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Research on the impact of reclamation project on surrounding water environment

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A B S T R A C T

This paper adopts the MIKE3 model, combined with the hydrodynamic and thermo-salt modules, and establishes a large-scale three-dimensional baroclinic numerical model of the Yangtze River Estuary-Hangzhou Bay, which has been combined with 10 tide level stations, 6 tide stations, and 2 temperature stations. Compared with the measured data of six salinity measurement stations, the hydrodynamic and thermo-salt parameters were calibrated. Relying on the large-scale numerical model, this paper established a small-scale three-dimensional baroclinic numerical model of the Yangtze River Estuary, which combined the hydrodynamics. Thermosalinity and water quality modules, through the Yangtze River Estuary Chl-a, DIN, and PO_4^{3-}. The measured plane distribution is compared, and the water quality parameters are calibrated.

Keywords: Yangtze River Estuary; Numerical simulation; Reclamation project; Hydrodynamics; Salinity; Water quality

1. Introduction

Since the 21st century, China's coastal areas have formed a large amount of land through reclamation to alleviate the contradiction between scarcity of land resources and rapid economic development. However, due to long-term large-scale reclamation activities, coastal wetlands have been reduced in large areas, and natural coastlines have been sharp. In recent years, the state has adopted a series of sea reclamation management and control measures to prevent all violations of laws and regulations with the promotion of scientific concepts such as "ecological and intensive use of sea". The behavior of using sea areas to reduce the negative impact of reclamation [1,2]. Many scholars at home and abroad have also conducted a series of studies, from the perspectives of shoreline changes, tidal current patterns, tidal absorption, water exchange, wetland environment, and ecological environment. Analyze the impact of reclamation activities on the sea and land. The direct impact of reclamation projects on the bay is the reduction of the bay's tidal capacity, and the indirect impact is the weakening of the hydrodynamic environment of the bay and the slowdown of the transport and diffusion of pollutants. Unfavorable factors such as increased sedimentation. Therefore, domestic scholars pay more attention to the erosion and deposition evolution, hydrodynamics, and water exchange of the Gulf.

This paper takes Hengsha Island as the research object, and uses the two-dimensional tidal current mathematical model based on the measured topographic data and hydrological test data to explore the impact of reclamation projects in the bay on the hydrodynamics of the bay and the development of Hengsha Island. Utilization has certain reference value.

2. Literature review

Yunfei and Yang [3] based on Landsat image, the establishment of Sanya Phoenix Island water around the

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Chl-a concentration mathematical regression model, the inversion of the Phoenix Island water around the Chl-a concentration, from the perspectives of time and space Phoenix Island phase II construction effects on water Chl-a concentration changes. The results show that the Sanya Bay and Phoenix Island waters near the Chl-a concentration on the rise year by year. In April 2014, Phoenix Island began construction of phase II, waters around the Chl-a concentration rise faster, reclamation after the completion of this effect will gradually disappear. The waters near the Phoenix Island than high concentrations of Chl-a, away from the seas, the construction during the construction of coastal water Chl-a concentration change rate is different from far away from the island waters. With the same offshore distance, the water adjacent to Phoenix Island has a higher concentration of Chl-a than the water far away from Phoenix Island, which reflects that some influences caused by the reclamation process of Phoenix Island will promote the rapid increase of Chl-a concentration in local waters, thus changing the ecological environment of coastal marine water to some extent [3]. Jiangzhu et al. [4], with the method of historical review and comparative analysis, from several aspects such as the hydrological dynamics analyses the reclamation engineering in our country in recent decades the impact on the Marine environment. The results show that the reclamation engineering can produce huge damage to the marine environment, cause the loss of waters near water exchange rate, tidal volume to reduce the problems, such as, the harm to the marine environment than its positive effects, and long-term effects are unpredictable [4].

