Ecological Damage Assessment of Coastal Wetland Protection Project in Hangzhou Bay Area

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Abstract. The assessment of Ningbo Hangzhou Bay Coastal Wetland Protection Project is an important measure for the ecological restoration of ecological development. Combined with the collected data and the current situation investigation results, the changes of marine hydrodynamic environment, seawater quality and sediment environment, marine biological ecology, and ecological sensitive targets around the project before and after the implementation of Ningbo Hangzhou Bay Area Bank Protection Project were analyzed. The impact on marine ecology was analyzed, and the value of ecological damage was calculated. The ecological issues generated by the Hangzhou Bay New Area Bank Protection is Scientifically analyzed, to present a comprehensive assessment of the marine ecological impact of the project.

Keywords: Ecological Damage; Hangzhou Bay; Seawater Quality; Marine Supply

1 Introduction

Hangzhou Bay is a coastal section outside the mouth of the Qiantang River estuary, adjacent to the Yangtze River estuary to the north. The southward movement of sediment from the Yangtze River provides a rich material source for shaping the geomorphology of Hangzhou Bay, which has developed the southern coast of Hangzhou Bay, where the Hangzhou Bay New Area is located, into a typical estuarine type of muddy coast. It has played an important role in promoting and ensuring the expansion of living and production development space for coastal areas and promoting economic development. The coastal wetlands south of Hangzhou Bay are one of the eight major saltwater wetlands in China. Their marine dynamic environment and ecological diversity have been damaged to a certain extent, and their ability to prevent and mitigate disasters through dampness and wave dissipation has also decreased. In order to carry out large-scale reclamation and ecological restoration, restore the mudflat resource area and the damaged coastal wetland ecosystem, the Ningbo Hangzhou Bay New Area Bank Protection Project was implemented in three phases.

The Ningbo Hangzhou Bay New Area Bank Protection and Beach Protection Project (Phase III) under this assessment is an important measure for the ecological resto

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ration of coastal wetlands and the ecological development of mudflat resources in Hangzhou Bay New Area. The Bank Protection Project of Hangzhou Bay Area (Phase III) is an important measure for ecological restoration of coastal wetlands and ecological development of mudflat resources. It is of great significance to scientifically assess the ecological profit and loss and restoration effect of the project implementation, and provide the basis for the in-depth practice of ecological restoration of coastal wetlands in Hangzhou Bay Area, the development and utilization of mudflat resources, and the legal and scientific management of sea area use for the public welfare bank protection project itself and similar projects.

It is suggested that the government should update the sea area use fees for ecological damage compensation for reclaimed seawater aquaculture and collect sufficient funds to restore the damaged marine ecosystem[1]. Dong[2] selected typical cases of illegal dumping of solid waste in China, analyzed the causes, degrees, and characteristics of environmental damage, and focused on the physical quantification and evaluation of the damage components. Taking Dalian Maritime Airport in China's reclamation construction as an example, an indicator system was established and GIS technology was used to analyze the spatiotemporal dynamic changes of marine ecosystem health during the reclamation construction process[3]. Based on the value of marine ecosystem services and the sensitivity coefficient of marine ecological functional areas, quantitative prediction and calculation of marine oil spill ecological damage were conducted by Li[4], providing technical support for ecological damage assessment of marine oil pollution events. In view of the reclamation and its ecological impact in Jiaozhou Bay, Li[5] has assessed the damage degree and compensation scale of reclamation resources and ecological services. In order to study the impact of reclamation on the Rui'an coastal zone, combined with on-site data and numerical simulation, regional tidal and sediment dynamics were studied[6]. Cao[7] developed a new method, which uses the full time series of Landsat images based on Google Earth Engine platform to plot the monthly changes of Zhoushan Islands coastline and mudflat from 1985 to 2017. The obtained coastline and mudflat change information is very useful for the sustainable management and ecological research of coastal areas. Bodycomb[8] adapted an analytical 1D cross-shore wave attenuation model and tested the effect of (1) water depth, (2) vegetation density, and (3) longline density. the present and potential future role of seagrass in coastal risk reduction strategies were explored for the highly energetic Wadden Sea area of the German Bight by Jacob[9]. Silva[10] has studied the structure of mangrove vegetation at Kirinda, Kalametiya, and Rekawa in Sri Lanka that resisted tsunami waves for varying extents in 2004 in detail to discern the wave attenuation function of mangrove vegetation.

