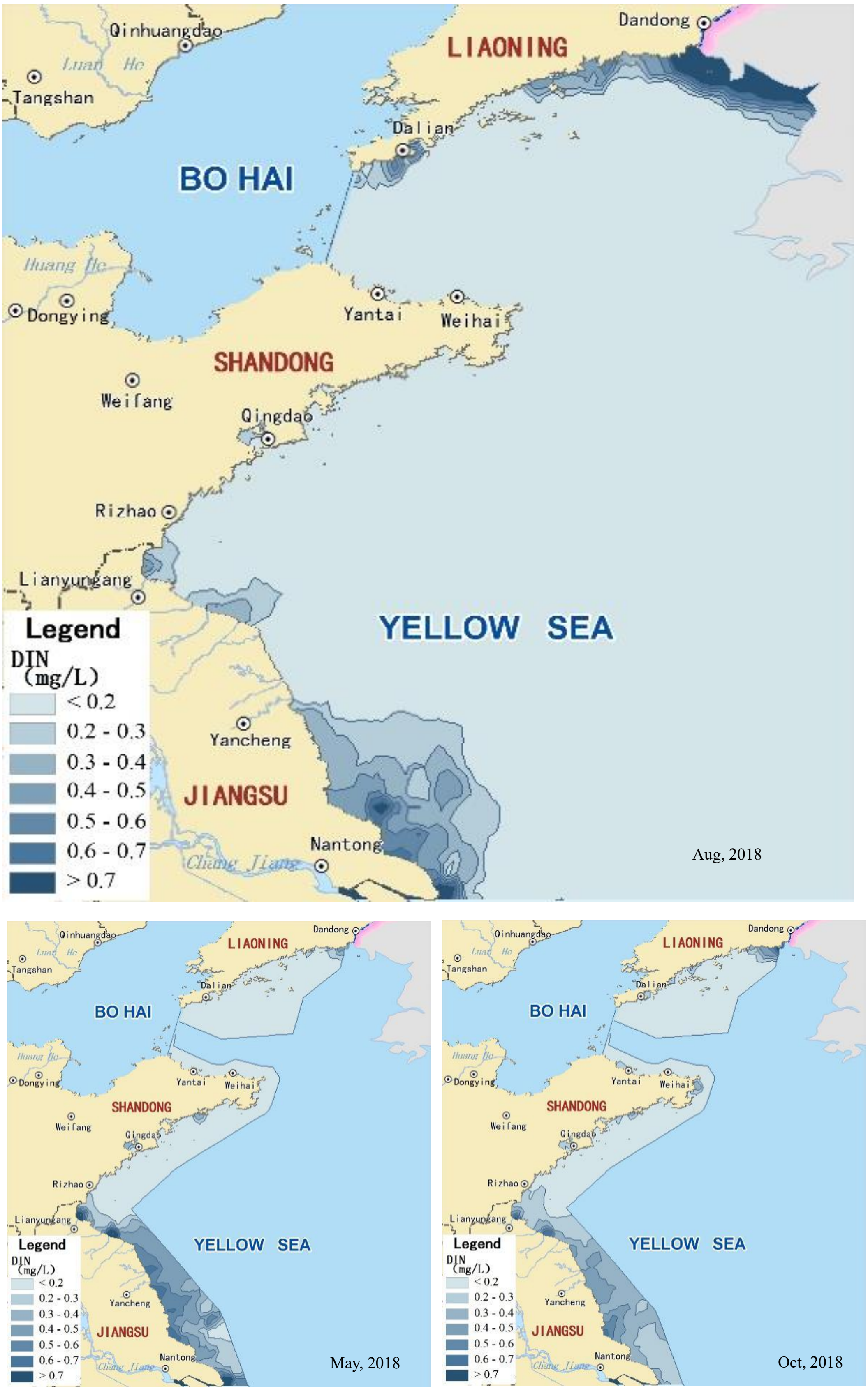


Fig.3 Distribution diagram of DIN(S) content of the Yellow Sea in 2018

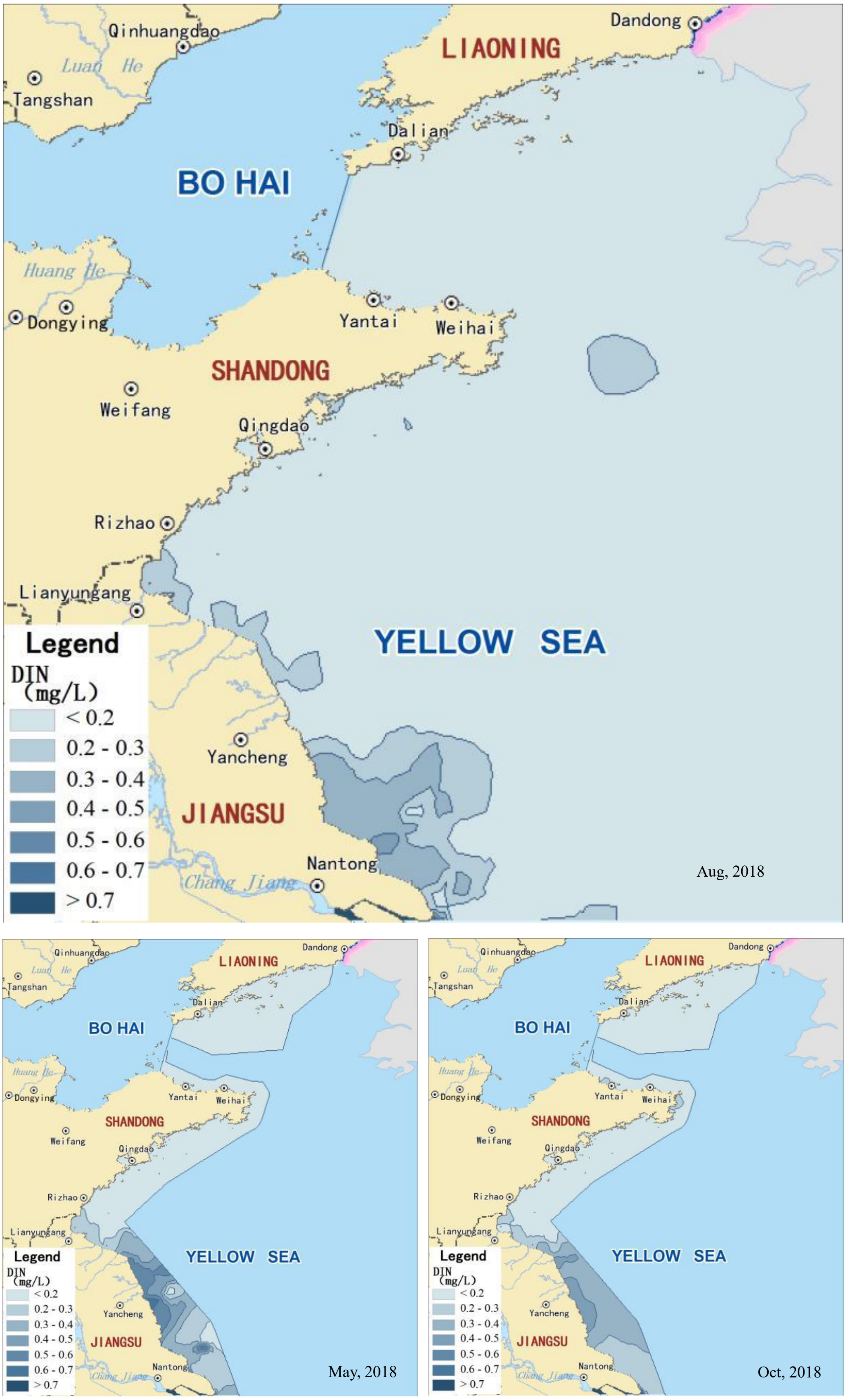
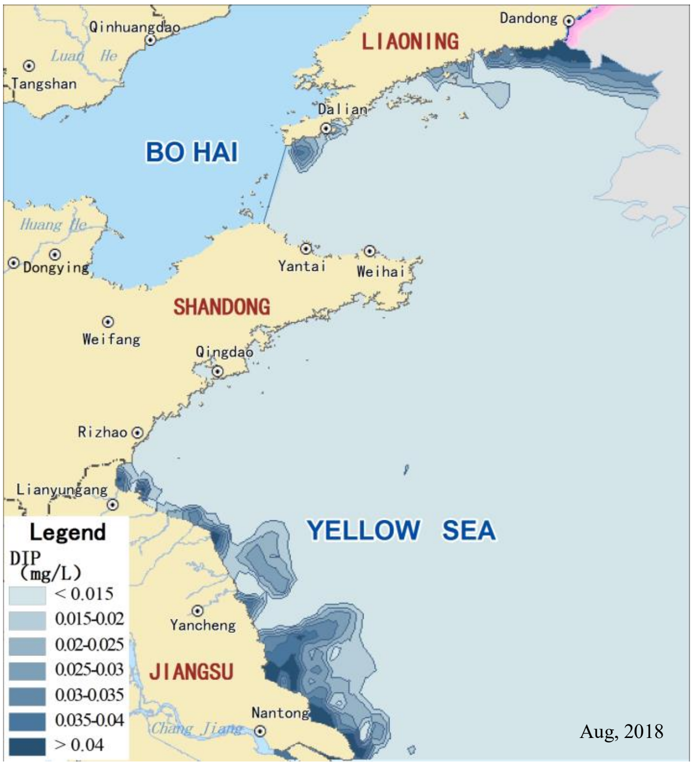


Fig.4 Distribution diagram of DIN(B) content of the Yellow Sea in 2018

1.1.3 Content Distribution of DIP

In 2018, the sea areas of the Yellow Sea with DIP content more than 0.015 mg/L in spring, summer, and autumn were 68370, 69740, and 93900 km^2, respectively. The sea areas with DIP content exceeded 0.045 mg/L were 12110, 7160, and 15700 km^2, respectively. These areas were mainly located at the coastal areas of Northern Yellow Sea and Jiangsu Coast.

As with DIN, DIP was also sampled from surface layer and bottom layer in the Yellow Sea. The samples from surface layer and bottom layer are named as DIP(S) and DIP(B), respectively.