3. Two-dimensional power flow mathematical model

3.1. Governing equation

The MIKE 21 Flow Model_FM HD module is used to build a two-dimensional tidal flow mathematical model. The power flow control equation used in this model is a two-dimensional shallow water equation with vertical average:

$$\frac{\partial h}{\partial t}+\frac{\partial h\bar{u}}{\partial x}+\frac{\partial h\bar{v}}{\partial y}=hs \tag{1}$$

$$\begin{aligned}\frac{\partial h\bar{u}}{\partial t}+\frac{\partial h\bar{u}^2}{\partial x}+\frac{\partial h\bar{v}\bar{u}}{\partial y}&=f\bar{v}h-gh\frac{\partial \eta}{\partial x}-\frac{h}{\rho_0}\frac{\partial p_a}{\partial x}\\&-\frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial x}+\frac{\tau_{sx}}{\rho_0}-\frac{\tau_{bx}}{\rho_0}-\frac{1}{\rho_0}\left(\frac{\partial S_{xx}}{\partial x}+\frac{\partial S_{xy}}{\partial y}\right)\\&+\frac{\partial}{\partial x}\left(hT_{xx}\right)+\frac{\partial}{\partial x}\left(hT_{xy}\right)+hu_sS\end{aligned} \tag{2}$$

$$\begin{aligned}\frac{\partial h\bar{u}}{\partial t}+\frac{\partial h\bar{u}\bar{v}}{\partial x}+\frac{\partial \bar{v}^2}{\partial y}&=-f\bar{u}h-gh\frac{\partial \eta}{\partial y}-\frac{h}{\rho_0}\frac{\partial p_a}{\partial y}-\frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial y}+\frac{\tau_{sy}}{\rho_0}-\frac{\tau_{by}}{\rho_0}\\-\frac{1}{\rho_0}\left(\frac{\partial S_{xy}}{\partial x}+\frac{\partial S_{yy}}{\partial y}\right)&+\frac{\partial}{\partial x}\left(hT_{xy}\right)\partial+\frac{\partial}{\partial x}\left(hT_{yy}\right)+hu_sS\frac{\partial}{\partial t}+\frac{\partial h\bar{u}}{\partial x}+\frac{\partial h\bar{u}}{\partial y}\end{aligned} \tag{3}$$

where t represents time, s; x, y are Cartesian coordinate systems; η is water level, m; h is total water depth, m, the expression is $h = \eta + d$, d is still water depth, m; $\bar{u}$, $\bar{v}$. Are the velocity components in the x and y directions averaged along the water depth, mms, and the expressions are, respectively, $\bar{u}=\frac{1}{h}\int_{-d}^{\eta}udz$, $\bar{v}=\frac{1}{h}\int_{-d}^{\eta}vdz$, f is the Coriolis force parameter, the expression is $f = \Omega\sin\phi$, where Ω is the rotation rate of the earth, and the value is 0.729×10^{-4} s^{-1}, ϕ is the geographic latitude; g is the earth's gravitational acceleration, mms 2; ρ is the density of water, kg gm^3; ρ_0 is the reference density of water, kg gm^3; τ_{sx}, τ_{sy} is the wind stress component, Pa; τ_{bx}, τ_{by} are bottom stress components, Pa; s_{xx}, s_{xy}, s_{yx}, s_{yy} are radiation stress components, Pa; P_a is the local atmospheric pressure, Pa; S is the source-sink term; us, v_s is the flow velocity component of the source-sink term, mms; T_{xx}, T_{xy}, T_{yx}, T (yy is the transverse stress component, Pa, and the expressions are, respectively, $T_{xx}=2A\frac{\partial \bar{u}}{\partial x}$, $T_{xy}=T_{yx}=A\left(\frac{\partial \bar{u}}{\partial y}+\frac{\partial \bar{v}}{\partial x}\right)$, $T_{xx}=2A\frac{\partial \bar{v}}{\partial y}$, A is the horizontal eddy current viscosity coefficient.

3.2. Calculation range and topography

In order to take into account the calculation accuracy and efficiency, the model uses large and small nested grids to simulate the impact of the project on the surrounding water environment. In order to better fit the shoreline changes and seabed undulations, the grid adopts a gradient triangular network in the horizontal direction. The grid is divided into 10 layers in the vertical direction using Sigma coordinates.

The large grid covers the Yangtze River Estuary, Hangzhou Bay, and its adjacent waters (120°E, 125°E, 28.5°N, and 33.5°N), with 10,998 nodes and 20,801 units on the plane, with a horizontal resolution of 1–22 km. The vertical resolution is 0.2–11 m, and the nested small grids only cover the sea area of the Yangtze River Estuary ((12.00 E) 12.30 E, (30.50 N) 32.50 N). In order to ensure the calculation accuracy, the small grids are encrypted near the shore. The plane contains 2,797 nodes and 5,012 elements.