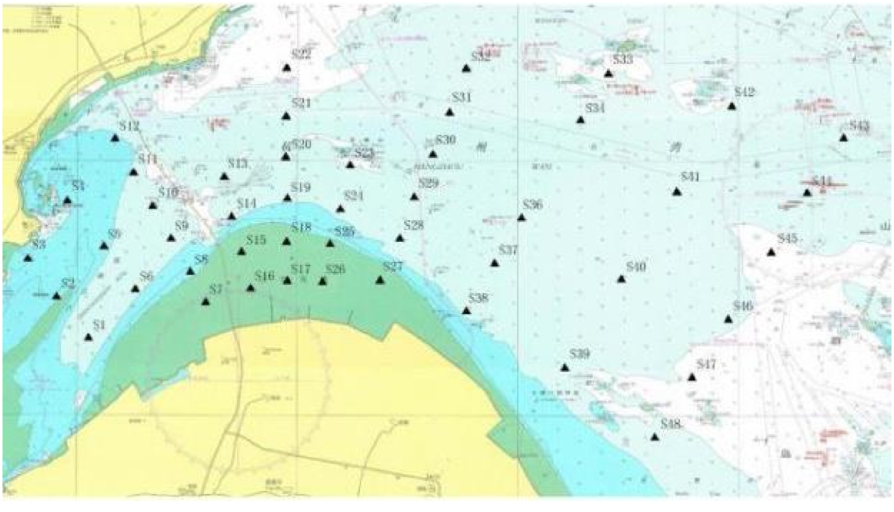
Survey was conducted on the site of the Ningbo Hangzhou Bay New Area Bank Protection and Beach Protection Project (Phase III), collect data on the topography, hydrology, marine ecological environment of the sea area before and after the project, as well as information on the development, utilization, and planning of nearby sea areas. Refer to technical specifications such as the "Technical Guidelines for Ecological Assessment of Reclamation Projects (Trial)" to analyze the hydrological and dynamic environment, topography, erosion and sedimentation environment, seawater quality, and sediment environment before and after the construction of the project

Calculate the ecological gains and losses caused by the implementation of the project, and ultimately draw ecological assessment conclusions based on the impact of marine biological ecology and ecologically sensitive targets.

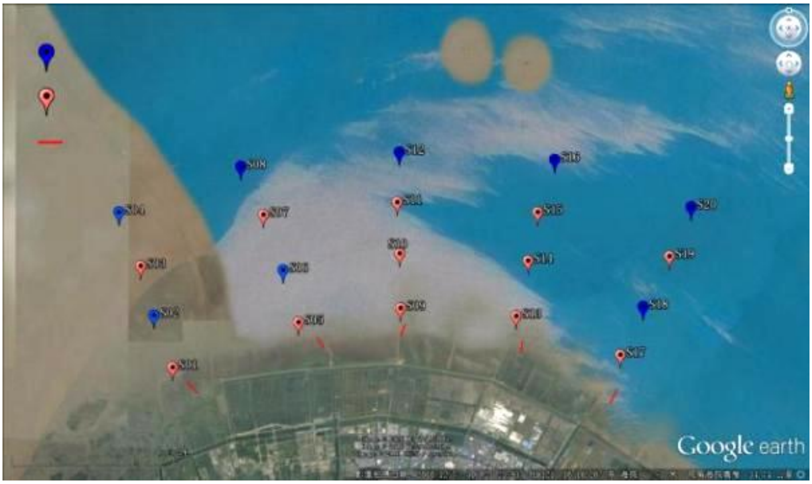
2 Data collection

Prior to the project, marine survey data were collected from the Ningbo Marine Environment Monitoring Center (CMA certificate number: 2014002216F) and the Ningbo Marine and Fisheries Research Institute (CMA certificate number: 160012192811) in the project area in April and September 2016. As shown in Fig.1, 48 water quality stations, 29 ecological stations and 8 intertidal zone sections were set up for spring survey. In autumn, there are 20 water quality stations, 12 sediment stations, 12 ecological stations and 5 intertidal zone sections.

After the project, marine survey data were collected from the Ningbo Marine Environment Monitoring Center (CMA certificate number: 2014002216F) in the project area in April and August 2019. There are 48 water quality stations, 24 sediment stations, 29 ecological stations and 8 intertidal zone sections in the project, which is shown in Fig.2.