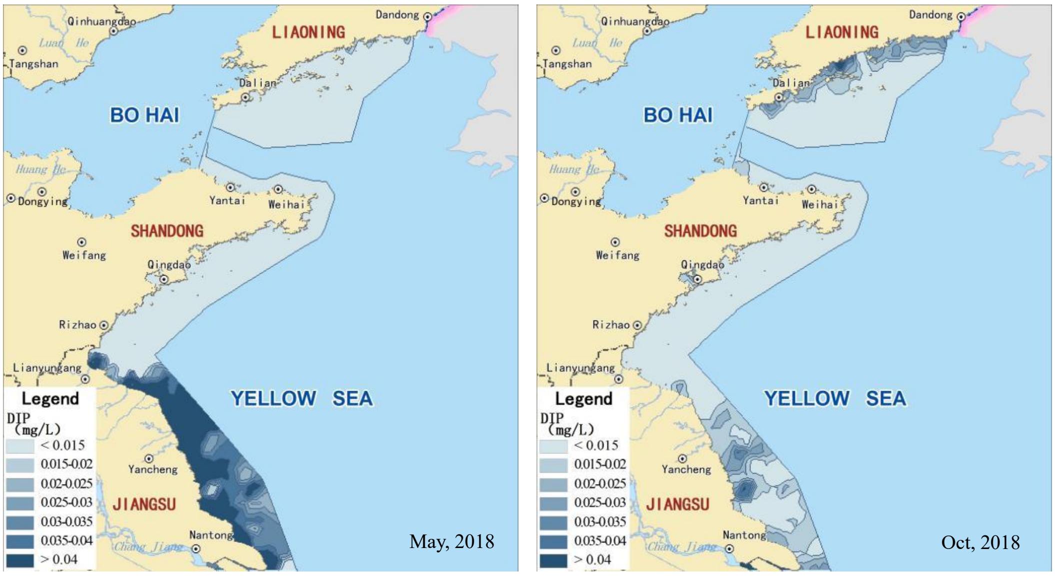
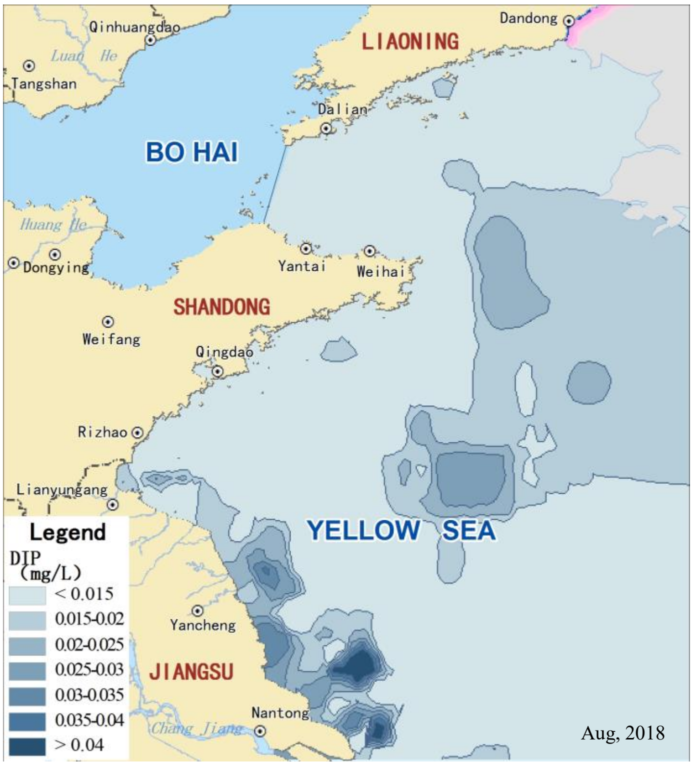


Fig.5 Distribution diagram of DIP(S) content of the Yellow Sea in 2018



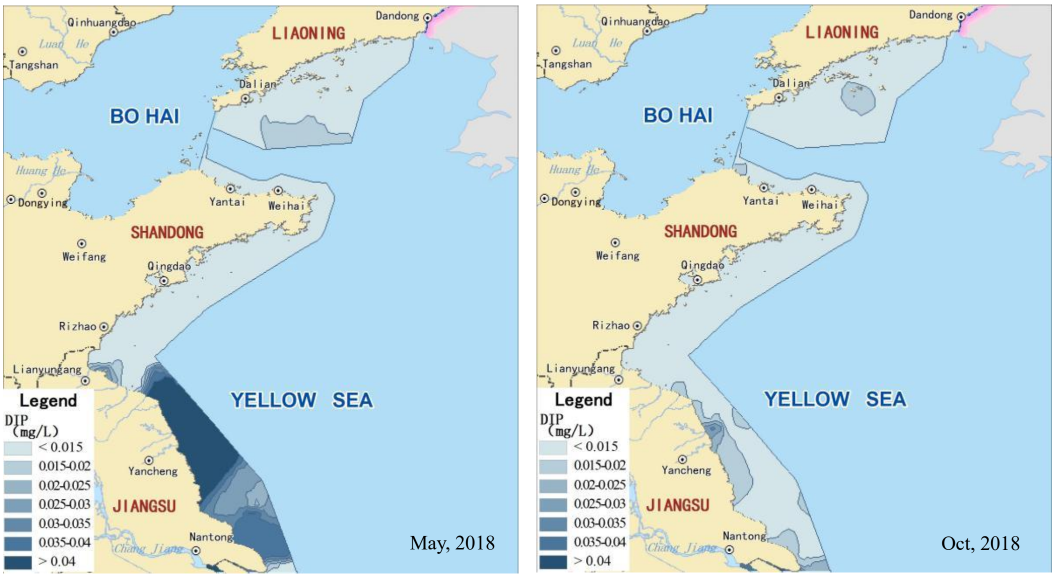


Fig.6 Distribution diagram of DIP(B) content of the Yellow Sea in 2018

1.1.4 Content Distribution of DO

Oxygen dissolved (DO) of seawater is indispensable for marine life. Only the concent distribution of DO from bottom layer of the Yellow Sea were showed in this report. In 2018, DO content of the Yellow Sea was the lowest in summer, and the highest in spring.

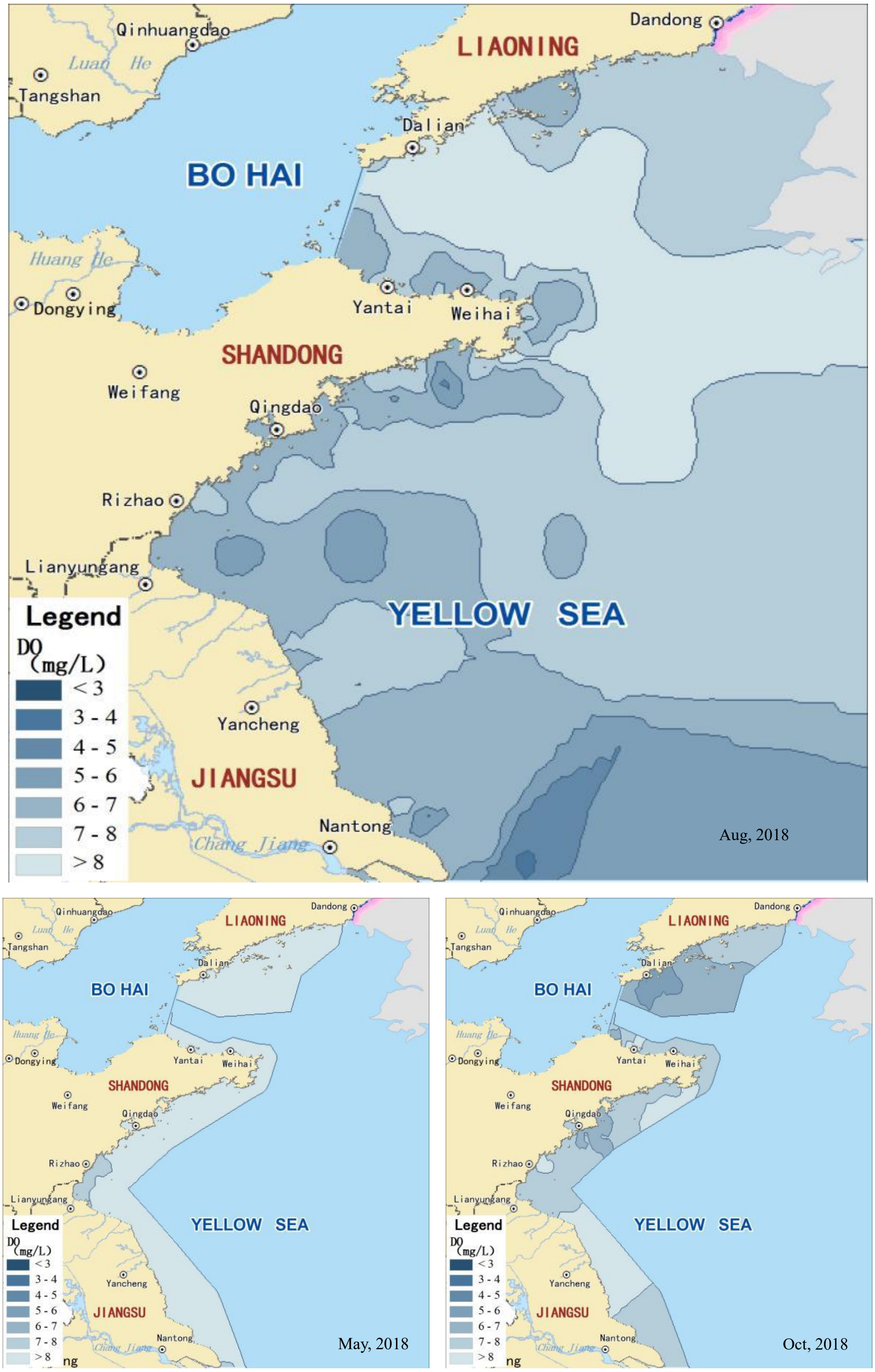


Fig.7 Distribution diagram of DO content of the Yellow Sea in 2018

1.2 Trends of Seawater Quality

1.2.1 General Trend

In the past decade, the water pollution degree of the Yellow Sea showed a trend of first serious and then reduced, and was the most serious in 2012. In 2008, some areas of Jiangsu Coast exceeded Seawater Quality Standard Grade II. In 2012, the water quality of large areas of Northern Yellow Sea and Jiangsu Coast was worse than Seawater Quality Standard Grade IV. With a series of land and sea integrated policies and treatment measures introduced by the state in recent years, the water pollution degree and areas in 2018 were significantly reduced compared with that in 2012.