4. Empirical analysis

4.1. Environmental impact analysis

In view of the characteristics of the water, sand, and topography of the Yangtze River estuary, a plan to build a dig-in port area on the Hengsha Shoal is proposed. The Hengsha Shoal is located between the Beigang Channel and the Beicao Deepwater Channel, on the east side of Hengsha Island. This article ignores the layout of the port area, mainly to study the impact of the reclamation project on the surrounding water environment. In order to finely analyze the changes in tide level, tidal current, salinity, and water quality before and after the project, this paper arranges 14 measurement stations around the project, of which the measurement stations 1–2 are located in the Beigang water area. Stations 3–5 are located in the northern waters of the project, stations 6–7 are located in the Nangang waters, stations 8–10 are located in the Beicao waters, stations 11–12 are located in the Nancao waters, and stations 13–14 are located in the east waters of the project.

4.2. Impact of tide level

This paper selects the tide level before and after the project from 00:00 on February 18, 2016 to 00:00 on February 20, 2016 for comparative analysis, and the results are shown in Figs. 1–3. After the implementation of the Hengsha Shoal Reclamation Project, the high tide level in Beigang waters. The high tide level in the northward and middle reaches of the project increased slightly, and the high tide level in the downstream waters decreased slightly, with a range of 0%–4%; low tide level. The increase is obvious, and its amplitude is high in the midstream and low in the upstream and downstream.

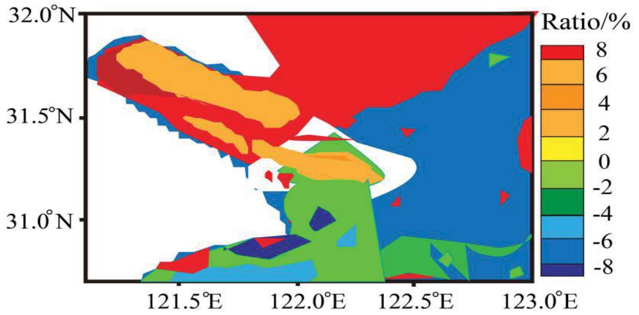

Fig. 1. Average high tide level change rate before and after the project.

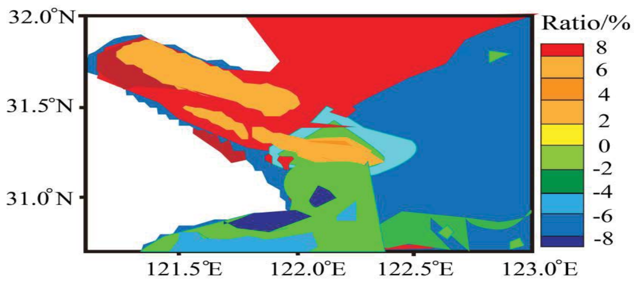

Fig. 2. Average low tide change rate before and after the project.

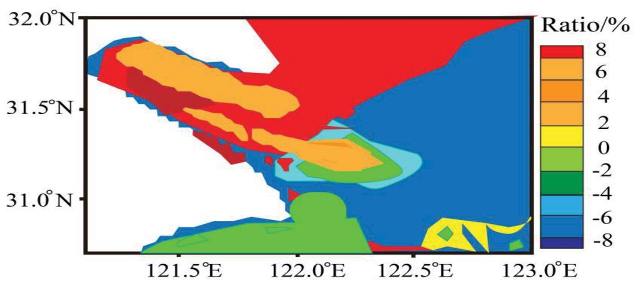

Fig. 3. Average tidal range change rate before and after the project.

The largest amplitude occurs near station 4, which is about 8% [5,6]. The high tide level in Nangang waters generally decreases, ranging from 4% to 6%; the low tide level rises The high tide level in the north channel waters has dropped significantly, with an amplitude of 2%–8%, and the decline has increased along the open sea; the low tide level in the upstream waters has increased slightly, with an amplitude of 0%–2%, but the low tide level in the middle and downstream waters generally decreases, ranging from 0 to 4%. The trend of high and low tides in the south passage is similar to that of the north pass, but compared with the north pass, the south pass has a small decrease in high tide level and a large decrease in low tide level. The high and low tide levels in the east waters are slightly reduced, and the decline on the north side is larger than that on the south side.