(a)



(b)

Fig. 1. Survey Stations at April and September 2016

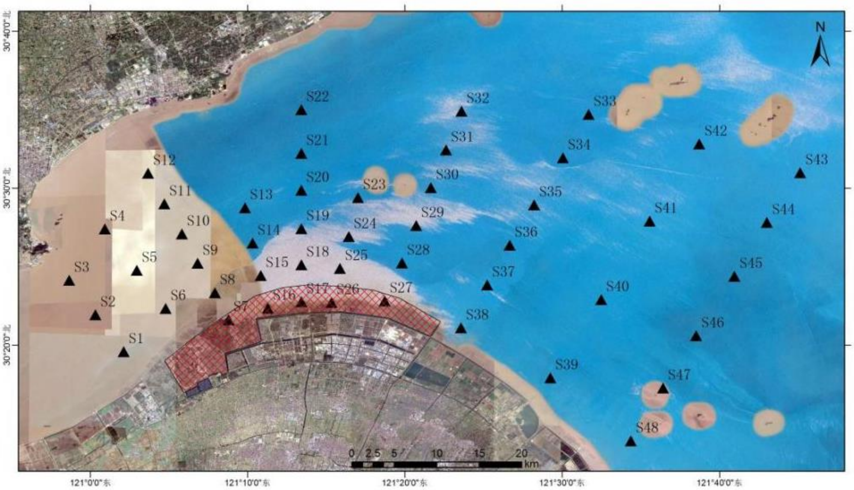


Fig. 2. Survey Stations at April and August 2019

3 Marine Ecological Impact Assessment

3.1 Changes in seawater quality

The data from April 2016 and April 2019 were used for comparative analysis before and after the project. The comprehensive collected water quality survey results show that the average and extreme values of water quality elements are detailed in Table 1. It can be seen that, except for dissolved oxygen, COD and inorganic nitrogen showing a slight upward trend, the average values of various indicators of seawater quality in the investigated sea area before and after the implementation of the project have little change and remain stable on the whole.

Table 1. Comparison of water quality before and after the project

Time	Standard II	Before the project			After the project		
		min	max	mean	min	max	mean
Water temperature		15.0	16.8	16.0	11.1	17.8	14.7
salinity		4.41	16.62	9.75	4.980	17.638	8.545
pH		7.86	8.05	7.96	7.93	8.07	8.00
Dissolved oxygen (mg/L)	>5	8.25	8.85	8.53	8.50	9.70	9.06
Petroleum (mg/L)	≤0.05	0.012	0.039	0.018	0.005	0.048	0.017
Suspended solids (mg/L)		98.0	4039.0	1677.4	40.0	3689.0	785.9
COD (mg/L)	≤3	0.86	1.30	1.12	1.35	2.90	2.09
Volatile phenol (μ g/L)	≤5	ND	5.6	2.6	ND	3.2	2.1
Sulfide (μ g/L)	≤50	ND	3.7	1.7	ND	3.2	1.5
Phosphate (mg/L)	≤0.030	0.0416	0.0805	0.0586	0.0136	0.0674	0.0367
Inorganic nitrogen (mg/L)	≤0.30	0.990	1.844	1.377	1.190	2.038	1.591
Hg(μg/L)	≤0.2	0.015	0.026	0.021	0.017	0.026	0.022
As(μg/L)	≤30	0.9	1.7	1.3	1.0	1.4	1.2
Zn(μg/L)	≤50	4.0	12.9	7.8	2.4	9.6	5.1
Cr(μg/L)	≤10	0.40	0.72	0.54	0.37	0.77	0.53
Pb(μg/L)	≤5	0.18	0.67	0.38	0.04	0.53	0.20
Cd(μg/L)	≤5	0.03	0.36	0.08	0.03	0.12	0.06
Cu(μg/L)	≤10	1.6	4.3	2.9	1.8	4.2	2.8
666(ng/L)	≤2000	ND	ND	ND	20.7	28.1	24.0
DDT(ng/L)	≤100	ND	10.6	9.52	ND	44.3	23.5
PCBs(ng/L)		ND	14.4	4.74	ND	12.9	1.73

3.2 Marine sediment impact assessment

Statistical analysis was conducted on the collected sediment survey results. The minimum, maximum, and average values of the main sediment monitoring items are shown in Table 2.

It can be seen that only some survey stations in the surveyed sea area have higher levels of petroleum and sulfide in sediment than before the project, while other indicators are lower than before the project, and all indicators meet the sediment class I standard after the project. The sediment indicators remained generally stable before and after the implementation of the engineering project.