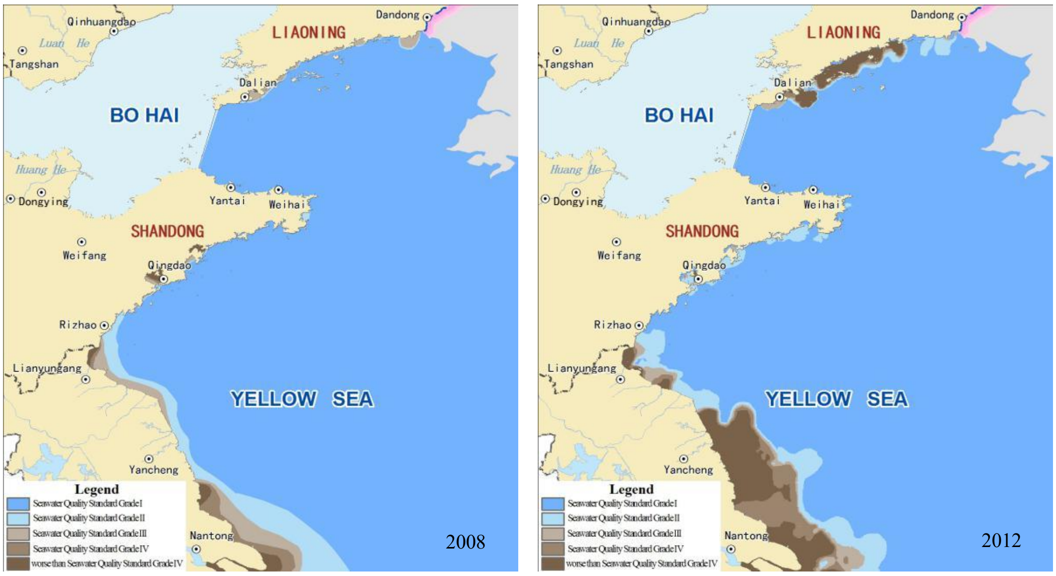


Fig.8 Distribution diagram of water quality trends of the Yellow Sea in summer from 2008 to 2018

Table 1 The sea areas with water quality below Seawater Quality Standard Grade I of the Yellow Sea in summer from 2008 to 2018 (km^2)

Year	Area of Grade II	Area of Grade III	Area of Grade IV	Area of Worse than Grade IV	Total
2008	65480	28840	17420	25260	137000
2012	46910	30030	24700	67880	169520
2015	54120	36900	23570	40020	154610
2018	38070	22320	16130	33270	109790

1.2.2 Trend of DIN

1.2.2.1 DIN(S)

The DIN(S) content of the Yellow Sea has generally increased first and then decreased from 2008 to 2018, and was the highest in 2012. In 2008, the DIN(S) content of 0.6 mg/L was detected in individual areas, but hardly exceeded 0.7 mg/L. In 2012, the DIN(S) content of larger areas in Northern Yellow Sea and Jiangsu Coast exceeded 0.7 mg/L. In 2018, the DIN(S) content was significantly reduced compared with that in 2012, and basically the same as that in 2008.

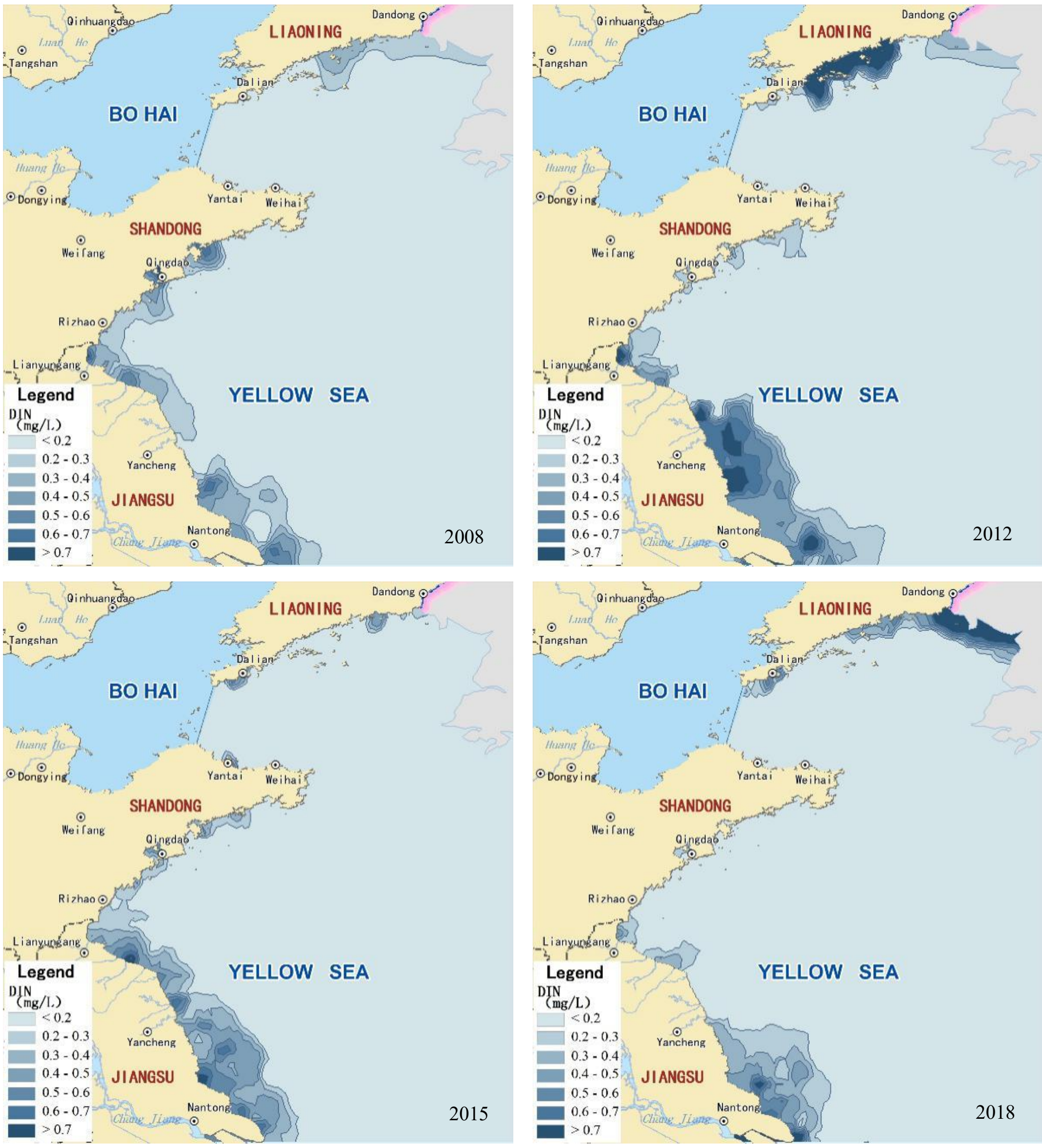


Fig.9 Distribution diagram of DIN(S) content of the Yellow Sea from 2008 to 2018

1.2.2.2 DIN(B)

In the past ten years, the DIN(B) content of Northern Yellow Sea has never exceeded 0.2 mg/L. The DIN(B) content of Qingdao Coast was slightly higher than 0.2 mg/L, and that of Jiangsu Coast generally increased 2015
first and then decreased. In 2008 and 2012, the DIN(B) content of some waters of Nantong Coast and Lianyungang Coast was more than 0.2 mg/L,

but basically no exceeded 0.5 mg/L. In 2015, the DIN(B) content of the Yellow Sea was the highest, and all of Jiangsu Coast waters were more than 0.2 mg/L and exceeded 0.6 mg/L in individual areas. Compared with 2015, the DIN(B) content in 2018 have decreased, only Nantong Coast waters were more than 0.4 mg/L.

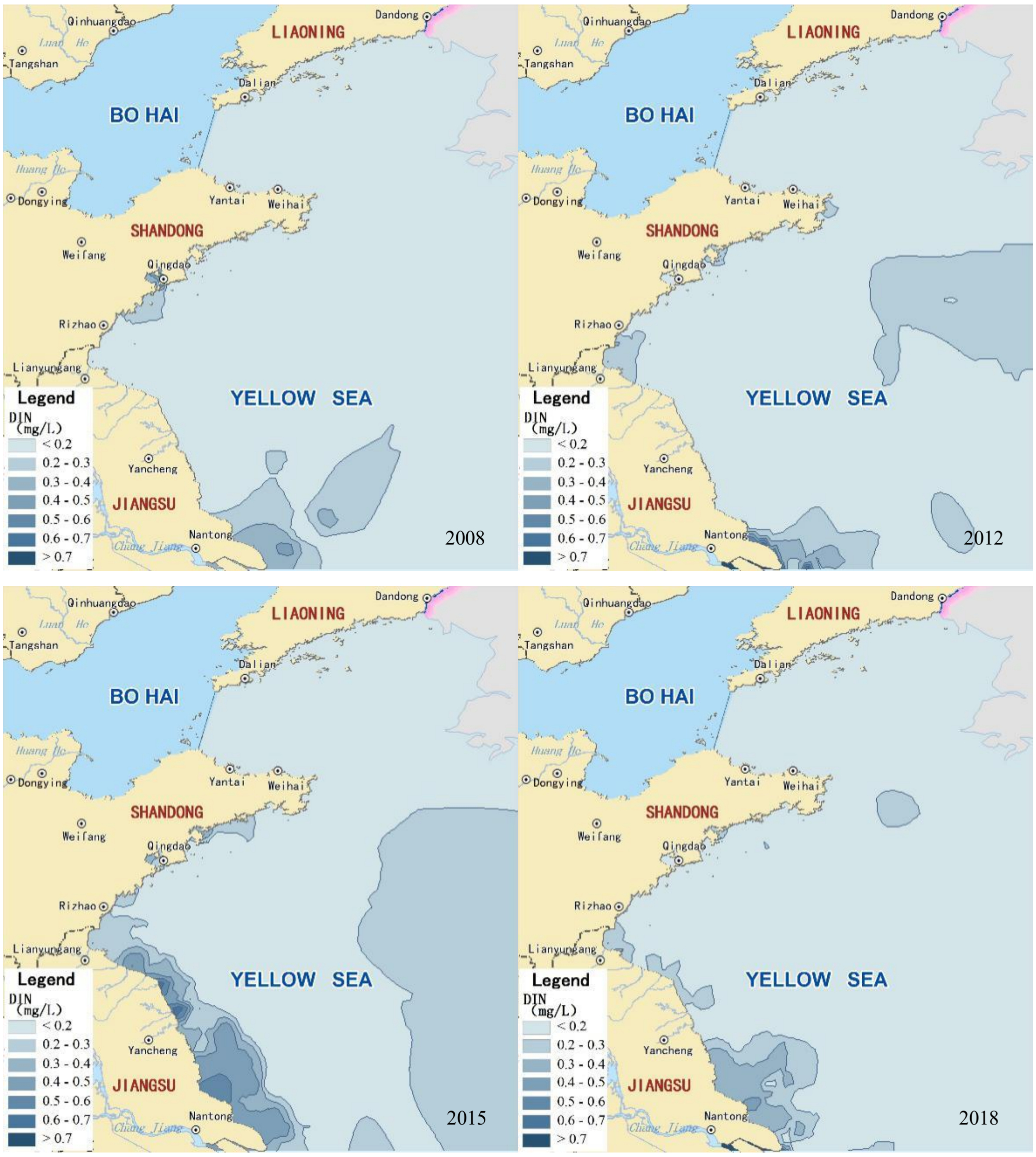


Fig.10 Distribution diagram of DIN(B) content of the Yellow Sea from 2008 to 2018

