

Analysis of the impact of reclamation project on the health of Marine ecosystem in Cangzhou coastal area

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Abstract. For a comprehensive understanding of Cangzhou nearshore reclamation project construction effect on Marine ecosystem health, the evaluation scope is divided into six areas. According to the spring monitoring data in 2017, the regional ecosystem health evaluation method is used to evaluate the health index, and five evaluation indexes including seawater environment, sediment environment, biological habitat, biological forms and organisms are selected. Studies have shown that: the seawater environment, sediment environment and biological forms in the Cangzhou coastal area were all healthy; biological habitats, organisms and marine ecosystems were Unhealthy or sub-healthy; Reclamation activities are associated with the deterioration of seawater quality and the reduction of benthic and plankton biomass. The destruction of biological habitats is the main reason for the low ecosystem health index.

1 INTRODUCTION

For a long time, reclamation has been regarded as an important way to solve the shortage of land resources in coastal areas. Since the late 1990s, large-scale reclamation has been mainly used for engineering purposes, such as port construction, ship repair and airport construction, industrial purposes, such as steel production and oil storage, and residential development and construction. At the same time of forming remarkable social and economic benefits, the disorderly, unrestrained and free reclamation also brings serious negative impact on the Marine environmental resources in coastal areas [1-3].

From a single project in the early days to a large-scale regional reclamation, the sea area is facing increasing risks of high pollution and Marine ecological damage while making remarkable progress. [4-5].

Cangzhou is located in the eastern part of Hebei province, near the border of Shandong Province. Cangzhou Bohai New Area began large-scale reclamation in 2007, and by 2016 the reclamation activities had basically ceased, with a total reclamation area of 76 square kilometers. With the expansion of the reclamation area, a series of ecological problems, such as the change of the natural properties of coastal zones and the reduction of coastal wetlands, have been brought about. In order to rationally develop and utilize marine resources and protect marine ecosystem, it is urgent to carry out health assessment of marine ecosystem in the coastal areas of Cangzhou.

2 METHODS

In order to reflect the impact of reclamation activities on the marine ecosystem, the assessment scope was divided into six areas and numbered as Area I, II, III, IV, V and VI. All the reclamation areas are located in area III.

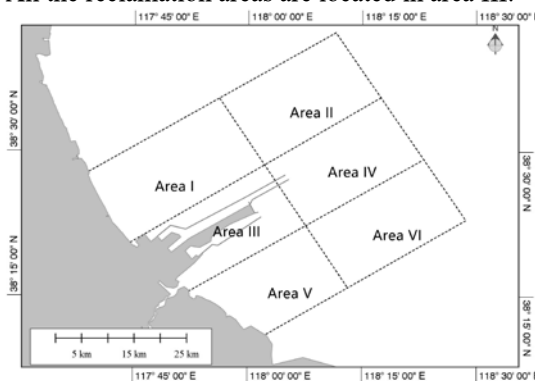


Figure 1. Cangzhou coastal area division map.

Based on spring monitoring data of Cangzhou coast area in 2017, this study constructed the marine ecosystem health evaluation index system.

2.1 Classification and weight of evaluation index

According to the “eco-environmental health assessment method for estuarine and Gulf ecosystems” in the 《Guidelines for Evaluation of Nearshore Marine Ecological Health》 (HY/T 087 -- 2005), 5 kinds of evaluation indexes were selected: seawater

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environmental index, sediment environmental index, biological habitat index, biological forms index and organisms index.

2.2 Research methods

The indicators, requirements and valuations of estuaries and bays are shown in Table 2.

Table 1. Indicators and weights for evaluating ecosystem health in estuaries and bays

Evaluation index	Seawater environment	Sedimentary environment	Biological forms	Biological habitat	Organisms
Weight	15	10	10	15	50