To sum up, in addition to the slight increase in the high tide level of the waters in the north and middle reaches of the project, the high tide level of the waters near the project generally decreases, but the amplitude is small, and the maximum amplitude occurs in the upper reaches of the north trough, which is about 8%; except for the south and north troughs. In addition to the slight decrease in the low tide level in the downstream waters, the low tide level in the waters near the project increased slightly, and the maximum occurred in the waters of the north and middle reaches of the project, which was about 8%; due to the general decline in the high tide level, the low tide level increased slightly, and the water near the project was tide. The difference is generally reduced, with a range of 0%–4%, and the project has caused a decrease in the amount of tidal absorption in the surrounding waters.

4.3. Trend influence

This paper selects the flow field before and after the project from 00:00 on February 18, 2016 to 00:00 on February 20, 2016 for comparative analysis, and the results are shown in Fig. 4. In terms of flow direction, compared with before the project, the flow of water near the project occurred. With a major change, the water flow changed from a weak rotating flow to a strong reciprocating flow, flowing in the direction of the outer contour of the project; affected by the engineering barrier, a clockwise local circulation appeared in the water area near the east station 14 of the project.

In terms of rapid rise and flow rate, the project has changed the hydrodynamic conditions of the surrounding waters compared to before the project: the diversion ratio of the north port increased while the south port decreased; the diversion ratio of the north channel decreased, while the south channel increased; the high tide water flux entering the waters north of the project increased, while the south of the project decreases; the high tide water flux into the waters of the south branch increases [7,8]. Affected by the increase of the high tide water flux, the rapid rise of the waters of the south branch increases slightly; the north port and the northward and middle reaches of the project runoff and high tide. The water fluxes all increased, but the rapid rise and flow rate of the water area generally decreased. The rapid rise and flow rate of the water areas at station 3 and station 4 decreased by 14% and 11.7%, respectively, indicating that the water area is mainly controlled by runoff. The north lower reaches of the project suddenly opened up, the effect of runoff is weakened. Affected by the engineering contour and Coriolis force, the rapid rise velocity increases significantly, and the largest amplitude occurs in the waters near station 5, reaching more than 20%. The change in the rapid rise velocity of Nangang waters is small, and the runoff decreases. The rapid rise and rapid flow rate increased slightly, and the largest rate occurred in the waters near station 7, which was only 2.65%. Although the runoff of the Beicao water area increased and the high tide water flux decreased, the rapid rise flow rate was affected by the narrow river channel of the project. Generally increased, but the amplitude is mostly within 10%. Considering the project outline, the rapid rise and flow rate of the water area at station 4 is slightly reduced. The rapid rise and flow rate of the Nancao water area shows the characteristics of an increase in the upper and middle reaches and a decrease in the downstream, and the amplitudes are all within 10%. This is because the upper and middle reaches of the south passage are mainly controlled by runoff, which reduces the runoff and increases the rapid rate of rise; while the downstream is controlled by tidal currents, the flux of the rising tide decreases, and the rate of rapid rise decreases. The waters on the northeast side of the project have a slight rise rate. However, in the southern waters, the outline of the project is close to the flow line, blocking the advancement of the rising tide, resulting in the formation of a slow current zone in the waters near the station 14, and the rapid rise and flow rate dropped by 46.67%.

In terms of the rapid flow rate, the rapid flow rate of the southern branch waters has increased slightly compared to before the project. Due to the control of runoff, the increase in the runoff has led to a slight increase in the rapid flow rate of the Beigang waters. The northern waters of the project are subject to narrow rivers, runoff and low tide water. Due to the impact of the increase in the amount of water, the rapid flow rate generally increased, and the largest amplitude appeared in the waters near station 5, reaching more than 20%. Due to the decrease in runoff in the Nangang waters, the rapid flow rate generally decreased by about 5%. Due to the influence of beam narrowing, the rapid rate of fall generally increased, and the largest magnitude occurred in the waters near station 10, reaching more than 20%. The rapid rate of fall of the Nancao waters increased slightly, with a smaller amplitude, mostly within 3%. The rapid flow rate is significantly reduced, and the south side has a greater decline than the north side. The rapid flow rate in the water area of station 14 is reduced by 61.14%.