1.2.3 Trend of DIP

1.2.3.1 DIP(S)

Same as DIN(S), the DIP(S) content of the Yellow Sea has generally increased first and then decreased from 2008 to 2018, and was the highest in 2012. In 2008, the DIP(S) content of Northern Yellow Sea and Nantong Coast was more than 0.015 mg/L, but hardly exceeded 0.03 mg/L. In 2012, the DIP(S) content in Dalian Bay and Jiangsu Coast was the highest, and exceeded 0.04 mg/L. The DIP(S) content in 2015-2018 decreased slightly compared with that in 2012, but it has not yet recovered to the level of 2008.

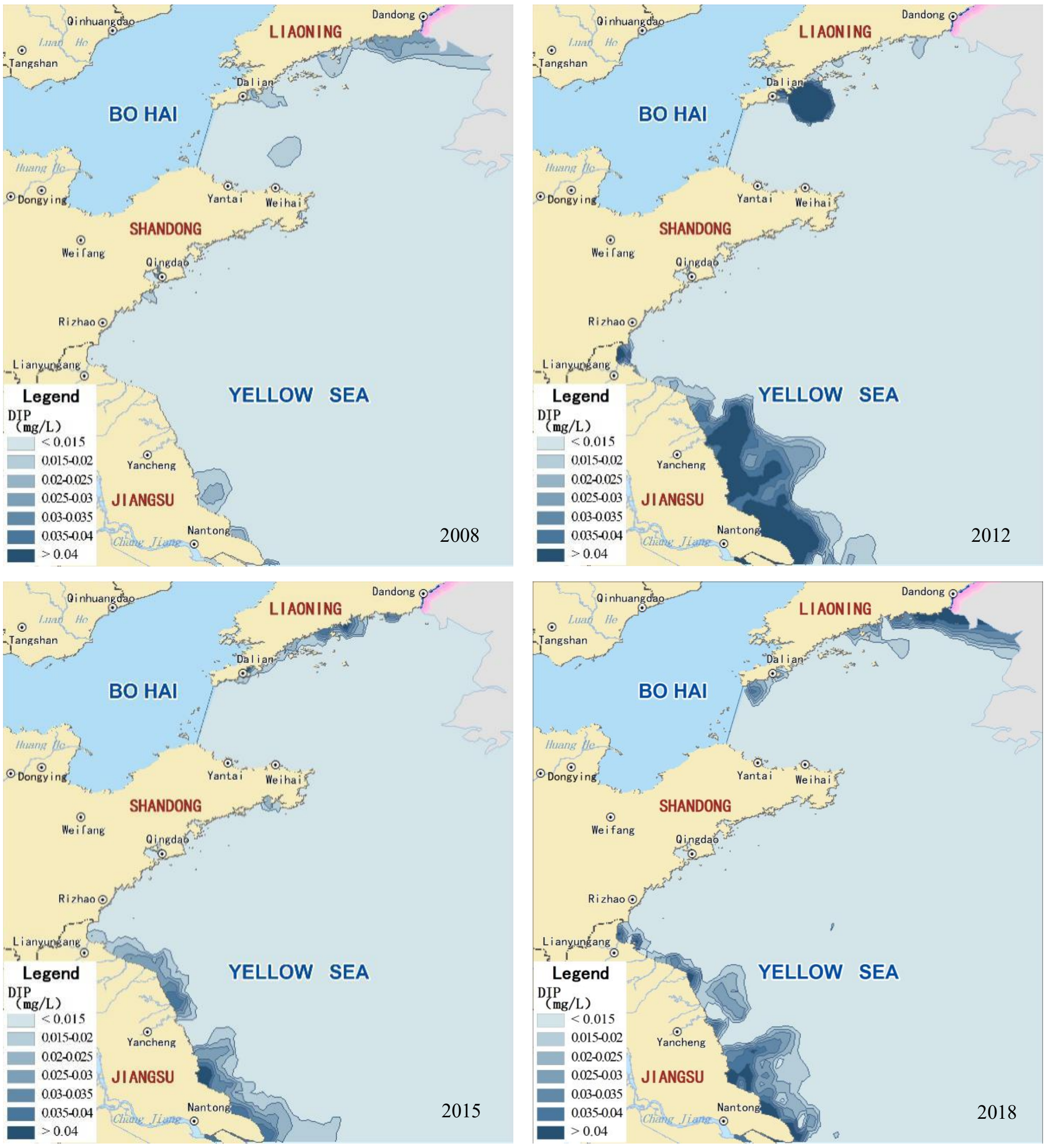


Fig.11 Distribution diagram of DIP(S) content of the Yellow Sea from 2008 to

2018

1.2.3.2 DIP(B)

The DIP(B) content in offshore waters of the Yellow Sea, Dalian Coast and Jiangsu Coast was above 0.015 mg/L. The DIP(B) content of Dalian Coast gradually decreased, and hardly exceeded 0.015 mg/L in 2018. However, which of Jiangsu Coast gradually increased and was almost all more than 0.015 mg/L, and even some waters exceeded 0.04 mg/L in 2018.

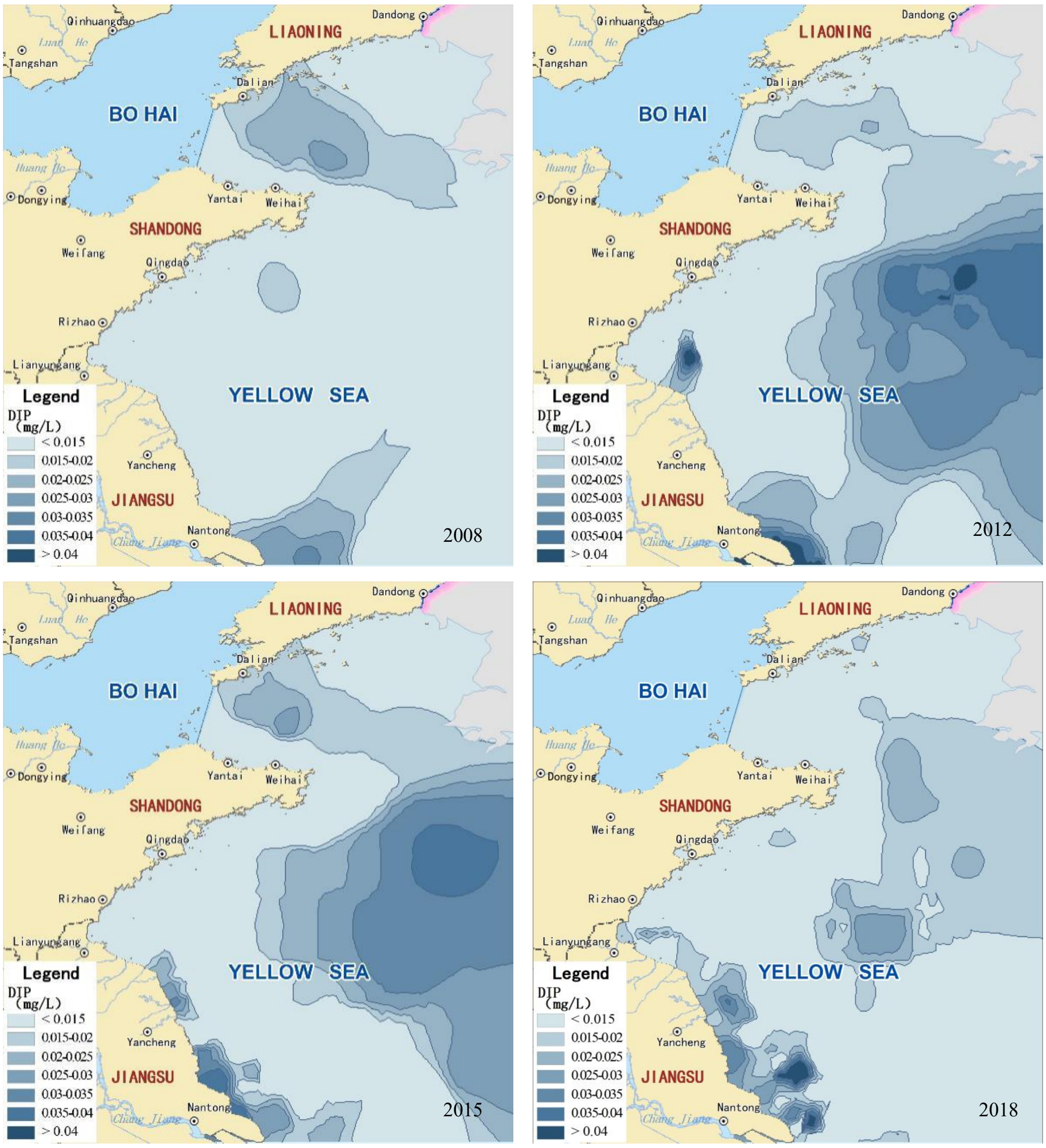


Fig.12 Distribution diagram of DIP(B) content of the Yellow Sea from 2008 to 2018

1.2.4 Trend of DO

From 2008 to 2018, the low oxygen area in bottom layer (oxygen content < 3 mg/L) of the Yellow Sea was mainly distributed in Nantong Coast, connected with large areas of low oxygen area in the Yangtze River Estuary. The low oxygen environment posed a serious threat to the survival of marine organisms.