Table 2. Comparison of sediment indicators in the sea area before and after the project

Sediment indicator	Standard I≤	Before the project			After the project		
		min	max	mean	min	max	mean
Petroleum(10^{-6})	500	3	26.7	14.9	22.5	48.9	33.1
TOC(%)	2.0	0.14	0.59	0.38	0.09	0.41	0.28
Sulfide (10^{-6})	300	0.63	2.16	1.4	0.7	10.5	3.3
Zn(10^{-6})	150	87.8	153	110.7	17.8	76.4	47.9
Pb(10^{-6})	60	24.1	44.7	34.3	8.1	31.8	16.3
Cd(10^{-6})	0.5	0.12	0.22	0.16	0.04	0.12	0.08
Cr(10^{-6})	80	55.5	82.1	68.5	21.9	44.4	33.3
Cu(10^{-6})	35	36	55.6	44.9	7.3	26.1	15.3

3.3 Marine supply services

Marine supply services refer to the services provided by ecosystems for the production or provision of products. Specifically, coastal wetland ecosystems refer to the services provided by marine products such as fish, shrimp, crabs, and shellfish as food for people's daily lives, as well as the services provided for various types of raw materials used in human production activities such as papermaking, chemical engineering, and processing.

The supply service is mainly calculated based on the value of primary production services in the Technical Guidelines for Environmental Impact Assessment of Bay Reclamation Planning (GB/T 29726-2013), and the calculation formula is as follows:

$$D_{hr} = \frac{P_0 E}{\delta} \sigma P_s \rho_s S \tag{1}$$

in which D_{hr} is the loss of primary production services caused by reclamation, in yuan/a; P_0 is the primary productivity per unit area of the filled sea area [kgC/(m^2 • a)]; E is the conversion efficiency of primary productivity into mollusks,%; δ is the mixed carbon content of fresh meat in shellfish products,%; σ is the ratio of fresh meat weight to shell weight of shellfish products; P_s is Average market price of shellfish products (yuan/kg); ρ_s is sales profit margin of shellfish products,%; S is the area of reclamation, in square meters (m^2).

According to the primary productivity measurement results in November 2014, the primary productivity in the project area is 49.461mgC/(m2· d), and the project occupies about 15.37hm2 of intertidal zone benthic area. Based on this estimation, the primary production loss of the dredging project is approximately 45900 yuan/year.

3.4 Marine gas regulation

The regulation of gases by ecosystems is mainly reflected in the fixation of atmospheric CO_2 by plant photosynthesis and the release of O_2 into the atmosphere. The value of gas regulation includes two parts: the value of fixing C and the value of releasing O_2. According to the Technical Guidelines for Environmental Impact Assessment of Bay Reclamation Planning (GB/T 29726-2013), the losses caused by reclamation on gas regulation services can be estimated using the alternative market method, referring to the costs of fixed CO_2 and O_2 production. The calculation formula is as follows:

$$D_{ga} = (C_{co2} + 0.73C_{o2})XS \quad (2)$$

In the equation, D_{ga} is the loss of gas regulation services caused by reclamation (yuan/a); C_{co2} and C_{o2} are the cost of fixed carbon dioxide and cost of producing oxygen (yuan/t); X is the amount of fixed carbon dioxide per unit area of the sea [t/($m^2 \cdot$ a)]; S is the reclamation area, in square meters (m^2).

The average primary productivity of the sea area near the project is 49.46mgC/(m^2. d), and the project occupies about 15.37hm^2 of intertidal zone benthic area. The average of carbon tax rate and afforestation cost price is taken. At present, the international common carbon tax rate is generally 150 USD/t for Sweden, 6.9 for the US dollar exchange rate, and 250 yuan/t for China's afforestation, so the average value is 642.5 yuan/t (C). Taking the average value of afforestation cost price and industrial oxygen production price, according to Chen Yingfa et al.'s research, the cost of producing oxygen is 400 yuan/t, which is 325 yuan/t (O). Based on this, it is estimated that the gas regulation value loss caused by the Ningbo Hangzhou Bay New Area Bank Protection and Beach Protection Project (Phase III) is about 2400 yuan/year.

3.5 Marine waste treatment

Reclamation projects directly alter the characteristics of tidal currents in the area, causing changes in sediment erosion and migration patterns of pollutants, reducing the environmental capacity of seawater and reducing the diffusion capacity of pollutants. Therefore, reclamation projects damage or weaken the self purification function of marine water bodies. On the basis of obtaining the changes in environmental capacity of typical pollution factors in the sea area, the value loss of waste treatment services caused by reclamation is estimated by referring to the cost of sewage treatment. The calculation formula is as follows:

$$V_d = \frac{X(C_i - C)P}{C_w} \quad (3)$$

In the equation, V_d is value of waste treatment functions; X is net water exchange loss caused by reclamation; C_i is background concentration value of COD in seawater; C is control objectives for seawater pollutants; P is unit cost of domestic sewage treatment; C_w is average COD concentration in domestic sewage.