To sum up, compared to before the project, the water flow near the project has changed from a weak rotating flow to a strong reciprocating flow; the rapid rise and fall velocity of the Beigang waters generally decrease, and the rapid fall velocity increases slightly; the rapid north rise velocity of the project decreases in the upper and middle reaches. However, when the downstream increases, the rapid, and rapid flow rate generally increases; the rising rapid flow rate in the Nangang waters slightly increases, and the falling rapid flow rate slightly decreases; the rapid rising and falling rapid flow rates of the north channel waters generally increase; the rising rapid flow rate of the south channel is in the upper and middle reaches increases, but decreases in the downstream, and the rapid rise and fall flow rate slightly increase; the east water area of the project rises sharply, and the fall rapid flow rate decreases, and the decline is greater than the north side and the south side [9,10].

4.4. Influence of salinity

This paper selects the rising and falling salinity fields before and after the project from 00:00 on February 15, 2016 to 00:00 on February 20, 2016 for comparative analysis, and the results are shown in Figs. 5 and 6.

In terms of surface salinity, the salinity contours around the project moved significantly downstream compared to before the project, and the salinity of the surrounding waters generally declined, with a slight increase in local areas, and the decline in the waters south of the project was greater than that of the waters north of the project. The water flux increased, and the salinity of the waters of the south branch increased significantly. The salinity of the upstream waters of Beigang was affected by the south branch, and the salinity of the waters of the north port increased significantly, while the middle and lower reaches of the Beigang and the north waters of the project were affected by the increase in runoff, and the salinity of the waters of the north port generally decreased. The degree

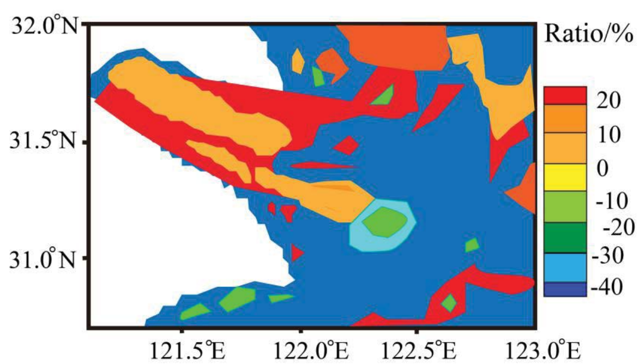

Fig. 4. Rate of change of rapid rise and flow rate before and after the project.

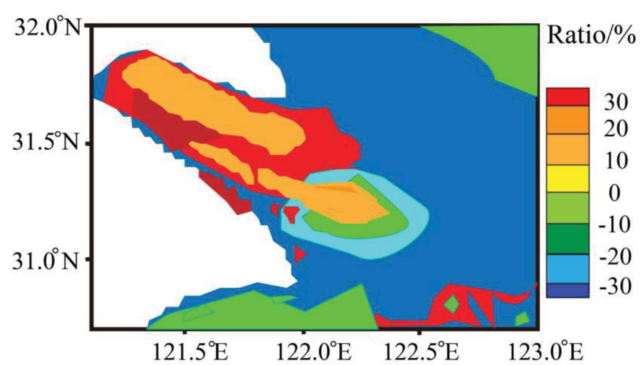

Fig. 5. Rate of change of salinity before and after the project.

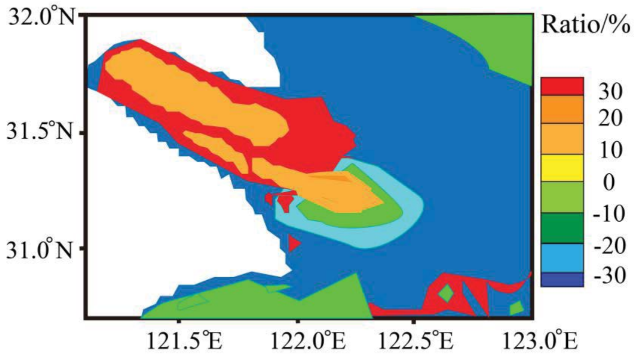

Fig. 6. Salinity change rate before and after the project.