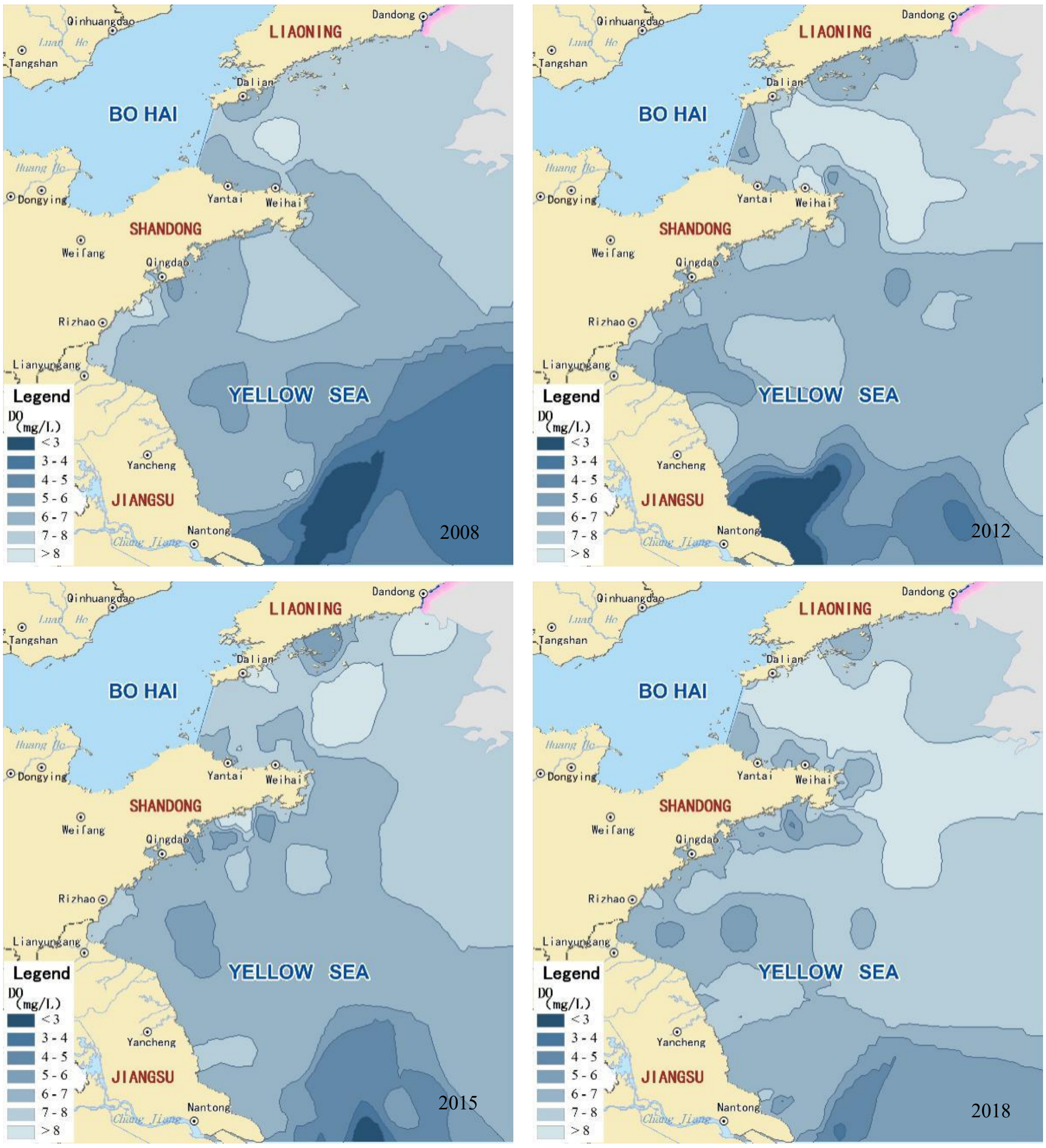


Fig.13 Distribution diagram of DO content of the Yellow Sea from 2008 to 2018

1.3 Summary

In the past decade, the water pollution degree in the Yellow Sea showed a trend of first serious and then reduced, and was the most serious in 2012. With a series of land and sea integrated policies and treatment measures introduced by the state, the water pollution degree and areas were significantly reduced compared with that in 2012, but have not yet recovered to the level of 2008. The main influencing factors of the seawater quality in the Yellow Sea were DIN and DIP. The high DIN(S) and DIP(S) content was mainly located at the coastal areas of Northern Yellow Sea and Jiangsu Coast. The high DIN(B) and DIP(B) content was mainly located at the coastal areas of Jiangsu Coast. The main reason was the excessive discharge of artificial nutrients from rivers into the sea. It had no impact on neighboring countries.

2．Status of Sources of pollutants in Yellow Sea

2.1 The spatial distribution of major pollution sources in the Yellow Sea

In the past few years, about 27 rivers have been monitored in the yellow sea, including 3 in Liaoning, 7 in Shandong and 17 in Jiangsu. About 131 sewage outlets were monitored, including 39 in Liaoning, 86 in Shandong and 17 in Jiangsu Province. The spatial distribution of pollution sources entering the Yellow Sea is shown in figure X.

Fig.14　The spatial distribution of main river entering the Yellow Sea

Fig.15 The spatial distribution of Sewage outlet into the Yellow Sea

2.2 Status of main rivers and pollutant fluxes into the Yellow Sea

Since 2010, the Yellow Sea has monitored the status of rivers reaching the sea as shown in Table 5 below. Over the years, the discharge of pollutants from the Yellow Sea river is shown in table 6 and figure 7. The annual discharge of pollutants from the Yellow Sea River from 2010 to 2017 is between 330,000 tons and 2,010,000 tons, with an average value of 1.09 million tons. The largest discharge of pollutants into the sea is COD. From 2010 to 2017, the water quality status of the Yellow Sea River sections monitored into the sea is shown in Table 7. The proportion of Inferior v water quality in dry season, high season and normal season is 63.8% , 61.3% and 55.2% respectively.

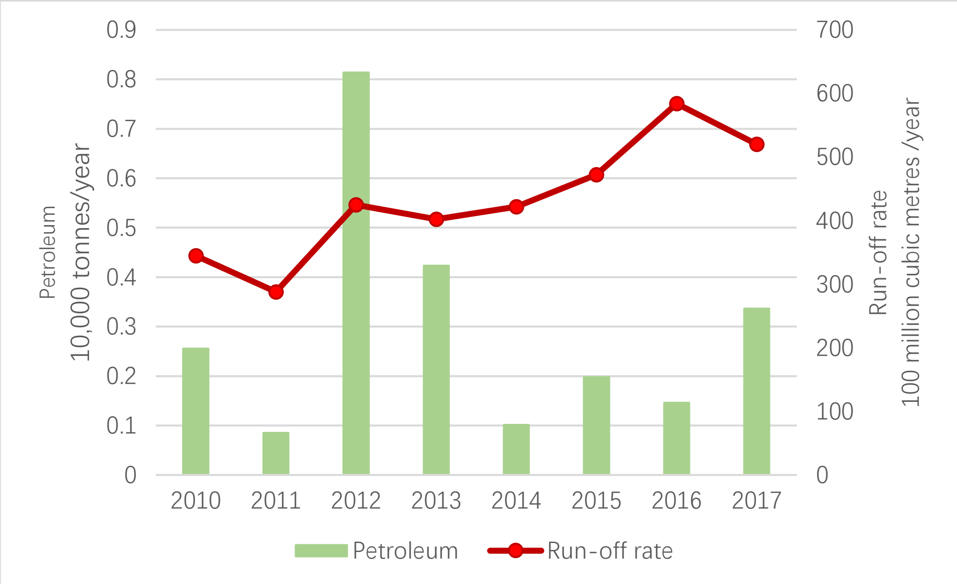
Table 2 summary of monitoring of Rivers entering the Yellow Sea

Year	Monitoring Quantity	Name of Monitoring River
2010	24	Yalu River, Biliuhe River, Dagu River, Rushan River, sow river, Futuan river, Xiuzhen River, Linhong River, Guanhe River, Sheyang River, Doulong port, Huangshagang River, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, Chuandong port into the sea, Xinyang port, Simao Youyou Gate into the sea, Yuanwang Port Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2011	8	Yalu River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Futuan River, Xiuzhen River,
2012	26	Yalu River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Xiuzhen River, Linhong River, Guanhe River, Sheyang River, Doulong port, Huangshagang River, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang port, Simao Youyou Gate into the sea, Yuanwang Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2013	26	Yalu River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Xiuzhen River, Linhong River, Guanhe River, Sheyang River, Doulong port, Huangshagang River, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang port, Simao Youyou Gate into the sea, Yuanwang Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2014	26	Yalu River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Xiuzhen River, Linhong River, Guanhe River, Sheyang River, Doulong port, Huangshagang River, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang port, Simao Youyou Gate into the sea, Yuanwang Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2015	27	Yalu River, Biliuhe River, Dagu River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Xiuzhen River, Linhong River, Guanhe River, Sheyang River, Doulong port, Huangshagang

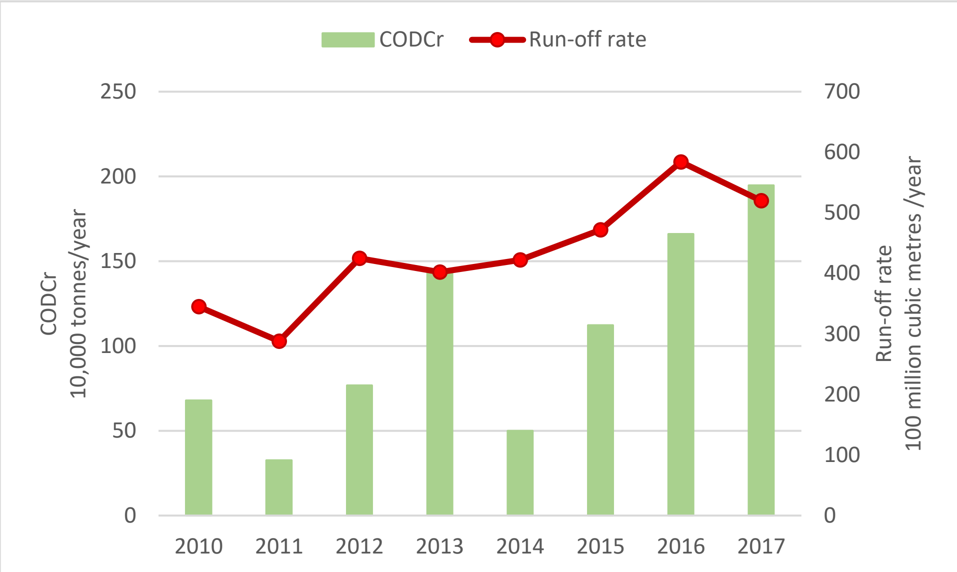
		River, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang Port, Siyouzha into the sea, Yuanwang port into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2016	27	Yalu River, Ocean River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Liangcheng River, Linhong River, Guanyang River, Sheyang River, Doulong port, Huangsha port, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang port, Siyoumao Gate into the sea, Yuanwang Port Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River
2017	27	Yalu River, Ocean River, Biliuhe River, Dagu River, Dagu River, Rushan River, sow river, Wulong River, Futuan River, Liangcheng River, Linhong River, Guanyang River, Sheyang River, Doulong port, Huangsha port, North Jiangsu Irrigation Main Channel river, Limin River, Dafeng River, Liangduo Nanhe, Liangduo Beihe, East Sichuan port into the sea, Xinyang port, Siyoumao Gate into the sea, Yuanwang Port Gate into the sea, Tonglv River, Xiaoyangkou outer gate, Zhongshan River