Table 2 Criteria for evaluating ecosystem health in estuaries and bays

Evaluation index	level		
	healthy	sub-healthy	unhealthy
Seawater environment (W_{indx})	$11 \leq W_{indx} \leq 15$	$8 \leq W_{indx} < 11$	$5 \leq W_{indx} < 8$
Sedimentary environment (S_{indx})	$7 \leq S_{indx} \leq 10$	$3 \leq S_{indx} < 7$	$1 \leq S_{indx} < 3$
Habitat (H_{indx})	$11 \leq H_{indx} \leq 15$	$8 \leq H_{indx} < 11$	$5 \leq H_{indx} < 8$
Biological forms (B_{indx})	$7 \leq B_{indx} \leq 10$	$4 \leq B_{indx} < 7$	$1 \leq B_{indx} < 4$
Organisms (O_{indx})	$35 \leq O_{indx} \leq 50$	$20 \leq O_{indx} < 35$	$10 \leq O_{indx} < 20$
Marine ecological health index (CEH_{indx})	$CEH_{indx} \geq 75$	$50 \leq CEH_{indx} < 75$	$CEH_{indx} < 50$

Table3 Environmental assessment indicators, requirements and values for estuaries and bays

	Indicators	I	II	III
	Assignment	15	10	5
Seawater environment	Dissolved oxygen (mg/L)	≥ 6	$\geq 5 \sim < 6$	< 5
	pH	$> 7.5 \sim < 8.5$	$> 7.0 \sim < 7.5$ or $> 8.5 \sim < 9.0$	≤ 7.0 or > 9.0
	reactive phosphate ($\mu\text{g/L}$)	≤ 15	$> 15 \sim < 30$	> 30
	Inorganic nitrogen ($\mu\text{g/L}$)	≤ 200	$> 200 \sim < 300$	> 300
	Petroleum ($\mu\text{g/L}$)	≤ 50	$> 50 \sim < 300$	> 300
Sedimentary environment	Organic carbon	$\leq 2.0\%$	$> 2.0\% \sim < 3.0\%$	$> 3.0\%$
	Sulfide ($\mu\text{g/g}$)	≤ 300	$> 300 \sim < 500$	> 500
Biological forms	Hg ($\mu\text{g/g}$)	≤ 0.05	$> 0.05 \sim < 0.10$	> 0.10
	Cd ($\mu\text{g/g}$)	≤ 0.2	$> 0.2 \sim < 2.0$	> 2.0
	Pb ($\mu\text{g/g}$)	≤ 0.1	$> 0.1 \sim < 2.0$	> 2.0
	As ($\mu\text{g/g}$)	≤ 1.0	$> 1.0 \sim < 5.0$	> 5.0
	Petroleum hydrocarbons ($\mu\text{g/g}$)	≤ 15	$> 15 \sim < 50$	> 50
Habitat	Coastal wetland habitat decreased in 5 years/%	≤ 5	$> 5 \sim < 10$	> 10
	Annual variation of major components in sediment /%	≤ 2	$> 2 \sim < 5$	> 5
Organisms	Phytoplankton density (ind/m^3)	$> 50\% A \sim < 150\% A$	$> 10\% A \sim < 50\% A$ or $> 150\% A \sim < 200\% A$	$\leq 10\% A$ or $> 200\% A$
	Zooplankton density (ind/m^3)	$> 75\% B \sim < 125\% B$	$> 50\% B \sim < 75\% B$ or $> 125\% B \sim < 150\% B$	$\leq 50\% B$ or $> 150\% B$
	Zooplankton biomass (mg/m^3)	$> 75\% C \sim < 125\% C$	$> 50\% C \sim < 75\% C$ or $> 125\% C \sim < 150\% C$	$\leq 50\% C$ or $> 150\% C$
	Density of fish eggs and larvae (ind/m^3)	> 50	$> 5 \sim < 50$	≤ 5
	Benthic density (ind/m^2)	$> 75\% D \sim < 125\% D$	$> 50\% D \sim < 75\% D$ or $> 125\% D \sim < 150\% D$	$\leq 50\% D$ or $> 150\% D$
	Benthic biomass (mg/m^2)	$> 75\% E \sim < 125\% E$	$> 50\% E \sim < 75\% E$ or $> 125\% E \sim < 150\% E$	$\leq 50\% E$ or $> 150\% E$
Note: According to Appendix A of 《The Guideline for Evaluation of Coastal Marine Ecological Health》, the values of Bohai bay in May were taken with reference to: $A=3 \times 10^3 \text{ind/m}^3$; $B=10 \times 10^3 \text{ind/m}^3$; $C=400 \text{mg/m}^3$; $D=150 \text{ind/m}^2$; $E=25 \text{g/m}^2$				

$$W_q = \frac{\sum_1^n w_i}{n} \tag{1}$$

2.3 Index assignment calculation and health evaluation method

The calculation formula of index assignment is:

W_q ——the q indexes assignment;
 W_i ——the evaluation index of item Q of station I;

N —the total number of monitoring stations in the evaluation region.