of decline gradually increased along the open sea, and the rising salinity of the waters of station 4 decreased by about 18%. The upper water area of Nangang was affected by the south branch, and the rising salinity increased significantly, while the middle and downstream waters were affected by the high tide water flux. As a result of the decrease, the salinity of rising and rest was significantly reduced, and the degree of decline gradually increased along the open sea, and the salinity of the rising and rest of the water area of station 7 decreased by about 28%. The runoff of the Beicao water area increased, and the water flux of the rising tide decreased. It is difficult to trace the tide, and the salinity of the rise and fall is greatly reduced, especially in the upper and middle reaches of the north channel, which is greatly affected by the runoff. The rising salinity of the upper and middle reaches of the trough decreased significantly, while the downstream waters increased slightly. Affected by the changes in the surrounding hydrodynamic conditions, the rising salinity of the east water area of the project decreased, and the decline was about 10%.

In terms of surface salinity, the salinity of the southern branch waters increased slightly compared to before the project. Due to the impact of runoff, the closer to the downstream, the greater the increase. As the salinity of the southern branch rises, the Beigang waters are affected by the southern branch. Under the influence of runoff discharge, the salinity of fall-off was significantly increased, and the increase was reduced along the way, and salinity of the water area of station 2 increased by about 49%. The north-upstream water area of the project was affected by the inflow of water from Beigang, and the salinity of off-off was slightly increased, and the rapid rise of the falling speed in the middle and lower waters caused the falling salinity to gradually decrease along the way, and the falling salinity of the waters of the station 5 decreased by about 13.5%. Due to the reduction of the diversion ratio, the Nangang waters were affected by the water from the south branch. It is smaller than Beigang, and its fall salinity has increased significantly, especially in the upstream waters. The fall salinity of station 6 has increased by about 86%. The fall rapid flow rate of Beicao waters has decreased, and its fall salinity has decreased significantly. The salinity of the waters of 9, 10 decreased by 49.34% and 34.84%, respectively. The salinity of the upper and middle reaches of the south channel decreased, and the decrease was smaller than that of the north channel, and the salinity of the lower waters increased slightly. The bottom layer increased. The salinity of latitude and latitude has similar laws to that of the surface, but the range and amplitude of its change are larger than that of the surface.

To sum up, in terms of rising salinity, except for the slight increase in the southern branch and the lower reaches of the Nancao, other waters have decreased, especially in the upper and middle reaches of the north channel. The waters in the middle and lower reaches of the branch, Beigang, Nangang, and Nanzhi increased, and the upstream waters of the South and Beigang increased the most; other waters all decreased to varying degrees, and the waters in the middle reaches of the north channel decreased the most. The salinity of the surface layer of the station 9 dropped by 49.34%.

4.5. Water quality impact

This article selects Chl-a, DIN, and PO_4^{3-}. The average concentration of the table and the bottom layer are respectively compared and analyzed, and the results are shown in Figs. 7–9.

In terms of surface Chl-a, compared to before the project, the concentration contours generally move toward the sea, and the concentration of Chl-a around the project generally increases. The high tide water flux in the southern branch waters increases, and the waters gather more Chl from the outer sea boundary -a caused a slight increase in the concentration of Chl-a in the water area. The diversion ratio of the north Harbor water area increased, and the concentration of Chl-a in the water area increased slightly due to the increase in the water flux from the south branch and the high tide. The increase in the upper and middle reaches of the north water area of the project. It is smaller, and the downstream waters have a larger increase, which may be caused by the combined effect of Coriolis force and engineering contours. Nangang is affected by the water coming from the south branch, and the concentration of Chl-a increases slightly. The concentration of Chl-a in the north channel waters increases. The magnitude is larger, which may be caused by the decrease in tidal absorption in the water area and the decline in water exchange capacity due to the construction of the project. The concentration of Chl-a in the water area of the south channel increased, and the increase was much smaller than that of the north channel due to the distance from the project. The concentration of Chl-a in the eastern waters has increased greatly, and the maximum can reach more than 40%.