Table 3 discharge of pollutants from Yellow Sea rivers (ton / year)

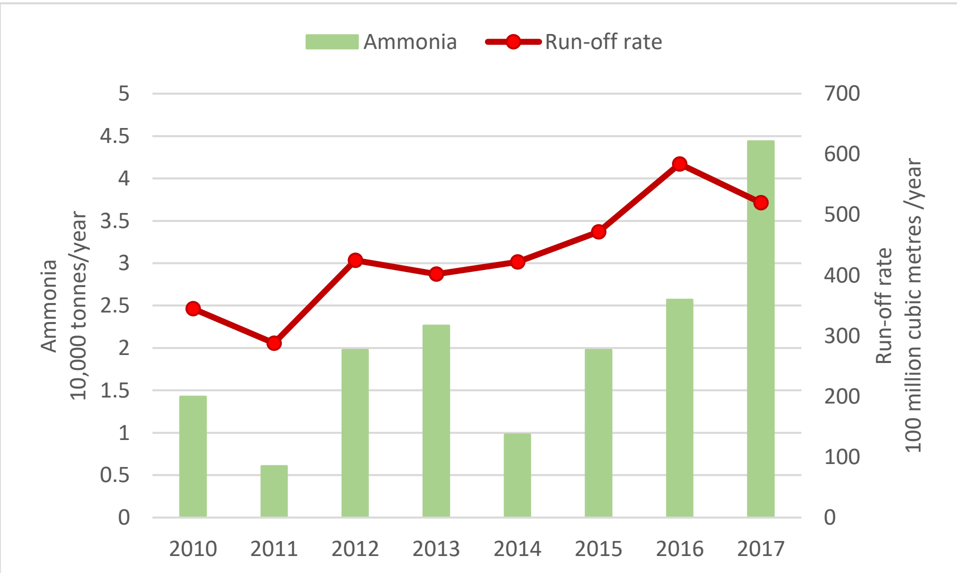
Year	Run-off rate (100 million cubic metres /year)	Oil	COD_{Cr}	Ammonia	Total P	Heavy Metals	Total
2010	345	2553	679069	14272	3729	918	700540
2011	288	849	326172	6074	698	865	334658
2012	425	8139	768167	19783	10538	564	807191
2013	402	4230	1447721	22631	10424	1505	1486510
2014	422	1014	498702	9811	11203	235	520964
2015	472	1980	1123264	19760	21923	1434	1168361
2016	584	1462	1661262	25708	12210	648	1701290
2017	520	3365	1947263	44386	15608	1115	2011737



Petroleum
10,000 tonnes/year
Run-off rate
100 million cubic metres /year
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
700
600
500
400
300
200
100
0
2010
2011
2012
2013
2014
2015
2016
2017
Petroleum
Run-off rate



CODCr
Run-off rate
CODCr
10,000 tonnes/year
Run-off rate
100 million cubic metres /year
250
200
150
100
50
0
700
600
500
400
300
200
100
0
2010
2011
2012
2013
2014
2015
2016
2017



Ammonia
Run-off rate
Ammonia
10,000 tonnes/year
Run-off rate
100 million cubic metres /year
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
700
600
500
400
300
200
100
0
2010
2011
2012
2013
2014
2015
2016
2017

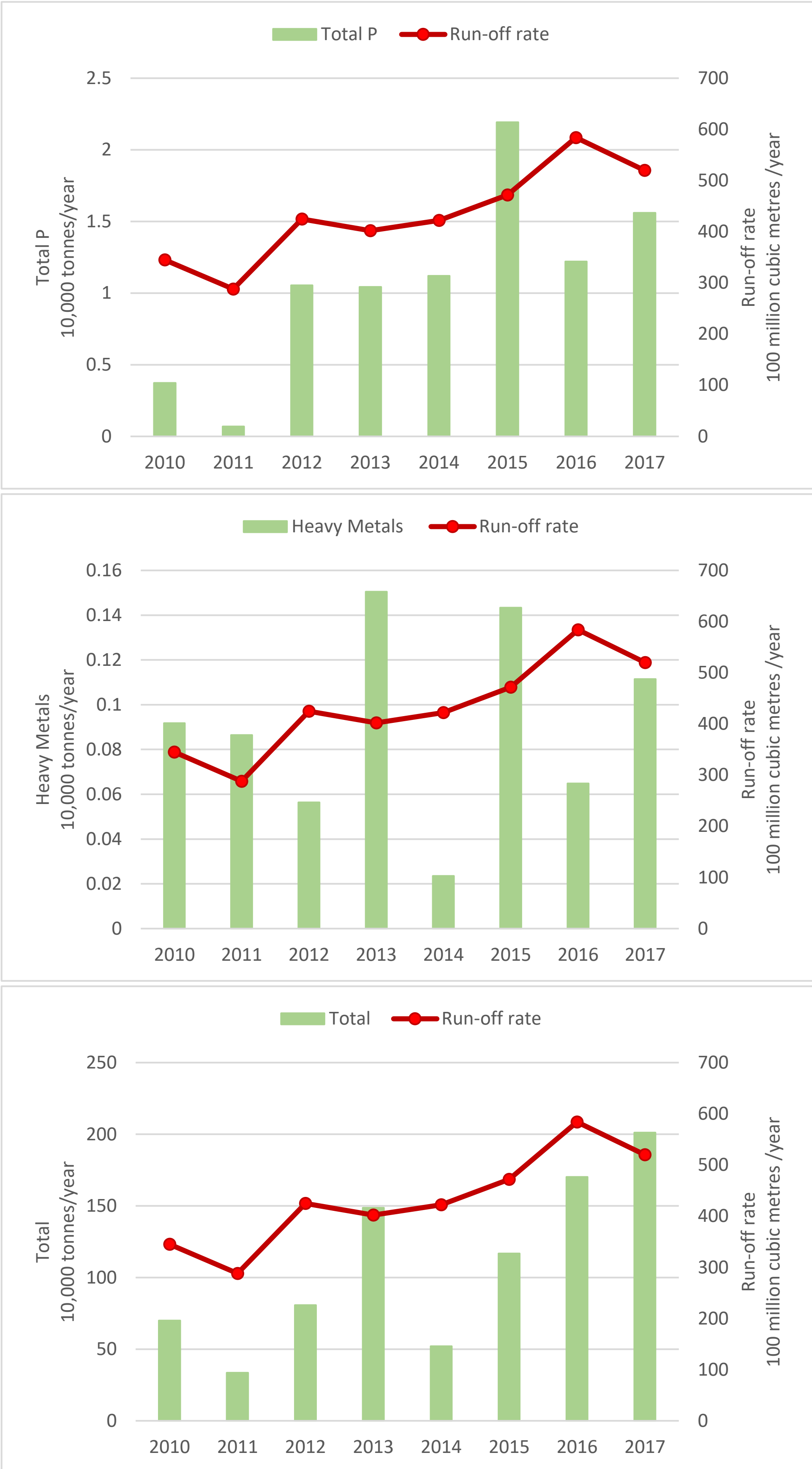


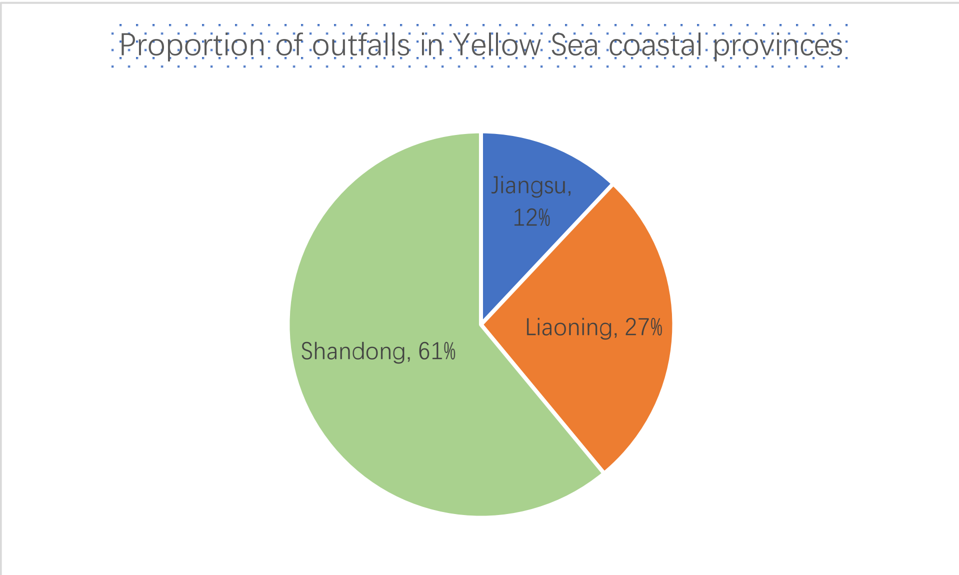
Fig. 16 Interannual variation of the discharge of major pollutants into the sea

from Yellow Sea rivers

2.3 Status of discharge outlets and pollutant fluxes into the Yellow Sea

2.3.1 Type characteristics of sewage outlet

Among the monitored sewage outlets, industrial and municipal sewage outlets accounted for 27% and river discharge 39% respectively. 88 sewage outlets were discharged into agricultural and fishery areas, tourist, recreational and recreational areas and Marine protection areas, accounting for 62% of the total sewage outlets monitored.