The formula for calculating the index health index is:

$$W_{indx} = \frac{\sum_1^m W_q}{m} \quad (2)$$

W_{indx} —the environmental health index;

W_q —the evaluation index of item Q;

M —the total number of evaluation indicators in the evaluation region.

The ecological health index is calculated as follows:

$$CEH_{indx} = \sum_1^P INDX_i \quad (3)$$

CEH_{indx} — the ecological health index;

$INDX_i$ —the health index of the category I index;

P—the total number of evaluation index.

3 RESULTS AND DISCUSSION

3.1 The seawater environment

Cangzhou nearshore index of seawater environment evaluation results are shown in table 4, from which it can be seen that, the seawater environment is in a healthy state, and the health index of area III (reclamation area) is the lowest. The analysis shows that the increase of human activities in the reclamation area leads to the increase of the concentration of active phosphate and petroleum. thus resulting in the lower seawater environmental health index.

Table 4 Evaluation of seawater environment health index

Area code	Target assignment					Seawater Environmental Health Index	level
	Dissolved oxygen	pH	active phosphate	Inorganic nitrogen	Petroleum		
Area I	15.00	15.00	15.00	5.00	13.75	12.75	healthy
Area II	15.00	15.00	15.00	5.00	15.00	13.00	healthy
Area III	15.00	15.00	14.44	5.00	12.78	12.44	healthy
Area IV	15.00	15.00	15.00	5.00	15.00	13.00	healthy
Area V	15.00	15.00	15.00	5.00	14.00	12.80	healthy
Area VI	15.00	15.00	15.00	5.00	15.00	13.00	healthy

3.2 The sediment environment

Cangzhou nearshore index of sediment environment evaluation results are shown in table 5, from which it can be seen that, the sediment environment is in a healthy state, and there is no significant difference between different areas.

3.3 Biological forms

Cangzhou nearshore index of biological forms evaluation results are shown in table 6. It can be seen from table 6 that the biological forms is in a healthy state, and there is no significant difference between different regions.

Table 5 Evaluation of sediment environment health index

Area code	Target assignment		Sediment environmental health index	level
	Sulfide	Organic carbon		
Area I	10	10	10	healthy
Area II	10	10	10	healthy
Area III	10	10	10	healthy
Area IV	10	10	10	healthy
Area V	10	10	10	healthy
Area VI	10	10	10	healthy

Table 6 Evaluation of biological forms

Area code	Target assignment					the health index of biological forms	level
	Hg	Cd	Pb	As	Petroleum hydrocarbons		
Area I	5	5	5	10	10	7	healthy
Area II	5	5	5	10	10	7	healthy
Area III	5	5	5	10	10	7	healthy
Area IV	5	5	5	10	10	7	healthy
Area V	5	5	5	10	10	7	healthy
Area VI	5	5	5	10	10	7	healthy

3.4 Organisms

Cangzhou nearshore index of organisms evaluation results are shown in table 7. It can be seen from table 7 that half of the coastal areas are in a sub-healthy state and half in an unhealthy state. It shows that the coastal Marine biological environment has been damaged to varying degrees. The reclamation area (area III) and its northwest adjacent area (Area I) had the lowest biohealth

index, which was mainly related to the low biomass of benthic organisms and plankton.

The reclamation activities in Cangzhou Bohai New Area are carried out from southeast to northwest, which makes the biological environment of area I, adjacent to the reclamation area III, also affected by the reclamation activities. Analysis shows that the destruction of organisms caused by reclamation activities is obvious, which is directly reflected in the biomass reduction of benthic organisms and plankton.

Table 7 Evaluation of Biohealth index

Area code	Target assignment						Biohealth index	Level
	Phytoplankton density	Zooplankton density	Zooplankton biomass	Benthic density	Benthic biomass	Density of fish eggs and larvae		
Area I	10	10	30	10	10	10	13.33	Unhealthy
Area II	10	10	10	10	50	10	16.67	Unhealthy
Area III	10	10	10	30	10	10	13.33	Unhealthy
Area IV	10	10	50	10	30	10	20.00	sub-healthy
Area V	10	10	30	50	10	10	20.00	sub-healthy
Area VI	10	10	50	10	50	10	23.33	sub-healthy

3.5 Biological habitat

Cangzhou nearshore index of habitat evaluation results are shown in table 7. It can be seen from table 7 that except for area III (reclamation area), which is in an unhealthy state, all the other areas are in a sub-healthy state.