Surface DIN and PO_4^{3-}, on the other hand, compared with before the project, the rapid rise, and fall of the southern branch waters have increased, which is conducive to the diffusion of pollutants. PO_4^{3-}, the concentration is slightly reduced. The Beigang water area is affected by the decrease of the rapid rise velocity and the increase of the rapid fall velocity. The concentration of DIN and PO_4^{3-} in this water area decreases slightly, and the DIN and PO_4^{3-} of the water area of the station 2 are slightly reduced. PO_4^{3-}, the concentration dropped by 1.53% and 0.74%, respectively. PO_4^{3-}, the concentration has increased significantly, and the increase will be larger as it is closer to the project and larger along

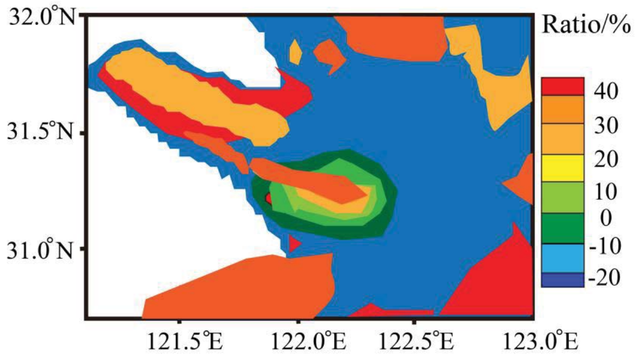

Fig. 7. Chl-a average concentration change rate before and after the project.

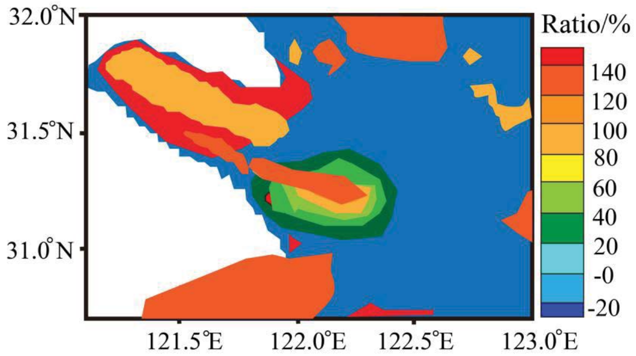

Fig. 8. Average concentration change rate of DIN before and after the project.

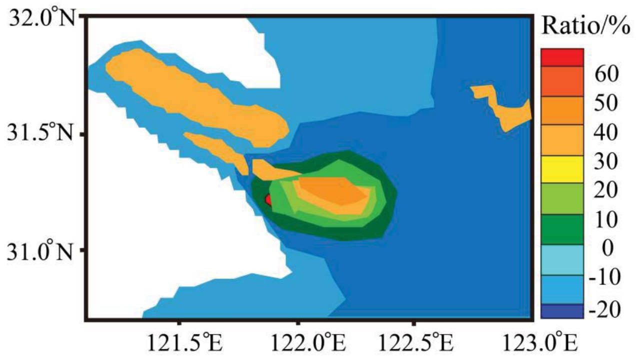

Fig. 9. Before and after the project PO_4^{3-} average concentration change rate.

the open sea. Nangang DIN and PO_4^{3-}, the concentration decreases slightly in the upper and middle waters, and the DIN and PO_4^{3-}, the concentration decreased by 1.72% and 3.82%, respectively, and increased slightly in the downstream waters. PO_4^{3-}, the concentration has increased by 1.85% and 1.11%. The DIN and PO_4^{3-}, the concentration increases significantly, and the increase is larger as it is closer to the project and increases along the open sea. The DIN and the water area of the station 10 PO_4^{3-}, the concentration has increased by 80.13% and 48.96%, respectively, which may be caused by the reduction in tidal capacity of the water area due to the engineering construction and the reduction of the exchange capacity of the water body. PO_4^{3-}, the concentration increases in the upper and middle waters, and decreases in the downstream waters, which may be due to the fact that the engineering construction is not conducive to the high concentration of DIN and PO_4^{3-}, the rapid rise and fall of the east water area of the project reduce the rapid flow rate and the formation of a slow flow zone, which is not conducive to the diffusion of substances, which leads to a substantial increase in the concentration of DIN and PO_4^{3-}. The concentration of DIN and PO_4^{3-} in the water area of the side station 13 increases by 111.78% and 22.54%, respectively.