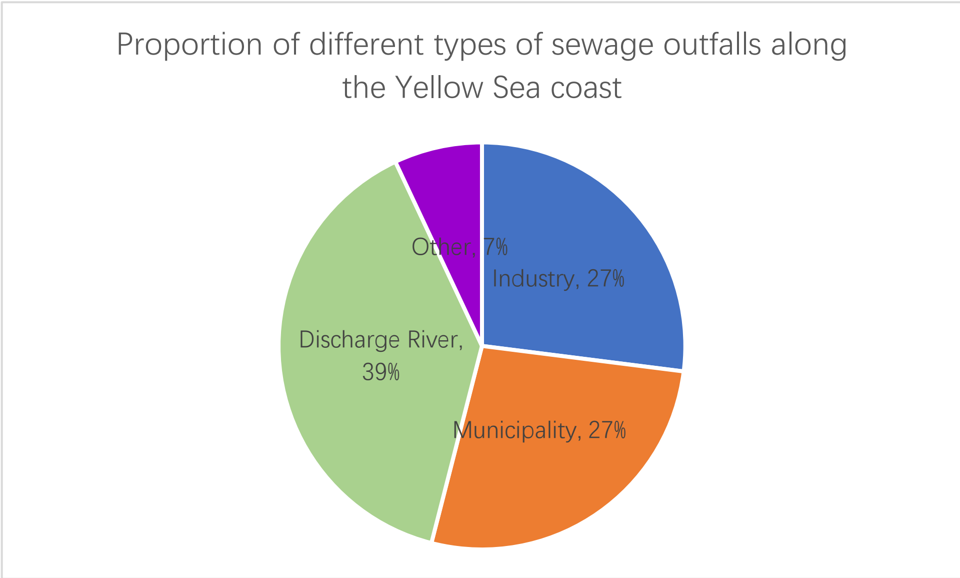


Fig. 17 distribution of sewage outfalls in the provinces along the Yellow Sea

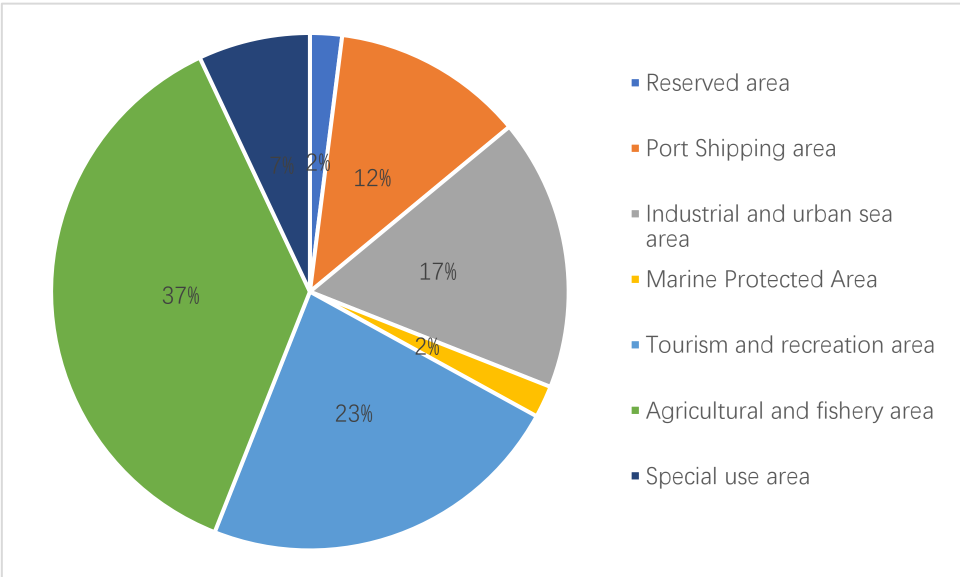


Fig. 18 distribution of sewage outfalls in different marine functional zones in the coastal provinces of the Yellow Sea

2.3.2 status of excessive discharge at outfalls

From 2010 to 2017, the proportion of the discharge outlets exceeding the discharge standard in the Yellow Sea is above 65% , and the proportion of the discharge outlets exceeding the discharge standard in Jiangsu Province is the highest. Total phosphorus, CODCR, suspended solids and ammonia nitrogen are the main pollutants discharged beyond the standard.

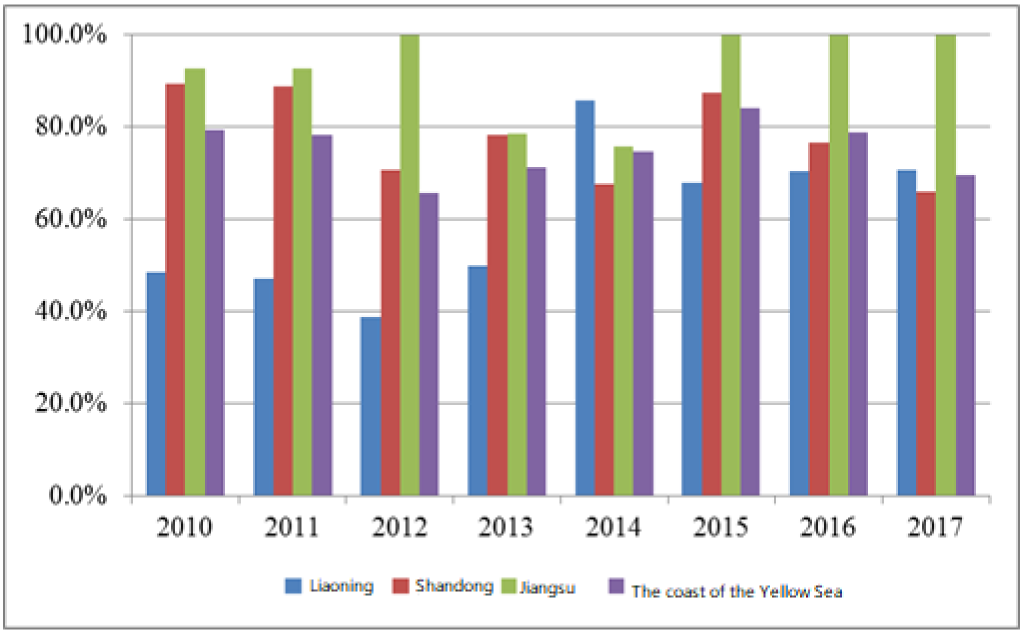


Fig. 19 monitoring of excessive discharge outlets in the Yellow Sea over the past years

2.3.3 Discharge of sewage and pollutants into the sea

From 2010 to 2017, the average annual amount of sewage discharged into the Yellow Sea reached 1.41 billion tons, and the average annual amount of pollutants discharged into the sea reached 180,000 tons, of which, the average annual amount of CODCR was 102,000 tons, suspended solids 69,000 tons, ammonia nitrogen 0.59 million tons, and total phosphorus 0.17 million tons. The contribution of major pollutants to the sea in the coastal provinces of the Yellow Sea is shown in the following figure.

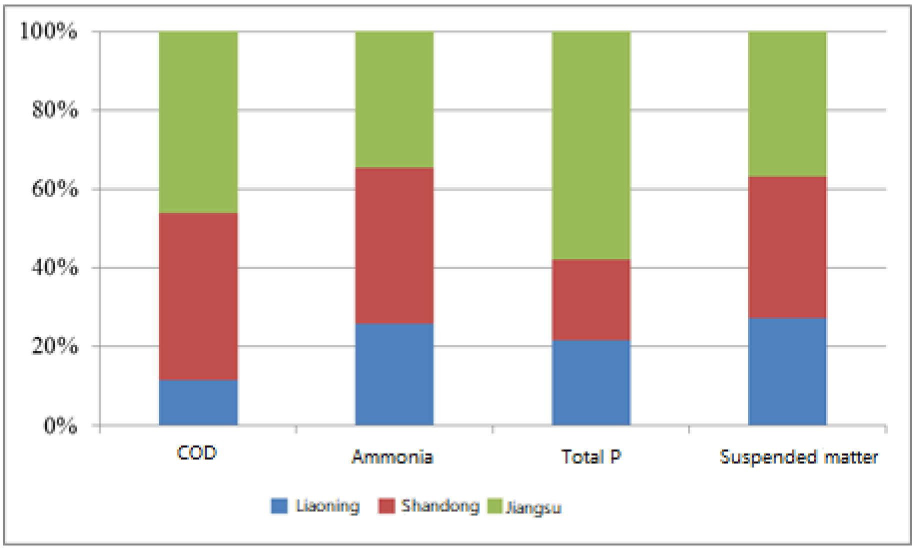


Fig. 20 contribution rate of main pollutants to the sea in the coastal provinces of the Yellow Sea

(1) Sewage and pollutants into the sea

From 2010 to 2017, the discharge volume of the Yellow Sea coastal outfalls into the sea ranged from 540 to 2.45 billion tons per year, and the discharge volume of pollutants into the sea ranged from 538 to 328,000 tons per year.