Since 2012, the total reclamation area of Area III (reclamation area) has been 32.8 square kilometers, all of which are coastal wetlands. Therefore, the index of reduction of coastal wetland area is assigned as 5.

With the implementation of the reclamation project, the topography of the coastal area in Cangzhou also changed significantly, and the hydrodynamic environment and the sediment environment also changed, resulting in the change of sediment particle size.

Therefore, the annual variation index of the content of the main components in the sediments in each region was all 5, which was also the main reason for the sub-health of the habitat environment in most of the coastal area in Cangzhou.

3.6 Marine ecosystem

Cangzhou nearshore index of habitat evaluation results are shown in table 7. The evaluation results of Marine ecosystem in the coastal waters of Cangzhou are shown in Table 9, and the contour map of Marine ecosystem health index in the coastal waters of Cangzhou is shown in Figure 2.

Table 8 Habitat environmental assessment

Area code	Target assignment		Habitat environmental health index	Level
	Coastal wetland habitat decreased in 5 years	Annual variation of major components in sediment		
Area I	15.00	5.00	10.00	sub-healthy
Area II	15.00	5.00	10.00	sub-healthy
Area III	5.00	5.00	5.00	Unhealthy
Area IV	15.00	5.00	10.00	sub-healthy
Area V	15.00	5.00	10.00	sub-healthy
Area VI	15.00	5.00	10.00	sub-healthy

Table 9 Marine ecosystem assessment

Area code	Sea water Environmental Health Index	Sediment environmental health index	The forms of health index	Habitat environmental health index	Biohealth index	Marine ecosystem Health index	Level
Area I	12.75	10	7	10	13.33	53.08	sub-healthy
Area II	13.00	10	7	10	16.67	56.67	sub-healthy
Area III	12.44	10	7	5	13.33	47.78	Unhealthy
Area IV	13.00	10	7	10	20.00	60.00	sub-healthy
Area V	12.80	10	7	10	20.00	59.80	sub-healthy
Area VI	13.00	10	7	10	23.33	63.33	sub-healthy

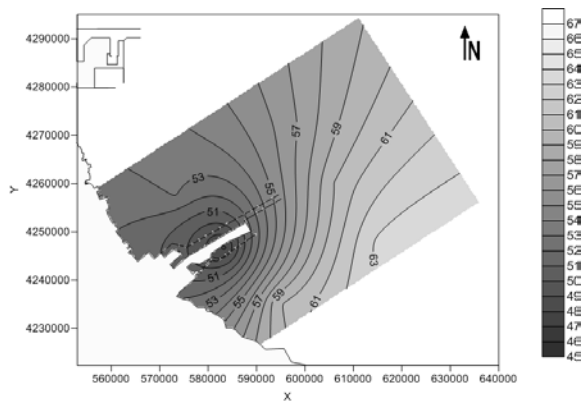


Figure2 Contour map of ecological health index (In 2017)

As can be seen from Table 8, except for area III (reclamation area), which is in an unhealthy state, the rest of the areas are in a sub-healthy state. It shows that the Marine ecosystem has been damaged to different degrees, especially the impact of reclamation activities on the Marine ecosystem.

According to the analysis in Figure 2, the whole survey area is basically in a sub-health state. In the regional distribution, the nearshore is lower than the open sea, and the reclamation area is in the low value area. The coastal wetland habitat is reduced due to land reclamation, which results in its biological habitat health index lower than the surrounding area, and this is also the main reason for its low ecological health index.

4 CONCLUSION

According to the results of this study, in 2017, most of the Marine ecosystems in the coastal area of Cangzhou were treated as sub-healthy, while the reclamation areas were unhealthy. By comparing the different zones, it can be seen that reclamation activities are related to the deterioration of seawater quality, the biomass reduction of benthic organisms and plankton, and the destruction of biological habitats is the main reason for the low ecosystem health index.

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