The concentrations of Chl-a, DIN, and PO_4^{3-} at the bottom of the project before and after the project are basically the same as those on the surface. In summary, in terms of the concentration of Chl-a, the increase in the waters of Nanzhi, Beigang, Nangang, and Nancao is relatively small. The trough and the east waters of the project have increased significantly, and the closer they are to the project, the greater the increase, and the largest increase occurs in the east waters of the project; DIN and PO_4^{3-}, in terms of concentration, the waters of the Nanzhi, Beigang, the upper, and middle reaches of the Nangang and the lower reaches of the Nancao have slightly decreased. The waters of the north, the lower reaches of the Nangang, the north channel, and the east of the project around the project have increased significantly, and the closer the distance to the project, the greater the increase. The largest increase in DIN concentration occurred in the east waters of the project, while PO_4^{3-} is the largest increase in concentration occurred in the middle reaches of the North Channel.

Based on the small-scale three-dimensional baroclinic model of the Yangtze River Estuary, this chapter analyzes the impact of the Hengsha Shoal reclamation project on the surrounding waters from the four aspects of tidal level, tidal current, salinity, and water quality.

In terms of tide level, compared with before the project, the high tide level of the waters in the north and middle reaches of the project slightly increased, while the high tide level of the waters near the project decreased slightly; except for the slight decrease of low tides in the middle and downstream waters of the south and north troughs, the low tide level of the waters near the project was slightly lower. Rising due to the general decrease in the high tide level and the slight increase in the low tide level, the tidal range in the waters near the project generally decreases.

In terms of the rapid rate of increase, the waters in the north lower reaches of the project, the south port, the north channel, and the upper and middle reaches of the south channel increased, and the largest increase occurred in the waters of the north lower reaches of the project, reaching more than 20%; the north port, the north upper and middle reaches of the project, the lower reaches of the south channel, and the east waters of the project decreased. The largest drop occurred in the waters on the southeast side of the project, reaching more than 45%. In terms of the rapid flow rate, the waters of the north port, the north passage, the north passage, and the south passage of the project all increased, and the largest increase occurred in the downstream waters of the north passage, reaching more than 20%. The east water area of the project decreased, and the largest decrease occurred in the water area on the southeast side of the project, reaching more than 60% [11–13].

5. Conclusions

Based on the small-scale three-dimensional baroclinic numerical model of the Yangtze River Estuary, this paper analyzes the tidal level, tidal current, salinity, water quality, and particle transport five aspects elaborated the impact of the Hengsha Shoal reclamation project on the surrounding waters. Compared with the previous project, the conclusions are as follows: (1) in terms of tidal level, the range of tidal level change is small, and the range of tidal range generally decreases, (2) in terms of rapid rise and flow rate, the north lower reaches of the project, the south port, and the waters in the upper and middle reaches of the north channel and the south channel have increased, and the largest increase occurred in the waters of the northern and lower reaches of the project, reaching more than 20%; the upper and middle reaches of Chengbei, the lower reaches of Nancao, and the east waters of the project are reduced, and the largest drop occurs in the waters of the southeast side of the project, reaching more than 45%, (3) in terms of falling velocity, the water area of the north port, the north channel, the north channel, and the south channel all increased, and the maximum increase occurred in the north channel downstream waters, up to more than 20%; Nangang and the east water area of the project decreased, and the biggest decrease occurred in the southeast water area of the project more than 60%, (4) in terms of rising salinity, except for a slight increase in the lower reaches of the south channel, other waters have decreased, especially in the north channel. The waters in the upper and middle reaches have decreased significantly, (5) in terms of salinity, the waters of north and south ports have increased, and the increase in the upper reaches. The largest decrease in other waters, and the largest decrease in the middle reaches of the north channel, (6) in terms of Chl-a concentration, the concentration in the surrounding waters generally increases, and the closer to the project, the greater the increase, with the largest increase occurring in the east waters of the project, (7) DIN with PO_4^{3-}, in terms of concentration, the waters in the upper and middle reaches of Beigang and Nangang and the lower reaches of Nancao are slightly reduced. The increase in Beicao and the east waters of the project is greater, and the closer to the project, the greater the increase, and the largest increase in DIN concentration occurs. In the east waters of the project, and PO_4^{3-}. The largest increase in concentration occurred in the middle reaches of the north channel.

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