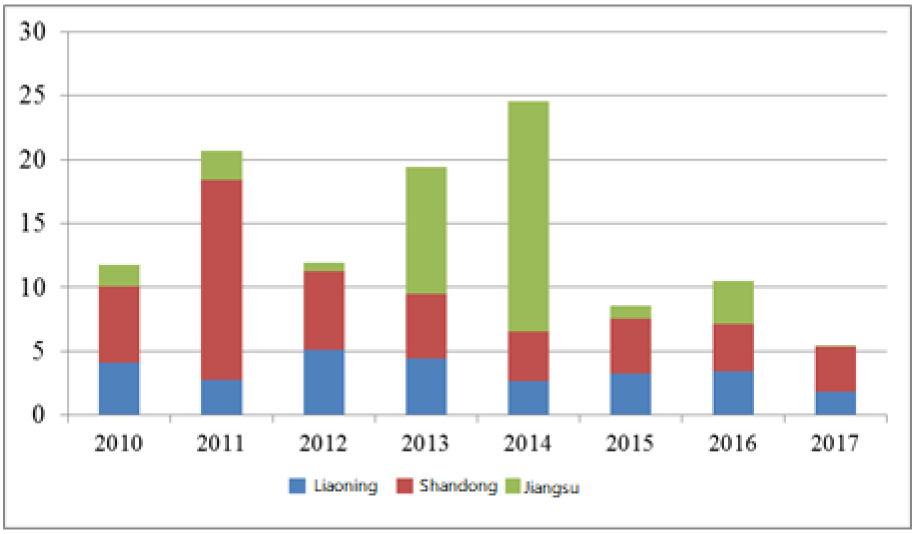


Fig. 21 2010 ~ 2017 sewage discharge into the sea (100 million tons/year)

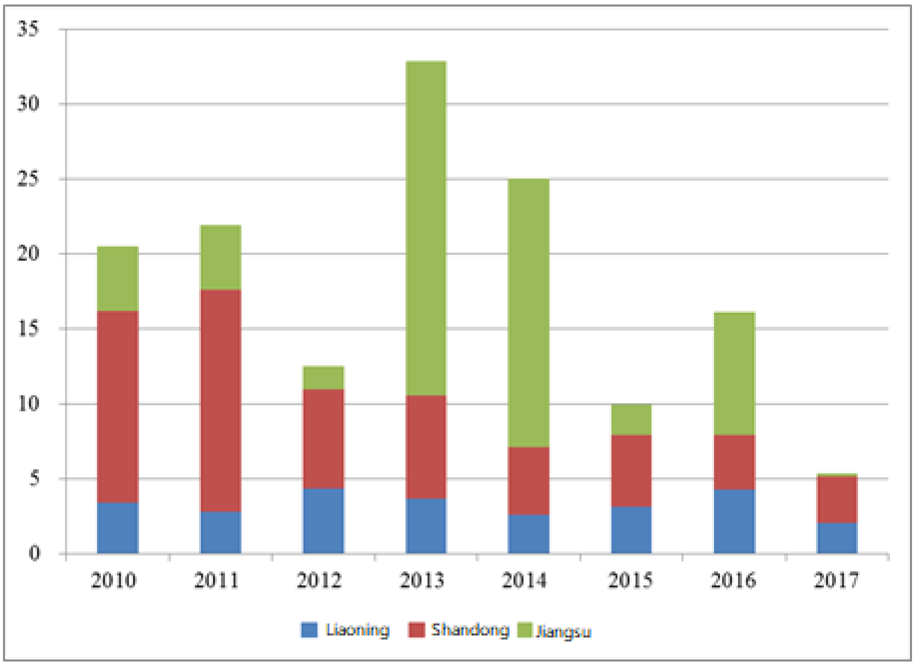


Fig. 22 the amount of pollutants discharged into the sea by each province and city from 2010 to 2017(10,000 tons /year)

（2） COD Sea Volume

From 2010 to 2017, the CODCR inflow into the sea outlet of the Yellow Sea coast ranged from 294 to 189,000 tons per year. The annual change of CODCR inflow into the sea in each province is shown in the following figure.

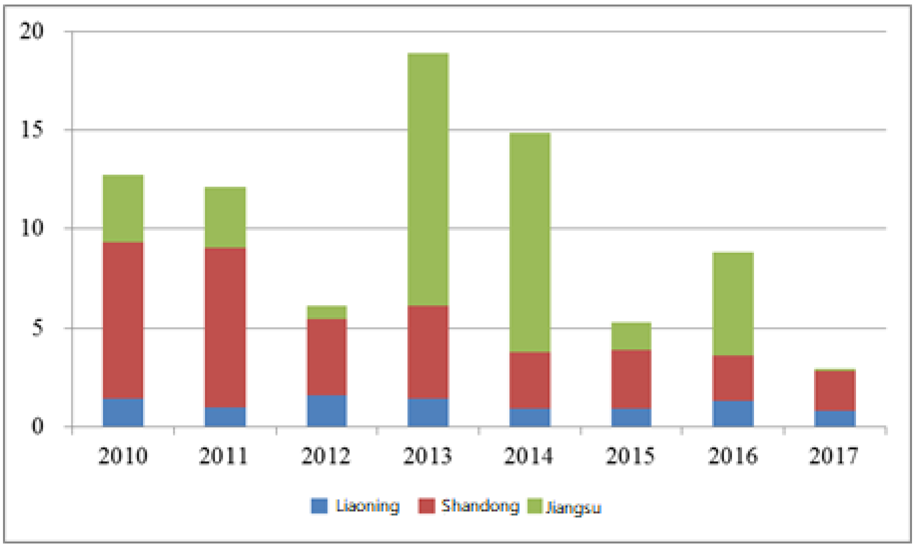


Fig. 23 The amount of CODCR entering the sea in each province and city from

2010 to 2017(10,000 tons /year)

(3) Ammonia nitrogen into the sea

From 2010 to 2017, the annual variation of nh3-n input to the sea in the Yellow Sea coastal outfall is shown in figure 9.

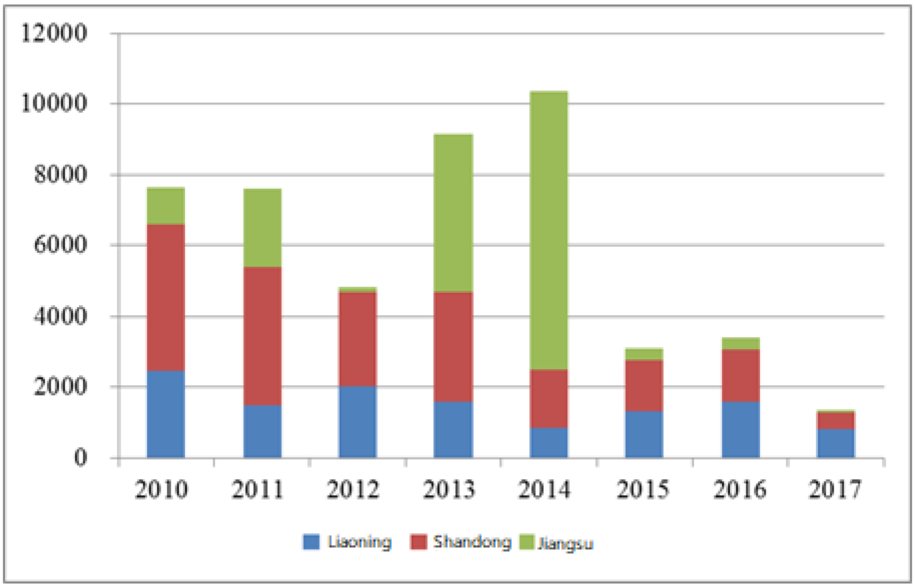


Fig. 24 The amount of ammonia nitrogen into the sea by provinces and cities from 2010 to 2017(tons /year)

(4) the amount of total phosphorus

From 2010 to 2017, the total phosphorus discharged into the sea from sewage outfalls ranged from 648 to 6687 tons per year.

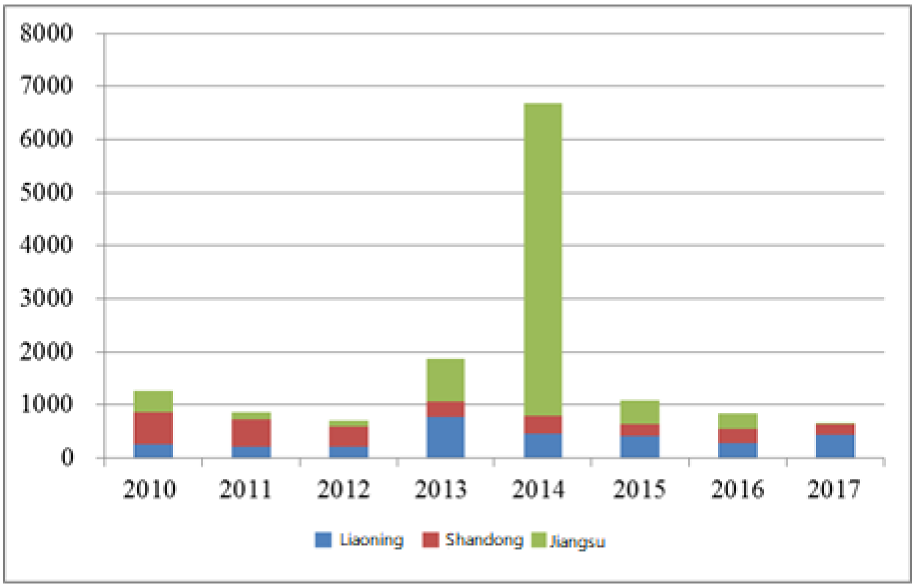


Fig. 25 Total phosphorus input to sea by provinces and cities from 2010 to 2017 (tons /year)

(5) Mass influx of suspended solids

From 2010 to 2017, the amount of suspended solids discharged into the sea from sewage outfalls ranged from 18.8 to 128,000 tons per year. The annual variation of suspended solids discharged into the sea from various provinces and cities is shown in figure 11.

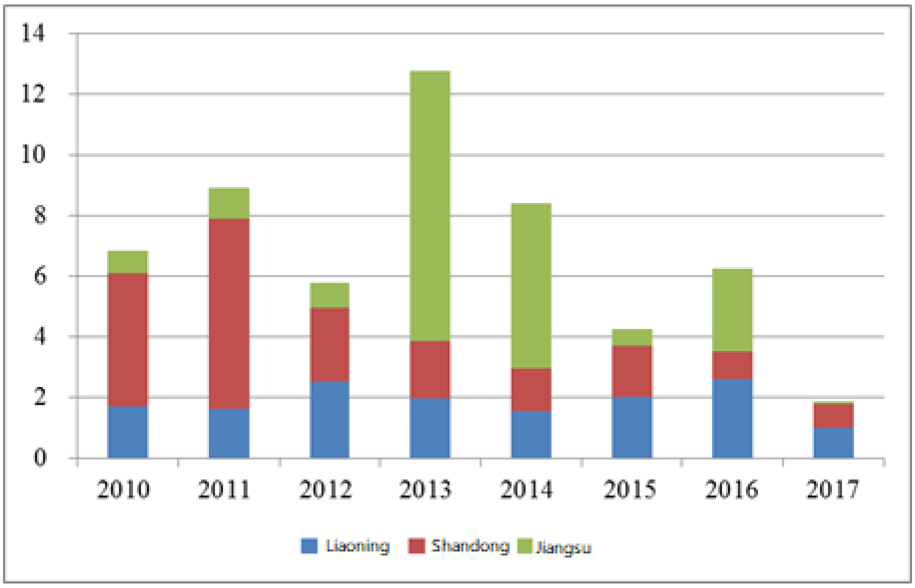


Fig. 26 2010-2017 sea level of suspended solids (10,000 tons/year)