According to the topographic map, the average depth of the sea area where the Ningbo Hangzhou Bay Revetment and Beach Protection Project (Phase III) is taken as 2 meters, and the volume of the occupied water area is about 307386 m^3; The price of domestic sewage treatment is 0.9 yuan/m^3; According to the marine survey conducted by the Ningbo Marine Environment Monitoring Center and the Ningbo Marine and Fisheries Research Institute in April 2016 (spring) in the project area, the chemical oxygen demand (COD) in the pre engineering area was 0.86-1.30mg/L, with an average value of 1.12 mg/L. Therefore, the estimated COD background value is 1.12mg/L. The sea area where the project is located belongs to the Class III functional zone, and the seawater quality protection target is the Class III seawater quality standard. Therefore, the COD control target is taken as the Class III seawater standard, which is 3.00 mg/L. The average concentration of COD in domestic sewage is about 150 mg/L. Based on this, it is estimated that the waste treatment value loss caused by this dredging project is approximately 35000 yuan/year.

4 Discussion

Before and after the implementation of the project, there was little change in various indicators of seawater quality. Except for dissolved oxygen, COD, and inorganic nitrogen, which showed a slight upward trend, the average values of other indicators did not change significantly and remained stable overall. The water in the region was generally eutrophic. After the implementation of the project, there was little change in various indicators of sediment, and all indicators met the sediment class I standard.

5 Conclusions

The Ningbo Hangzhou Bay Revetment and Beach Protection Project (Phase III) has changed the local hydrodynamic environment, mainly causing a reduction in power between the spur dikes and an increase in power in the local area of the spur dikes, with a relatively small impact on the hydrodynamic environment of the outer sea area of the project area. There was no deterioration in seawater quality and sediment quality.

The project mainly causes the loss of benthos in the occupied mudflat area, but the newly added mudflat also contributes to the recovery and increase of biological resources in the intertidal zone. The project will not cause serious damage to the ecological environment of the surrounding sea area, basically do not affect the structure and function of the ecosystem, and have no significant impact on the regional marine ecological environment.

References

1. Zhang, A, Yin, J, Wang, L, et al. Ecological damage assessment and compensation for reclaimed coastal pond aquaculture: A case study in Qingduizi Bay, China[J]. Aquac Res. 2020; 51: 2091– 2101.
2. Rencai Dong, Chencan Lv, Chen Weng, Anxin Lian, Lulu Zhang, Jialiang Chen, Mai Ye, Environmental damage compensation for illegal solid waste dumping in China[J], Ecotoxicology and Environmental Safety, Volume 253, 2023, 114657
3. Nan-qi Song, Nuo Wang, Wan-ni Lin, Assessment of the impact of artificial island airport reclamation on marine ecosystem health: A case study of the Dalian offshore airport, China[J], Ocean & Coastal Management, Volume 226, 2022, 106281,
4. Li Z, Bu Z,Yin C, et al. Research on the Application System of Marine Oil Spill Ecological Damage Assessment[C]//Advanced Science and Industry Research Center.Proceedings of 2014 International Conference on Energy, Environment and Materials Engineering(EEME 2014).DEStech Publications,2014:7.
5. Li Jingmei, Liu Tieying. Ecological damage assessment of jiaozhou bay reclamation based on habitat equivalency analysis[J]. Acta Ecologica Sinica,2012,32(22).
6. Chen, P., Sun, Z., Zhou, X. et al. Impacts of coastal reclamation on tidal and sediment dynamics in the Rui'an coast of China[J]. Ocean Dynamics 71, 323–341 (2021).
7. Wenting Cao, Yuyu Zhou, Rui Li, Xuecao Li, Mapping changes in coastlines and tidal flats in developing islands using the full time series of Landsat images[J], Remote Sensing of Environment, Volume 239, 2020, 111665
8. Bodycomb R, Pomeroy AWM, Morris RL. Kelp Aquaculture as a Nature-Based Solution for Coastal Protection: Wave Attenuation by Suspended Canopies. Journal of Marine Science and Engineering. 2023; 11(9):1822. https://doi.org/10.3390/jmse11091822
9. Jacob, B., Dolch, T., Wurpts, A. et al. Evaluation of seagrass as a nature-based solution for coastal protection in the German Wadden Sea. Ocean Dynamics 73, 699–727 (2023). https://doi.org/10.1007/s10236-023-01577-5.
10. de Silva, W., Amarasinghe, M.D. Coastal protection function of mangrove ecosystems: a case study from Sri Lanka. J Coast Conserv 27, 59 (2023). https://doi.org/10.1007/s11852-023-00990-8